Exploring the barriers and strategies in the innovation phase: a case study in renewable energy technologies

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MSc Management of Technology

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by

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Executive summary

More than ever, there is a growing importance of renewable energy technology (RET) as a part of the global energy source. Many countries have invested more actively in different types of renewable energies and included technological innovations in the industry as a part of their economic and infrastructure agenda. With the increasing need of a cleaner energy and abundance incentives from the government, the evolution of innovating firms who are developing radical innovations related to RET products has been expanding, especially in the Netherlands. However, there is usually a long time frame in the innovation phase in which the innovative technological principle is translated into a viably commercialised product. This is due to the occurrence of certain barriers that may hamper the development of the product and thus, innovative products may fail even before entering the market.

In this research, we aim to identify the barriers that can occur and inhibit the innovation phase and analyse the strategies that can be implemented in order to remove or circumvent these barriers, which will lead to an initial framework of barriers and strategies for the innovation phase. In order to reach this objective, a three-stage methodological approach has been followed. The first stage comprises of literature review that examines the factors that may influence a new, high-tech product to develop and diffuse from the perspective of RET and other technological innovations in general, as well as the strategies that can be used to tackle these factors when they become a barrier. The second stage consists of developing a conceptual framework through logical reasoning by first classifying these factors and strategies into the respective categories (product and infrastructure for the factors, and commercial and non-commercial for the strategies) and identifying which of these factors and strategies can exist during the innovation phase. The third stage applies the use of case study method by choosing cases of innovating firms that are developing RET innovations and examining which of the factors from the conceptual framework can turn into a barrier and thus, impeding the innovation phase, as well as which strategies that can be implemented.

From this research, we have developed an adapted framework of barriers and strategies for the development of a new, high-tech product in the innovation phase. It was found that the barriers

that can persist in the innovation phase from the product perspective include the lack of product performance & quality, the lack of knowledge & awareness of the technology that can come from either the firm's or the society's (or potential customer's) side, an unaffordable product price, and the lack of knowledge & awareness of the market, while from the infrastructure perspective include the lack of financial resources from investors, the lack of coordination with the business partners, the lack of coordination with human resources, the lack of acceptance or high expectation from the society, unfavourable economic condition, and the lack of managerial system. The strategies that are found to be implemented in the innovation phase to remove or circumvent these barriers include, from the non-commercial category, pilot, in-house, outsourcing, governmental funding, business partnership, lobbying, strategic planning, educate, lead user, redesign, conventional, and alternative financing strategy, while there is no applicable strategy from the commercial category.

This result of this research also provides us with several insights about the innovation phase, factors and barriers, strategies, and linkages. In the innovation phase, there is already a starting point of key actors and factors that enable the product to begin developing. Not only the technical aspect is important, building up the infrastructure around the innovation is also required in this phase and factors that are more market- or customer-oriented can also affect the development of product. It is imperative for innovating firms to have a long-term perspective when aligning the resources and competencies, but also have a broader view in formulating the surrounding system and integrate the market, society, and many else. Using the factors from Ortt & Kamp (2018) as a starting point also gives us a full-on look on important aspects, not only technical but also institutional, financial, and other elements. However, an additional factor, shared vision, is proposed, which refers to how the product is envisioned and also the sense of union from the firm's perspective.

There is also a more complex iterated process where the use of one strategy can lead to another barrier, from which a new strategy is implemented. This could be beneficial to the innovating firms as it can bring in new actors and resources. From the results of the case studies, it can be observed that the relationship between barrier and strategy is not as straightforward as expected, in which there is an interplay from the presence of opportunity and consideration of available resources. This can provide us with an insight on the linkages and another mechanism on how a certain barrier or strategy can be approached.

In the end, we provide a recommendation from the managerial perspective and ideas for future research regarding the topic of this research. For the innovating firms, the findings of this research can provide a guideline of what barriers can occur and hamper the development of the product in the innovation phase as well as the appropriate strategies to remove or circumvent them, in order to ensure a sustained position in said phase and progress to the market introduction. Several actionable aspects include seeking initial funding from the government, using lobbying to not only the government but also to the business partners, executing strategic planning as a foundation for how the firm can operate based on long-term objectives, and be aware of window of opportunities to implement strategies, especially in pilot, financing and educate strategy. From the academic perspective, including more innovating firms and cases of different RET innovations would be beneficial to generalise the results further and analyse the differences of barriers and strategies in different RETs. It is also imperative to study further about the linkages between the barriers and strategies in order to build up a more concrete guideline of how a strategy is chosen through looking into the decision-making process of an innovating firm when deciding strategy and analysing the underlying motives and steps.

Another important aspect is to analyse the long-term perspective and broader view formulating surrounding system, such as how to incorporate the long-term view into enabling the broader system around the product, so that not only the innovation phase is managed but also the two other phases will take place more smoothly. It is also recommended to investigate the influence of these barriers on the innovation phase through quantitative method, for example by considering the causal relationship between factors and product success. In order to align the interests of different actors, we can also examine the barriers and strategies from the perspective of governmental bodies. Another idea is to investigate the different barriers and strategies that exist throughout the three phases of the diffusion pattern. Through this study, we can observe how the dynamic of the barriers and strategies change overtime, according to each phase, build up a comprehensive guideline on how to progress from one phase to another, as well as to maintain the innovating firm's position in each phase.

Acknowledgements

Ever since I came to the Netherlands to pursue my study, I thought that the wind was always blowing against me, in quite both a literal sense –when you bike in the winter, with the wind and rain stabbing your face constantly, you know what I am talking about—and figuratively. A great deal of challenges was coming at me all at once, I had no idea what to do and where to start. Throughout this thesis journey, I began to get myself back up and made a lot of changes in myself, both as a Master's student and an individual. And here I am, for the first time ever, I feel that the wind is finally on my side. To me, this thesis is more than just another milestone that I have proudly accomplished. It is, in its entirety, a truly defining moment.

First and foremost, I would like to express my highest gratitude to Dr. L.M (Linda) Kamp, for all of her support and motivation as my first supervisor during this thesis period. From the start of Sustainable Innovations and Transitions course to the end of this thesis, Linda has always given me valuable insights every time I got stuck and despite any struggles, Linda always believes in my potentials even when I did not. Her guidance means a lot to me and I cannot thank her enough for the opportunity to work closely with her.

Second of all, I would also like to thank Dr. J.R. (Roland) Ortt as the chair and second supervisor of this thesis. His constructive feedbacks and insights have helped me a lot to develop the thesis project and recognise *"the music to the ears"* in the research. Because of his assessments and interesting views on this project, I was able to shift my perspective towards finding solutions for the problems encountered during the thesis. I would also like to thank the interviewees who have been participating in this thesis, without whom any intriguing insights produced in this thesis would not be possible.

Last but surely not the least, this journey would also not be possible without the support from my family back in Jakarta, especially my mum, who always has faith in me no matter what. Thank you for giving me the freedom to pursue my passions, whether it is in Japan or the Netherlands. I would also like to thank my friends at TU Delft for making my journey even more delightful. A special thank you to Ankit, Chris, Jaap, Jason, Jesse, Jovano, Piyush, and Yawar, who have stuck by my side with all of their encouragement and cheer, and helped me get through the last two years, especially when I felt doubts about myself. Big thanks to everyone!

Two years do not seem so long to some. But all the lessons I have learned and the experiences I have gone through during my time in TU Delft have shaped me into an individual who perseveres, thrives to fight in difficult moments, and dedicates the best effort into my work and the values that I believe in. One of my favourite authors, T.S. Eliot, once said, *"For last year's words belong to last year's language, and next year's words await another voice. And to make an end is to make a beginning"*. With this thesis, I would like to close my chapter at TU Delft and begin a new one, with more adventures, more milestones, and more priceless experiences. Let the wind takes me away again!

Izma R. Effendi

Delft, November 2018

Dedicated to the memory of my late father. To me, you are the true virtue of hard work and determination.

Table of contents

List of tables

List of figures

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1. Introduction

1.1 Background

Many European countries have started promoting and implementing renewable energies, such as wind, solar, and hydropower. The Paris Agreement, for instance, was established in order to bring all countries to reduce climate change by keeping the global temperature rise below 2°C (UNFCCC, 2015). It is aimed to make all nations more resilient to the impact of climate change and how to lower greenhouse gases (GHG) emissions through placing a robust policy framework and stimulating the use of sustainable technologies. Renewable Energy Directive of the EU gives a policy framework for the European Union regarding the renewable energy sector where it targets 20% greenhouse gas emission reduction, 20% share of renewable energy sources, and 20% energy efficiency improvement by the year 2020 throughout the entire EU (European Commision, 2017).

In the Netherlands, the government has been actively supporting renewable energy. The Dutch government gave subsidies to over 4,500 renewable energy projects with over 5.8 billion euros (Pieters, 2017). In collaboration with the Netherlands Investment Agency (NIA), the Ministry of Economic Affairs has launched Energy Transition Financing Facility (ETFF) to finance projects related to renewable energy (Ministry of Economic Affairs, 2016). In the Dutch Energy Agenda, innovation is considered as an integral part of the energy transition. It states that*," The development of radical innovations takes a long time, which is why it is important to provide better incentives for the development of relatively unknown, but potentially highly promising technologies in the framework of CO2 reduction"* (Ministry of Economic Affairs, 2016). As producing renewable energy is also not always profitable, the Ministry of Economic Affairs and Climate Policy launched the *"SDE+"* (Stimulering Duurzame Energieproductie) grant, which is an incentive scheme for individuals or firms who are looking to generate their own renewable energy (Rijksoverheid, 2008). This grant was established in order to achieve the Dutch

government's energy agreement of having a 14% share of renewable energy for consumption by 2020.

The changing trends of energy consumption and the existing support from the government have begun to stimulate an emergence of entrepreneurial activities through the formation of start-ups in the Netherlands that are working on projects involving renewable energy technologies, such as E-kite, Bluerise, and SolarSwing. Both the Ministry of Economic Affairs and popular publications have pointed out that the innovative process of technology and entrepreneurship can serve as a central force in the development of an ecologically, socially sustainable economy, and catalyse the energy transition.

While there is already an extensive literature on innovation, technology entrepreneurship and commercialisation strategies, there is still a gap between these theoretical concepts with the practices of commercialisation specifically in the field of renewable energy technologies. Kaplan (1999) stated that commercialisation of new energy technologies using large-scale, large-investment schemes can be counterproductive and that small-scale efforts can be more successful for such innovations. The sources of innovation of RET typically have been from small and medium enterprises (SMEs) that have either organically grown or have been acquired by a large incumbent energy firm for the purpose of improving the acquirer's value chain (Walsh, 2012). Recent publications have also pointed out some of the difficulties in moving towards a sustainable energy system in the Netherlands. There have been already technology-specific studies such as Kamp (2004) that looked at the wind turbine development in the Netherlands and Denmark, Agterbosch, Vermeulen, & Glasbergen (2004) that analysed at the obstacles for wind power implementation, while Negro, Hekkert, & Smits (2007) and Raven (2005) that reported the slow diffusion of biomass technologies.

Diffusing or commercializing these new innovations or high-tech products (that use these innovations) in the market is not straightforward and faces multiple barriers. New high-tech products, being different from existing products face challenges in terms of price and performance and their successful diffusion or commercialization takes multiple years. Ortt (2012) states that the diffusion of new high-tech products is done by initially introducing them in niches before a mass market for the product emerges. These niches act like a transition towards a mass market (Ortt, 2012). Weber, Hoogma, Lane, & Schot (1999) observed that these niches possess important features that enable diffusion and development of a new technology.

1.2 Problem exploration

Technological innovation has been a great importance in playing a role in the society, especially in the context of organisations' and firm's resources by offering a competitive advantage to succeed in the industry. Technological innovation can also give benefit to the society such as improving the gross domestic product (GDP) of an economy, contributing to better ways of communication and mobility, and advancing innovations in many industries such as medical and energy field (Schilling, 2013). While fostering innovation in organisations and firms is crucial to the development of the society, the development and diffusion of a certain technology involve a significant risk and are heavily influenced by a variety of factors, such as the market dynamics, infrastructure, culture, and many else.

Ortt & Schoormans (2004) stated that breakthrough technologies are characterised by a discontinuous advance in technology and by the emergence of new markets. The phases in the pattern of development and diffusion consist of three phases; innovation, market adaptation, and market stabilisation phase. Ortt, Langley, & Pals (2013) also explored the barriers that may hamper new high-tech products from having a large-scale diffusion as well as strategies that can be used to circumvent these barriers. However, it is not clear what barriers that occur in which phase of the development and diffusion, especially in the innovation phase, and what strategies that can be implemented accordingly. In this research, we would like to explore the different barriers in the innovation phase, specifically involving renewable energy technologies (RETs) innovations developed in the Netherlands. The renewable energy industry is chosen as a scope in this research because the market of renewable energy technologies, on its own, is particularly unique. We also would like to see the different strategies implemented in the innovation phase and provide recommendation of strategies that are specific to the innovation phase in order to sustain the company's position in said phase and move onto the next phase towards a large-scale diffusion of the product.

1.3 Scientific background

There have been several studies regarding the development and diffusion of an innovation, such as Rogers' S-shaped diffusion curve which indicates the percentage of a population which uses a certain product in the course of time (Rogers, 1986). Ortt & Schoormans (2004) also proposed a modified model of a breakthrough technologies which gives an insight about the three distinctive phases a technology goes through from the time of its invention to its stabilisation in the market.

This model has been constructed through exploring more than 100 different cases that involve radical, new-high tech products in many different industries.

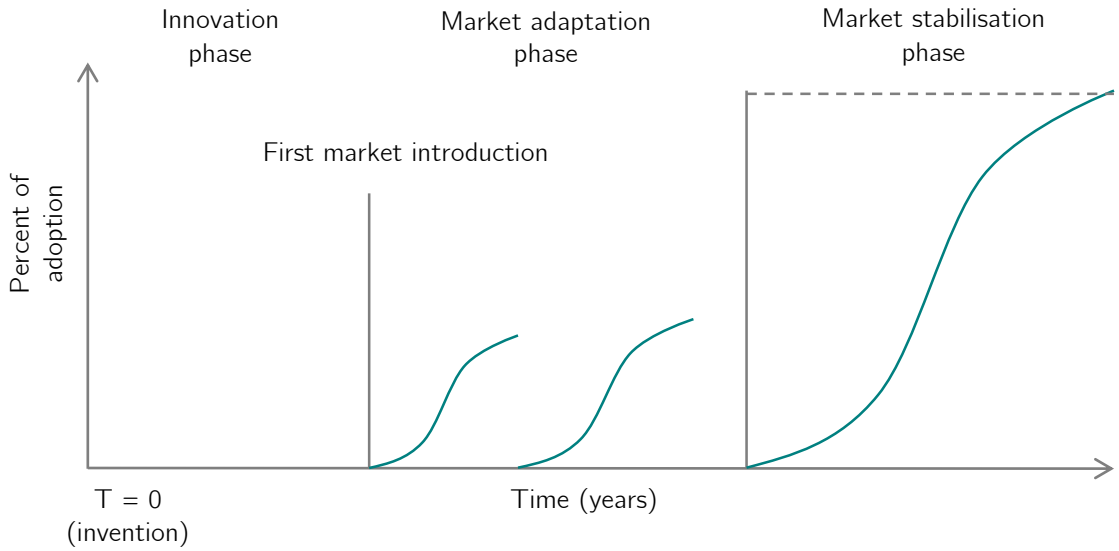


Figure 1 The pattern of development and diffusion of a new high-tech product (Ortt and Schoormans, 2004)

These three phases include the innovation phase which is from the invention of a technology to its first market introduction as a product, the market adaptation phase which occurs when the first introduction to the market starts to when the large-scale diffusion takes off, and the market stabilisation phase which is when large-scale diffusion starts and ends with a substitution of an old technology. *Figure 1* illustrates the three subsequent phases.

The framework proposed by Ortt & Kamp (2018) will be used as the critical concept in this research. The study involves investigating barriers that may hamper large-scale diffusion of a new high-tech product which can be differentiated into seven core factors and seven influencing factors. This framework was constructed based on historical case studies that involve new-high-tech product in the market adaptation phase. The absence of a certain factor could inhibit the commercialisation of a product. Based on the combination of these core and influencing factors, a specific niche strategy can be derived and applied in order to circumvent or remove these barriers so that the product can diffuse further into the market. *Figure 2* summarises the influencing (left) and core factors (middle) that may hamper large-scale diffusion of a new high-tech product.

In this model, an assumption is made that barriers already start to exist in the innovation phase and are fully overcome as the product reaches market stabilisation phase. In the previous work of Master's theses, Moschos (2016) and Mannheimer (2016) have explored the barriers in the

innovation phase. However, there is still a need for an extensive research to understand the development of new high-tech product in this phase, especially for its barriers and strategies. In this research, we will follow the assumption that barriers already start to exist and give an influence to the development of the product from the innovation phase and thus, there are certain strategies to implement to overcome these barriers. We will also follow the assumption that the radical innovation is already fully envisioned, meaning that the new high-tech product already has a clear purpose and its functionality is definitive. This point will be discussed further in Chapter 7.

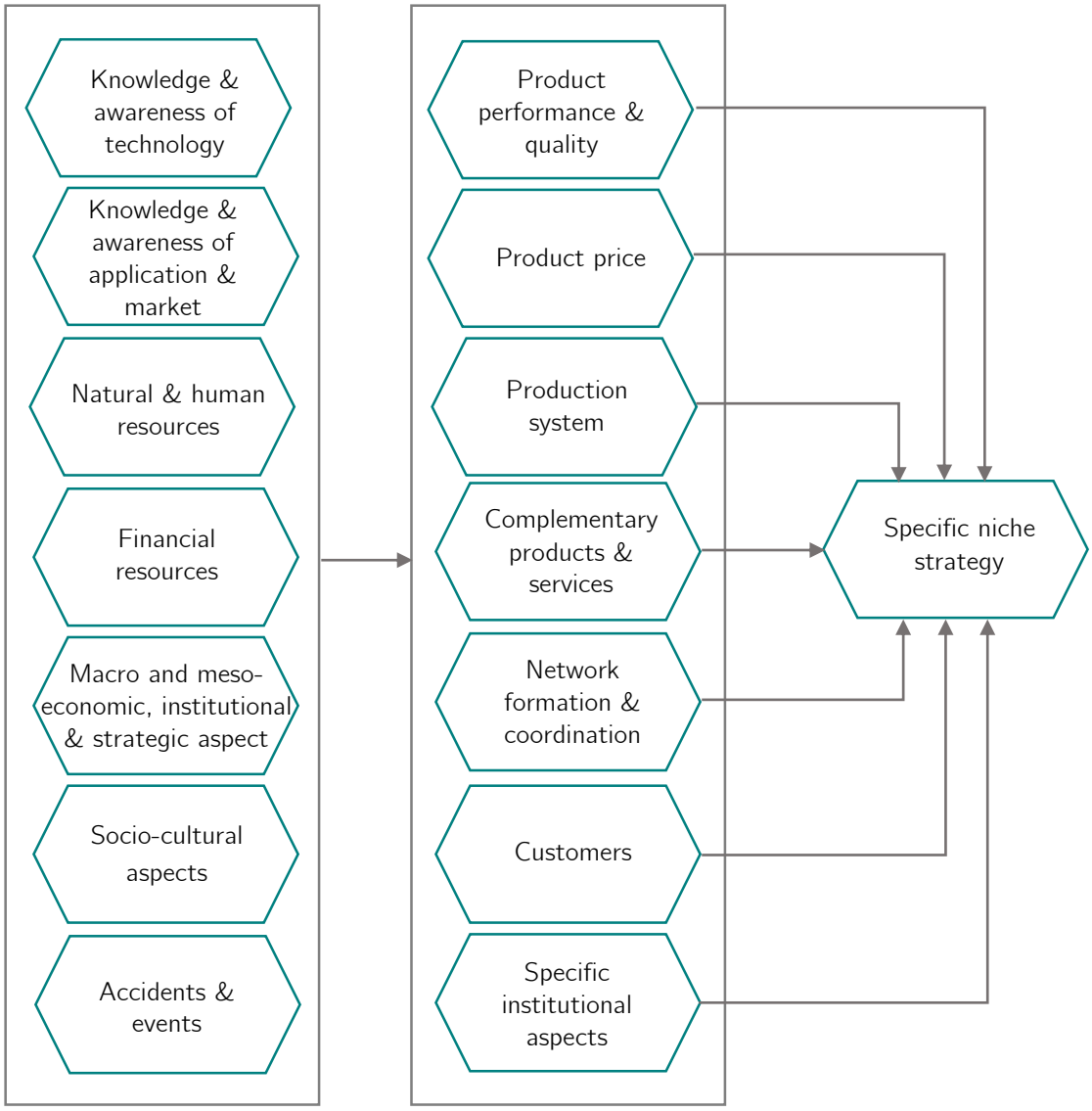


Figure 2 Ortt and Kamp's framework (Ortt & Kamp, 2018)

1.4 Identification of knowledge gap

Previous theses have been conducted in order to extend the Ortt & Kamp's framework to several situations (Harahap, 2014; Doe, 2013; Bruinsma, 2015; Vintilă, 2015; Pratiwi, 2016; Van den Berg, 2017; Manchanda, 2017; Parthasarathy, 2017; Lestari, 2017). For instance, Pratiwi (2016) categorised different barriers and strategies based on the cases in BRICS countries regarding the implementation of electric vehicles and Van den Berg (2017) focused on the barriers and strategies for the scale up of RE-desalination technology in developing countries. All of these 9 thesis works have focused on cases that are in the market adaptation phase and built up the list of barriers and strategies according to the situation, while there are only 2 thesis works, such as Moschos (2016) and Mannheimer (2016), that have explored the barriers in the innovation phase. Thus, there is still a lack of knowledge in terms of which barriers and strategies are used in the first phase, which is the innovation phase, in the diffusion pattern.

This research aims to identify the barriers that exist in the innovation phase, what roles they play in this phase, and how they influence the initial stage of the development of the product. We also aim to identify what strategies that can be used to overcome these barriers in the innovation phase. These objectives will be achieved through adapting the original framework of Ortt & Kamp (2018) of barriers and strategies into the innovation phase. There might also be addition to the barriers and strategies that can be implemented to eliminate or circumvent these barriers in said phase. Thus, the list of barriers and strategies from the original work will have to be adjusted according to the innovation phase, but to what extent they should be modified is unclear.

2. Research approach

2.1 Research objectives

The objective of this research is to identify the barriers and strategies that exist in the innovation phase of the diffusion pattern of a new high-tech product. The field of renewable energy technologies (RETs) in the Netherlands is chosen as the level of analysis in this research. We would like to understand more about the innovation phase and what factors influence the development of the product in this phase. This research is a type of exploratory study in which comparisons are being made to see the differences and similarities of barriers in the innovation phase faced by the firms in the field of renewable energy technologies in the Netherlands and the strategies used to remove or circumvent these barriers.

2.2 Research question and sub questions

To be able to answer the research objective, research questions are formulated and serve as a guideline of the research. The main research question of this thesis is:

"What are the barriers faced and strategies implemented by firms in the field of renewable energy technologies in the Netherlands that influence the innovation phase of the diffusion pattern?"

Several sub-questions (SQ) are developed to support in answering the main questions:

SQ1. What are the barriers faced by firms in any phases of the diffusion pattern and specifically in the innovation phase of their new high-tech products differ based on the literature and reasoning?

SQ2. What are the strategies implemented by firms in any phases of the diffusion pattern and specifically in the innovation phase of their new high-tech products differ based on the literature and reasoning?

SQ3. What are the barriers faced by firms in the Netherlands in the field of renewable energy technologies during the innovation phase based on the case studies?

SQ4. What are the current strategies used by the firm to overcome these barriers based on the case studies?

SQ1 and SQ2 aim to identify what barriers that are experienced and strategies that are used by firms to overcome these barriers in the innovation phase of the diffusion pattern. This will be answered through looking at different literature and logical arguments as to which barriers and strategies that are more likely to present in each phase. These two sub-questions will also include literatures that identify what barriers that are experienced and strategies that are used to overcome these barriers specifically in the field of renewable energy technologies. SQ3 aims to link these barriers and strategies in order to understand which strategies to use according to the barriers that exist in a particular situation.

SQ3 focuses on addressing the actual barriers that firms in the Netherlands who are working in the field of renewable energy technologies experience during the innovation phase. This will be answered through multiple-case study of two different cases in which each exists in the innovation phase. SQ4 focuses on addressing the actual strategies that firms in the Netherlands who are working in the field of renewable energy technologies implement to overcome the barriers in the innovation phase. This will be answered through the same multiple-case study as explained before. Cross-case analysis based on the previous multiple-case study will be conducted in order to see any similarities and differences in barriers and strategies.

2.3 Research scope

Due to the time constraint of the Master's thesis, this research is limited in the following aspects:

1. Technology phase and type

   The technology that will be used as case studies are related to innovations in the field of renewable energy technologies that are in the innovation phase. While some RET innovations are now currently in the market adaptation or even stabilisation phase, many of these innovations face challenges before entering the market. Choosing the cases in

the innovation phase will give an insight specifically to what is happening in terms of barriers and strategies in said phase. Note that any RET innovations that do not include the fundamental concept of generating energy from a renewable source or any innovations that are aimed towards sustainable living will not be eligible as a case.

2. Technology phase

   The technology that will be investigated is limited to two cases related to specific renewable energy technologies that are in the innovation phase.

3. Geographical location

   This research is focused on the cases in the Netherlands.

4. Actors

   This research will only investigate private firms in the Netherlands. Actors related to the governmental agencies will not be explored in this research.

2.4 Scientific relevance

This research aims to expand the barriers and niche strategies framework proposed by Ortt & Kamp (2018) through analysing the barriers faced and strategies implemented by firms in the Netherlands, specifically in the renewable energy technologies field during the innovation phase. The research will analyse how the barriers and niche strategies explained in the literature differ with those in practice and how they play a role in the innovation phase of the diffusion pattern. It is expected that this research will add several newly identified barriers and niche strategies to the existing framework by Ortt & Kamp (2018) as this research will focus on the barriers and strategies according to the first innovation phase. Since this research will also look at the different barriers and strategies of the cases in the innovation phase of the diffusion pattern, the result of this research will provide an initial framework for firms in said phase to flourish in the innovation phase and eventually progress to the next market adaptation phase.

The result of this research will also be relevant to the knowledge of the Master's programme, Management of Technology, as this research will be conducted from the perspective of the firm and aims to understand how technology acts as a firm resources, how new technological production takes place, what important factors in terms of technological trends and socio-cultural aspects exist and how they affect the implementation of a certain high-tech product in the market.

2.5 Practical relevance

The result of this research will be significant to firms in the Netherlands in the field of renewable energy technologies and generally in other fields in order to manage efficiently the barriers they encounter while implementing their high-tech product in the market and improve their strategies to accelerate the development of their innovation and move into the market adaptation phase for commercialisation. This research can provide an insight on how these barriers can play a role to their product development and what appropriate strategies to use. Additionally, the result will be relevant for governmental agencies in the Netherlands to collaborate with the firms in order to manage the barriers that exist in the implementation of renewable energy technologies. This could develop into further energy transitions towards renewable energy in order to achieve one of the goals of the Dutch government.

3. Research methodology

3.1 Methodology

The research question to be answered in this research is *"What are the barriers faced and strategies implemented by firms in the field of renewable energy technologies in the Netherlands during the innovation phase of the diffusion pattern?"*. In order to answer this question, a literature review, and a multiple-case study, and a cross-case analysis will be conducted.

Sekaran & Bougie (2009) defines literature review as follows: *"a step-by-step process that involves the identification of published and unpublished work from secondary data sources on the topic of interest, the evaluation of this work in relation to the problem, and the documentation of this work".* Literature review is required in this research in order to understand the current state of the topic, especially related to firms in the Netherlands, the large-scale diffusion of renewable energy technologies, as well as barriers and strategies that exist in the field. The literature review will make use of scientific articles available on the internet and TU Delft Library database. The use of textbooks, conference proceedings, and governmental and/or corporate reports will also be used. Keywords such as *"firms in the Netherlands*", *"Renewable energy technologies"*, *"Barriers"*, *"Strategies"*, *"Niche"*, *"Innovation"*, *"Diffusion of high-tech products"*, and other related terms will be used to find relevant literature.

Yin (2006) defines case study as a research method that is conducted when the main question of the research is a *"what"* or *"how"* question. It is also preferable when the investigator has little or no control over the events and the research focuses on a contemporary phenomenon within a real-life context (Yin, 2006). This research will investigate real-life contexts of different cases in the Netherlands, the barriers experienced by the firms in the cases for a large-scale diffusion of their renewable energy technologies, and the strategies employed by them. Thus, it can be concluded that case study method is the most suitable for this research. A multiple-case study

method will be used in this research in order to see the differences of barriers and strategies in the different cases that will be investigated in this research. Then, cross-case analysis will be conducted to compare the cases, observe the similarities and differences, generalise the barriers that occur in the case studies and strategies that are implemented.

This research can be considered as an exploratory study which is conducted when there is some information known about the subject in question and more information is required in order to develop the theoretical framework (Sekaran & Bougie, 2009). Interviews with different subjects are necessary in order to understand better regarding the situation at hand. As the Master's thesis has a limited timeframe, this research can be considered as a cross-sectional or one-shot study. This indicates that the data required to answer the main research question are gathered once, over a period of months (Sekaran & Bougie, 2009).

Figure 3 Specific methodology for each research sub-question

Figure 3 above summarises how each research sub-questions will be answered. For SQ1, we will gather information about factors and barriers that can influence any phase of the diffusion pattern by looking at different literatures, keeping in mind of Ortt & Kamp (2018) as the main framework. Then, we will categorise the factors that have been generalised into appropriate groups and see which ones are relevant in the innovation phase, through logical reasoning. SQ2 has a similar approach as SQ1, only that the subject in question will be about strategies. SQ3

and SQ4 will involve interviews on the cases accordingly and analysis of the results through individual and cross-case analysis for all the three aspects. In Chapter 7, all of the answers to these sub-questions and the main research question will be summarised. *Figure 4* below outlines the overview of the methodological approach in this research.

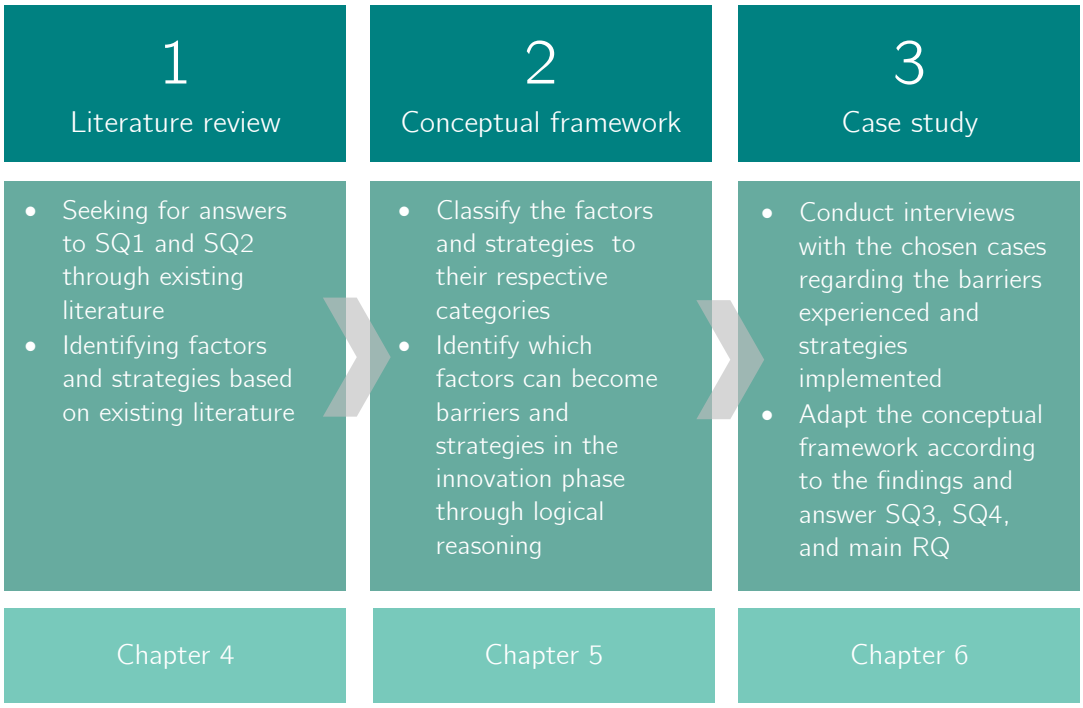


Figure 4 Overview of the methodological approach

3.2 Structure of the report

Figure 5 below gives an outline of the report structure. The report will start with an introduction to the background, problem exploration, and identification of knowledge gap as Chapter 1. Chapter 2 will elaborate on the research approach, including research objectives, questions, and any relevance that this research will contribute to. The research methodology will be explained in Chapter 3. Then, Chapter 4 will elaborate on the theoretical background, such as on diffusion of high-tech products, factors and strategies of commercialising a new high-tech product.

Chapter 5 will elaborate on the conceptual framework that has been developed with the aid of Chapter 3 and 4. Case studies of the selected cases will be conducted and elaborated in Chapter 6. This will be done using the methods explained in Chapter 3 and conceptual framework in Chapter 5. Then, the results as well as the analysis will be investigated in Chapter 6. Cross-case

analysis will also be elaborated here. At the end, conclusion and discussion will be outlined in Chapter 7 which will address the answers to the research questions, discussions, recommendations, and any additional insights for future research.

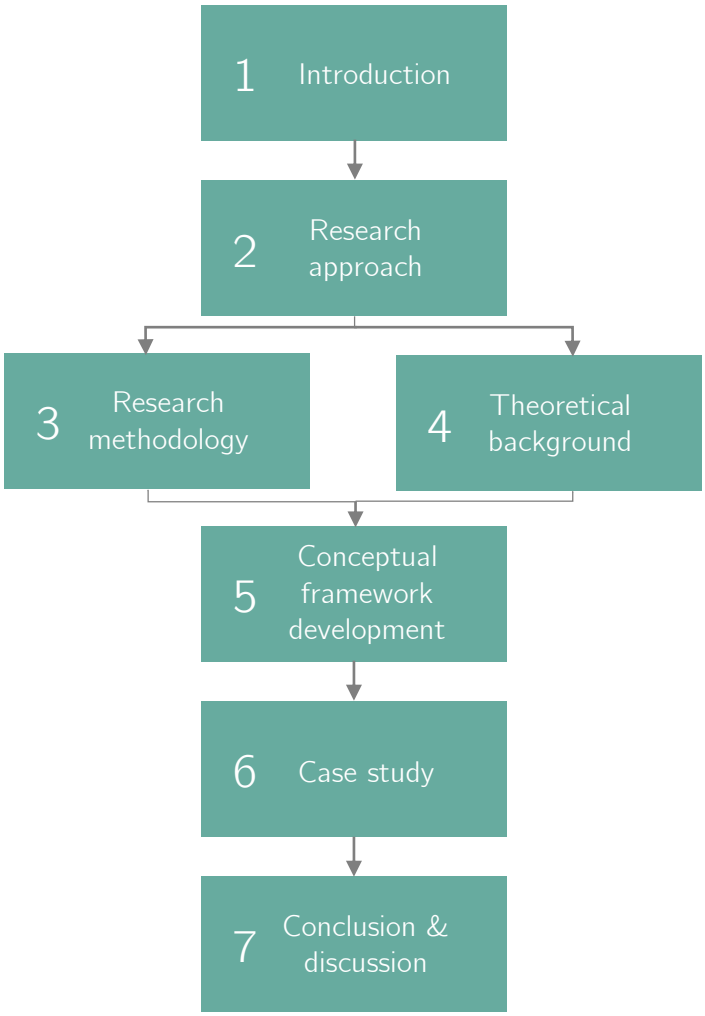


Figure 5 Structure of the report

3.3 Selection of cases

In order to conduct the case study, two cases that involve the development of renewable energy technologies products will be looked into further. The cases that are chosen are currently in the innovation phase. This will give us an insight to the barriers and strategies that currently exist and are implemented by the firms during this innovation phase. Barriers faced in the cases and the current strategies that are implemented for the development and diffusion of their products will be identified. While some of the points below have already been mentioned in Section 2.3,

we would like to make clear again that the selection of these cases as the unit of analysis are based on the following criteria:

1. The units should be located in the Netherlands.
2. The units should have high-tech products related to the field of renewable energy technologies.
3. The units should have an RET product that is currently being developed in the innovation phase.
4. The units should be present cases instead of historical cases. Present cases will give more insight in more details regarding specific reasons underlying a factor or strategy that is identified. This is because with present cases, we can ask the interviewee in real-time about any experiences with the barriers and strategies, their views will still be up-to-date with the current situation, and follow-up questions regarding any ambiguity or additional information can be inquired.

Table 1 shows the list of the firms to be interviewed. The second column lists out the firm name, the third column describes the location of the firm in the Netherlands, and the fourth column mentions the type of product they offer. We would like to note that due to certain constraints in contacting the initial list of the firms, the objective of this research was shifted accordingly to only the innovation phase. *Appendix I* will mention any additional remarks regarding this shift.

Table 1 List of firms to be interviewed

No.	Firm name	Location	Product name
1	Kitepower	Delft, NL	Kitepower system
2	Physee	Delft, NL	PowerWindow

The cases are explained briefly below, refer to Chapter 6 for more details:

1. Kitepower is a company located in Delft which develops innovative and cost-effective alternatives to existing wind turbines by using kites to generate electricity. The product does not need towers and heavy foundations and thus, it is less resource intensive and easier to transport. The company is currently responsible in projects to implement the system as a demonstration, however not yet for commercialisation. From this information, we can consider that their position is in the innovation phase.

2. Physee is a Delft-based company which develops a product that integrates glass, solar cells, and smart sensor technologies. The product generates electricity that is easily accessible and can be applied to buildings and windows. The company is currently responsible in installing PowerWindows in new building apartments and offices by commercialising their product, contributing to a sustainable way of living. From their business journey, it can be considered that their product is in the innovation phase.

4. Theoretical background

4.1 Technological innovations

Previous literatures have indicated that innovation occurs in the context of innovation system which can be defined as a set of elements, be it technologies, actors, networks, and institutions, that contribute actively to the development of a specific technological field or its products and applications (Bergek et al., 2015). In the beginning, the linear model of innovation, views the innovation as an autonomous development that occurs through a linear process from invention, innovation, to diffusion. However, this perspective began to be challenged as more studies have shown the importance of social contexts in the development of technology and innovation which shifted the autonomous process into a more dynamic one (Nelson & Winter, 1997; Bijker, 1995).

This brings us to the rise of system approach which indicates that innovation is dependent on the quality of the system that can include the infrastructure, involvement of various actors and users, institutional aspects, and many else. As more factors in the system can affect how an innovation develops, there is a higher uncertainty and need for learning from the network of actors (Ortt & Smits, 2006). Innovation also becomes a more entrepreneurial activity which suggests that innovation has a more direct contribution to a firm's business goals. This affects the R&D activities from being solely technical-oriented to business-focused, for example R&D venturing.

According to Schilling (2013), technological innovation can be defined as the act of introducing a new device, method, or material for application to commercial or practical objectives. The importance of innovation from a technological perspective is becoming more important as the globalisation and human development significantly improve. These innovations are often categorised into different types, depending on the degree of its novelty, the knowledge

competency they offer, and to what extent the innovation changes the overall system. In the case of the innovation streams model developed by Tushman, Anderson, & O'Reilly (1997), for example, it highlights the use of degree of novelty in an technology to distinguish the two types: radical and incremental innovation, and focuses on whether the innovation itself would establish a new market or focus on the existing ones. *Figure 6* below represents the innovation streams model.

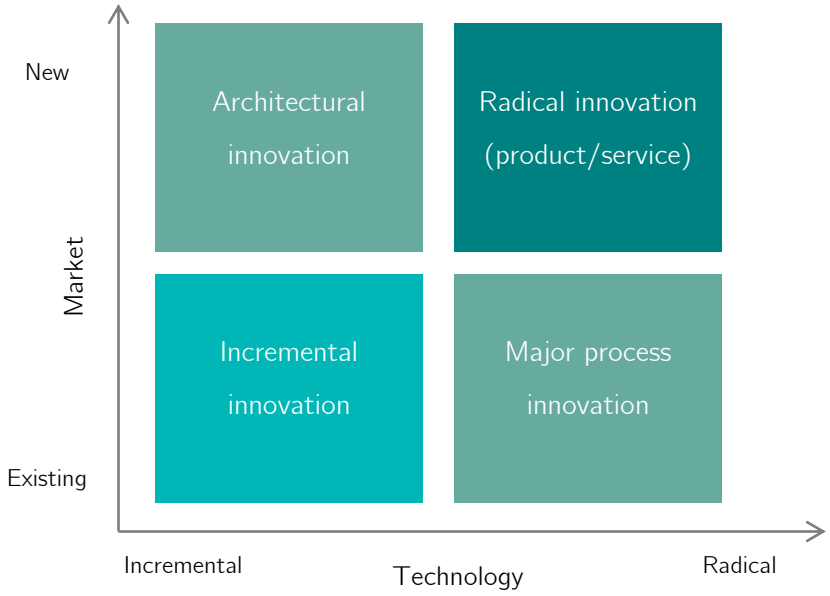


Figure 6 Innovation streams model (Tushman et al., 1997)

Radical innovation refers to an innovation that is very new, different, and distinctive compared to what is offered by the pre-existing products or processes. This type of innovation can also be characterised by its high risk, as radical innovations usually arise from integrating new knowledge and thus, there are more risks involved in terms of its technical feasibility, cost, and reliability (Dewar & Dutton, 1986). Incremental innovation, however, refers to an innovation that provides minor changes into any existing products or processes and thus, its degree of novelty is not as significant as radical innovations. However, this type of innovation is also crucial, in terms of improvements to the existing practices. Architectural innovation refers to an innovation that reconfigures the overall system in order to link together the existing components in a new way (Schilling, 2013; Henderson & Clark, 1990). While when there is a closing of a dominant design, the innovation stream shifts away from product towards major process innovation. The next section will elaborate on how the radical innovation in a new, high-tech product can develop and diffuse.

4.2 Diffusion of high-tech products

In the context of technology management, the term *"diffusion"* is the process of adoption of a particular innovation in a gradual manner by a market segment or the society. Rogers (1986) described how diffusion of a technology takes place in an S-shaped curve where it indicates the percentage of adoption related to the course of time. The S-shape curve starts off with a low number of adopters initially, then the increase of adopters of which the steepness of the diffusion curve relates to the rate of adoption, and ends with a maximum number of adopters, rendering the curve stagnant. However, the S-curve has shown to be a limited model since it does not give an insight about the development of technology just after the invention phase and the erratic pattern that occurs after the first market introduction of the technology (Ortt & Schoormans, 2004).

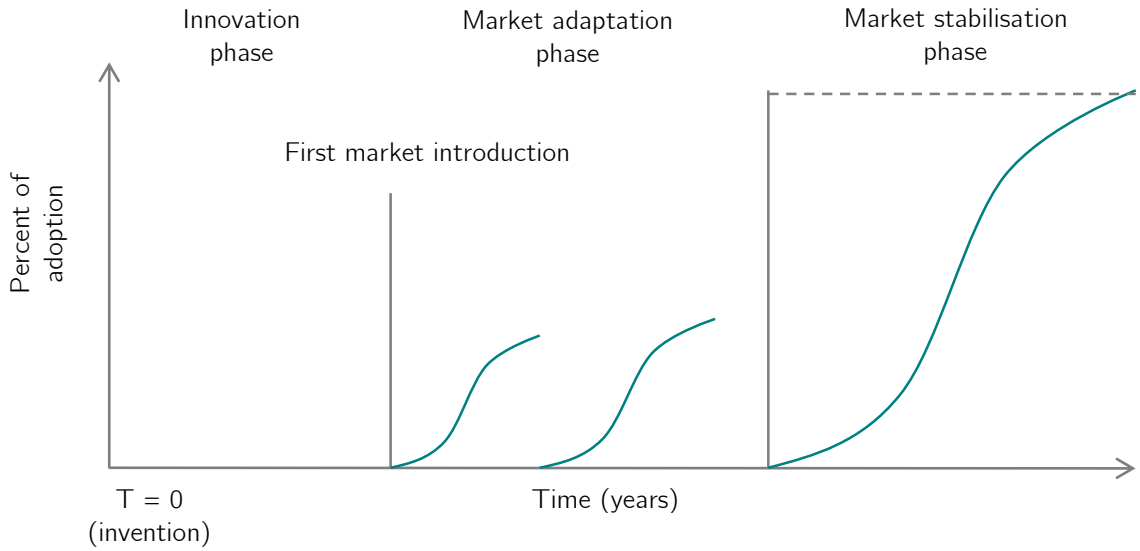


Figure 7 Diffusion pattern of a new high-tech products (Ortt & Schoormans, 2004)

Ortt & Schoormans (2004) introduced a diffusion pattern of new high-tech products from its early invention to the large-scale diffusion (*Figure 7*). This model involves three distinctive phases: innovation phase, market adaptation phase, and market stabilisation phase which will be elaborated more in the next section. The length of each phase can vary and there are also possibilities that one or more of the phases do not even occur or that the entire process of adoption breaks off in each of the phase (Ortt, 2009). *Figure 8* shows the different possible scenarios that describe the diffusion pattern (Ortt, 2009).

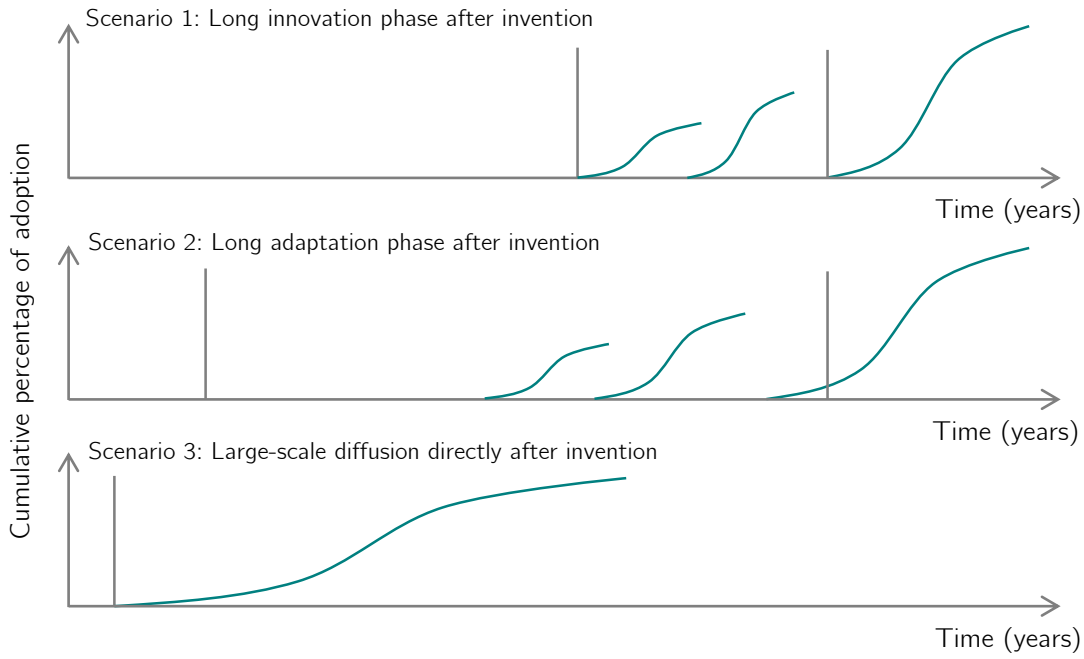


Figure 8 Different possible scenarios that describe the diffusion pattern

4.2.1 Innovation phase

Innovation phase is the period when a technology is first invented into its first introduction to the market. This is the phase where the technological principle is transformed into a marketable product (Ortt & Schoormans, 2004). According to Mansfield (1968) and Utterback & Brown (1972), the length of this phase can vary from 15-23 years. This variation depends on the type of industry, the kinds of technologies in one industry, and the specific definition of invention (Ortt & Schoormans, 2004). During this phase, actors such as universities and research institutions usually contribute significantly to the development of the innovation. The main goal in this phase is to also increase the performance and quality of the product while reducing the price, in order to appeal to the potential customers (Ortt & Schoormans, 2004). Before the technological innovation can be introduced to the market, the reliability, performance, and potential applications of the technology need to be established and the most important pre-condition of the market mechanism in this phase is to have a supply and demand of research funds and researchers (Ortt & Schoormans, 2004).

In this phase, research and development (R&D) for the new product is a crucial element. In the early phase, Kelm, Narayanan, & Pinches (1995) suggested that there is a two-stage

classification of R&D in which the events occurring before the new product launch are classified as an innovation stage. This includes the initiation of a project, its progress, and any other events that show the product has not reached a successful result yet. Another stage after that is referred to as the commercialisation stage of R&D where it marks the introduction of the new product to the market and being commercialised (Kelm, Narayanan, & Pinches, 1995). During this innovation stage, there is more risks in technological capability and feasibility which influence the progress of the R&D. According to Kelm, Narayanan, & Pinches (1995), it is critical that in the innovation stage for the firm to focus their attention to achieving feasible solutions of any technological problems as it may gain more acceptance by the market in the later stage.

Other than the technical perspective of R&D, there are other factors to consider in developing a product innovation such as an adequate understanding of the market by the firm, laws & regulation, inter-functional collaboration between the innovating firm and other stakeholders, any learning that is oriented towards the development of the innovation, and R&D investments (De Medeiros, Ribeiro, & Cortimiglia, 2014). It can be considered that when developing a new product on the innovation phase, there are various factors that can influence the development. It is important to not only focus on the technical aspect, but also the surrounding infrastructure around it that includes laws, society, external stakeholders, and many else. An unideal condition of any of these factors can result to a delay in the innovation phase and thus, can be considered as a barrier.

The Valley of Death

Markham, Ward, Aiman-Smith, & Kingon (2010) defined *"The Valley of Death"* as the gap between the formal roles, activities, and resources poured into research and the existing formal new product development (NPD) roles, activities, processes, and resources that lead toward commercialisation. In the pattern of development and diffusion of a new high-tech product by Ortt & Schoormans (2004), this valley exists in the innovation phase, where the product is not introduced to the market yet. *Figure 9* shows the valley of death as an illustration.

The figure suggests that there are enough resources required for research during the discovery but then drop significantly in the valley of death. The resources then become adequately available again for developing the product and its commercialisation (Markham et al., 2010). The study also suggests the so-called role theory of innovation which explains that in order to overcome the valley, there should be an emergence of key informal roles with activity sets that interact with each other. These roles include: (1) a champion to adopt and advocate a project; (2) a

sponsor to provide project sanctioning and resources; and (3) a gatekeeper to establish criteria and make decisions about the future of the project (Markham et al., 2010).

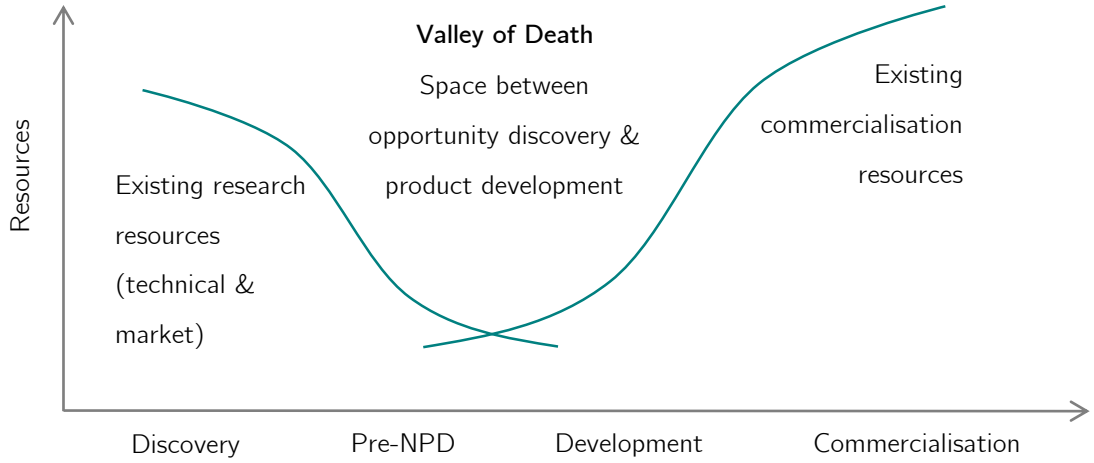


Figure 9 Valley of death (Markham et al., 2010)

4.2.2 Market adaptation phase

Market adaptation phase is the period when the first introduction to the market starts to when the large-scale diffusion takes off. Early niches arise in this phase in which the new high-tech product is introduced. Large-scale diffusion does not take place right after the innovation phase but rather small-scale use occurs in a gradual manner (Ortt & Schoormans, 2004). This erratic pattern during this phase is due to the interactions among factors that have opposite effect (Ortt & Delgoshaie, 2008).

According to this model, early niche markets occur during the market adaptation phase where the technology is used by a small group of users with a specific application. During this phase, the introduction of the niche is initiated, followed by the decline of the niche, and when it became stagnant, a new niche is introduced (Ortt & Schoormans, 2004). These early niches appear when development, production or large-scale diffusion of a new high-tech product is hampered Ortt & Kamp (2018). This is due to 14 factors that influence the large-scale diffusion of a certain technology which will be discussed in the next section. The length of this phase vary considerably, more or less a decade or more. In this phase, more competitions between firms to establish a standard in the market can be observed, especially those working in the same type of technology. There is also a need for coordination between actors in the market, such as potential customers, producers of complementary products, and regulators, in order to move to a large-scale diffusion of a particular technology, which introduces the chicken-and-egg problem (Ortt & Schoormans,

2004). Generally, producers of these complementary products or services require a critical mass of users in order to enter the market, and yet these mass users also need to be established in the first place. Thus, the most important pre-condition of the market mechanism in this phase is to find the best product-market combination based on the technology, establish standard, and have a supply and demand for complementary products.

In the market adaptation phase, we can observe that there are more factors that can turn into a barrier and hamper the initial commercialisation of the product. This is because there are more interplay from the market as the product is being introduced. There might be even the same barriers from the innovation phase that come into effect in this phase, but the way the barrier influences the diffusion of the product is different.

4.2.3 Market stabilisation phase

Market stabilisation phase is the period when large-scale diffusion starts and ends with a substitution of an old technology. This phase can be considered as equivalent to the phase in the technological cycle by Anderson & Tushman (1990) where a dominant design is selected and there is a discontinuity of the old technology. In this phase, firms typically aim for large market share and profits and thus, several standard strategies are usually implemented by the firms (Ortt & Schoormans, 2004). For example, minor changes to the product or technology are added in order to improve the product and elaborate on the dominant design.

Anderson & Tushman (1990) describes this event as the era of incremental change where incremental innovations are applied to make small improvements for the dominant design. Firms also attempt to obtain greater market segmentation by offering different models and price points, or to achieve economies of scale by lowering production costs and making the design simpler (Schilling, 2013). The market mechanism in this phase follows the product life cycle mechanism with substitution by the new product in a gradual manner. *Figure 10* below illustrates the product life cycle in this phase.

In this phase, it can be considered that most of the required infrastructure are already established because the large-scale diffusion is already possible to take off. Some of the factors that influence the innovation or the market adaptation phase might still be present in the market stabilisation phase, but play a different role. However, it is important to note that in order for the product to reach its optimal percentage of adoption (depicted as the stagnant line of the S-curve) and carry

out any activities related to incremental innovation, some of the factors in the infrastructure need to be present consistently.

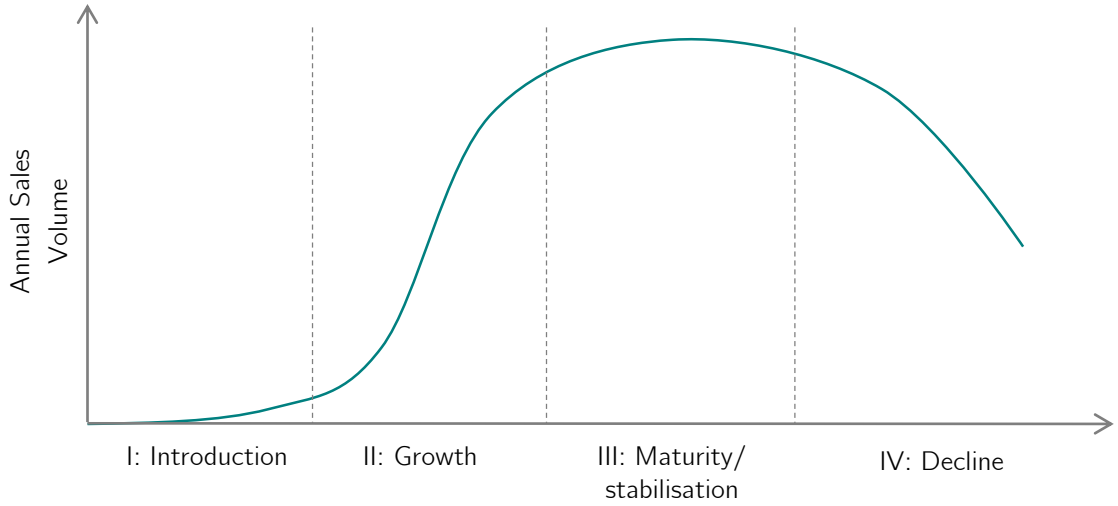


Figure 10 Product life cycle mechanism

4.3 Factors and barriers

So far, we have seen the use of the terms *"factor"* and *"barrier"*. In this research, we would like to use the definition of innovation barrier as any factor that can delay, hinder, or completely block the innovation (Hueske & Guenther, 2015). A factor is any aspect related to the innovation that influences its progress, however it becomes a barrier when it impedes this progress. A factor might also remain a factor that influences the development, but does not become a barrier. It can also turn into a driver or a facilitator when the factor accelerates the development of the innovation instead of impeding it. It is crucial for any firms or organisations to conduct any activities related to innovation as it can maintain a competitive advantage for the firm and thus, firms should be able to identify the barriers hampering their innovation in order to overcome it (Hueske & Guenther, 2015). There have been various studies regarding the barriers that block innovation which are distinguished from different sources, such as the barriers that exist from the technology, surrounding or external environment, organisational issues, individuals within the organisation, or the innovation value chain (e.g. R&D and production) (Kemp, Schot, & Hoogma, 1998; Antlová, 2009; Larsen & Lewis, 2007; Hueske & Guenther, 2015). Some of these barriers are often categorised into internal and external barriers where the former refers to barriers from inside the organisation, such as resources and organisational culture, while the latter refers

to barriers from outside the organisation, such as environmental issues, regulations, and macro-economic condition (Hadjimanolis, 1999).

Similar to the idea of internal and external barriers, in this research, we would first like to categorise the factors that can influence the development of a new product in the innovation phase by looking at two different categories that give us a distinction on where the factor is originating from. The two categories of factors are product and infrastructure category. The difference with internal and external category is that the product and infrastructure category looks at the factors that can influence the development of the innovation more intrinsically (or extrinsically, in the case of infrastructure category) to how the product can be manufactured, instead of from the perspective of within or outside the organisation. This categorisation of factors will be elaborated further in the next chapter. However, as the objective of this research is to see what factor acts as a barrier in the innovation phase, it is important that from this section onwards to make clear that there is a distinction to what counts as a factor and barrier from this point onwards. In Chapter 6 where case study is introduced and analysed, we can observe the change of using the term *"factor"* into *"barrier"*. This can be seen from the use of phrases such as *"the lack of"*, *"unfavourable"*, or *"hindering"*.

4.3.1 Barriers on large-scale diffusion of new high-tech products

Figure 11 below gives a visual representation of the influencing factors (left), core factors (middle), and specific niche strategy (right). The framework proposed by Ortt & Kamp (2018) will be used as the critical concept in this research. The study involves investigating barriers that may hamper large-scale diffusion of a new high-tech product which can be differentiated into seven core factors and seven influencing factors. This framework was constructed based on historical case studies that involve new-high-tech product in the market adaptation phase. The absence of a certain factor could inhibit the commercialisation of a product. Based on the combination of these core and influencing factors, a specific niche strategy can be derived and applied in order to circumvent or remove these barriers so that the product can diffuse further into the market.

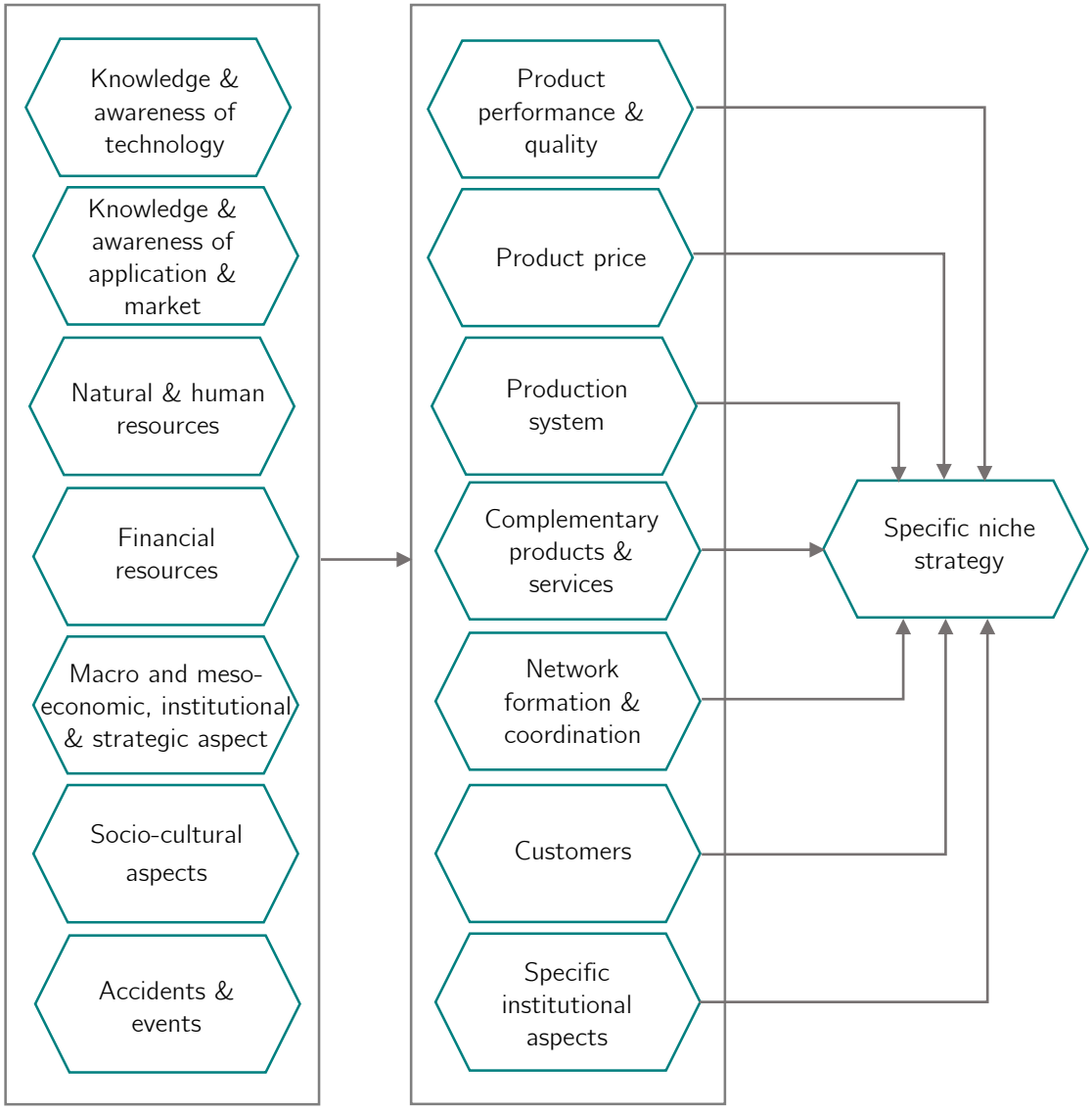


Figure 11 Factors influencing development and large-diffusion of a technology (Ortt & Kamp, 2018)

For example, a lack of suppliers can be caused by several reasons, such as lack of knowledge of technology or socio-cultural aspects, and thus, the niche strategy for both influencing factors will be different. The two layers of core and influencing factors can provide a guideline to deciding what particular strategy to implement based on what certain influencing factors that are responsible for the barrier. As these two layers were originally developed for the market adaptation phase, the innovation phase might not necessarily need the dynamic of the two layers in order to implement a specific strategy since the innovation phase will naturally have different characteristics of how the barriers play a role and how the strategies can be implemented.

Therefore, in this research, we would like to focus on first identifying the key barriers and strategies that are applicable in said phase, before going into the details of classifying these barriers into two different layers as in the original work. However, we would like to keep an open mind about the presence of the two layers in the innovation phase which might be relevant for any additional insights for future research. This point will be discussed further in Chapter 7.

Table 2 List of core and influencing factors of a large-diffusion of a technology (Ortt & Kamp, 2018)

No.	Factor	Definition
1	Product performance and quality	The product, its components, and subsystems, have a sufficient performance and quality
2	Product price	The product, its components, and subsystems, should have an affordable price (absolutely or relatively compared to other competitive products)
3	Production system	The system required in order to manufacture the product. Large-scale diffusion will be possible if industrial production and the technologies required for it are available.
4	Complementary products and services	Any products or services necessary for producing, distributing, adopting, and using the new high-tech product. Large-scale diffusion will be possible if these elements exist which helps to form a socio-technical system.
5	Network formation and coordination	The actors that participate in the value chain of the product which can include production, supplier, distributor, and many else. Coordination can be emergent and implicit or formal and explicit.
6	Customers	People who buy the new high-tech product. Large-scale diffusion will be possible if these customers are aware of the product and its benefits and willing to pay.
7	Specific Institutional aspects	Laws and regulations that deal specifically with the field of the new high-tech product and its socio-technical system. Large-scale diffusion will be possible if these laws do not hinder the application of the high-tech product.

8	Knowledge and awareness of technology	Fundamental and applied knowledge necessary to develop the new high-tech product, such as the product, production system, design development, and many else. Large-scale diffusion can be blocked if the knowledge required is lacking.
9	Knowledge and awareness of application and market	Knowledge about the potential applications of the product and the market structure where all actors involved should acquire. Large-scale diffusion is possible when there is an adequate knowledge of these two elements.
10	Natural and human resources	Any resources and labour needed to produce and develop the new high-tech product. Large-scale diffusion will be possible if these elements are not lacking.
11	Financial resources	Any forms of financial resources from platforms (e.g. crowdfunding, capital) and organisations (banks, investors) to provide finance for development, diffusion, adoption, and maintenance of the product.
12	Macro and meso-economic, institutional, and strategic aspects	Any economic situations, economic and strategic interests of a particular country or industry that might affect large-scale diffusion.
13	Socio-cultural aspects	Any beliefs, norms, and values existing in the society and industry. While they are less formalised compared to laws in the institutional aspect, large-scale diffusion can be blocked if these elements are not sufficient.
14	Accidents or events	Any unexpected accidents or events outside the socio-technical system with large impact that might either stimulate or block the development of the new high-tech product. This can include wars, political riots, and epidemic.

Table 2 above lists all the factors influencing the development and large-diffusion of a technology with their brief definitions in which the first seven factors are the core factors and the last seven factors are the influencing factors (Ortt & Kamp, 2018). In the original work, an assumption is made that barriers already start to exist in the innovation phase and are fully overcome as the product reaches market stabilisation phase. In this research, we will follow the assumption that

barriers already start to exist and give an influence to the development of the product from the innovation phase and thus, there are certain strategies to implement to overcome these barriers.

4.3.2 Other factors or barriers in the literature

There are barriers in other literature that have been identified, especially regarding renewable energy technologies and innovation in firms. In this section, we will elaborate on what findings each literature have encountered. Several barriers on renewable energy technologies and innovations for firms that have been identified in the literature are gathered. This was conducted through literature search using Google Scholar and TU Delft Library database. In this case, only scientific articles in academic journals are used as literature. Keywords such as *"renewable energy technologies", "barriers", "diffusion", "commercialisation", "innovation", "firms", "technology", "product development"*, are used to find relevant articles. The use of the articles that have been found will be limited to two articles related to renewable energy and three articles related to innovation in general. The use of previous Master's theses that are related to this research will also be used.

Generally, these five articles are chosen out of the others because they provide a clear, well-reasoned set of factors that we can use for the cases in this research. The articles have set themselves apart from the others as they touch upon the topic of barriers in innovation, be it specifically in renewable energy technologies or general. They also provide a wide range of perspectives to look at the barriers, such as from the institutional perspective or the managerial perspective of the firm. The reason why these specific articles add value to this research will be explained below.

Kemp et al., (1998) identified seven different factors that affect the development and use of sustainable technologies. These factors include the technological factors, government policy and regulatory framework, cultural and psychological factors, demand factors, production factors, infrastructure and maintenance, and undesirable societal and environmental effects of new technologies. This article is considered to be relevant for this research because the factors mentioned in the article have touched upon the most fundamental aspects in implementing renewable energy technologies in the society and the general viewpoint that the article provides has made it simpler to understand them. Painuly (2001) also categorised barriers that can hamper the penetration of renewable energy technologies. While the factors in Kemp et al., (1998) are more general, this article gives more insights for this research as it looks into more details on

what aspects are relevant in each factor category. These factor categories include market failure/imperfection, market distortions, economic and financial, institutional, technical, social, cultural, and behavioural, and other barriers.

Kleinknecht (1989) looked into the Dutch manufacturing industries and observed what barriers that are encountered by firms when it comes to their innovation. The article is interesting for this research as it looks into innovations in general but specifically in the Dutch industry. This can give an insight to what factors can act as a barrier from a firm's perspective. These barriers include lack of capital, difficulties in forecasting market demand, expected costs of an innovation project are too high, problems in adapting marketing function, costs of ongoing projects hard to control, technical information and know-how difficult to find, problems to find employees with certain qualifications, and problems with government regulations. Freel (2000) analysed what barriers may hamper product innovation, specifically in small manufacturing firms. This article can give an insight for this research as it touches upon the importance in management and marketing in developing a new product in a firm. This would be an interesting addition to the factors that might inhibit innovation. These barriers include lack of access to finance, less competence in management and marketing, lack of skilled labours, and lack of external information and linkages.

Larsen & Lewis (2007) looked into how award-winning SMEs can manage the barriers to Innovation in their firms. The article is interesting for this research as it not only touches upon management and marketing factor as Freel (2000) mentioned, but also addresses how lack of knowledge of the new product development (NPD) process can act as a barrier as well as research management and protection, which is an important aspect many literature has not mentioned. These barriers include financial issues, marketing skills, management and personal characteristics, competitions, knowledge of the new product development (NPD) process, product manufacturing, education and training, and research management and protection.

Key insights from previous theses

The framework presented by Mannheimer (2016) is based on the innovation phase, more specifically referred to as the valley of death in the thesis work, of the biopharma industry and the factors that may affect the phase. As this work focuses on the innovation phase, it is relevant to ours as we are exploring the barriers and strategies in said phase. In the work, it is also mentioned that the findings can be applicable to other industries, such as environmental

technologies, as the time frame to bring these products to the market also takes long as it is in biopharma (Mannheimer, 2016). However, as this thesis dealt with the biopharma industry, some of the circumstances in which the barriers and strategies were formulated are not applicable to the objective of this research as they are too specific to the industry, such as the necessity to conduct a clinical trial or stricter regulations. Naturally, some factors related specifically to the biopharma should be excluded and the actors should be adjusted accordingly. However, it applies to the firms developing environmental technologies to consider if they develop the right product, have the right skills and resources, acquire funding, and protect their technology. As these factors can be applied to our case, we will also include this work as one of our literature to construct the combined factors.

The factors have been grouped into 6 different categories which include technology, skills, resources, planning and process, market, and regulations. While many of the factors under the 6 groups are relevant for this research, these factors were not clearly defined in the thesis work and elaborated as to what each of them entails. The work also does not apply the original framework of Ortt & Kamp (2018) as a basis of factors and strategies. However, when looking at the factors listed in the thesis work, we can see that there are factors that overlap with those of Ortt & Kamp (2018) and other literature we have discussed previously. Thus, we will treat any information regarding factors and strategies as it is, categorise any overlap with the original framework, and classify them into the appropriate combined factors. These factors include:

- Technology: innovative idea, cost-effectiveness of technology, and commercial issues
- Skills: leadership skills, communication, right skills & resources at the right time, commitment, and relevant knowledge & innovative capability
- Resources: access to capital, human resources, IT, technological resources, support resources
- Market: market understanding
- Regulations: regulations and IP regulations

The framework presented by Moschos (2016) involved exploring the innovation phase of a radically new high-tech product. The thesis aimed to analyse the barriers in such phase by looking at three different levels: micro-, meso-, and macro-level. Many of the barriers exist on the macro level, such as the technological factors, legislation, and supply and production networks, are similar to those in Ortt & Kamp (2018) framework, while those in meso- and micro-level were

not included in the framework. This shows that the factors in Ortt & Kamp (2018) framework focused on the market environment and the socio-technical landscape as a whole, while the factors in meso- and micro-level also looked at the characteristics of the organisations and the project itself.

Unfortunately, these factors are not clearly defined as it is in the original framework. However, the factors identified in the meso-level (organization) gives us a more detailed insight about the importance of management factors in the innovation phase as has been mentioned in the previous literature (Kleinknecht, 1989; Freel, 2000; Larsen & Lewis, 2007), while the factors in the micro level (project) are too specific into the NPD process within the project which is not a focus in this research and thus, they will be disregarded. We will treat any information regarding factors in this work as it is, categorise any overlap with the original framework, and classify them into the appropriate combined factors. These factors include:

- Macro-level: Technological factors, infrastructure & maintenance networks, psychological & cultural factors, social networks, perceived user preferences, economic factors, legislation & regulation, supply & production networks, social & environmental effects, and governmental policy
- Meso-level: scientific knowledge & firm-specific techniques, technical systems, managerial systems, organizational culture & values, and financial resources

4.3.3 Generalisation of factors

In this section, we will use a *"top-bottom"* approach in generalising these factors. This means that we first look at the different factors in other literature and see the overlap of terms and definition with the factors in Ortt & Kamp (2018). The factors that fit in the description of those in Ortt & Kamp (2018) are categorised together and put into a combined factors as listed on the fourth column of *Table 3*. Since all of these factors from the other literature are not specifically intended for the innovation phase (as the case, as well, with the factors in Ortt & Kamp (2018)), we treat all of the factors as ones that can influence any phase of the diffusion pattern. This is necessary because in order to see what factors can influence only the innovation phase, we have to look at the bigger picture and consider all factors that can influence the other two phases. Note that the argument for why certain factors are (and are not) in the innovation phase will be provided in Chapter 5.

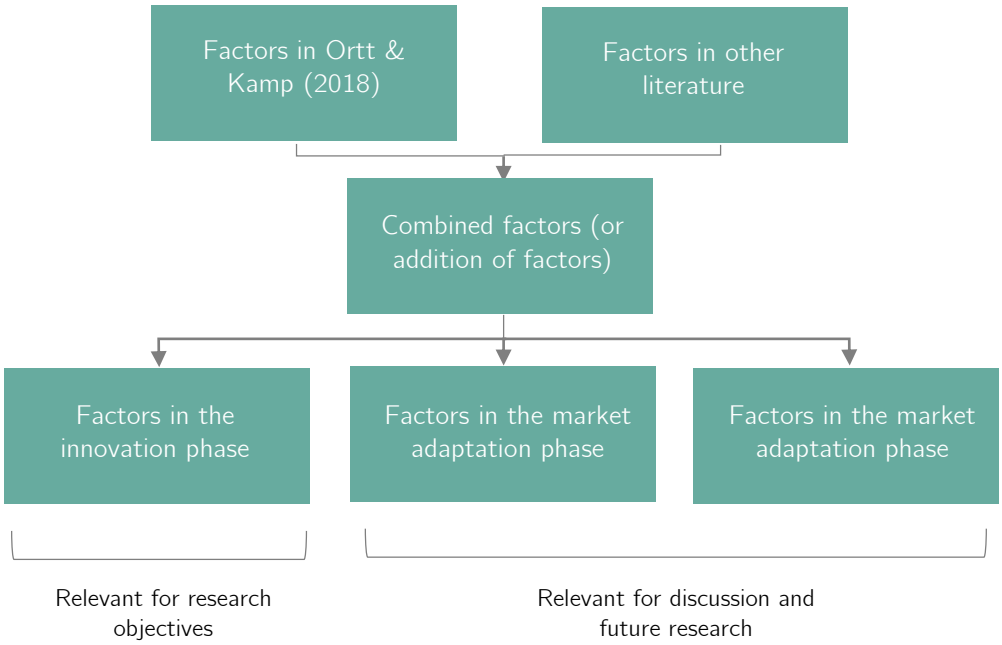


Figure 12 Top-down approach of factors generalisation and categorisation

Then, the factors that are relevant for only the innovation phase will be categorised accordingly in Chapter 5. As the initial objective of this research was to identify the barriers in all of the three phases, the categorisation of barriers for the other two phases (i.e. market adaptation and stabilisation phase) will be mentioned briefly in Chapter 7 and elaborated in *Appendix V* and *VI* for any additional future research. This approach is visualised in the *Figure 12* above. In *Table 3* below, the factors that have been identified from the previous section are generalised. For simplicity reason, the factors listed in the five articles will be combined in one column instead of separately.

Table 3 Generalising factors from all literature

No	Factor in Ortt & Kamp (2018)	Factors in other literature	Combined factors
1	Product performance and quality	Technological factors, lack of R&D culture, lack of standard and codes and certification, system constraints, and products are not reliable, research management, technological factors, technical systems	**Product performance and quality**

2	Product price	Economically not viable, cost-effectiveness of technology, commercial issues	**Product price**
3	Production system	Production factors, lack of O&M (operation and maintenance) facilities, product manufacturing, supply & production networks	**Production system**
4	Complementary products and services	Support resources, infrastructure & maintenance networks	**Complementary products and services**
5	Network formation and coordination	Lack of involvement of stakeholders in decision making, clash of interests, lack of external information and linkages, social networks	**Business network**
6	Customers	Lack of consumer acceptance of the product, demand factors, small market size, perceived user preferences	**Customers**
7	Specific Institutional aspects	Government policy and regulatory framework, highly controlled energy sector, favour (such as subsidies) to conventional energy, taxes on RETs, lack of financial institutions to support RETs, lack of instruments, lack of institutions/mechanism to disseminate information, lack of a legal/regulatory framework, problems in realising financial incentives, lack of professional institutions, problems with government regulations, regulations and IP regulations, research protection, legislation & regulation, governmental policy	**Specific Institutional aspects**
8	Knowledge and awareness of technology	Lack of information and awareness, technical information and know-how difficult to find, knowledge of the new product development (NPD) process, innovative idea, relevant	**Knowledge and awareness of technology**

		knowledge & innovative capability, scientific knowledge & firm-specific techniques	
9	Knowledge and awareness of application and market	Difficulties in forecasting market demand, market understanding, problems in adapting marketing function, marketing skills, less competence in marketing	**Knowledge and awareness of application and market**
10	Natural and human resources	Lack of skilled personnel/training facilities, lack of entrepreneurs, problems to find employees with certain qualifications, right skills & resources at the right time, lack of skilled labours, education and training, human resources	**Human resources/labour**
11	Financial resources	High transaction costs, high investment requirements, high discount rates, high payback period, high cost of capital, lack of access to capital, high up-front capital costs, lack of access to credit to consumers, lack of capital, expected costs of an innovation project are too high, costs of ongoing projects hard to control, lack of access to finance, access to capital, financial resources	**Financial resources**
12	Macro- and meso-economic, institutional, and strategic aspects	Missing market infrastructure, unstable macro-economic environment, economic factors	**Macro-economics**
13	Socio-cultural aspects	Cultural and psychological factors, lack of social acceptance, psychological & cultural factor	**Socio-cultural aspects**
14	Accidents or events	Undesirable societal and environmental effects, social & environmental effects	**Accidents or events**
15	Natural and human resources	Right skills & resources at the right time, technological resources	**Natural resources**

16		Lack of competition, lack of private sector participation, competitions	**Competition**
17		Management and personal characteristics, less competence in management, managerial systems, organizational culture & values, leadership skills, communication	**Managerial system**

In this part, we will provide any remarks about several factors that have been listed above. We would like to make clear that the knowledge & awareness of the technology and of application & market are factors that are viewed from the firm's perspective. This means that if there is any lacking of either of these factors, it would be experienced by the firm, and not the customers or society in general. Note that network formation and coordination has been renamed into business network because only actors in the value chain of the product should be relevant while other actors such as the government would not count as an actor in the network as they are an actor that regulates the institutional aspect. Natural and human resources has been divided into two factors: natural resources and human resources/labour. The reason for that is these two factors are independent of each other which will make a difference in categorising factors and strategies for the two factors. Macro- and meso-economic, institutional, and strategic aspects has been renamed into macro-economics, solely for simplicity.

We added two extra factors into the mix: competition and managerial system. Competition is also a crucial factor because the lack or too much competition can inhibit the commercialisation of a certain type of high-tech product, making it difficult for the firms to stay profitable and operating (Parthasarathy, 2017). Competition has not been added on the original list of factors and considering its relevance, we would like to add it to the list. As discussed in Kleinknecht (1989), Freel (2000), and Larsen & Lewis (2007), managerial system is an important factor that influences new innovation to succeed. In this case, we would like to refer managerial system in the most general sense which is any aspects, measures, or processes within the firm that helps to establish shared vision between the individuals of the firm, organisational culture and values, and improve the dynamics of the work environment so that every individual is working towards a common, long-term objective of the firm and stimulate innovating activities.

However, as can be seen from the other factors that are on the list, managerial system is different in its nature as it is more about the competence of the innovating firm. Therefore, it is important to note that this factor becomes a competency barrier when it is lacking. Nonetheless, the

occurrence of this barrier can hamper the innovation to develop and on its own, managerial system gives a foundation on how the firm operates and ensures a unity among the employees which makes the factor not redundant with ones that are in the original list and thus, we will add it as an extra and highlight it in blue, as an indication of competency. *Table 4* below summarises the definition of the combined factors.

Table 4 Definition of factors

No	Factors	Definition
1	Product performance and quality	Any aspects of the product, such as its components and subsystems, should have a sufficient performance and quality
2	Product price	The product, its components, and subsystems, should have a reasonable price
3	Production system	The system required in order to manufacture the product should be functional and sufficient
4	Complementary products and services	Any products or services necessary for producing, distributing, adopting, and using the new high-tech product should be available
5	Business network	Any actors involved in the development and diffusion of the new product should be established
6	Customers	Anyone who are aware of the benefits of the product and are willing to pay for the new product should sufficiently exist
7	Specific Institutional aspects	Laws and regulations that deal specifically with the field of the new high-tech product and its socio-technical system should not hinder the new product to develop and diffuse
8	Knowledge and awareness of technology	Fundamental and applied knowledge necessary to develop the new product should be available to the innovating firm
9	Knowledge and awareness of market	Knowledge about the potential applications of the product and the market should be available to the innovating firm

10	Human resources/labour	Any skilled human resources or labour that are involved in the development and diffusion of the new product should be available
11	Natural resources	Any materials or substances that are required to develop the new product should be sufficiently available
12	Financial resources	Any forms of financial resources from platforms (e.g., crowdfunding, capital) and organisations (banks, investors) to provide finance for development, diffusion, adoption, and maintenance of the product
13	Macro-economics	Any economic situations, economic and strategic interests of a particular country or industry should be favourable
14	Socio-cultural aspects	Any beliefs, norms, and values existing in the society and industry should be favourable
15	Accidents or events	Any unexpected accidents or events, such as wars and natural disasters, outside the socio-technical system with large impact should not be present
16	Competition	Any rivalries regarding the development of the product and speed of market entry between the main firm and other entities that are developing a similar type of product should be in ideal condition
17	Managerial system	Any aspects, measures, or processes within the firm that helps to establish shared vision between the individuals of the firm, organisational culture and values towards a common, long-term objective of the firm and stimulate innovating activities

4.4 Strategies

4.4.1 Ortt's niche strategies for large-scale diffusion of new high-tech products

With the six core factors and six influencing factors that have been outlined, there are theoretically 36 combinations of niche strategies that can represent different market. However, since not all influencing factors affect a certain core factors, there are less niche strategies in practice. Ortt et al. (2013) have identified ten different niche strategies which are summarised in *Table 5* below.

Table 5 Ten niche strategies (Ortt et al., 2013)

No.	Strategies	Definition
1	Demo and develop niche strategy	Demonstrating the high-tech product in public and experimenting with it in order to observe the potential of the product under a controlled condition and develop it further.
2	Redesign niche strategy	Redesigning the product to be more suitable with the market condition; through producing a cheaper version or using the product for other applications.
3	Stand-alone niche strategy	Using the high-tech product on its own or with a combination of its complementary products.
4	Hybridisation or adaptor niche strategy	Using the high-tech product by combining it with an already existing product with an existing network of complementary products/services.
5	High-end niche strategy	Selling the products to a certain, smaller high-end market with higher price.
6	Educate niche strategy	Educating customers and suppliers with knowledge about the technology and increase their awareness.
7	Lead user niche strategy	Assigning lead users consisting of experts and innovators so that they can experiment with the product and it can be well-developed further.
8	Explore multiple market niche strategy	Putting the products into multiple markets and finding successful application through trial-and-error.

9	Subsidised niche strategy	Acquiring subsidies from public funds for the development of the product which can be done if society at large believes the importance of the product.
10	Geographic niche strategy	Selling the product in a particular geographical region, depending on the market potential and availability of resources, customers, and suppliers for the product.

Niche strategies, apart from helping circumvent or remove the barriers can also enable to create new markets. For instance, using the high-end niche strategy will not only allow a firm to sell its products to people with higher affordability but also enable the firm to slowly increase their production rates of the product which in turn reduces its cost, thus creating a new market (Ortt et al., 2013). The use of niche strategy is meant to introduce the technology where there is a specific demand in a small customer group. Nonetheless, these strategies are generally implemented for any radical innovations before large-scale diffusion takes off (Ortt, 2009; Ortt & Kamp, 2018).

4.4.2 Other strategies in the literature

There are strategies in other literature that have been identified, especially regarding renewable energy technologies and innovation in firms. In this section, we will elaborate on what findings each literature have encountered. Several strategies on renewable energy technologies and innovations for firms that have been identified in the literature are gathered. This was conducted through literature search using Google Scholar and TU Delft Library database. The use of previous Master's theses that are related to this research will also be used. Keywords such as *"renewable energy technologies", "strategies", "diffusion", "commercialisation", "technology", "product development"*, are used to find relevant articles.

Other than identifying the factors that may hamper RETs, Kemp et al. (1998) also proposed strategies to promote large-scale diffusion of renewable energy technologies. The findings in this article can give more insight for this research as it addresses how creating temporary protected space and building awareness on these technologies are crucial in promoting the diffusion. These strategies are: change the structure of incentive in which market forces play, create and build a new socio-technical regime, build on the ongoing dynamics of socio-technical change and to exert

pressures so that the sociotechnical change will move into desirable directions, and create temporary protected spaces for more sustainable technologies.

Painuly (2001) also looked into the strategies for renewable energy penetration. The article is interesting for this research because it built up to what Kemp et al. (1998) has already mentioned previously. The strategies include: energy sector liberalisation through restructuring energy sector and introducing competitions, create guaranteed markets for renewable energy producers, economic/financial incentives, government investments, information and awareness campaigns, establish standards and regulations, create specialised agencies that support renewable energy technologies producers in promoting the technology, establish long term R&D programmes, establish facilitating measures for producers, such as RET targets, trainings, and consider moral and ethical aspects in decision making process.

Shakeel, Takala, & Zhu (2017) also looked into different strategies that are important for the commercialization of renewable energy technologies. The findings in this article are interesting for this research as it touches upon developing a technology that is more customer-oriented which is an aspect that was not mentioned yet so far. These strategies are: encourage collaboration and resources sharing, customer-oriented technology development, and improving financial institution's performance.

Chen & Yuan (2007) looked at the innovation strategy of high-tech firms in China and found that a firm can implement in-house and outsourcing strategy for its innovation strategy. This article gives an insight to the strategies involved specifically for R&D which is a crucial part in the innovation phase. In-house strategy refers to developing the technology and product within the firm using its own resources, knowledge, and production system. The strategy allows the firm to control and monitor their innovation and any expenses or resource use more closely, R&D teams can be more agile to adapt if any change is encountered, and any intellectual property of the firm is kept safely within the firm. Outsourcing strategy involves acquiring the technology from external sources through R&D agreement with external researchers, licensing or purchasing contract. This strategy can be useful for firms as it lowers the R&D cost and increases transfer of knowledge (Chen & Yuan, 2007).

Smith (2009) looked at the importance of bootstrapping strategy in firm's innovation which refers to the act of financing the firm's innovation activities by using the individuals' own money or individuals' personal network to obtain money. While this strategy can be considered risky, it is also useful, especially for start-ups and small firms in technological innovation, as it does not

rely on the conventional source of finance and lowers the need for finance in the first place (Smith, 2009). Any problems with the difficulty of accessing finance is also tackled with this strategy. Lam (2010) also suggested the importance of this strategy by managing and accessing resources necessary for business start-up and development to reduce the need for financial capital or to provide alternative sources of capital.

Key insights from previous theses

Parthasarathy (2017) is based on the different organisational setups in the field of sustainable energy technologies that operate in developing countries. There are 7 additions to the strategies which include government collaboration strategy, business partnership strategy, political insurance strategy, company finance strategy, horizontal integration strategy, foreign exchange hedging strategy, and market data acquisition strategy. Political insurance strategy and foreign exchange hedging strategy will not be considered relevant in this research as we are dealing with a much less volatile political situation in the Netherlands and foreign exchange is not applicable in the context of this research.

Moschos (2016) involved exploring the innovation phase of a radically new high-tech product. There are several generic strategies that were proposed by Moschos (2016). These include collaboration with other knowledge producing institutions, strategic patent acquisition, working together with potential early adopters, and long-term investment in technology. Looking at the definition and its generic nature, they are applicable to the innovation phase and the renewable energy technologies industry. Thus, they will be considered in the categorisation of strategies in the next section and redefined specifically for the context of this research.

Mannheimer (2016) explored the innovation phase, more specifically referred to as the valley of death in the thesis work, of the biopharma industry and the factors that may affect the phase. One of the most important key insights from this work is that it focuses on the innovation phase of the diffusion pattern which will be relevant in this research as we are exploring the barriers and strategies in said phase. However, as this thesis dealt with the biopharma industry, some of the circumstances in which the barriers and strategies were formulated are not applicable to the renewable energy technologies sector as they are too specific to the industry, such as the necessity to conduct a clinical trial or stricter regulations. Strategies proposed in this work include large-scale collaborations between industry and academia to develop the product, implementing multi-disciplinary teams, drug repurposing, which generally overlaps with the redesign niche

strategy, as well as crowdsourcing and crowdfunding strategy. Crowdfunding has been popularly used by new firms and businesses as an alternative to the conventional venture capitals and investors in order to bridge financing gaps for the innovation activities through platforms on the internet via a large number of people (Metelka, 2014).

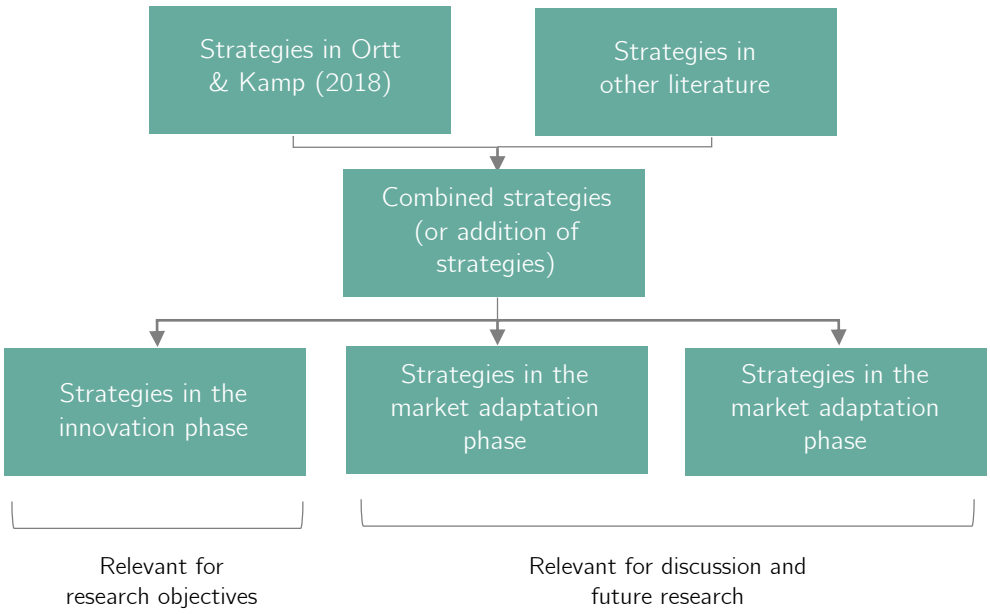


Figure 13 Top-down approach of strategies generalisation and categorisation

4.4.3 Generalisation of strategies

Similar to Section 4.3.3 with the factors, we will use a *"top-bottom"* approach in generalising the strategies. This means that we first look at the different strategies in other literature and see the overlap of terms and definition with the strategies in Ortt & Kamp (2018). The strategies that fit in the description of those in Ortt & Kamp (2018) are categorised together and put into a combined strategies as listed on the fourth column of *Table 7*. Since all of these strategies from the other literature are not specifically intended for the innovation phase (as the case, as well, with the strategies in Ortt & Kamp (2018)), we treat all of the strategies as ones that can be implemented in any phase of the diffusion pattern. Then, the strategies that are relevant for only the innovation phase will be categorised accordingly in Chapter 5.

As the initial objective of this research was to identify the strategies in all of the three phases, the categorisation of strategies for the other two phases (i.e. market adaptation and stabilisation phase) will be mentioned briefly in Chapter 7 and elaborated further in *Appendix V* and *VI* for any additional future research. This approach is visualised in the *Figure 13* above. In the *Table*

6 below, the strategies that have been identified from the previous section are generalised. For simplicity reason, the strategies listed in all the articles will be combined in one column instead of separately.

Table 6 Generalising strategies from all literature

No	Strategies in Ortt & Kamp (2018)	Strategies in other literature	Combined strategies
1	Demo and develop	Customer-oriented technology development	**Pilot**
2	Redesign	Customer-oriented technology development, drug repurposing (redesign product in general)	**Redesign**
3	Stand-alone		**Stand-alone**
4	Hybridisation or adaptor		**Hybridisation/adaptor**
5	High-end		**High-end**
6	Educate	Build on the ongoing dynamics of socio-technical change, Information and awareness campaigns, marketing strategy	**Educate**
7	Lead user	Customer-oriented technology development, working together with potential early adopters	**Lead user/customer-oriented**
8	Explore multiple market		**Explore multiple market**
9	Subsidised	Economic/financial incentives, government investments, government collaboration strategy	**Governmental funding**
10	Geographic		**Geographic**
11		Change the structure of incentive in which market forces play, create and build a new socio-technical regime, create temporary protected spaces for more sustainable technologies, energy sector liberalisation	**Lobbying**

		through restructuring energy sector, create guaranteed markets for renewable energy producers, establish standards and regulations, create specialised agencies that support renewable energy technologies producers in promoting the technology, establish facilitating measures for producers	
12		Encourage collaboration and resources sharing, business partnership strategy, horizontal integration strategy, collaboration with other knowledge producing institutions, large-scale collaborations between industry and academia to develop the product, implementing multi-disciplinary teams	**Business partnership**
13		Improving financial institution's performance, company finance strategy (from VCs and investors)	**Conventional financing**
14		Bootstrapping, managing and accessing resources necessary for business and development to reduce financial capital or provide alternative sources of capital, crowdsourcing, crowdfunding method for bridging finance gaps	**Alternative financing**
15		Establish long-term R&D programmes, long-term investment in technology, in-house R&D	**In-house**
16		Outsourcing R&D, strategic patent acquisition, market data acquisition	**Outsourcing**
17		Entrepreneurial orientation, training provision, sharing values and norms	**Strategic planning**

In this part, we will provide any remarks about several strategies that have been listed above. Demo and develop strategy has been renamed into pilot strategy, because we would like to be

specific on through what way the demonstration of the technology is conducted, which in this case is through a pilot. It can be observed that some of the strategies mentioned above are more suitable as a strategy to create a policy by the government, especially ones suggested by Kemp et al. (1998) and Painuly (2001). In order to provide a more appropriate list of strategies for the firms, some modifications have been applied to some of the strategies found in literature. Many of these strategies will be modified as a form of advocacy which involves lobbying and persuading the government and are labelled under lobbying strategy. This can accelerate the transition to the use of new technologies (Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007). Subsidised strategy has been renamed into governmental funding strategy, because *"subsidising"* is not an action that is performed by the firm as a strategy, but provided by the government. By renaming it to governmental funding, it would mean that the firm would use this strategy by seeking, which is an action the firm can do, any forms of funds or aids, be it a subsidy, grants, and awards, from any governmental bodies as a financial resource.

This follows with financing strategy, which the literature has shown that there are ways to gain access to financial resources through a more conventional or an alternative way. The nature of these two methods are very different because a conventional financing would come from traditional methods of finance such as venture capitalist, angel investors, banks loans, and many else, while alternative financing consists of a more unorthodox ways, such as crowdfunding. Thus, we would like to distinguish the two strategies. These two strategies are a new addition to the list as none of the strategy mentioned has touched upon strategies to obtain financial resources. We would also like to refer business partnership strategy as any measures, arrangements, or agreement that would allow a smooth collaboration with other actors involved in the development of the product. This strategy is also new because it concerns with building up a business network, which is not necessarily always related to commercialisation, but helps to develop the infrastructure around the product. As there is no overlap with the original list, we would like to add this.

Another thing we would like to add is strategies that are more closely related to the R&D aspects and obtaining other required resources. As stated by Chen & Yuan (2007), these two strategies are important to the innovating firms, especially in the beginning stage of their product development which refers to the innovation phase. And since there is no overlap with the original list of strategies, we intend to add these into the list. We also would like to refer strategic planning in the most general sense, which is any set of measures or activities that are implemented to manage resources, establish processes and practices for the employees in order to develop the

product more efficiently and achieve a common, strategic objectives of the firm in the long-term. It is important for a strategy to touch upon this as not only the technical, market, or societal aspects that can influence the development and diffusion of a new product, but also the organisational strategic aspects.

However, as can be seen from the other strategies that are on the list, strategic planning strategy is different compared to the rest of the strategies. This is because this strategy provides a fundamental layer of any operations occurring in the innovating firm, including all the other strategies used to develop or commercialise the product. While it is important to include this strategy to the list, it is also worth noting that strategic planning is not on the same level as the other strategies and should not be treated as an alternative, but rather as an underlying strategy required to ensure the implementation of other strategies. This will be discussed further in Section 7.2.5. Thus, we intend to add this strategy to the list as there is no overlap with the existing ones and highlight it in blue, as an indication of its fundamental nature. *Table 7* below defines and summarises the strategies that have been mentioned accordingly.

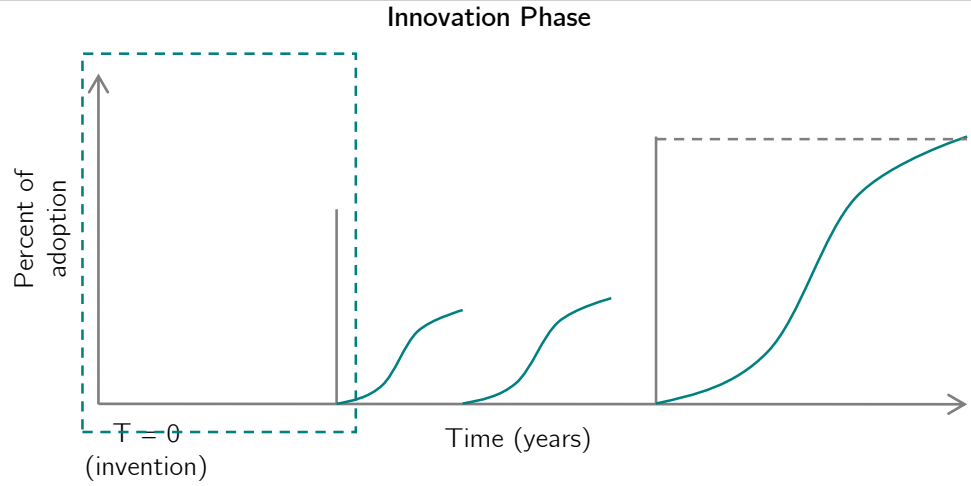
Table 7 Definition of strategies

No	Strategies	Definition
1	Pilot	This strategy can be used to demonstrate the new product in a controlled way using a pilot project
2	Redesign	This strategy can be used by adopting the product to a simpler version that may result in a lower price and a better quality for the new function of the product
3	Stand-alone	This strategy can be used through using the product on its own or having an infrastructure specifically designed for it
4	Hybridisation/adaptor	This strategy can be used by using the product together with an old technology or using a modified existing infrastructure
5	High-end	This strategy can be used to target specific high-end market with customers who are willing to pay for the high price
6	Educate	This strategy can be used to increase awareness of the society about the product and its benefits to attract new customers

7	Lead user/customer-oriented	This strategy can be used by bringing in early users to use the new product, gain their feedback, identify key customers, and establish customers network
8	Explore multiple market	This strategy can be used to commercialise the product in other market segments or other applications
9	Governmental funding	This strategy can be used by acquiring funding from any governmental agencies or non-profit organisations, such as grants, loan programs, and subsidies
10	Geographic	This strategy can be used through diversifying geographical locations for product commercialisation
11	Lobbying	This strategy can be used by influencing the decisions by the government and collaborating with them
12	Business partnership	This strategy can be used to establish partnership with other firms or actors in the value chain for the development and diffusion of the product
13	Conventional financing	This strategy can be used by obtaining funding through conventional methods such as bank loans, angel investors ,and venture capitalists
14	Alternative financing	This strategy can be used by obtaining financial resources from alternative sources such as crowdfunding, awards/competitions, and bootstrapping
15	In-house	This strategy can be used through developing the technology and product within the firm by using and managing its own resources
16	Outsourcing	This strategy can be used through bringing in the technology, system, knowledge, or resources from external sources
17	Strategic planning	This strategy can be used by establishing processes and practices for the employees to fulfil strategic objectives of the firm in the long-term

4.5 Preliminary categorisation

Table 8 Preliminary categorisation of factors and strategies in the innovation phase

	
Factors	Product performance and quality, Production system, Knowledge & awareness of technology, Knowledge & awareness of market, Natural resources, Financial resources, Business network, Specific institutional aspects, Human resources/labour, Managerial system
Strategies	In-house strategy, Outsourcing strategy, Lead user strategy, Crowdfunding strategy, Conventional financing strategy, Alternative financing strategy, Governmental funding strategy, Business partnership strategy, Lobbying strategy, Strategic planning strategy

So far, we have identified 17 factors and 17 strategies that are generalised through a set of literature in order to obtain a comprehensive list. Since the aim of this research is to identify which of these factors can turn into a barrier and strategies into the innovation phase of the diffusion pattern, we would like to formulate an idea of which factors and strategies are possible in said phase, which are listed in *Table 8* above, before coming into the categorisation in Chapter 5 next. Note that the categorisation listed on *Table 8* is only preliminary and that a valid line of reasoning will be provided in Chapter 5.

5.

Conceptual framework development

In this chapter, we aim to categorise the set of factors and strategies from Chapter 4 into the innovation phase of the diffusion pattern. We will combine similar factors together into groups and provide a line of reasoning for the innovation phase. To categorise the strategies, we will consider the factors that have been identified in said phase, opt for strategies that will remove or circumvent the factors, and categorise them into the innovation phase.

5.1 Categorisation of factors

5.1.1 Initial categorisation of factors

Product	Infrastructure
•Product performance & quality •Product price •Knowledge & awareness of technology •Knowledge & awareness of market •Production system •Natural resources	•Complementary products & services •Business network •Customers •Specific institutional aspects •Human resources/labour •Financial resources •Macro-economics •Socio-cultural aspects •Accidents or events •Competition •Managerial system

Figure 14 Initial categorisation of factors

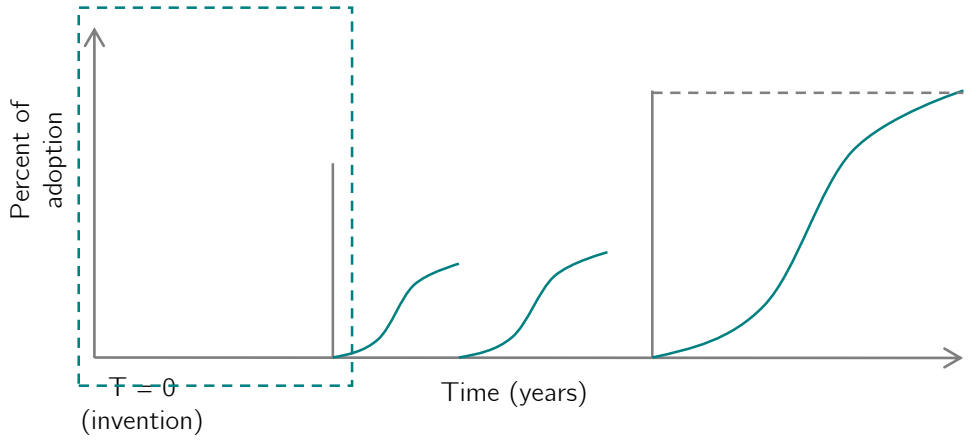
In this section, we would like to make an initial categorisation of factors. *Figure 14* above summarises the categorisation. The idea is to put the factors relevant in the phase into two large categories: product and infrastructure. Product category is any aspects from within the innovation itself which are directly involved and used in the development and characteristics of the product, while infrastructure category is any aspects which are indirectly involved in the development and characteristics of the product. We want to make clear that in any phase of the diffusion pattern including the innovation phase, there are certain factors that are more closely related to the product intrinsically, such as its performance and knowledge to produce it, and others that are more extrinsically related to the product, such as business network and customers. The distinction of the two categories will help us recognise more clearly the different factors that exist specifically in the innovation and provide an initial framework for the other two phases (e.g. looking at factors that exist in the three phases by looking at two constant perspectives throughout the diffusion pattern) for future research.

5.1.2 Categorisation of factors in the innovation phase

Figure 15 below shows the categorisation of factors in the innovation phase. During the innovation phase, the technological principle is transformed into a marketable product through R&D (Ortt & Schoormans, 2004). In this phase, factors such as product performance & quality, production system, knowledge & awareness of technology, knowledge & awareness of market, and natural resources are crucial to develop the product. Since this phase is the beginning stage of the development and diffusion of the product, many of the aspects required to develop the characteristics of a commercially viable product are still missing. Research and development is conducted to build up the product innovation with a great performance and quality and affordable price. Naturally, the production system and natural resources are necessary to manufacture the product. Without the knowledge and awareness of technology and market, the product would be technically impossible to develop and commercially unviable. Thus, the lack of any of these factors would act directly as a barrier in the innovation phase.

To help building up the factors directly related to the product, the innovation phase would also require a certain infrastructure that would allow the product to be developed. Auerswald & Branscomb (2003) highlighted the importance of funding and having a sufficient financial resources in the early stage of innovation. Naturally, any R&D activities for the product development will not be possible without financial resources. In the innovation phase, building up

a business network comprising actors that are involved in the development of the product is necessary. This is because not every part of the development can be done by the firm itself. The involvement of other actors, such as universities and other firms, will help to develop the product more efficiently and induce knowledge spill-over.



Product	Infrastructure
• Product performance & quality • Production system • Knowledge & awareness of technology • Knowledge & awareness of market • Natural resources	• Financial resources • Business network • Specific institutional aspects • Human resources/labour • Managerial system

Figure 15 Categorisation of factors in the innovation phase

Institutional aspects in this phase should also not hinder the product development, especially those involving subsidies or tax reduction for firms innovating in renewable energy technologies. The need of human resources or labour who are highly skilled and familiar with the knowledge to develop the product can also affect how the innovation phase proceeds, as the lack of the right labour would inhibit the development of the product. The innovating firm would also need to implement a functional managerial system that manages resources, policies, people, and any practices to accomplish the firm's objectives and innovation. Thus, the lack of any of these factors would act indirectly as a competence barrier in the innovation phase.

As the innovation phase does not include any commercialisation activities but rather is oriented towards product development activities, factors that are significantly relevant after the first market introduction occurs are not considered as crucial in the innovation phase. These factors include the price of the product, complementary products and services, customers, competition,

macro-economics, socio-cultural aspects, and accidents or events. The assumption is that because the product is not yet introduced or adapted to the market, the aforementioned factors do not influence the development of the product in the innovation phase as the nature of these factors are rooted from the adaptation of the product in the market.

Another reason is the distinction of factor and barrier as we have seen in Section 4.3. A factor can stay as an aspect that influences the development of the product if it does not hamper and becomes a barrier. These factors that are not included can, in fact, still influence the product in the innovation phase, but does not become a barrier because it does not inhibit the development. For example, the customers might be a factor that influence how the product is developed to become market viable, however it is not a barrier in the innovation phase because there is no customers yet before market introduction. In this research, our focus is to only identify the barriers that may hamper the innovation phase. Therefore, even though the categorisation focuses on the factors rather than barrier, the case study will focus on identifying the barriers based on the list of these factors.

5.2 Categorisation of strategies

5.2.1 Initial categorisation of strategies

In this section, we would like to male an initial categorisation of strategies into the respective groups. *Figure 16* below summarises the categorisation of these strategies. The idea is to put the strategies that are relevant to the factors identified in the phase into two large categories: commercial and non-commercial strategies. We want to make clear that in each phase of the diffusion pattern, there are certain strategies that can be used to commercialise the product and thus, they generate financial gain for the company (commercial strategies), and strategies that are used solely for the purpose of building what is lacking within each phase and thus, do not necessarily generate any financial gain (non-commercial strategies).

Commercial strategies consist of all the strategies that will essentially generate financial gain from any selling or commercialisation activity. This includes most of the niche strategies identified by Ortt & Kamp (2018), because their nature is to sell the product after being introduced to the market. Non-commercial strategies consists of all the strategies that can be implemented from any activities that do not include selling or commercialisation activity, but the use of these

strategies will help building up the necessary factors for the product to develop and diffuse further.

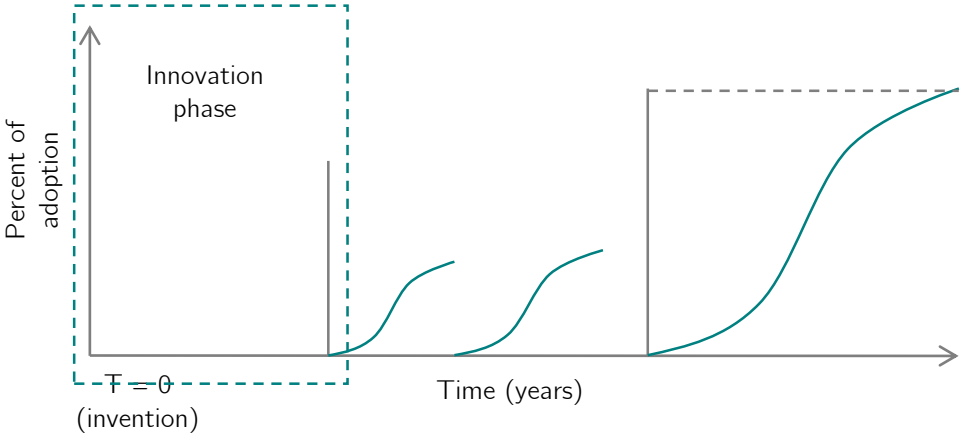
Commercial	Non-commercial
• Pilot • Redesign • Top-end • Explore multiple markets • Geographic • Hybridisation • Stand-alone • Lead user	• In-house • Outsourcing • Lead user • Educate • Conventional financing • Alternative financing • Governmental funding • Business partnership • Lobbying • Strategic planning

Figure 16 Initial categorisation of strategies

Note that lead user and educate strategy from Ortt & Kamp (2018) are categorised into non-commercial instead of commercial strategy. This is because the main goal of the two strategies are not to sell the product, but rather gain feedback for improvements (lead user) and increase awareness about the benefits of the technology (educate). The distinction of the two categories will help us recognise more clearly the different strategies that exist in the innovation phase by looking at two constant perspectives for the analysis of the cases. Note that the categorisation of these strategies are independent to that of the factors in the previous section and the strategies listed in each phase can be implemented in combination depending on the need of the firm.

5.2.2 Categorisation of strategies in the innovation phase

Figure 17 below shows the categorisation of strategies in the innovation phase based on its commercial function. Note that commercial strategies are not applicable in this phase. This is because the product has not yet been introduced into the market and thus, no commercial activities that can generate financial gain are possible. From Section 4.5, we have made a preliminary categorisation of strategies into the innovation phase. In the innovation phase, the strategies implemented should focus on non-commercial activities that aim to build up the lack of aspects needed for the product to develop.



Commercial	Non-commercial
Not applicable	• In-house • Outsourcing • Lead user • Conventional financing • Alternative financing • Governmental funding • Business partnership • Lobbying • Strategic planning

Figure 17 Categorisation of strategies in the innovation phase

Looking at the factors identified in Section 5.1.2, we can see that if there is a lack of product performance or quality, production system, and natural resources, the development of the product may be hampered. The firm can implement in-house and outsourcing strategy to remove or circumvent this barrier. In-house strategy refers to developing the technology and product within the firm using its own resources, knowledge, and production system. The strategy allows the firm to control and monitor their innovation and any expenses or resource use more closely, R&D teams can be more agile to adapt if any change is encountered, and any intellectual property of the firm is kept safely within the firm. Outsourcing strategy involves acquiring the technology from external sources through R&D agreement with external researchers, licensing or purchasing contract. This could also refer to obtaining any sub-components and gain any information and data, technology or market wise, from an external source. This could be a research organisation, experts, and consultancies that offer these services. Through this, firms can obtain more information about the market that the firm itself cannot internally produce and thus, the market

in which the product will be introduced can be validated. This strategy can be useful for firms as it lowers the R&D cost and increases transfer of knowledge (Chen & Yuan, 2007).

The lack of knowledge & awareness of technology and of market can be circumvented by implementing lead user strategy. Lead user strategy refers to assigning early users of the new product in order to identify key customers, market, and develop the new product concept before market introduction occurs. The users can also consist of experts in the field of the innovation with whom the product can be co-developed together. Using this strategy, firms can gain more knowledge about the technology and gain more of an insider view from the customers' side about the product and the market, find the right type of customers to target, and at the same time, design the product around the needs of the customers.

Naturally, financial resources are required significantly in this phase and a lack of it would restrict any innovation activities. In this case, we can implement conventional and alternative financing strategy, as well as governmental funding strategy. Conventional financing strategy refers to obtaining funding through investors and venture capitalists. These can include funding from angel investors, venture capital firms, banks, and many else, while alternative financing strategy refers to obtaining financial resources from alternative sources such as crowdfunding and bootstrapping. Crowdfunding refers to the process of acquiring funding for a project by raising small amounts of money from a large number of people through the internet. Nowadays, there are many platforms and types of crowdfunding that are available for anyone to access. Other than offering a low-cost capital from funders all around the world, firms can also raise more awareness of their product to the public, engage potential customers and gain market testing feedback which are all important aspects in the innovation phase.

Bootstrapping refers to the act of financing the firm's innovation activities by using the individuals' own money or individuals' personal network to obtain money. While this strategy can be considered risky, it is also useful, especially for start-ups and small firms in technological innovation, as it does not rely on the conventional source of finance and lowers the need for finance in the first place (Smith, 2009). Any problems with the difficulty of accessing finance is also tackled with this strategy. Governmental funding refers to acquiring funding from any governmental agencies or non-profit organisations. Usually, there are various governmental grants, awards, loan programs, subsidies, and tax reduction for firms who are developing their innovation. All of the three strategies can be used in parallel with each other, as long as the firms are actively putting their efforts into it.

Other than having enough financial resources, building up the business network that allows the new product to be established are also crucial in this phase. The presence of business network, which comprises of the formation and coordination of any actors that participate in any value chain of the product, influences the innovation phase as it provides a foundation for supporting the development and commercialisation of the product later on and thus, the lack of it will impede the innovation phase. Business partnership strategy can be implemented by forming strategic alliance with other relevant actors and building partnerships with other firms to create win-win situation. To build up the laws and regulations that stimulate the development of the new product in the innovation phase, lobbying strategy can be used to influence the decisions by the government and collaborating with them to establish a favourable institutional aspect. As to tackle the lack of skilled human resources and unreliable managerial system, strategic planning strategy can be applied by establishing processes and practices for the employees within the firms that ensure employees and other stakeholders to work toward common goals of the firm and manage priorities and resources to strengthen any innovating operations.

6. Case study

6.1 Data collection methods

6.1.1 Interview aim

The aim of the interview is to obtain any data and information that are related to achieving the objectives of this research. This is conducted by exploring any views and experiences that the interviewees have regarding a specific matter in this research, which is the barriers faced by the firm the interviewees are associated with and their implemented strategies in developing their products during the innovation phase. Interview is chosen for the main methodology because it provides us with an in-depth details of the study phenomena we would like to analyse by interacting with the individuals of the firms which gives us an insider's view of the phenomena.

6.1.2 Interview methods

The interview will be carried out through face-to-face interaction with a representative of each firm in the Netherlands. Both of the interviews and the questions will be presented in English. The length of the interview is ranging between 30 to 45 minutes. The structure of the interview questions is a semi-structure, consisting of both closed and open questions. This interview structure provides us with a clear set of instructions for the interviewer in order to gain a reliable, qualitative data, and at the same time allowing more flexibility and freedom to where the discussion goes. Before the interview, a set of questions and exhibits are formulated in order to obtain the desired data for the research and help the interviewees visualise any important information to answer the questions. Refer to Section 6.1.4 for a more detailed process on how the interview is conducted. The interviewees are also informed with any information regarding the research and its objectives before the interview. Interview questions are listed on *Appendix IV.*

6.1.3 Interview materials

The interview will be conducted with the aid of recording device, notes, list of exhibits, and a laptop. The list of exhibits, which refer to *Appendix II* and *III*, is as follows:

- Exhibit 1: Possible barriers in the innovation phase
- Exhibit 2: Possible strategies in the innovation phase

6.1.4 Interview process

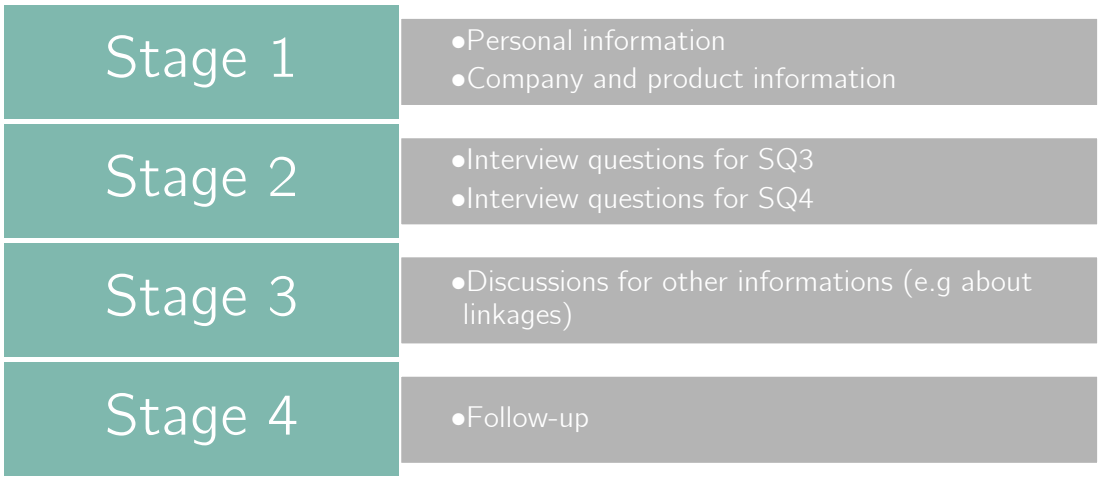


Figure 18 Interview process

Figure 18 above summarises how the interview process will be conducted. The interview process is divided into four stages. The first stage includes exchanging personal information between the interviewer and interviewee, establishing the objectives of the research for the interviewee, and gathering information about the company such as the vision and mission, history, and values, and the product itself. The second stage includes the interviewer asking questions that are related to SQ3 and SQ4, by first asking their opinions then showing Exhibit 1 and 2 in *Appendix II* and *III*. The third stage involves interview questions regarding other information that will lead for an insight in the discussion, such as linkages. This will involve more of an open discussion between the interviewer and interviewee. The fourth stage includes follow-up that will be conducted after the interview has been done and data has been fully analysed. The data will be sent to the interviewees to see if they would like to add any other points or feedback. All of the interview questions are listed in *Appendix IV*.

6.1.5 Interview analysis

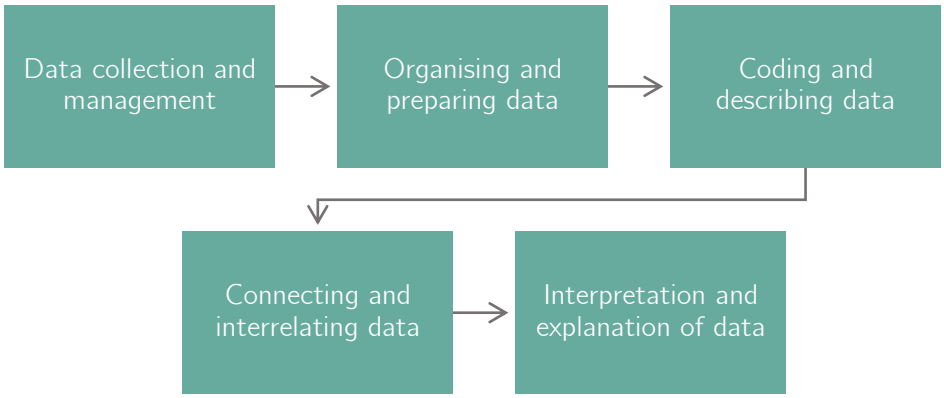


Figure 19 Interview analysis

Figure 19 above summarises how the interview data is going to be analysed. First, data will be collected through the interview process and managed carefully. Second, the data will be organised and prepared. This will be done through gathering all the notes, writing, and the recordings into a whole document. Third, the relevant pieces will be coded and described. The relevant codes can be any words, phrases, sentences, or about actions, concepts, and opinions that are relevant to the research in general and specifically to the conceptual framework discussed in Chapter 5. Fourth, we will analyse how the data are connected to each other. The last step is to write out the interpretations of the data and discuss the result. The result will be compared with the conceptual framework discussed in Chapter 5.

6.2 Case 1

6.2.1 Firm description

Kitepower is a start-up company located in Delft and was founded by Johannes Peschel and Roland Schmehl in early 2016. Focus area for the company is in the field of airborne wind energy, developing a cost-effective technology alternatives to the existing, conventional wind turbines. Its main innovative product is a Kitepower system that requires 90% less material and does not need resource-intensive towers which makes it easier to transport and implement. *Figure 20* below shows the illustration of the Kitepower system.

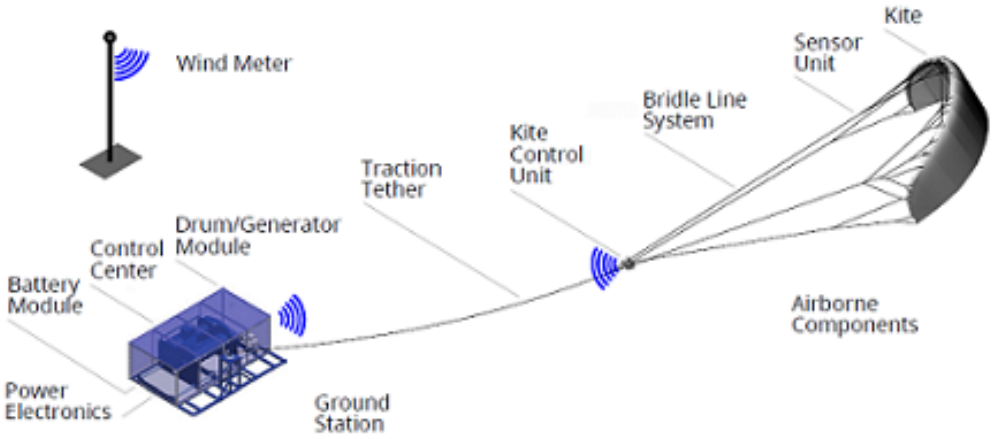


Figure 20 Illustration of the Kitepower system (TU Delft, n.d.)

The system comprises of kite control unit (KCU) which is equipped with high-precision motors that can control the inflatable kite during flight. The ground station includes a generator module which is important for the traction power conversion. Through this, the design and functionality can be optimised by the separation of the kite and ground station. The product can also withstand stronger winds at higher altitude and a offers a more cost-effective way to generate electricity. The interview was conducted with Roger Coenen, who has worked in Kitepower for over 2 years. The following section contains the results per research sub-question in the research.

6.2.2 Identified barriers

SQ4: *What are the barriers faced by firms in the Netherlands in the field of renewable energy technologies during the innovation phase based on the case studies?*

Table 9 Comparison of barriers between preliminary list and Kitepower interview

Preliminary list	Before Exhibit 1	After Exhibit 1
Product performance & quality	X	
Production system		
Knowledge & awareness of technology	X	
Knowledge & awareness of market		
Natural resources		
Financial resources		X
Business network		X
Specific institutional aspects		X
Human resources		X
Managerial system		
Extra barriers	**Before Exhibit 1**	**After Exhibit 1**
Product price	X	
Socio-cultural aspects	X	

During the interview, there are several barriers mentioned that are experienced in the development of the product by the company. *Table 9* above summarises the barriers experienced by Kitepower in the innovation phase, where *"X"* shows that the factor has been identified during the interview. The price of the product becomes a barrier in this case because the product itself is high-tech and very innovative compared to the usual wind power technology and thus, potential customers would like to see a bigger difference in price with the conventional wind power. Although Kitepower is aiming for half of the price of what a conventional wind turbine generally costs, there is still a challenge in balancing the price and the performance of the product. There is also a barrier in the society, especially the lack of knowledge and awareness about the technology by the customers. Even after educating people of how the technology works, there is still a general feeling of scepticism in the society about the technology whether it will actually work and give values or not.

After showing Exhibit 1, several other barriers from the preliminary list have also been identified in the company. Business network can become a barrier when developing the product, as the company involves several other companies to supply some components of the product, such as the generator and kite, especially when a specific customisation of the components for the

product is required and a part of main priority to Kitepower. During this phase, it is important to find business partners with the same focus and priority for the project. Financial resource given by the EU grant is currently still adequate for Kitepower to operate. Although the technology is already proven of its benefits compared to a conventional wind turbine, finding investors has the same barrier at this stage as other business partners. Sharing a vision and sense of priority ensures smooth cooperation and successful collaboration. Nonetheless, it is imperative to find investors in this case is not only necessary for financial reasons but also to expand business network and collaborate.

Specific laws and regulations are also identified as barriers. As Kitepower needs to test their product in the Dutch airspace, a license from the air traffic control is required to conduct this. However, there is only a temporary license and this becomes a barrier in the development of the product. Another point that was raised during the interview is that there is an uneven distribution of tender by the government for the airborne wind energy technologies. This shows that the playing field of RET innovations is still not as open and level for the company's product to live up to its potentials. Although there is not much issue with the availability of skilled human resources, the employees sometimes have to conduct tasks that are not in the job description, mostly about logistical aspects of the company business. The company intends to expand the team with the additions of skilled workers so that every employee can conduct their prescribed tasks more efficiently.

6.2.3 Unidentified and additional barriers

From Section 6.2.2, we have seen the barriers that Kitepower has faced in the innovation phase. We can see that there are several differences between the factors that influence the innovation phase and the preliminary list of factors we have developed in Chapter 5. As can be seen from *Table 10* above, there are several barriers that have been identified from the conceptual framework that do not apply to this case. Production system, for example, was not a barrier for Kitepower in the innovation phase. This is because they are only developing a prototype in the beginning and thus, production system is not yet necessary. Since the market of airborne wind energy is relatively small and easier to enter, knowledge of the market by the company did not present as a barrier. The Kitepower system also requires less materials compared to a conventional wind turbine and since large-scale production has not occurred yet, the materials and resources needed to develop the product are not considered as a barrier and are adequate in the innovation phase. Although the company is still in the early stage, managerial system has not

shown to inhibit any daily operations of the company in the innovation phase while developing the product.

From the interview, there are two extra barriers that were mentioned in this phase: product price and socio-cultural aspects. The preliminary argument not to include those two factors is that since the product is not commercialised yet in this phase, the price of the product should not portray an issue to the development of the product and socio-cultural aspects are still assumed favourable because the product is still under development and not yet observed by the society. However, the price of the product in this case is considered as a barrier because potential customers have certain expectations that this alternative technology will cost lower than the traditional. As for the socio-cultural aspects, there is still scepticism about the technology even after knowing how it works. It is also interesting to notice that in this case, not the knowledge of the technology by the firm becomes a barrier, but by the potential customers or investors as they are not aware of the benefits of the product.

6.2.4 Identified strategies

SQ5: *What are the current strategies used by the firm to overcome these barriers based on the case studies?*

Table 10 Comparison of strategies between preliminary list and Kitepower interview

Preliminary list	Before Exhibit 2	After Exhibit 2
In-house		X
Outsourcing		X
Lead user		
Conventional financing		
Alternative financing		
Governmental funding	X	
Business partnership	X	
Lobbying		X
Strategic planning		X
Extra strategies	**Before Exhibit 2**	**After Exhibit 2**
Pilot	X	
Educate		X

During the interview, there are several strategies implemented in the development of the product by the company. *Table 10* above summarises the strategies implemented by Kitepower in the innovation phase, where *"X"* shows that the strategy has been identified during the interview. Kitepower has been implementing pilot strategy in order to demonstrate a 100-kW Kitepower system with the collaboration with the Ministry of Defence, Ministry of Foreign Affairs and the Netherlands Enterprise Agency (RVO). Many sustainable energy experts, especially from countries with more remote communities such as Kenya and Nigeria, were in the event to see the potential of the product as well as its benefits (Kitepower, 2018). The goal of this strategy is mainly to educate the Dutch government about the product and demonstrate it in order to reaffirm confidence about the product by the Dutch government, gain feedback from experts for quality improvements, and increase awareness about the technology by other countries. It is also aimed to validate the technology for future commercialisation.

The company also relies on the governmental funding strategy as their main financial resource. In 2015, the company received an EU grant of around 3.7 million euros as a part of the EU's Horizon 2020 Initiative. The goal of this strategy is to mainly take off with the last stage of product research and development towards market introduction. They have also implemented business partnership strategy by working with two major diesel generator rental companies, the Dutch military, and kite manufacturers in order to exchange knowledge or resources required for the product.

After showing Exhibit 2, several other strategies from the preliminary list have also been implemented by the company. Kitepower mainly uses in-house strategy as a part of their research and development of the product and most knowledge about the Kitepower system is cultivated within the company. The goal of this strategy is to keep some of the sub-components of the system that add values to the company as the company's proprietary, such as the kite design. Outsourcing strategy has also been implemented to obtain any sub-components of the product, especially the generator, and any advice for product improvements from any external experts. The goal of the outsourcing strategy is interrelated with that of the in-house strategy, as the former strategy aims to keep several sub-components that do not add competitive advantage to the company as non-proprietary.

The company also frequently uses lobbying strategy, especially to the Ministry of Infrastructure regarding the license for testing in Dutch aerospace and to business partners for technical specifications of any sub-components. This strategy is also implemented for lobbying the

municipalities regarding the tender for RET, in order to make it a more open-playing field. Another strategy that has been used by Kitepower is educate strategy in order to increase awareness to the society about the company, for an instance through collaborating with Dutch designers, Ministry of Infrastructure and Environment, and local governments in a design innovation program known as Icoon Afsluitdijk. This strategy is also done through providing regular news updates on the website, newsletter, LinkedIn, and other social media channels. The goal of implementing this strategy is not only to show the presence of the company through publicity, but also to increase awareness about the product to the society. Lastly, strategic planning strategy is implemented by Kitepower in order to establish daily practices and how the company operates in order to achieve specific long-term goals. This strategy is significantly related with the way the company manages their financial and human resources, as well as making decisions about approaching investors and collaboration projects, by considering a long-term goal of making the technology commercially ready.

6.2.5 Unidentified and extra strategies

There are several strategies that have been identified from the conceptual framework that do not apply to this case. Lead user strategy, for example, is not cost-effective to implement in this case due to the scale of the technology. In order to balance the resources, in-house strategy is used to develop the Kitepower system as the knowledge and intellectual properties belong to the company, while the sub-components of the system is outsourced through other manufacturers, such as the generator and kite. As seen on the table, neither conventional nor alternative financing is implemented by the company during the innovation phase. The reason for the former is because even though the technology that Kitepower is creating has been proven of its benefits, finding investors for financial purposes has the same barrier at this phase as finding other business partners, while the latter strategy was never considered in the process.

From the interview, there are two extra strategies that are implemented by Kitepower. Pilot strategy through collaborating with the Ministry of Defence has been executed by the company in a 100-kW unit of the Kitepower system. The preliminary argument not to include this strategy in the innovation phase is based on the assumption that pilot strategy is only feasible after the first market introduction takes off and is, therefore, categorised as a commercial strategy. However, this strategy is used not for commercial purposes by the company in this phase, but rather as a way to develop the technology, demonstrate the system and show the potentials of the technology. Another strategy implemented is educate strategy that is carried out through

collaborating with Dutch designers, Ministry of Infrastructure and Environment, and local governments in a design innovation program known as Icoon Afsluitdijk. The preliminary argument for not including this strategy in the innovation phase is based on the assumption that the educate strategy is only relevant when customers are already available which is after the product is introduced to the market. However, this case indicates the importance of raising awareness about both the company and the product to the society early on the diffusion pattern in order to gain a head start in attracting customers for the market adaptation phase. These two strategies are an important addition to the preliminary list as they show that in the innovation phase, there are more aspects to consider in the development of the product other than the development of the technology itself. Aspects such as gaining more confidence from the society towards the product through pilot or educate strategy can determine how successful the product is developed and will be commercialised.

6.3 Case 2

6.3.1 Firm description

Physee is a start-up company located in Delft and was founded in 2014 by Ferdinand Grapperhaus Jr. and Willem Kesteloo, focusing on technology that involves the combination and integration of glass, solar cells, coatings, sensor technologies, and many else. This leads to three main innovative products from the company, including PowerWindow which is a transparent, double-paned window that can convert light into electricity. *Figure 18* below shows the illustration of the PowerWindow.

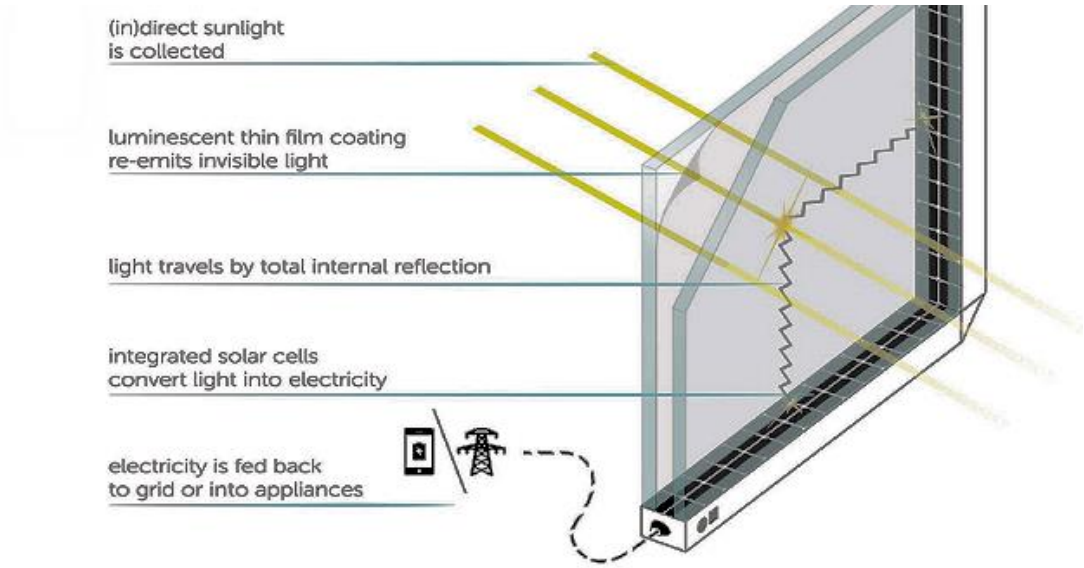


Figure 21 Illustration of PowerWindow ("Physee - PowerWindow," n.d.)

The energy-harvesting PowerWindow tackles the issue of placements of traditional solar panels on off-site locations or rooftops as it can be implemented into any building facades. While conventional glass reflects 30% of the incoming light, PowerWindow collects this light, transfers it to the edges of the window in which the solar cell strips are installed and converts it into electricity. The product can save up to 50% of the total energy demand when combined with a thermal storage system in existing buildings and up to 100% in newly constructed ones. The interview was conducted with Camilla Massacesi, who is working at Physee in the software and hardware department. The following section contains the results per research sub-question in the research.

6.3.2 Identified barriers

SQ4: *What are the barriers faced by firms in the Netherlands in the field of renewable energy technologies during the innovation phase based on the case studies?*

Table 11 Comparison of barriers between preliminary list and Physee interview

Preliminary list	Before Exhibit 1	After Exhibit 1
Product performance & quality	X	
Production system		
Knowledge & awareness of technology		X
Knowledge & awareness of market	X	
Natural resources		
Financial resources		X
Business network		X
Specific institutional aspects		
Human resources	X	
Managerial system	X	
Other barriers	**Before Exhibit 1**	**After Exhibit 1**
Product price	X	
Macro-economics	X	

During the interview, there are several barriers that are identified in the company when developing the product. *Table 11* above summarises the barriers experienced by Physee during the innovation phase. Technical performance of the product becomes a barrier as Physee strives to achieve a better-performing product significantly in the innovation phase. There are few other research parties that are also conducting research on the technology PowerWindow is implementing. However, as Physee's goal is to commercialise, the product has to be market viable. Looking into the market that the product will be introduced, which is the real estate market, is also necessary in this phase and more knowledge on the market is required. In the beginning, the company is also lacking in organisation structure and since the company is still small in size, the employees also have to do some tasks that are not specifically related to their position. While the solar energy market in the Netherlands is blooming, the economic situation in the Netherlands

for the real estate market becomes a barrier because the product's success is dependent on this one market which possesses a risk.

After showing the Exhibit 1, there are several barriers that are recognised in the company. Knowledge of the technology becomes an issue as it is impossible to obtain all the required knowledge internally in order to develop the technology. Financial resource was an issue in the beginning, however after seeking an investment round from EU grant and winning the Postcode Lottery Green Challenge and raising 1.5 million euros in a specifically assembled clean-tech consortium, the development of the product was accelerated. There was also an issue of getting investors to get on board with the technology in the beginning of the product development as they were still unsure about how much values are added with the technological features. While in the interview it was mentioned that forming network of alliances with business partners is not a barrier, coordinating and communicating with different clients and partners is sometimes an issue, as there are diverse interests from the actors involved. Interestingly in Physee's case, the laws and regulations of the EU to aim more energy-neutral buildings have been a positive influence to the development of their product and offer them more opportunity to grow which thus presents as a facilitator rather than a barrier.

6.3.3 Unidentified and additional barriers

From Section 6.3.2, we have seen the barriers that Physee has experienced. We can see that there are several differences in the factors that influence the innovation compared to the preliminary list we have developed in Chapter 5. As can be seen from *Table 14* above, there are several barriers that have been identified from the conceptual framework that do not apply to this case. Production system, in this case, is not considered as a barrier for Physee as they only need to manufacture several prototypes that do not require the conventional production system as a mass-scale production would. Natural resources also did not present as a barrier as the materials needed to build up the product are abundant and readily available. Another interesting finding in this case is how institutional aspects that are related specifically to the development of the product do not act as a barrier but rather as a catalyst for the product to grow. The European Union's directive on nearly zero-energy building requires all new buildings to be nearly zero-energy by the end of 2020, which indicates the need of Physee's product as it provides a way to generate energy from a renewable source produced on-site. This could also allow Physee to expand their market into other countries in Europe.

From the interview, there are two extra barriers identified in the innovation phase: product price and macro-economics. Similar to the case of Kitepower, the preliminary argument not to include the product price as a factor is because in the innovation phase, the product is not introduced to the market yet and thus, the price of the product will not influence how the product is developed in this phase. And similar to the preliminary argument for socio-cultural aspects, macro-economic condition, especially in the Netherlands, is relatively stable and favourable for the product to be developed and does not affect how its development as the product is still in the innovation phase. However, as the performance and quality of the product are being improved constantly in this phase, the product price is also increasing and at the same time, the product needs to be affordable and market viable. Therefore, finding the right balance between the quality and the price is a challenging task. The macro-economic situation, in this case, refers specifically to the real estate market in the Netherlands. There is a changing condition of the market that is affected by macro-economic factors which leads to a fluctuation in the real estate prices. As Physee's operations are highly dependent on said market, this was seen as a risk.

6.3.4 Identified strategies

SQ5: *What are the current strategies used by the firm to overcome these barriers based on the case studies?*

Table 12 Comparison of strategies between preliminary list and Physee interview

Preliminary list	Before Exhibit 2	After Exhibit 2
In-house		X
Outsourcing		X
Lead user	X	
Conventional financing		X
Alternative financing		X
Governmental funding		X
Business partnership		X
Lobbying		X
Strategic planning		X
Other strategies	**Before Exhibit 2**	**After Exhibit 2**
Pilot	X	

Educate		X
Redesign	X	

Table 12 above summarises the strategies implemented by Physee in the innovation phase, where *"X"* shows that the strategy has been identified during the interview. During the interview, several strategies that Physee is implementing have been mentioned. In order to improve the performance and quality of the product, the team coupled the characteristics of the sub-components of the PowerWindow and redesigned it so that it will provide the best performance. The goal of this strategy is to increase the product performance by changing the perspective of focus of the design which helped substantially in making the product as viable as possible.

Another strategy used by Physee is assigning ambassadors or lead users to test out the product in the field through personal connections. With this strategy, the aim of the company to gain feedback for the product performance relatively quicker, interact more easily with the users, and build a close relationship with them, is achieved. More knowledge about the market is also gained throughout the whole process of lead user. Together with OVG Real Estate and Rabobank, Physee has implemented the first pilot project where the PowerWindow is installed in Rabobank office. The goal of this strategy is not only to improve the product performance and quality but also to validate their product and business model and as a means of trial before commercialisation starts.

After showing Exhibit 2, there are other strategies that have been implemented by the company. For the research and development of the product, in-house strategy is used as it gives the company an opportunity to grow a competitive advantage to their product. This strategy also includes research and development activities on the market and application. As there is not enough manpower and resources to do everything required in the development process, outsourcing strategy is used to gain these resources from other parties, for example hiring skilled labours and the PV production line. As Physee also strived to be a *"technology and project"* company which means focusing on developing the core technology and carrying out projects for their clients, the company chooses to outsource any aspects that do not add a significant value to the product and that they are not focusing on producing internally. This is also used so that they can save time or other resources in developing the product and do not have to *"reinvent the wheel"* of existing technologies by outsourcing. As for the lack of financial resources in the beginning, it was difficult to attract conventional investors, which led the company to implement other financing strategies such as the governmental funding from European Innovation Council's

SME grant and alternative financing by focusing on small prize competitions and challenges. The goal of these strategies is to start off with the product development by gaining financial resources and maximising the available opportunities of less formal platforms. Then, conventional financing strategy was also used through an investment from real estate companies as the opportunity opened up.

Business partnership strategy has also been implemented, especially with companies Physee is outsourcing from and the government. The goal of this strategy is to maintain the relationships and refine different types of partnerships, such as with glass manufacturers, real estate companies, and the government, as well as to create a win-win situation for both parties. Other than forming alliances, this strategy is also used to obtain external knowledge Physee through a more informal way, such as by asking questions, or where the company inquires any knowledge needed on any issues related to the product and market to their business partners. Although laws and regulations are in favour of the product development, lobbying strategy is still carried out by the company, especially when it comes to requesting sub-components with the manufacturers and with potential business network.

Strategic planning strategy has also been implemented from early on where long-term goals and roadmaps are established and daily operations of the company are improved by consistently checking up progress of each individual. This strategy is implemented also to ensure that every activity in the company is conducted based on a long-term goal of the product development and commercialisation, have a clear timeline, and manage resources efficiently. It was also mentioned that organisational culture and values are cultivated through the measures that are taken through this strategy. Another strategy mentioned but was not on the list was educate strategy by which Physee increases visibility of their company through publicity and presented the benefits of the product to the society. This was done through participating in World Economic Forum in China, collaborating with MediaMarkt to showcase the PowerWindow so visitors can gain knowledge about the product and give their opinions, and presenting the product in a Dutch late-night television show. All of these efforts helped Physee to be exposed more to the society and potential partners.

6.3.5 Unidentified and extra strategies

As can be seen from *Table 12* above, Physee adapted most of the strategies listed on the preliminary list of the innovation phase and three extra strategies were added. The three

strategies that were identified out of the preliminary list were pilot, redesign, and educate strategy. The preliminary argument not to include the first two strategies in the innovation phase is based on the assumption that these strategies are means to commercialisation and only suitable to implement after the product has been introduced to the market, in which there is an opportunity to use these strategies as a way of responding to the barriers that particularly belong to the market adaptation phase (e.g the availability of customers who are willing to buy the product).

However, pilot strategy has been implemented by Physee through implementing 30 m^2 of PowerWindow in a Rabobank office in collaboration with OVG Real Estate, one of the leadings in Dutch commercial real estate developer. The strategy was used as a way to introduce their product to the potential partners and society as well as to validate their product and business model. Redesign strategy has been implemented during the innovation phase by changing focus or coupling sub-components of the product to achieve the best performance. The strategy was used in order to manufacture a high-performing product that is as viable in the market as possible. Similar to the Kitepower case, the preliminary argument not to include educate strategy in the innovation phase is because there is no real customers yet before the product is introduced to the market and thus, this strategy is still irrelevant. However, there is a need from the company to expose their presence and technology to the society and potential partners. Physee has executed several actions in implementing the educate strategy, such as participating in conferences (e.g World Economic Forum in China, Consumer Electronics Show in Las Vegas), presenting their technology in MediaMarkt, and many else.

6.4 Cross-case analysis

In this section, we will investigate the two cases through cross-case analysis by looking at the similarities and differences of the barriers and strategies that are experienced by the two cases. From this, we will be able to examine further the occurrence of the barriers and the goals of the strategies implemented by the firms.

6.4.1 Similarities between the cases

Barriers

Table 13 Comparison of barrier similarities and differences between the two cases

Barriers	Case 1	Case 2
Product performance & quality	X	X
Production system		
Knowledge & awareness of technology	X	X
Knowledge & awareness of market		X
Natural resources		
Financial resources	X	X
Business network	X	X
Specific institutional aspects	X	
Human resources	X	X
Managerial system		X
Product price	X	X
Socio-cultural aspects	X	
Macro-economics		X

Table 13 above summarises the similarities and differences of barriers from the two cases. From the perspective of barriers, we can see that both cases do share similarities in the barriers that they have experienced in the innovation phase which include product performance & quality, product price, knowledge & awareness of the technology, financial resources, business network, and human resources. Both companies have expressed the importance of having a high-performing product. However, it becomes a barrier when it comes to their new, high-tech innovation as improving the performance is not a trivial task, especially when coupled with the

problem of balancing it with an affordable price of the product. From this, it can be concluded that both product performance/quality and price are interrelated and are considered important factors in the innovation phase.

Knowledge & awareness of the technology has also been identified as a barrier by both cases. However, the first case (Kitepower) sees this lacking from the customer's perspective, instead of the firm's perspective. The problem lies with the lack of knowledge & awareness of the technology by the customers as they are not aware of the benefits and/or do not believe of the technology. In the second case (Physee), the same barrier comes from within the company as not all knowledge of the technology can come from in-house. From this point, it can be observed that the lack of knowledge & awareness of the technology can come from either the firm or the society.

Financial resources were discussed as a barrier by both companies in the beginning of the innovation phase, but the issue was quickly resolved after obtaining some governmental funding. Business network is also identified as a barrier by both cases, where forming the network is not the main issue, but rather coordinating with them and making sure that their interests are aligned. Human resources have also been identified as a barrier by both cases. Interestingly, the two cases do not have difficulty in finding skilled human resources, but instead with having a set of tasks for the employees to complete that are not necessarily on the job description. This condition is typically found in start-ups in the innovation phase and can lead to an inefficient product development.

Strategies

Table 14 Comparison of strategies similarities and differences between the two cases

Strategies	Case 1	Case 2
In-house	X	X
Outsourcing	X	X
Lead user		X
Conventional financing		X
Alternative financing		X
Governmental funding	X	X
Business partnership	X	X
Lobbying	X	X

Strategic planning	X	X
Pilot	X	X
Educate	X	X
Redesign		X

Table 14 above summarises the similarities and differences of strategies from the two cases. From the perspective of strategies, we can also see the similarities that the two cases have displayed. The strategies that both cases implemented include in-house, outsourcing, governmental funding, business partnership, lobbying, strategic planning, pilot, and educate strategy. Both cases use the combination of in-house and outsourcing strategy as they develop their core technology and the knowledge within the company, while at the same time obtain other resources needed for the sub-components of the product from other actors. Outsourcing several elements of the product means that the firm is able to focus on its R&D activities on the innovation and thus, extending the firm's capabilities (Love & Roper, 2001).

The use of governmental funding strategy has been mentioned in both cases to be the fundamental strategy in order to obtain the required financial resource in the beginning of the phase. This is mainly due to the opportunity that new energy innovations are acquiring from the Dutch government R&D support. Up to 90% of the total budget in the government's Energy Transition programme and the Innovation Agenda for demonstration projects are allocated to finance the R&D for energy innovation (Noailly & Batrakova, 2010). This opens up a significant window of opportunity for the products from both of the cases to develop and flourish, especially in the innovation phase.

Business partnership strategy is used in the two cases, not only as a way to outsource any knowledge or resources (in which case, outsourcing strategy is used), but also as a means to collaborate with other companies and the government to achieve the objectives of each involved parties. The two cases also implement lobbying strategy, especially when it comes to their business partners regarding any inquiries about the sub-components of the products. This also can be considered as lobbying because the business partners do not have the company's interest as a priority and they have other agendas to fulfil (e.g executing their other clients' orders). This finding shows that lobbying strategy is not only useful for influencing decisions by the government as what has been the case for previous works (Pratiwi, 2016; Parthasarathy, 2017), but also to the business partners that are involved in the product value chain. Another similarity shows in the use of strategic planning strategy in which both cases established a set of long-term objectives

and daily practices that are organised to achieve the goals and nurture an organisational culture that promotes the development of the innovation (e.g cooperative teamwork and flexibility).

Pilot and educate strategy are also another similarity shared by the two cases. Both cases use pilot strategy not as a means for commercial gain, but as a way to demonstrate their product to the government or partners and gain assessments for improving the product performance and quality. The pilot projects from both of the cases have shown to be a successful kick-off strategy in the innovation phase for the initial phase of their product development. Educate strategy is implemented by both cases, mainly for the purpose of increasing awareness about the benefits of their products to the society and the presence of their companies. While the actions carried out in order to use the educate strategy are naturally different, the goal of this strategy and the essence of collaboration with other actors in implementing the strategy are alike for both cases.

6.4.2 Differences between the cases

Barriers

From the perspective of barriers, we can also see several differences between the two cases where some barriers are experienced by one case but not the other. First case presented specific institutional aspects as one of the barriers in developing their product during the innovation phase, while the second case did not. Even though both cases are in the field of renewable energy technologies, the two products exhibit different natures and functions. The laws and regulations that are specifically related to the two cases are also different and thus, one can act as a barrier while the other as a facilitator. From this information, we can say that the hindering laws and regulations is only a specific barrier to case 1.

Another barrier identified in the first case comes from the socio-cultural aspects. There is still a perceived notion of scepticism from the society about the product, while this event is not experienced by the second case. From the interview, it was discussed that this might be due to two possible reasons: (i) the technology itself that the product is based on is generally still in the early stage of development and thus, public attitude is likely to be negative towards its functionality or (ii) there is a possible *"not-in-my-backyard"* (NIMBY) syndrome which indicates that even though a general support of wind energy from the public is observed, it disappears when there is a specific project in the local area regarding the technology, due to the perception of unreliability and noise/visual impacts (Krohn & Damborg, 1999). This phenomena has been noticed specifically in the Netherlands where the acceptance towards wind energy project is lower

during the implementation of the project (Gipe, 1995). Therefore, as this barrier is not experienced by the second case, it is specific to the first case.

The second case experienced three other barriers that were not mentioned in the first case, including knowledge and awareness of the market, managerial system, and macro-economic. It was discussed that knowledge on the market for the second case is required as it does not only involved the solar energy market, but also the real estate market as the product is installed on new buildings and homes. Baas (2013) pointed out that there is a recognised importance in implementing sustainable components into buildings in the real estate market. However, many investors are still uncertain about the actual added value of these features in a building (Baas, 2013) and therefore, Physee sees this as a barrier and a high risk to depend on one market. We can say that this barrier is specific to the case.

This also relates to the macro-economic condition as a barrier in the second case, regarding the real estate market in the Netherlands as there is an increase on the price of real estate in the recent year which is affected by a combination of several macro-economic factors such as demographics and interest rates (Lennartz & Vrieselaar, 2018). Other than the perceived risk of adding PowerWindows feature on building by the investors (Baas, 2013), the macro-economic condition that affects the market can act as a barrier which makes said barrier specific to the case. Another barrier mentioned in the second case was managerial system in which there is a lack of organisational structure observed in the beginning of the innovation phase. This acted as a barrier in the early stage, but later was quickly resolved by adapting company practices into the daily operations.

Strategies

From the perspective of strategies, several differences are seen in the two cases. The first case does not implement neither conventional nor alternative financing strategy as implemented in the second case. It was discussed that in the first case, Kitepower started out the innovation phase with a governmental funding which is considered to be adequate to conduct any R&D activities. Kitepower's project is also a part of the EU's Horizon 2020 Initiative which allows them to rely on the governmental funding strategy. While in the second case, Physee started out with implementing a combination of governmental funding and alternative financing strategy by participating in the EU grant and Postcode Lottery Green Challenge to kick off the innovation activities further. Thus, alternative financing strategy can be considered as specific to the case.

The first case does not implement lead user strategy, while the second case relies significantly with this strategy. In the second case, lead user strategy provides a platform to gain insights and feedback from the early users of the product and due to the size and nature of the technology, using this strategy is more feasible to achieve this goal more efficiently and quickly. The reason why the first case does not implement lead user strategy is due to the larger size of the product and financial unfeasibility, making it too inefficient to gain feedback this way. Thus, pilot strategy is used as an alternative instead and lead user strategy can be considered as specific to the case. Redesign strategy is another strategy used in the second case but not the first. The goal of this strategy from the second case is to find the right balance between the performance of the product and the price from the point of view of its market viability. Although the first case also has the same goal of trying to find the right balance between the product performance and its price, there was not any particular strategy that is implemented by the company other than tuning in the characteristics of the product through in-house strategy. The redesign strategy, therefore, can be considered as specifically applicable only to the second case.

6.5 Adapted framework for factors in the innovation phase

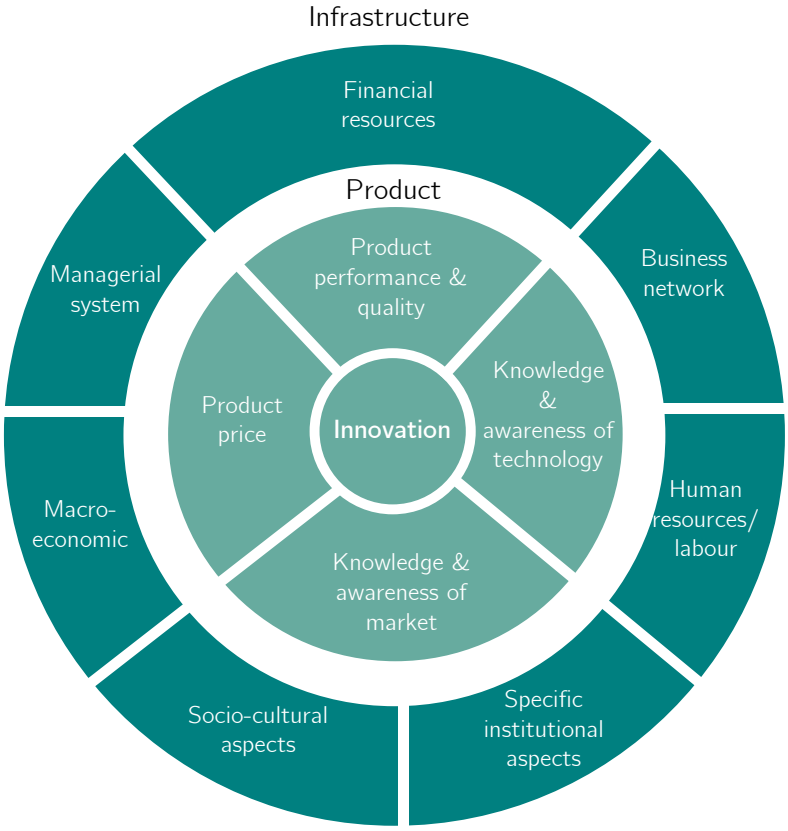


Figure 22 Adapted framework for factors in the innovation phase

In the previous sections, we have seen the different barriers experienced in the case study during the innovation phase. *Figure 22* above shows the adapted framework for the factors identified in the innovation phase through the case study. In this section, we would like to summarise these factors, redefine them based on our findings, and elaborate what happens if a particular factor turns into a barrier and hamper the innovation phase.

Product category

First of all, we can see that there are four factors from the product category that influence the development of the product in the innovation phase: product performance & quality, product price, knowledge & awareness of the technology, and of the market. Product performance & quality refers to any aspects of the product or the sub-components of the product with a sufficient performance and quality which allow the product to function well. When there is a lack of product performance & quality, the product is less appealing for investors and commercialisation as it has

to compete with the conventional technology. The innovating firms will aim to devote more resources for any improvements through further research and development which pushes the time frame of the innovation phase.

Knowledge & awareness of the technology refers to any knowledge, understanding, and perception that are related to the technology and required for the development of the product. If there is a lack of this factor, there is an issue with figuring out how to create or improve the product, if needed. One thing to note is that this barrier can come from either the firm or the society/potential customers. This means that if there is a lack of knowledge & awareness from within the firm, then the previous reasoning still follows. However, when it comes from the society/potential customers, then there will be less acceptance and awareness of the benefits of the radical innovation compared to the conventional option. This hampers the innovation phase because they will be the customers in the future and thus, there will be more processes involved in order to educate them more about the benefits.

Product price refers to any aspects of the product or sub-components of the product with an affordable price compared to the conventional option. If the price of the product is unaffordable, then potential customers will less likely to opt for the product compared to the conventional one. Similar to the lack of product performance & quality, the innovating firms have to spend more resources in R&D to lower the price but also keep a good level of performance which will then take longer to go through the first market introduction.

Knowledge & awareness of the market refers to any knowledge, understanding, and perception that are related to the market in which the product will be introduced and are required for the development of the product. If there is a gap in this knowledge in the innovation phase, then there is a higher risk of the product to fail in the market as it was not developed based on its potential customers and the market the product would like to target. Notice that this factor only becomes a barrier in case 2 because the product involves a function that is not only concerning the RET market, but more importantly the real estate market. Therefore, it is important to note this barrier as a specific one, depending on what other markets are essential to the commercialisation of the product.

Infrastructure category

From the infrastructure category, we have seven factors: financial resources, business network, human resources/labour, specific institutional aspects, socio-cultural aspects, macro-economic,

and managerial system. Financial resources refer to the availability of finance from potential investors to obtain finance in order to sufficiently fund any innovating activities that are related to the development of the product and for the firm to sustain. If there is a lack of financial resources, then the development of the product will be set back and the innovating firm cannot sustain its position.

Business network refers to the coordination of any actors in the value chain of the product developments or other actors (excluding the government) who can be involved and collaborate with for the development of the product. If there is a lack of the coordination of the business network, then the innovating firms will have their agenda for the sake of their product development pushed back and thus, the innovation phase will take longer to complete. Human resources/labour refers to the coordination of the skilled human resources or labours with a specific set of tasks who are involved in any innovation activities related to the development of the product. If there is a lack of this coordination, then the individuals of the innovating firm will have an issue to focus and allocate their resources and time efficiently to implement innovative solutions for the development of the product. This would lead to an inefficient innovation activities and thus, the time frame of the innovation phase will be delayed.

Specific institutional aspects refer to any laws and regulations that are related specifically to getting the product developed and demonstrated. If these regulations are hindering the development of the product, then there will be an issue with getting the product further developed or demonstrated and can push the timeline of the innovation phase. This example is seen from case 1, where testing of the prototype requires a certain license from the Dutch airspace. As this license is temporary, the company has to obtain it every time they conduct a testing and this can be quite troublesome. It is important to note that this barrier is also specific to the case and thus, any other innovating firms should keep in mind that depending what is required during the development of the product (e.g testing, certifications, trials), this certain factor can inhibit the innovation activities.

Socio-cultural aspects refer to any beliefs, norms, and values from the society about the product and how they percept and expect the potential benefits of the product. If there is a lack of acceptance or too high of an expectation from the society towards the product, then there will be an issue with the product to develop based on their expectations and an issue with getting potential customers to be attracted into buying the product. Because this barrier was only observed in case 1, there is also a particularity to this barrier and thus, it might not always occur

in other cases. Nonetheless, other innovating firms should be aware that there can be an unfavourable condition of the socio-cultural aspects that could potentially affect the development and even the commercialisation of the product.

Another similar factor is macro-economic which refers to any economic factors, interests, situations related to a particular country or industry in which the product is being developed, which was observed as a barrier in case 2 when there is an unfavourable aspects of the economic condition that could affect the market related to the product. It is interesting to observe from the two cases that there is at least one factor from the socio-technical landscape that is impeding the development of the product. While each of the barrier is specific to the case, it is still important to note that other innovating firms should recognise that a factor from the landscape under which the innovation is developed could become a barrier and affect any further development of the product.

Managerial system refers to any aspects, measures, or processes within the firm that helps to establish shared vision between the individuals of the firm, organisational culture and values towards a common, long-term objective of the firm and stimulate innovating activities. If there is a lack of this aspect which results in the competence barrier, then the development of the product might be hampered as there is an issue with managing some aspects in the innovating firm in order to work towards a common goal. However, it is also important to note that the occurrence of this barrier might be specific, depending on the stage of the innovating firm where it was only found as a barrier in the beginning and the type of measures that are established, culture, and the individuals of the firm, which should be taken into account for other innovating firms.

6.6 Adapted framework for strategies in the innovation phase

Figure 23 Adapted framework for strategies in the innovation phase

In the previous sections, we also have identified the different strategies implemented by the companies in the case study during the innovation phase. *Figure 23* above shows the adapted framework for the strategies identified in the innovation phase through the case study. In this section, we would like to summarise these strategies, redefine them based on our findings, and elaborate what happens if a particular strategy is used to remove or circumvent a particular barrier.

Non-commercial strategies

First of all, we can observe that no commercial strategies are applicable in the innovation phase because the product being developed has not yet entered the market and commercialisation has not taken off yet. From the perspective of non-commercial strategies, there are eight strategies that have been identified: pilot, in-house, outsourcing, governmental funding, business

partnership, lobbying, strategic planning, and educate strategy. We would also like to elaborate the other strategies observed in a specific case, such as lead user, redesign, conventional, and alternative financing.

Pilot strategy refers to the implementation of a small-scale pilot project as a way to demonstrate the technology and develop the innovation further. When there is a lack of product performance & quality, knowledge & awareness of the technology or market, and a lack of acceptance from the society, this strategy is advantageous because the goal of this strategy is not to only demonstrate, but also to validate their business model and evaluate the feasibility, cost, and make any improvements that are required for the product to be viable for commercialisation. The strategy can also involve collaboration with the governmental bodies, partners, experts, and potential investors, so that they can also give feedback for improvements and be shown the benefits of the product.

In-house strategy refers to the use of any activities and processes within the firm that are related to the research and development of the product. The goal of this strategy is mainly to develop the technology and improve it when the product performance & quality is not yet sufficient. However, the important aspect is that to keep the technology and proprietary knowledge within the firm in order to keep the competitive advantage. This strategy is used in combination with outsourcing strategy which refers to the use of external sources in order to obtain the technology, sub-components of the technology, or any resources and knowledge required for the development of the product. Other than obtaining resources, the goal of this strategy is also to form business network, keep some parts of the sub-components with no competitive advantage as non-proprietary and thus, focusing on the development of the main technology.

Governmental funding strategy refers to the use of any platforms and activities in order to acquire financial resources from any governmental bodies. This can be conducted through applying for different grants and awards, collaborating with the bodies through their initiative programmes, and subsidies or dispensation. The main goal of this strategy is to, of course, obtain an adequate initial capital needed for the development of the product and it gives the innovating firm a certain advantage because governmental bodies are more likely to support the innovation, compared to conventional investors. The use of this strategy can also lead to the opportunity of using other strategies, such as pilot.

Business partnership strategy refers to the use of any activities in order to establish a coordination and relationship with any actors in the value chain (or potential actors who might be involved)

for the development of the product. Other than cultivating this business network and refining partnerships, this strategy can also be advantageous when there is a lack of knowledge & awareness of the technology, then inquiring any knowledge and insights from the business partner can be helpful to reduce that barrier. If this strategy is extended into use towards the public, then the lack of acceptance of the technology by the society can also be removed. Another strategy related to this is lobbying which refers to the use of any actions and attempts to influence the decision made by regulatory agencies or any actors involved in the development of the product. Note that this strategy is not only used to the governments when the institutional aspects are hindering the innovation to develop, but also to business partners because during the product development, there are many resources required but due to diverse interests, the innovating firm's priority might be set back and thus, the firm can attempt to lobby.

Strategic planning refers to the use of any set of measures or activities that are implemented to manage resources, establish processes and practices for the employees. The main goal of this strategy is to develop the product more efficiently and achieve a common, strategic objectives of the firm in the long-term. Not only this aspect, but the strategy is used to manage financial, human, and natural resources, making decisions about any aspect related to the innovation by considering the long-term goals. Lastly, educate strategy refers to the implementation of any activities that are aimed at increasing awareness about the product, its benefits, as well as the visibility of the innovating firm. This can be conducted through many platforms, such as social media, collaborating with the governments or local businesses and artists, conventions and technology conferences, and many else. When there is a lack of awareness about the product and acceptance towards the technology by the society, this strategy is important because it gives the innovating firm an opportunity to showcase the product and also themselves.

Lead user refers to the assignment of early users to use the product in order to give feedback on the product and insight on the market potential which leads to any improvements for the product. The main goal of this strategy is to not only gain feedback, but also to validate the business model. Redesign strategy refers to redesigning the product by coupling characteristics of the sub-components to reach the desired performance. These two strategies are specific to case 2 due to the nature of its technology, making it more efficient to choose these strategies and thus, other innovating firm should consider this point when deciding to use these two strategies. Conventional financing refers to gaining financial resources through more conventional investors, while alternative financing refers to gaining financial resources through less traditional platforms such as prizes and challenges. Although the two cases experienced the same barrier of the

difficulty in finding conventional investors, case 2 applied these two strategies in the end and the implementation of these two strategies are made possible because there is a window of opportunity that opens up and thus, it should be noted by other innovating firms to look out for these opportunities.

7.

Conclusion & discussion

The research attempted to explore the barriers and strategies in the innovation phase of a new high-tech products using cases in the renewable energy technologies sector. The main research question is as follows:

> *"What are the barriers faced and strategies implemented by firms in the field of renewable energy technologies in the Netherlands that influence the innovation phase of the diffusion pattern?"*

Several sub-questions are formulated in order to help us answer the main research question which include:

- *SQ1. What are the barriers faced by firms in any phases of the diffusion pattern and specifically in the innovation phase of their new high-tech products differ based on the literature and reasoning?*
- *SQ2. What are the strategies implemented by firms in any phases of the diffusion pattern and specifically in the innovation phase of their new high-tech products differ based on the literature and reasoning?*
- *SQ3. What are the barriers faced by firms in the Netherlands in the field of renewable energy technologies during the innovation phase based on the case studies?*
- *SQ4. What are the current strategies used by the firm to overcome these barriers based on the case studies?*

In order to answer the research questions, two research methods were employed: a theoretical literature review, and two case studies. Based on the assumptions of existing literature, a conceptual framework was proposed in order to address the issue. Then,

interviews for the case studies were conducted in order to obtain data and information for the analysis. This chapter gives the conclusion of this research by answering the sub-questions and main research question. It also provides discussion for any further insights that were obtained during the research activities. We will also attempt to provide recommendations for managerial and practical relevance, as well as academic recommendation for the purpose of future research.

7.1 Conclusion

7.1.1 Research sub-question 1

SQ1: *What are the barriers faced by firms in any phases of the diffusion pattern and specifically in the innovation phase of their new high-tech products differ based on the literature and reasoning?*

Based on the literature review, there are 17 barriers that were identified. *Table 15* below summarises the barriers along with their definition. As has been mentioned in Section 4.3.3, we use the *"top-bottom"* approach where we identified factors that can act as barriers in any phase of the diffusion pattern, then attempted to categorise the barriers that can exist specifically in the innovation phase.

Table 15 Final list of barriers based on literature

No	Barriers	Definition
1	Product performance and quality	There is a lack of sufficient performance and quality in any aspects of the product, such as its components and subsystems.
2	Product price	The price of the product, its components, and subsystems, is still relatively or absolutely unaffordable.
3	Production system	There is a lack of functionality and sufficiency of the system required in order to manufacture the product.
4	Complementary products and services	There is an unavailability of any products or services necessary for producing, distributing, adopting, and using the new high-tech.

5	Business network	There is a lack of any actors involved in any of the value chain of development and diffusion of the new product.
6	Customers	There is an unavailability of anyone who are aware of the benefits of the product and are willing to pay for the new product.
7	Specific Institutional aspects	Laws and regulations that deal specifically with the field of the new high-tech product and its socio-technical system still hinder the new product to develop.
8	Knowledge and awareness of technology	There is a lack of fundamental and applied knowledge necessary to develop the new product by innovating firm,
9	Knowledge and awareness of market	There is a lack of knowledge about the potential applications of the product and the market by the innovating firm.
10	Human resources/labour	There is a lack of any skilled human resources or labour that are involved in the development and diffusion of the new product.
11	Natural resources	There is an unavailability of any materials or substances that are required to develop the new product.
12	Financial resources	There is a difficulty in accessing any forms of financial resources from platforms (e.g., crowdfunding, capital) and organisations (banks, investors) to provide finance for development, diffusion, adoption, and maintenance of the product.
13	Macro-economics	There is an unfavourable economic situations, economic and strategic interests of a particular country or industry.
14	Socio-cultural aspects	There is an unfavourable form of beliefs, norms, and values existing in the society and industry.
15	Accidents or events	There is a presence of any unexpected accidents or events, such as wars and natural disasters, outside the socio-technical system with large impact.
16	Competition	There is an unideal situation of any rivalries regarding the development of the product and speed of market entry between the main firm and other entities that are developing a similar type of product.

17	Managerial system	There is a lack of any measures, processes, management structures or organisational culture that companies use to direct actions and activities toward company goals.

Through logical reasoning, we proposed a conceptual framework where we categorised several barriers listed above into two groups: product and infrastructure. The innovation phase is characterised by a significant need to focus on the initial development of the innovation in order to manufacture a market viable product. This relates to building up and improving the characteristics of the innovation as its own entity and thus, there are barriers that can hinder this process that comes intrinsically from the product itself. These barriers include the lack of product performance & quality, production system, knowledge & awareness of the technology and market by the firm, and natural resources. All of these barriers influence the development of the innovation directly (without anything else being involved or in between).

However, not only these barriers can affect the innovation, but also barriers that occur from factors outside of the nature of the innovation that help to build up the system around it necessary for the development. This is because in order to create an innovation, there is a need of support system or infrastructure that indirectly affects how the product is developed. The lack of any factors in this infrastructure can lead to an occurrence of barriers which can include the lack of financial resources, business network, specific institutional aspects, human resources/labour, and managerial system as a competence barrier. *Table 16* below summarises the list of barriers for the innovation phase based on the conceptual framework.

Table 16 List of barriers in the innovation phase based on the conceptual framework

Phase	Category	Barriers
Innovation	Product	Lack of product performance & quality
		Lack of production system
		Unavailable natural resources
		Lack of knowledge & awareness of technology
		Lack of knowledge & awareness of market
	Infrastructure	Lack of financial resources
		Lack of business network
		Hindering specific institutional aspects
		Lack of human resources/labour
		Lack of managerial system

7.1.2 Research sub-question 2

SQ2: *What are the strategies implemented by firms in any phases of the diffusion pattern and specifically in the innovation phase of their new high-tech products differ based on the literature and reasoning?*

Based on the literature review, there are 18 strategies that were identified. *Table 17* below summarises the strategies along with their definition. As has been mentioned in Section 4.4.3, we use the *"top-bottom"* approach where we identified strategies that can be implemented in any phase of the diffusion pattern, then attempted to categorise these strategies that can be used specifically to tackle the barriers in the innovation phase.

Table 17 Final list of strategies based on literature

No	Strategies	Definition
1	Pilot	This strategy can be used to demonstrate the new product in a controlled way using a pilot project
2	Redesign	This strategy can be used by adopting the product to a simpler version that may result in a lower price and a better quality for the new function of the product
3	Stand-alone	This strategy can be used through using the product on its own or having an infrastructure specifically designed for it
4	Hybridisation/adaptor	This strategy can be used by using the product together with an old technology or using a modified existing infrastructure
5	High-end	This strategy can be used to target specific high-end market with customers who are willing to pay for the high price
6	Educate	This strategy can be used to increase awareness of the society about the product and its benefits to attract new customers
7	Lead user/customer-oriented	This strategy can be used by bringing in early users to use the new product, gain their feedback, identify key customers, and establish customers network
8	Explore multiple market	This strategy can be used to commercialise the product in other market segments or other applications

9	Governmental funding	This strategy can be used by acquiring funding from any governmental agencies or non-profit organisations, such as grants, loan programs, and subsidies
10	Geographic	This strategy can be used through diversifying geographical locations for product commercialisation
11	Lobbying	This strategy can be used by influencing the decisions by the government and collaborating with them
12	Business partnership	This strategy can be used to establish partnership with other firms or actors in the value chain for the development and diffusion of the product
13	Conventional financing	This strategy can be used by obtaining funding through conventional methods such as bank loans, angel investors ,and venture capitalists
14	Alternative financing	This strategy can be used by obtaining financial resources from alternative sources such as crowdfunding, awards/competitions, and bootstrapping
15	In-house	This strategy can be used through developing the technology and product within the firm by using and managing its own resources
16	Outsourcing	This strategy can be used through bringing in the technology, system, knowledge, or resources from external sources
17	Strategic planning	This strategy can be used by establishing processes and practices for the employees to fulfil strategic objectives of the firm in the long-term

Through logical reasoning, we proposed a conceptual framework where we categorised several strategies listed above into two groups: commercial and non-commercial. We argue that there are no commercial strategies that are applicable in this phase. This is because the product has not yet been introduced into the market and thus, no commercial activities that can generate financial gain are possible and thus, the strategies implemented in the innovation phase should focus on non-commercial activities that aim to build up the lack of aspects needed for the product to develop. *Table 18* below summarises the list of strategies for the innovation phase based on the conceptual framework.

Table 18 List of strategies in the innovation phase based on the conceptual framework

Phase	Category	Strategies
Innovation	Non-commercial	In-house
		Outsourcing
		Lead user
		Conventional financing
		Alternative financing
		Governmental funding
		Business partnership
		Lobbying
		Strategic planning
	Commercial	Not applicable

7.1.3 Research sub-question 3

SQ3: *What are the barriers faced by firms in the Netherlands in the field of renewable energy technologies during the innovation phase based on the case studies?*

Two cases were investigated during the research: Kitepower (case 1) and Physee (case 2). In case 1, the company experienced the lack of product performance & quality, lack of knowledge & awareness of the technology, and unaffordable product price from the product category as barriers that influence the development of their innovation. While from the infrastructure category, they experienced the lack of financial resources, lack of coordination with the business network, hindering specific institutional aspects, lack of coordination with human resources/labour, and unfavourable socio-cultural aspects as barriers.

In case 2, the company experienced the lack of product performance & quality, lack of knowledge & awareness of the technology, lack of knowledge & awareness of market, and unaffordable product price from the product category as barriers that influence the development of their innovation. While from the infrastructure category, they experienced the lack of financial resources, lack of coordination with the business network, lack of coordination with human resources/labour, lack of managerial system, and unfavourable macro-economic as barriers. *Figure 24* below summarises the final barriers in the innovation phase that were identified generally in the case studies.

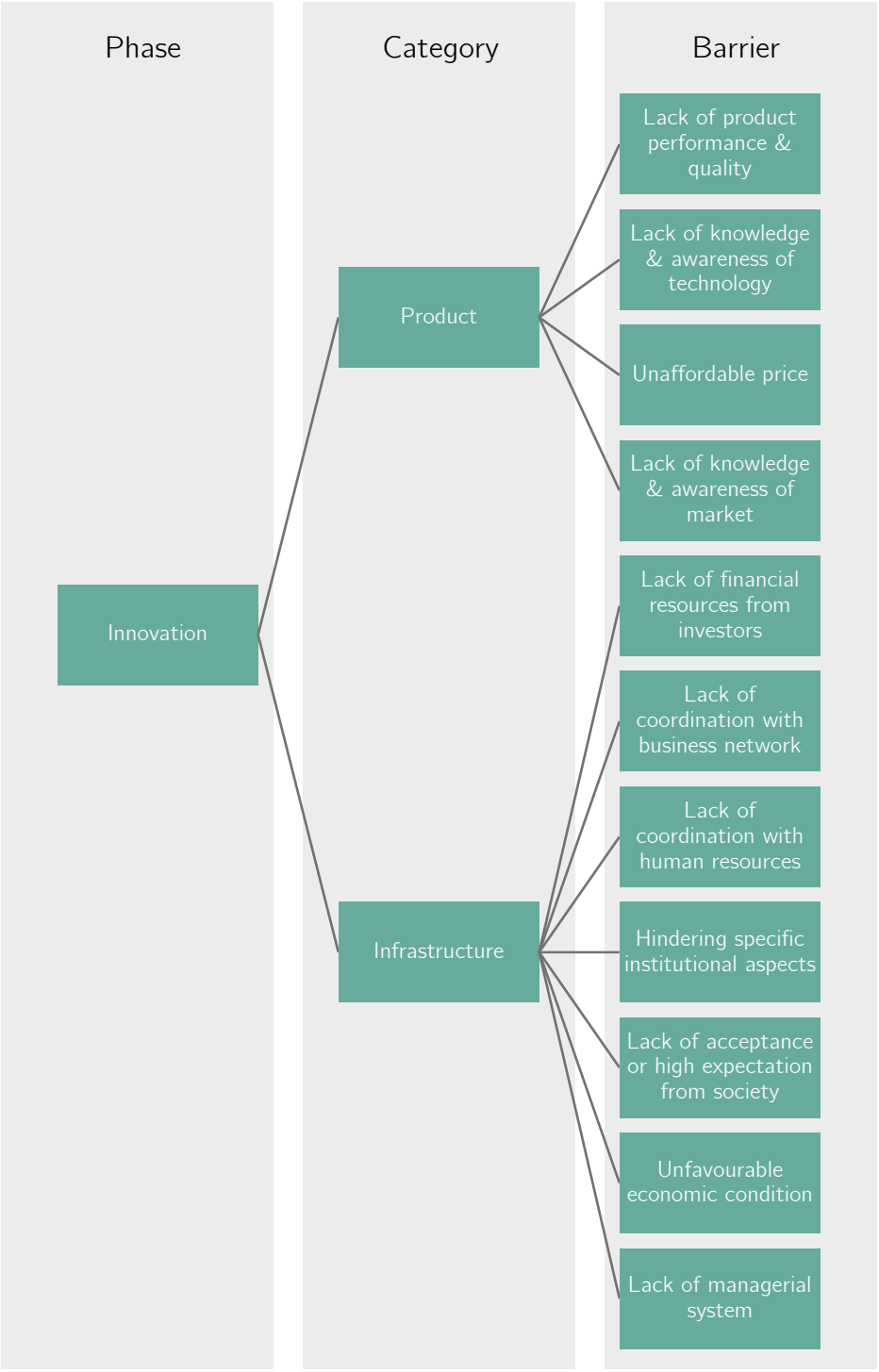


Figure 24 Final list of barriers in the innovation phase based on findings

Both cases explicitly mentioned the challenge in balancing the product performance & quality with the product price which causes traction in the development of the innovation. The lack of knowledge and awareness of the technology also acts as a barrier in both cases. However, case

1 sees the lack of this factor from the society and customers side while case 2 observes the lacking from within the company. Therefore, this barrier can influence the innovation, but it is important to distinguish where the source of this lacking is coming from. The lack of knowledge & awareness of the market was also experienced by case 2, because the product involves a specific market of real estate and thus, it is important to note that this barrier can occur depending on what markets are essential in the product commercialisation.

The lack of financial resources were also discussed as a barrier in both cases, but only in the beginning of the innovation phase. After requiring a form of governmental funding, this barrier was quickly overcome. Nonetheless, due to the early stage of the product, both cases also experienced the difficulty of getting investors to provide financial resource as a barrier which influences the progress of the innovating activities. They also identified business network as a barrier, not in terms of forming them but rather coordinating with them. Both cases also identified human resources as a barrier, not the lack of it but rather the problem with having set of tasks for the employees that are out of the job description which leads to inefficiency in the firm's innovating activities.

The other four barriers we have identified are also more specific to the case: hindering specific institutional aspects, the lack of acceptance or high expectation from the society, unfavourable macro-economic condition, and the lack of managerial system. Hindering specific institutional aspects was experienced in case 1 where regulations regarding testing can inhibit the development of the product. We can also see that the results have shown us that case 1 experienced the lack of acceptance or high expectation from the socio-cultural aspects to be a barrier, while case 2 found unfavourable macro-economic condition to be one. The two factors are originating from the socio-technical landscape which should be an important aspect to note that at least one factor from such landscape can hinder the product development. The lack of managerial system was also found in case 2, but it should be noted that this barrier might also be found only in the beginning stage of the innovating firm and specific to the types of measures that are in operation.

7.1.4 Research sub-question 4

SQ4: *What are the current strategies used by the firms to overcome these barriers based on the case studies?*

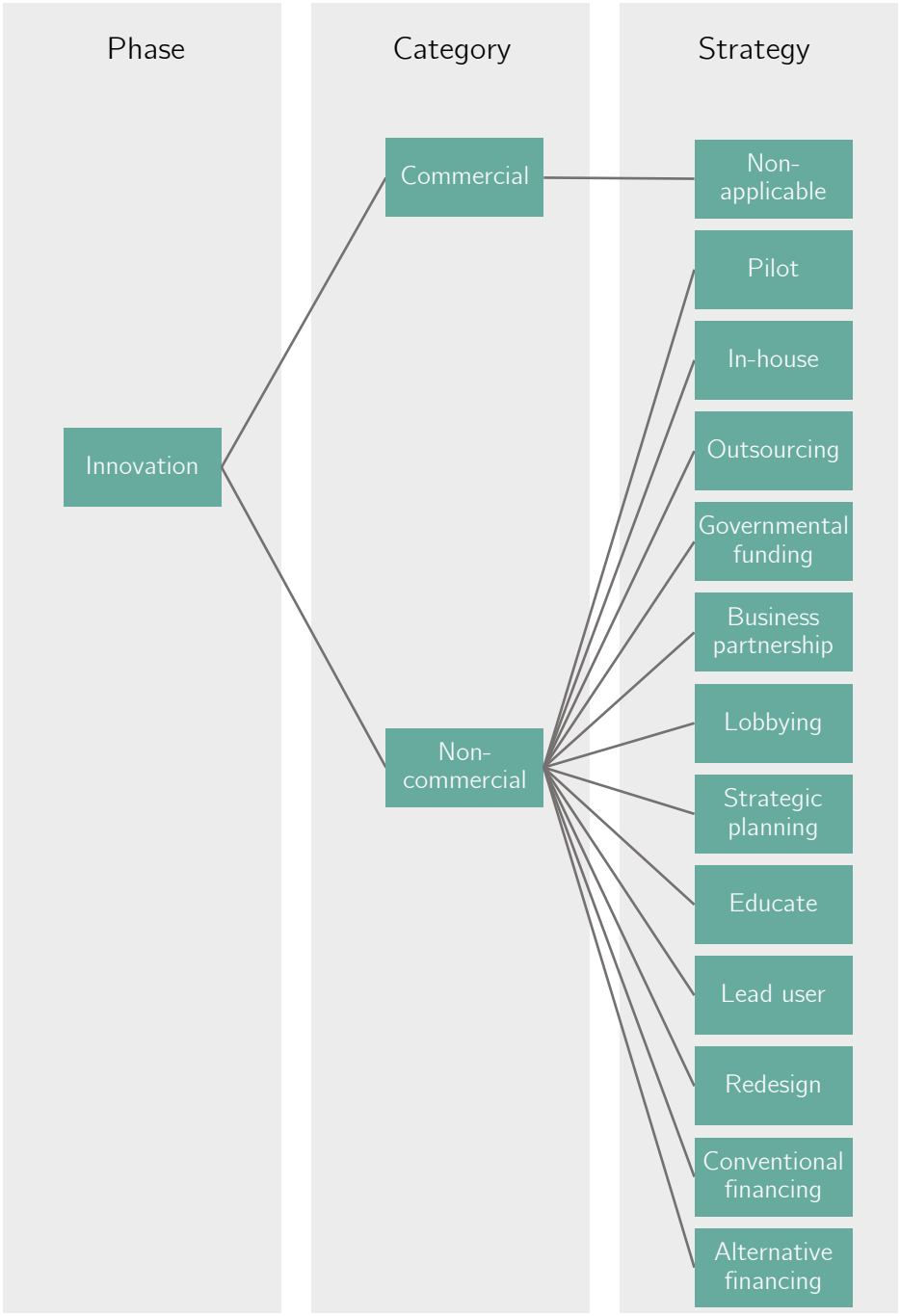


Figure 25 Final list of strategies in the innovation phase based on findings

Based on the two cases, we have identified the strategies implemented in order to circumvent or remove the barriers in the innovation phase. *Figure 25* above summarises the final strategies that

are generally implemented in the innovation phase based on the case studies. It is interesting to see that there are strategies that were categorised as commercial (and thus, irrelevant in this phase) but were identified, such as pilot. However, it is important to note that even though they can be considered commercial strategies, their role in this phase is for non-commercial purposes and no financial gain is generated. Case 1 implemented strategies such as in-house, outsourcing, governmental funding, business partnership, lobbying, strategic planning, educate, and pilot, while case 2 implemented similar strategies, with an addition of lead user, conventional financing, alternative financing, and redesign.

Both cases discussed the importance of using the combination of in-house and outsourcing strategy as they develop their core technology and the knowledge within the company, while at the same time obtain other resources needed for the sub-components of the product from other actors. Both cases also use governmental funding strategy in order to go over the hump in the beginning when financial resources were lacking. In both cases, it was discussed that business partnership strategy is important not only to exchange resources but as a means to collaborate. Lobbying is also implemented in both cases, especially to their business networks. Strategic planning is also important as there is a need to establish organisational culture and practices based on long-term goals.

Both cases use pilot strategy as a means to demonstrate their product to the government or partners and gain assessments for improving the product performance and quality, rather than commercial goals, while also use educate strategy in order to create awareness about the benefits of their products to the society and the presence of their companies. The four other strategies that have been identified are more specific to case 2 which include lead user, redesign, conventional, and alternative financing. Lead user and redesign strategies are specific to the case due to the nature of the technology, making it more feasible to use these strategies. While conventional and alternative financing were used because there was an opportunity available to implement such strategy.

7.1.5 Main research question

"What are the barriers faced and strategies implemented by firms in the field of renewable energy technologies in the Netherlands that influence the innovation phase of the diffusion pattern?"

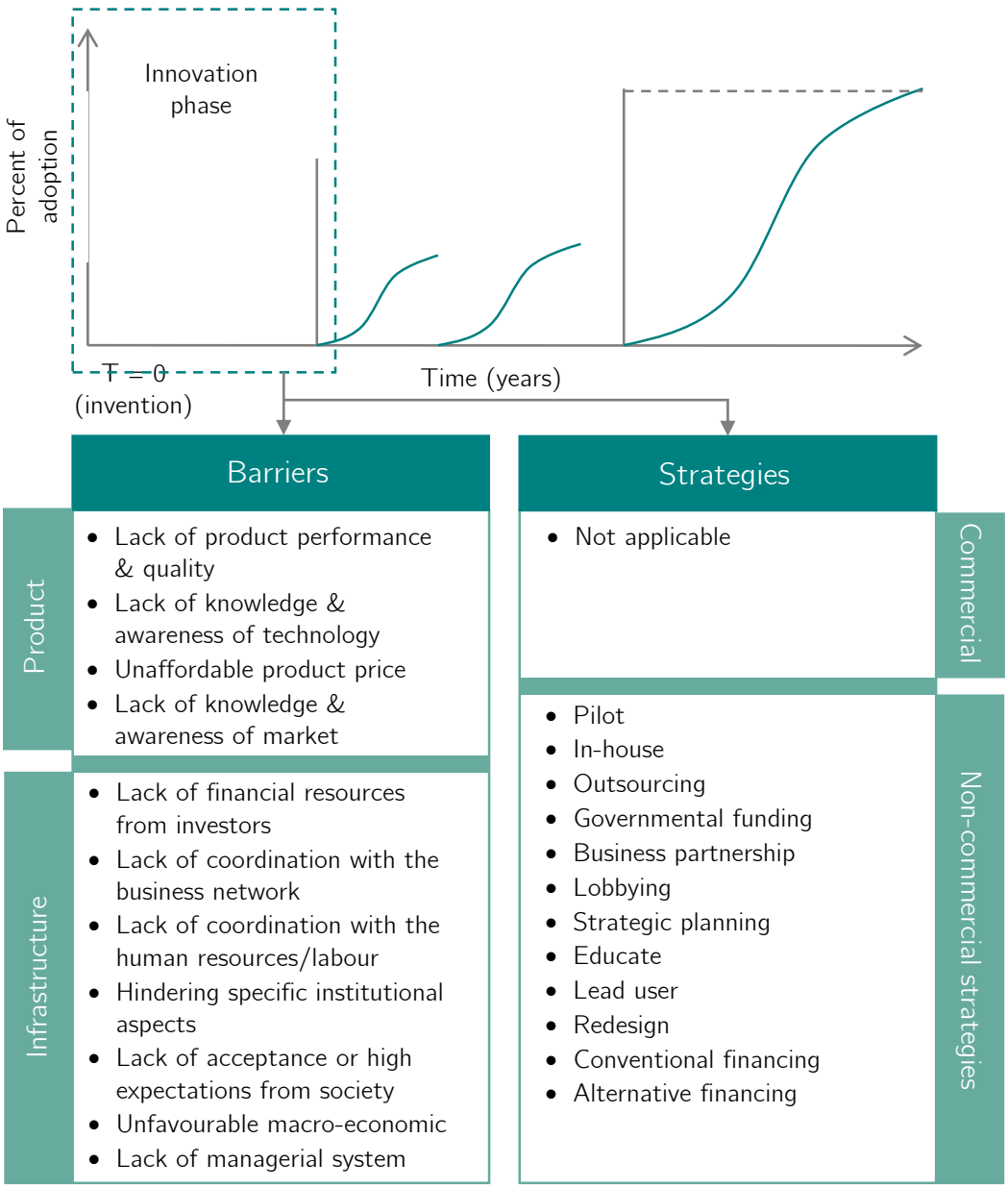


Figure 26 Barriers and strategies in the innovation phase

The innovation phase is characterised by a significant focus on developing the product through research and development activities which aim to improve the technical aspects and commercial viability of the product and by the notion that any factors can become a barrier. This study argues that there are certain barriers that firms in the field of renewable energy technologies face during the innovation phase and strategies that can be implemented in order to remover or overcome these barriers. This study also argues that the barriers and strategies can be understood better if they are categorised into different groups. The barriers are categorised into two groups: product category, where it represents any aspects from within the innovation that are directly

involved in the development and characteristics of the product, and infrastructure category, which is any aspects which are indirectly involved in the development and characteristics of the product, but helps to build the system around it.

Figure 26 above summarises the barriers and strategies that can occur in the innovation phase during the development of the new, high-tech product. From the findings, it was observed that the lack of product performance & quality goes hand-in-hand with unaffordable product price, in which there is a challenge in balancing the product performance & quality with the product price which causes traction in the development of the innovation. Interestingly, the lack of knowledge & awareness of the technology can also come from either the innovating firm's side or the society's (or potential customers') side. Another insight from the three other barriers is that they play a different role than conceptualised before: rather than having problems with acquiring the aspect (be it financial resource, business network, or human resources) that makes it a barrier, it is instead the next step that happens after acquiring it, such as trying to obtain finance from external investors, coordinating with business actors and employees. Other than these barriers, it is also important to note that there are barriers that can occur depending on the condition of the case, such as the lack of knowledge & awareness of the market from the product category, hindering specific institutional aspects, the lack of acceptance or high expectation from the society, unfavourable macro-economic condition, and the lack of managerial system from the infrastructure category.

The strategies are grouped into two categories: commercial, which refers to strategies that are aimed for financial gain through selling the product, and non-commercial which is strategies that are aimed not for financial gain, but rather building up the system around the innovation. The strategies include pilot, in-house, outsourcing, governmental funding, business partnership, lobbying, strategic planning, and educate strategy. Many of these strategies can be used in combination with each other and the use of one particular strategy opens up the opportunity to use another strategy. This example can be seen from the use of in-house and outsourcing strategy together or governmental funding and pilot strategy when the implementation of the former can lead to the possibility of using the latter strategy. In the innovation phase, it is important to choose a strategy based on the consideration of the barriers that are experienced by the innovating firms as well as the opportunities that open up to implement these strategies. Other than these strategies, it is also important to note that there are strategies that can be implemented depending on the condition of the case and opportunities present, such as lead user, redesign, conventional and alternative financing strategy.

7.2 Discussion

This section explores things that are discovered during the research but were not part of the research objectives.

7.2.1 The nature of the innovation phase

In the innovation phase, it was considered that any relevant factor can hamper the development of the product and become a barrier. There is a lack of facilitating aspects that are required for any innovation activities as they are not set up and established yet. However, from the case study, it can be observed that this is not always true. This is because before an innovating firm begins the development of their product, there is already an involvement of key actors and factors that enable this to start. Firms do not go *"blindly"* into the innovation phase without any consideration of actors and factors that would be significantly involved in the development. Therefore, these facilitating aspects have already started to build up from the beginning, although to what extent they are built up and whether this will still act as a barrier are the questions.

It is also worth mentioning the notion that the innovation phase is only about R&D and optimising the performance or price of the product are not entirely true. In this phase, it can be observed from the case study that building up the infrastructure around the product is also a crucial element. This can include collaborating with the government, growing a network of business actors, and increasing visibility of the company and technology to the society. This is because the success of an innovation does not only come from its technological capabilities (product perspective), but also the surrounding system around which the innovation is being developed (infrastructure perspective). These aspects are required in this phase to also reassure that moving into the market adaptation phase would be less problematic.

There is also an influence of factors that are more market- or customer-oriented in the innovation phase, such as the product price, socio-cultural aspects, and macro-economics. This is interesting to see because in the innovation phase, there is not yet *"real"* customers or any influence from the market as the product is not yet introduced and there are only expectations coming from them. However, even during the development of the product, there is already a real influence from these factors. It makes sense to think that this occurs due to the notion of social construction of technology (Bijker, Hughes, & Pinch, 1987), which indicates how technology is socially constructed and based on human choices. Although in the innovation phase, the case would be slightly different as the social construction that affects the development of the

technology comes from expectations which drives the trajectory of the technology being developed (Brown & Michael, 2003). It is also important to note that these expectations, especially coming from the public who have little influence on the development of a technology, mostly arise from an asymmetry of information and knowledge which these expectations are usually based (Brown & Michael, 2003; Borup, Brown, Konrad, & Van Lente, 2006). Thus, it is important for this aspect to be considered as a key factor and managed accordingly.

As has been mentioned previously about strategic planning strategy in Section 4.4.3, it is important to have a long-term perspective when it comes to aligning the competences and resources into a common, long-term objective of the innovating firm. However, looking at the factors that can become a barrier in the innovation phase and influence the development of the product, we can observe that there is another perspective that should be taken into account which is to have a broader perspective when formulating the surrounding system around the product. This means that when an innovating firm would like to enable their product during the innovation phase and moving to commercialisation, the firm has to consider the system in a broader view: not only the technical aspect that is crucial, but also integrating the market and potential customers into the product, the expectations of the society, governments, and many else. When the innovating firm is able to look at the long-term perspective of managing competences or resources and also the broader view of the system around the innovation, the barriers that can influence the development of the product can be more manageable.

In the innovation phase for the case of RET innovations, there is also a heavy influence of the role from the government, in terms of enabling the key factors for the development of the product. The innovating firms rely on the government for funding, whether it is in the form of grants or subsidies. This is also due to the difficulty in finding investors when it comes to investing in emerging technologies. However, this is also not always the case, both in RET and in other new, high-tech products. While there is a lot of governmental support for R&D activities for RET innovation, there is still a gap between the R&D and 'near commercial' support that inhibits the innovation to move from R&D stage into pre-commercial trials which has been observed in the case of RET innovations in the Netherlands where there is a large budget allocated for the R&D, but not for large-scale demonstrations or early market formation (Negro, Alkemade, & Hekkert, 2012). And the case for other new, high-tech products, the support from governmental bodies is even less and while RET innovations at least have the advantage of being on the agenda of the governments, many other technological innovations do not have the same advantage. This

indicates that even though the government plays an important role in enabling key factors for the innovation to develop, it is not always generally the case.

The success of the product is also affected by the institutional aspects that regulate the environment in which the product is developed. Many opportunities for the firm to use the strategies are also originating from the government, such as the opportunity to build a pilot project. This is because the government plays a vital role in mobilising resources in the innovation system and creating *"window of opportunities"* for the innovating firms to progress. Thus, it is important for firms with new products in the innovation phase to take advantage of any occasions or openings that are offered by the government.

7.2.2 Influence of the identified barriers on the innovation phase

Since we have identified the barriers through the case study, we would like to discuss what type of influence these barriers have on the innovation phase. Firstly, any barrier that exist in the innovation phase would push the timeline of any innovation activities related to the development of the product. The lack of a factor leads to the inhibition of product development and thus, the innovation phase would be longer. This would be an issue because innovating firms usually have project milestones that they have to achieve and they also have to consider the stakeholders they are collaborating with, such as the government and investors, as they have to fulfil the expectations.

Secondly, the processes occurring in the innovation phase would be more chaotic with the influence of barriers. This is because the existence of a certain barrier would complicate any innovation activities related to that barrier. For example, if there is a lack of product performance, more research towards its improvement will be needed. This will take more resources, be it financial, human, or any materials needed. If one of these resources are lacking in this situation, then the innovating firm would have to accommodate for that. This can create a positive feedback loop which leads to a more unstable innovation phase.

It is not a trivial task to observe the effect of these barriers and measure their influence on the innovation phase. An idea is to develop a quantifiable construct and an empirical test of the factors that become a barrier which can be conducted to see their influence on the outcome of the new product, whether it is successful or not. In this case, successful can mean that the product has successfully entered the market adaptation phase. Hypotheses regarding the relationship between a factor and the outcome of the product will be developed. For example, a

hypothesis could be: *"the abundance of financial resource is positively related to the success of the product and negatively related to the product failure".* Other hypotheses should involve the other factors that have been identified as a barrier in this research. The next step is to take a large samples of products that have succeeded and those that have failed. At the end, we can see the influence of these factors on the development of the product and measure the importance of each factor. By conducting this quantitative study, it can give us an idea of how the phase could behave with the occurrence of these barriers and how we can manage it.

7.2.3 Two-layer factors

We have explored the barriers that exist in the innovation phase of the diffusion pattern. From the results of the case studies, there is a dynamic in between the factors influencing the development of the innovation and also between the strategies that can be implemented. The original work of Ortt & Kamp (2018) proposed the two-layer factors consisting of core and influencing factors in which a lack of one of the influencing factors leads to a lack of one of the core factor and from that, a specific niche strategy can be implemented accordingly. In both cases used in this research, there is an interrelation between two core factors or influencing factors. For example, when there is a lack of product performance and quality, the amount of resources used to improve that increases and leads to a higher (more unaffordable) price. Even though the two factors are considered core, they also affect each other and the strategy implemented should also be chosen accordingly.

As we have chosen to not look at these factors in a two-layer perspective as it is in the case of the original framework (Ortt & Kamp, 2018), we can see some benefits and shortcomings in its removal. Firstly, as there is not yet much knowledge on the literature about the barriers and strategies specifically in the innovation phase, we have attempted to close this knowledge gap by identifying the barriers and strategies in the innovation phase through this research. With this objective, there is more of a focus on building the list of factors that can become a barrier and the strategies that can be implemented to remove or circumvent it and thus, the removal of the two-layer factors help us to simplify the study and focus more on this objective. Secondly, the innovation phase has a different nature compared to the market adaptation phase which the two-layer is built up for. The idea is that in the innovation phase, every aspect is more fuzzy and uncertain that even what counts as an influencing factor can act as a main barrier to the development of the product. This is because in the beginning, many aspects necessary for the innovation are not yet established, such as the key actors that are involved in the production,

financial resources, or even a functioning daily operation in the firm. Therefore, to divide the factors based on these two layers would not be so imperative in the case of the innovation phase.

However, the shortcomings of this removal can also be observed. The division of core and influencing factors is meant to see what mainly causes the core factor to exist as a barrier. With the removal of the two layers in this research, it is difficult to see whether one factor becomes a barrier and exists as it is or because there are some other factors influencing it. Without the two layers, it is not clearly examined as to how the barrier was formed. There is also more of a linear relationship between the barrier and chosen strategy, which is not always the case. As proposed in the original framework (Ortt & Kamp, 2018), if we examine what factor is influencing the core, then the chosen strategy might be different. The presence of the two layers helps us to see this relationship in more detail and build a more comprehensive linkage between the barriers and strategies. In hindsight, while the removal of the two layers in this research helped us to simplify the identification of barriers and strategies in the innovation phase which is the main objective, we believe that including the two layers will provide a better insight in why or how the barrier can form and a more in-depth view of the relationship between barriers and strategies. This insight is recommended to consider for future research.

7.2.4 Using the factors as a starting point

Using the factors from the original work of Ortt & Kamp (2018) as a starting point has given us a good base to build up an initial framework of barriers and strategies for the innovation phase. Due to the flexibility of the nature of these factors, they can be easily applied into the innovation phase and adjusted accordingly. At first, we used the same definition for most of the factors on the list. However, after looking at the result of the case study, we adjusted the definitions of the factors according to the findings which also reflects on the nature of the innovation phase and what roles these factors play. When thinking of what factors are important in the innovation phase, we immediately consider the technical aspects of the product development. However, using these factors as a starting point also provides us with a full-on look on other important aspects that are more related to the innovation system, such as the institutional aspects and socio-cultural aspects.

There are additional factors that might play a role in the innovation phase, but not yet on the list, such as shared vision in terms of product and within the firm itself. Another thing to remember is the assumption we have made in Section 1.3, which states that the radical innovation

is assumed to be fully envisioned and its purpose is already clear. Generally in the innovation phase, this assumption is not always true as there is usually a lack of shared vision on what the product should be like or what its purpose and functionality should be. Pearce & Ensley (2004) suggested that shared vision of what the future innovation looks like by the innovating teams leads to a higher innovation effectiveness, which refers to the speed, magnitude of the innovation, and its productive implementation (Gopalakrishnan, 2000; Pearce & Ensley, 2004). If there is a lack of shared vision of what the product should be, then there would be more issue in deciding what kind of market and customers the product should target, identifying any opportunities or resources needed for developing the product, and in terms of the innovating team, there would be miscommunications and diverse goals of what the product should be like among the team members. All of these issues would have a significant consequence on the timeline of the innovation phase and thus, creating a delay.

However, since we are using renewable energy technologies as our unit of analysis, our initial assumption still holds because RET products are usually developed with already a clear product definition and aim on what it is used for. This is an interesting aspect of RET when compared to other new high-tech products where pivoting and redesign of the purpose of the product are more likely to happen. However, it is important to include shared vision of the product as a factor that might play a role in the innovation phase, especially when it comes to other types of new, high-tech product.

Other than having a shared vision of what the product is, its functionality, and purpose, shared vision within the innovating firm is also an aspect that can influence the innovation phase. *Figure 27* below shows the two types of shared vision, looking at the product and firm perspective. Shared vision within the firm refers to a commitment from the individuals of the firm towards a desired future and a common sense of the organisational purposes (García-Morales, Llorens-Montes, & Verdú-Jover, 2006). The lack of commitment can inhibit with the individuals' capability in order to create innovative solutions collectively as an organisation and to obtain common objectives.

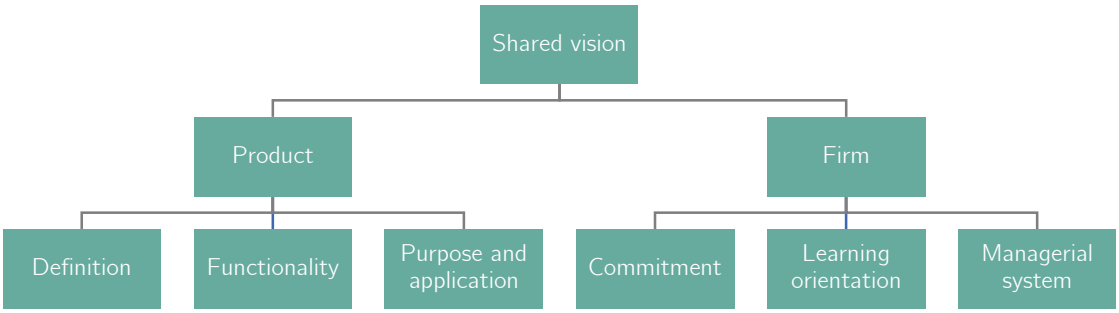


Figure 27 Two types of shared vision

Shared vision is also crucial in terms of organisational learning orientation, which refers to any activities conducted by an organisation to create and use knowledge in order to improve their competitive advantage that is the innovation itself (Calantone, Cavusgil, & Zhao, 2002). Without a shared vision in the learning processes of an organisation, many innovative ideas may fail to be implemented as actions because of diverse interests and different individuals coming from different fields (e.g. engineering, business, marketing) might interpret the knowledge received differently and thus, lack of focus on the integration of their knowledge towards a successful innovation (Eisenhardt, 2018; Calantone, Cavusgil, & Zhao, 2002). In order to have a shared vision within the firm, a managerial system needs to be established which prioritises the growth of organisational culture and any daily operations that stimulate the innovation to develop. This factor has been added in the list of the factors in this research.

Another thing we would like to highlight is the lack of managerial system would result in a competency barrier from the innovating firm. It is important to distinguish this barrier with the others because the nature of this barrier is about the competency of the firm, rather than a barrier that is coming from the resources as the rest are. It still makes sense to classify this barrier in the infrastructure category as the occurrence of this barrier would not directly hamper the development of the product, but rather disabling the means that are required to develop the product. However, it is also important to break down what managerial system clearly entails (e.g. breaking it into separate factors such as culture, values, and many else), how they would affect the development of the product, and what would happen to the innovation phase when they individually become a barrier. This could open up a whole new layer of factors that can influence the innovation phase and thus, should be considered in the future research.

7.2.5 Insights on strategies

As has been pointed out in Section 4.4.3, strategic planning is considered to be a fundamental strategy rather than an alternative to the other strategies. This is because this strategy is meant to manage all aspects of the other strategies so that they are aligned with the long-term goals and perspective which is an important angle to consider by the innovating firms. Therefore, other strategies such as business partnership or educate strategy should not only be implemented by looking at the short-term goals, but also by considering what the long-term goals are for the innovating firm, such as moving towards commercialisation and even large-scale diffusion of the product. It would be also interesting to see if there are other fundamental strategies that can be used to ensure this long-term view of all aspects involved in the development of the product.

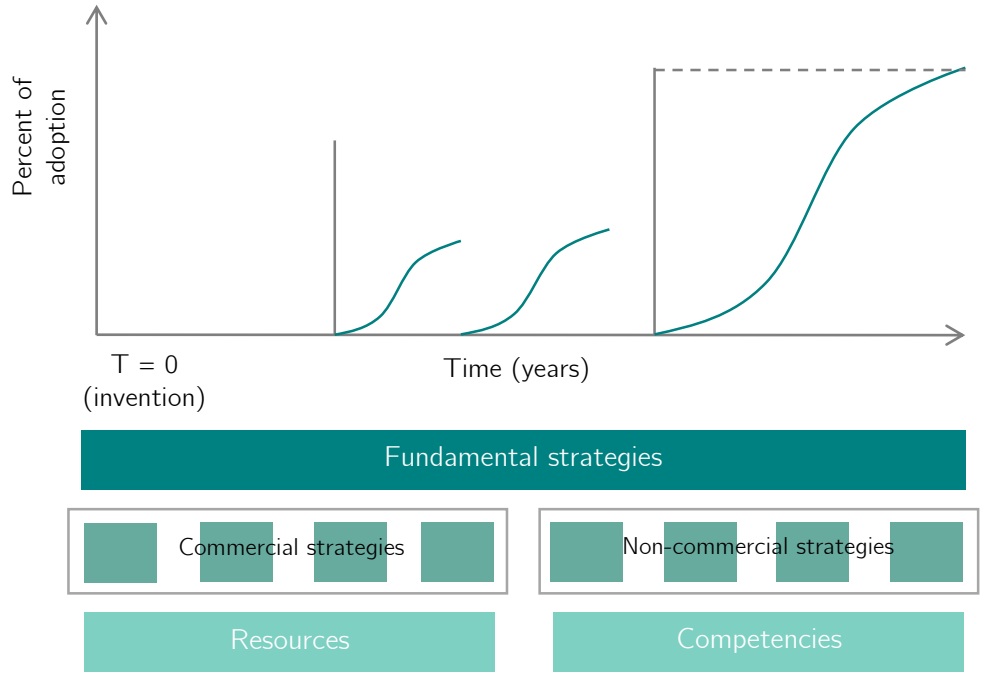


Figure 28 Long-term perspective in strategies, resources, and competencies

Other than the strategies, the resources (e.g. financial, natural, and human resources) and the firm's competencies (e.g. values, culture, and shared vision) should also be regarded not only in the short-term, but also in the long-term perspective. This is because the resources and competences are the main driver of the innovation to develop and diffuse and without managing them in the long-term perspective, there might be an issue with maintaining the firm's innovation as their competitive advantage in the other phases of the diffusion pattern. Again, this relates to making sure that the innovating firm has a strategic planning strategy for the long-term in mind by which these resources and competencies are managed. It is interesting to observe the

separation of fundamental strategies with the other strategies as well as their dynamic with the resources and competencies which is illustrated in *Figure 28* above, where the long-term perspective based on the diffusion pattern can be incorporated into the strategies, resources, and competencies.

For the strategies, it is interesting to see that there is a more complex dynamic between them. The use of one particular strategy can lead to the implementation of another strategy. For example, case 1 implemented the governmental funding strategy by applying to different grants and subsidies to obtain financial resources. Because now there is a favourable condition of the financial resources, the use of this strategy led to the implementation of pilot strategy in which the company demonstrates their technology to the government and potential investors. Another instance is when both cases decided to develop the technology and keep the proprietary knowledge within the company through in-house strategy, but there comes a barrier in obtaining sub-components or other resources needed in developing the innovation. This led to the use of outsourcing strategy by which the companies use the services from other companies to complete the necessary components or resources. This observation shows that there is an iterated process in the way a barrier occurs and strategy is implemented. *Figure 29* below shows how this process is iterated. Deen (2016), for example, analysed how there could be a follow-up barrier that another actor in the value chain experiences due to the implementation of an initial strategy and as a response to the occurrence of this follow-up barrier, a follow-up strategy is used to circumvent or remove it.

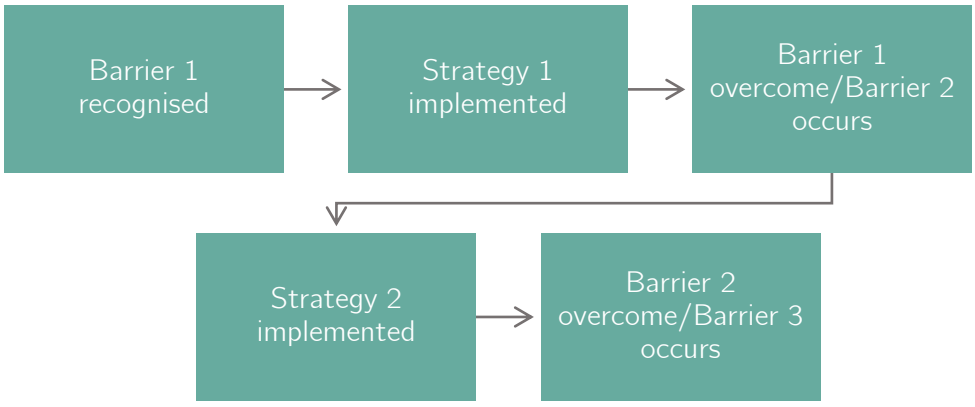


Figure 29 Iterated process of how barrier and strategy can occur

It is interesting to observe the similarity of the mechanism of how the barriers and strategies are formulated with the one observed by Deen (2016). However, in our case, the feedback effect of implementing a strategy is experienced by the innovating firm itself and the response by

implementing a follow-up strategy is also executed by the innovating firm. Deen (2016) also suggested that even though the strategies implemented can cause a follow-up barrier to another actor, it is important to note that maintaining the network should not always be the main objective as new actors entering the network might offer a benefit for the product. Applying a similar concept to our findings, we can also suggest that there is an added value to having these barriers in the innovation phase because as observed, the implementation of a certain strategy to remove or circumvent the barriers can bring in new actors, resources, and opportunities for the product to develop. This insight can lead to a more dynamic relationship between the factors and strategies implemented that can be further considered in the framework and thus, it is important for the innovating firm to consider this insight when managing a barrier and deciding a strategy.

7.2.6 Insights on linkages

In this research, we also have seen the linkages between the barriers and strategies in the innovation phase of the diffusion pattern. From the results of the case studies, it can be observed that the relationship between barrier and strategy is not as straightforward as expected. In an ideal situation, when a factor becomes a barrier and hinders the development of the product in the innovation phase, a particular strategy can be implemented in order to circumvent or remove said barrier. However, findings in this research pointed out that it is not always the case.

When asked about how the strategy was decided, the way company 1 decided which strategy to use is not always dependent on which barrier exist during the development of the product. For example, when a barrier such as specific institutional aspects comes into play and influences the development of the product negatively, then the company recognises that as a barrier and acts on it based on the appropriate strategy (*Figure 30*), such as using lobbying strategy through talking to the local governments and influencing the decision.

Figure 30 First possible mechanism in recognising the barrier and deciding a strategy

However, there are some cases where a window of opportunity comes along first, then implementing a particular strategy based on this opportunity is considered to be advantageous to overcoming a particular barrier. For instance, an opportunity of pilot project comes along with

the collaboration between the company and government. This relates to implementing the pilot strategy then follows with recognising that by implementing this strategy, the barrier of knowledge and awareness of the technology by the potential customers and any sceptical attitude from the socio-cultural aspect can therefore be overcome by demonstrating the potential and benefits of the technology (*Figure 31*).

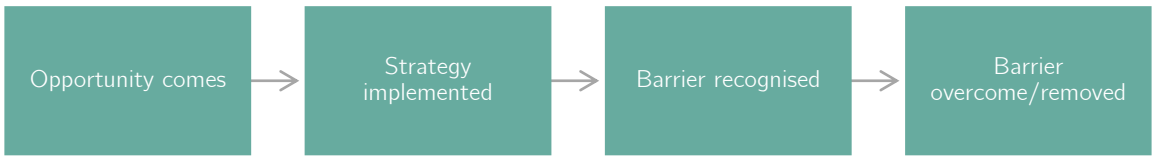


Figure 31 Second possible mechanism in recognising the barrier and deciding a strategy

While company 2 also experienced mechanism 1 as seen in *Figure 30*, this is not always the case because there are also scenarios when the opportunity to implement a strategy presents itself and a barrier is overcome through this. For example, it was mentioned that there was an opportunity of implementing lead user strategy through assigning some early users to try the product. By implementing this strategy, the company circumvented or overcome the barrier of the lack of knowledge and awareness of the market from within the company by gaining insights from the users and partners in collaboration (*Figure 32*). Another possible mechanism is that either a barrier is recognised first or an opportunity presents itself, then resources are considered in order to see if they are adequate for tackling the barrier or taking the opportunity, and after that, the strategy can be implemented which leads to the overcoming or removal of a barrier (*Figure 33*). This mechanism is interesting to observe as not only the window of opportunity is required to open, but also resources need to be considered to be sufficient in order to implement a certain strategy.

Figure 32 Third possible mechanism in recognising the barrier and deciding a strategy

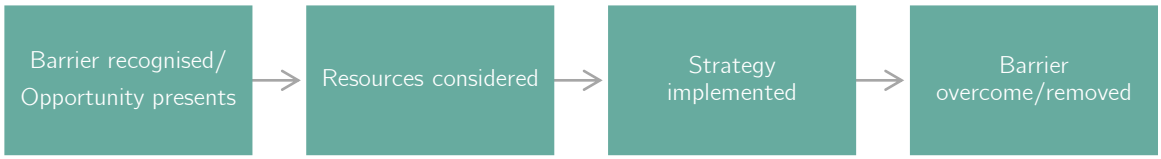


Figure 33 Fourth possible mechanism in recognising the barrier and deciding a strategy

In the cases that have been investigated, it is observed that there are situations when the relationship is inverted, where an opportunity to implement a strategy occurs, then said strategy is implemented which leads to a barrier being recognised and circumvented or removed completely. This is because many of the strategies involved do not only require a decision-making process from the company's side, but also a window of opportunity that allows the actors and issues to come together. Especially in the innovation phase when every aspect needed for the development and diffusion of the product has just started to build up and not many of them are established, the need for this opportunity to open up is higher compared to when the product is in the market adaptation or stabilisation phase. Another thing to note is the consideration of resources that the innovating firms have, whether they are adequate to tackle the barrier or take the opportunity for implementing a strategy. It is important to consider this finding when looking at the linkages between barriers and strategies as it might provide another mechanism on how a certain barrier or strategy can be approached and also change the perspective of the framework.

7.2.7 Reflection and limitations of the research methodology

In this research, we have chosen to conduct the case study by selecting one company per case. Naturally, this leads to a more specific outcome of the case study based on the environment of the chosen companies. For example, if we take one more company for case 1, then we might be able to compare a certain barrier if it occurs in the two companies. We can also see if a certain barrier exists, whether it is specific to one company or general to the case itself. However, by looking at one company per case, we can examine in details the identified barriers and any other aspects related to the development of the product. We can use what these companies experience as an initial framework for more cases in future study.

According to Sekaran & Bougie (2009), generalisability can be defined as the scope of applicability of the research findings in one organisational setting to other settings. In other words, we can look at generalisability as the extension of research findings and conclusion from a study that is conducted to a sample population to the population at large. If the data collected

from past observations is adequate, then a prediction about the outcome in a similar situation can be made. In this research, we have been looking at two cases, both related to RET product in the innovation phase. Granted, considering the small sample number, the generalisability in the outcome of the research is not very extensive. More samples for the case study is needed in order to make a significant generalisability of the situation to a larger population, for example in this case the Netherlands as a country or RET as a sector. This will need to be conducted in further research with less time constraint and other restrictions as the Master's thesis timeline. As the thesis is only looking at the renewable energy technologies industry, there is already a limitation to a generalised result which can be applied to other industries.

However, we can still consider applying the findings into other industries that are somewhat similar, such as the sustainable innovations industry that do not focus on renewable energy but rather on innovations that are created generally for sustainable developments. This can include more technological innovations for case studies, such as sustainable agriculture products, circular economy, green vehicles, waste management, and many else. It would be interesting to extend this research into a broader sense of *"sustainability"*. Another industry that would be interesting to look at and apply this research is other high-tech, emerging technologies in the IT and communications as well as transportation industry. Although the pace of the technology development is considered to be faster compared to that in RET industry, applying the findings of this research to these industries can provide us with an insight of the barriers and strategies for the new emerging technologies that are still in the research and development or early commercialisation phase. Examples of the technologies that are still in said phase are civic technologies (e.g. open data, smart cities), autonomous vehicles, and vactrain.

However, there are several elements in the research that can be transferred and applied into other situations. We can consider that the transferability of this research is a more relevant concept for case study research compared to its generalisability, which refers to the extent to which the results from one research are relevant in other contexts and is a process that is experienced by the readers of the study. If there are an adequate level of similarities between the two situations, then the result of the research can be inferred as the same or similar to the situation of the reader. In this case, we can consider that this research is transferable to firms who are in the innovation phase and at the beginning stage of developing their product. They might observe some similarities to the findings in this research, especially regarding identifying barriers that are experienced and strategies that can be implemented which thus, leads to applying the results to their situation.

For example, innovating firms who just created a new invention and are starting to enter the innovation phase can then see what factors that influence this phase and in what way they will become a barrier, such as already understanding that there can be a lack of knowledge & awareness of the technology coming from either the firm's or society's side. As there is also a lot of freedom with the strategies, they can implement it accordingly to the barriers they are experiencing and the resources they have. Since the goals of these strategies are also tackling many aspects in the development of the product that are lacking, innovating firms can implement the strategies based on their specific goals. Through this research, firms can also be more mindful about what elements in the innovation phase that should be considered and thus, the phase can progress more smoothly. It is also important to note that there is still not an extensive enough number of studies that covers the knowledge gap that is identified in this research. Therefore, we would like to provide an initial framework and findings for any future research related to this topic. Future research on this topic will be elaborated further in Section 7.4.

7.3 Recommendations

In this section, we would like to provide recommendation from a managerial and practical perspective for companies currently or wishing to participate in the innovation phase of developing a product, especially with RET-related innovations. Note that any recommendation from an academic perspective will be discussed in Section 7.4. If a company wishes to start developing a new product, then the following points should be noted:

1. There are prominent barriers that can occur during this innovation phase from the product perspective, such as the lack of product performance & quality, lack of knowledge & awareness of the technology from either the company's side or society/customer's side, unaffordable product price, and the lack of knowledge & awareness of the market.
2. From an infrastructure point of view, there are barriers that can also hinder the development of the product, such as the lack of financial resources from investors, the lack of coordination with the business network, the lack of coordination with the human resources/labour, hindering specific institutional aspects, the lack of acceptance or high expectation from the society, unfavourable macro-economic condition, and the lack managerial system.
3. It is important to note that there are commercial and non-commercial strategies that can be implemented along the diffusion pattern. However, in the innovation phase, since the product has not entered the market yet, non-commercial strategies should be the focus of implementation while keeping in mind that there are several strategies that are commercial by nature but can also be used in this phase for non-commercial purposes.
4. In order to overcome or circumvent a particular barrier, there are several strategies that can be used, either independently or in combination, such as in-house, outsourcing, governmental funding, business partnership, lobbying, strategic planning, pilot, and educate strategy. There are other strategies that can be implemented based on the case study results, such as lead user, redesign, conventional, and alternative financing strategy. However, it is important to analyse whether those strategies are applicable or not in other situations.
5. In order to decide the strategy, there are certain mechanisms that can be followed. Ideally, recognising the barrier first and choosing a particular strategy accordingly would be the preferred option as said barrier then can be specifically tackled. However, this is

not always the case and innovating firms should be aware of any *"window of opportunity"* that opens up to use a strategy and manage a barrier.

6. There are some actionable points that should be noted regarding the strategies that can be used in this phase which are as follows:
    a. The first step is to always seek funding from any platforms that are offered by the governmental bodies. This can include awards, grants, subsidies, joining their innovative programmes, and many else. The governmental bodies are more likely to provide an initial capital to innovating firms as technological innovation (especially in RET) is one of the main focus of the government. In the innovation phase, conventional investors are also less likely to provide capital and thus, it is imperative to seek for other alternatives.
    b. The use of one strategy can open up an opportunity to implement another. For example, the use of governmental funding can lead to a collaboration with them and a demonstration of the technology can be made possible through implementing a pilot strategy that involves the government. The use of outsourcing strategy can also lead to business partnership strategy and more collaboration with other actors in the network.
    c. Lobbying strategy can not only be implemented towards influencing the decisions made by the regulatory agencies, but also to the business network. This is because different actors that are involved in the product development have different interests and agendas and thus, it is sometimes necessary for the innovating firm to frame themselves and behave strategically according to their main objective, which is to complete the innovation.
    d. Strategic planning is very crucial in innovating firms as it provides a foundation for the firm and its individuals to operate as well as manages resources based on a long-term goal. In this phase, the most important goal is to enter the market and start commercialising the product. Therefore, any decisions and measures made for this strategy should keep that particular objective in mind. Another thing to add is that firms have different ways to implement this strategy and create their own identity through their culture, climate, dynamics, and values. This is an important point as an innovating firm should set themselves apart and make a *"brand"* for themselves.

e. It is important to not only increase awareness about the benefits of the technology but also to give more visibility for the innovating firm. Educate strategy should be used from the beginning of this phase in order to reach these objectives. With this strategy, the advantage is that there is a lot of freedom to what a firm can do in implementing this strategy. There are many opportunities to collaborate with different actors, such as local businesses, artists, and many else. The most important thing is to be aware of any opportunity that opens up and decide strategically which measures to take.

Once the innovating firms can recognise the barriers that hamper the development of their product in the innovation phase, take advantage of window of opportunities that opens up, and implement a particular strategy with an actionable set of measures, the innovating firm will be able to bring the development of the technology into completion with sufficient aspects, in terms of the product, and build up the system needed around it for the next market adaptation phase. And thus, the product can enter the market more smoothly and start commercialisation.

7.4 Future research

In this section, we would like to provide recommendation from an academic perspective for any future research regarding this topic. Future research regarding the barriers and strategies of a new, high-tech product during the innovation phase should include more companies and more cases of different RET innovations. By interviewing more companies, we can have more generalisability in each of the case and improve consistencies of the barriers and strategies that are identified, while having different RET innovations can provide us with an insight of the differences of the barriers and strategies in different types of RET and thus, we can have a comparison study about whether the barriers play the same role or not and the strategies are implemented in a distinctive way. As discussed in Section 7.2.7, it would also be interesting to conduct case studies on other sustainable innovations in a broader sense, not only clean energy, but also innovations related to sustainable agriculture, waste management, sustainable transportations, and materials. Since there are also many companies in the innovation phase in the Netherlands that are working on this type of technology, this study would open up more room for analysing variations in the barriers and strategies and generalising the results better.

Further study towards the linkages between the barriers and strategies should also be explored as it can give us more understanding towards how a barrier can be dealt progressively in a step-

by-step manner. This could provide the management with a more concrete guideline on how to decide which strategy to use from the occurrence of a barrier. Using the two-layer factors as proposed by Ortt & Kamp (2018) would also be helpful in order to investigate further the initial cause of a certain barrier, as we can see the influencing factors of a certain core factor. This is also important in terms of looking at the linkages between barriers and strategies. Another thing that can give us more insight regarding this point is to analyse the decision-making process of innovating firms in the innovation phase when they decide which strategy to use in order to tackle a certain barrier. As has been discussed in Section 7.2.6, there can be multiple mechanisms through which a company decides a strategy. By looking more in-depth into the decision-making process, we can understand the underlying motives and steps that innovating firms take in order to remove or circumvent a barrier. Through this study, we can also investigate if there are better ways to involve other stakeholders into the development of the product, such as the government, public, and other innovating firms.

As has been mentioned in Section 7.2.1, it is important to consider both the long-term perspective when it comes to aligning all aspects and a broader view when formulating the surrounding system around the product. It is interesting to look at this topic further in terms of how an innovating firm can use these two views to their advantage for bringing the product into the market. For example, we can analyse how to incorporate the long-term view into enabling the broader system around the product, so that not only the innovation phase is managed but also the two other phases will take place more smoothly. And combining our insight from Section 7.2.5 on the layers of strategies and factors, we can study further the dynamic between these aspects. For example, does having a fundamental strategy in place affect how the commercial (or non-commercial) strategies are used? Is there also a more direct relationship between the fundamental strategies with the factors involved? How do we make sure that these layers are aligned with the long-term goals, but also the broader view of formulating the system? Research questions such as these should be explored.

As we have identified the barriers that can occur in the innovation phase, it would also be interesting to look at the influence that these barriers have on the innovation phase, or in the development of the product specifically. As has been discussed in Section 7.2.2, these barriers can push the time frame of the innovation phase or cause the processes within the phase to be more chaotic. Using a quantitative method, such as through hypothesis testing and conducting surveys of a large sample, we can then investigate the causal relationship between the factor and the development of the product (e.g. a variable that can be used is whether a product is successful

or not). Another point to mention is that the main objective in the innovation phase is to enter the market and start commercialising the product. However, we need to explore if that is, in fact, the only main goal of this phase or whether there is more to it. For example, in the market adaptation phase, niches that are formed sometimes fail and do not diffuse further into a large-scale diffusion. This event could also happen when moving from the innovation to the market adaptation phase. Therefore, we also need to define what counts as a *"success"* in the innovation phase and in the market introduction.

It would also be interesting to explore the perspective of the governmental bodies or policy makers regarding the barriers and strategies in the innovation phase, as they have a vital role in the innovation phase according to this research. As innovation, especially in RET, is an important agenda for the government, we can analyse what barriers they are facing in terms of pushing the development of innovative products, the strategies that they are using, and their perspectives on what the innovating firms are experiencing in this case. Through this study, we could attempt to align the interests, agendas, and strategies between the innovating firms and government towards working a common goal.

The last thing to mention in the future research is to see the different barriers and strategies that exist throughout the three phases of the diffusion pattern. The initial objective of this research was to identify the barriers and strategies in the three phases of the diffusion pattern by looking at several cases that are already in the market stabilisation phase as it was expected to give insights on the three respective phases longitudinally. However, due to the time constraint and other restriction from the unavailability of companies willing to participate, the objective is shifted to only the innovation phase. With conducting this as a future research, we can see how the dynamic of the barriers and strategies change overtime, according to each phase. Another insight that this study can provide is to build up a comprehensive guideline on how to progress from one phase to another, as well as to maintain the innovating firm's position in each phase.

For this point, we have before proposed a conceptual framework that was built up for the initial objective which is elaborated in *Appendix V* and *VI*. *Figure 34* below summarises how the conceptual framework was developed for the other two phases. Generally, the method to decide which factors and strategies that can exist in the other two phases is the same as the way we conceptualised those in the innovation phase. Each factor and strategy that is proposed in each phase will be argued based on what has been found on the literature as well as logical reasoning.

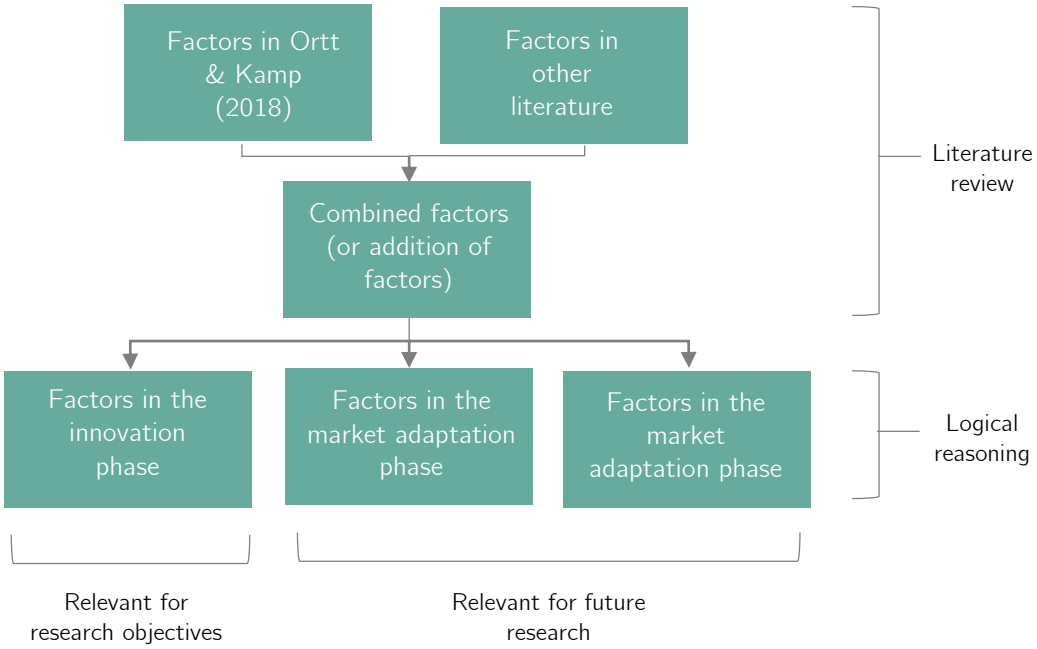


Figure 34 Method for conceptual framework of other two phases

After that, case studies need to be conducted in order to see which of our factors and strategies are found in real-life cases and adjust the framework accordingly. For choosing the case studies, we can opt for either a cross-sectional or longitudinal study. In cross-sectional study, we can choose cases that are already in the market stabilisation phase, look backwards through each phases, and gather the date only over a short period of time. The shortcoming of this method is that it would be difficult to gain an accurate insight of the two phases before, which are the market adaptation and innovation phase. While longitudinal study can provide us with a more accurate insight, it will take a long period of time to observe the phenomena of dynamic changes over each phase. Thus, it is important to design the research strategically by considering these points.

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I: Additional remarks on contacted firms

Table 19 Initial list of the firms to be interviewed

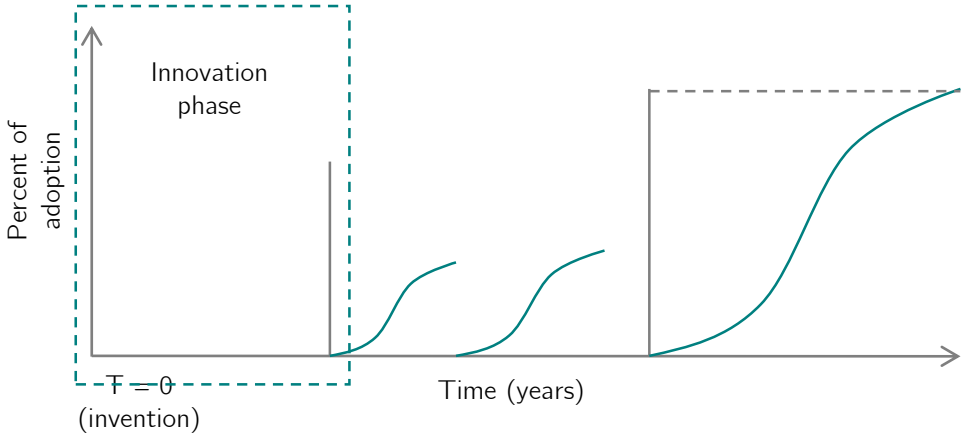
No.	Firm name	Location	Product name
1	Physee	Delft, NL	PowerWindow
2	Kitepower	Delft, NL	Kitepower system
3	Bluerise	Delft, NL	B-TEC ocean thermal technology
4	Wind Energy Solutions	Spanbroek, NL	WES wind turbines
5	Tocardo Tidal Power	Den Oever, NL	Tocardo tidal turbine

The initial objective of this research was to identify the barriers and strategies in the three phases of the diffusion pattern by looking at several cases that are already in the market stabilisation phase as it was expected to give insights on the three respective phases longitudinally. *Table 19* above shows the list of the firms to be interviewed for the aforementioned objective. However, after contacting all of the companies listed, only the first two are responsive and willing to collaborate and after the interview, it was found their innovations are still in the innovation phase.

Due to this situation and the time constraint in which this research is being conducted, the aim of the research is now shifted into looking more specifically at the barriers and strategies in the innovation phase. However, the initial conceptual framework development that was built up for the initial objective will still be elaborated in *Appendix V* and *VI*, in order to help any future research regarding said initial objective. A future research regarding this objective is relevant as it will distinguish the different barriers and strategies based on their respective phase (i.e. market adaptation and market stabilisation phase) and provide a guideline for firms in one phase with new high-tech products to implement a particular strategy based on the barrier that exists as well as progressing into the next phase. Therefore, the current objective and any findings that

will be obtained from this research, which is to look at the innovation phase, will contribute to this line of research in the future.

II: Exhibit 1 - Possible barriers



Product	Infrastructure
• Lack of product performance & quality • Lack of production system • Lack of knowledge & awareness of technology • Lack of knowledge & awareness of market • Lack of natural resources	• Lack of financial resources • Lack of business network • Hindering specific institutional aspects • Lack of human resources/labour • Lack of managerial system

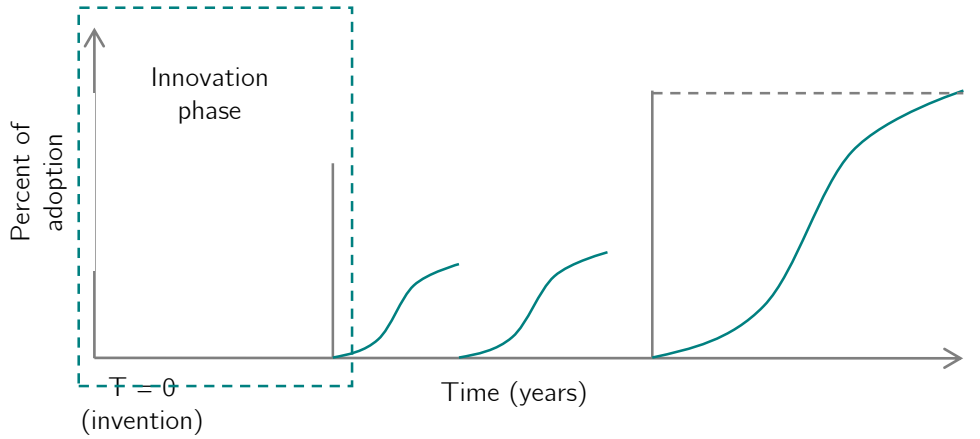
Figure 35 Exhibit 1 – Possible barriers in the innovation phase

The definition of these barriers are as follows:

- Lack of product performance & quality: There is a lack of sufficient performance and quality in any aspects of the product, such as its components and subsystems.
- Lack of production system: There is a lack of functionality and sufficiency of the system required in order to manufacture the product.
- Lack of knowledge & awareness of the technology: There is a lack of fundamental and applied knowledge necessary to develop the new product by innovating firm,
- Lack of knowledge and awareness of market: There is a lack of knowledge about the potential applications of the product and the market by the innovating firm.

- Lack of natural resources: There is an unavailability of any materials or substances that are required to develop the new product.
- Lack of financial resources: There is a difficulty in accessing any forms of financial resources from platforms (e.g. crowdfunding, capital) and organisations (banks, investors) to provide finance for development, diffusion, adoption, and maintenance of the product.
- Lack of business network: There is a lack of any actors involved in any of the value chain of development and diffusion of the new product.
- Hindering specific institutional aspects: Laws and regulations that deal specifically with the field of the new high-tech product and its socio-technical system still hinder the new product to develop.
- Lack of human resources/labour: There is a lack of any skilled human resources or labour that are involved in the development and diffusion of the new product.
- Lack of managerial system: There is a lack of any measures, processes, management structures or organisational culture that companies use to direct actions and activities toward company goals.

III: Exhibit 2 - Possible strategies



Commercial	Non-commercial
Not applicable	• In-house • Outsourcing • Lead user • Conventional financing • Alternative financing • Governmental funding • Business partnership • Lobbying • Strategic planning

Figure 36 Exhibit 2 - Possible strategies in the innovation phase

The definition of these strategies are as follows:

- In-house: This strategy can be used through developing the technology and product within the firm by using and managing its own resources
- Outsourcing: This strategy can be used through bringing in the technology, system, knowledge, or resources from external sources
- Lead user: This strategy can be used by bringing in early users to use the new product, gain their feedback, identify key customers, and establish customers network
- Conventional financing: This strategy can be used by obtaining funding through conventional methods such as bank loans, angel investors ,and venture capitalists

- Alternative financing: This strategy can be used by obtaining financial resources from alternative sources such as crowdfunding, awards/competitions, and bootstrapping
- Governmental funding: This strategy can be used by acquiring funding from any governmental agencies or non-profit organisations, such as grants, loan programs, and subsidies
- Business partnership: This strategy can be used to establish partnership with other firms or actors in the value chain for the development and diffusion of the product
- Lobbying: This strategy can be used by influencing the decisions by the government and collaborating with them
- Strategic planning: This strategy can be used by establishing processes and practices for the employees to fulfil strategic objectives of the firm in the long-term

IV: Interview questions

In this section, the interview questions that were asked to the interviewees will be outlined based on the interview process as follows:

- Stage 1: Personal, company, and product information
  1. What is your name and how long have you worked for the company?
  2. What are the vision and mission of the company?
  3. How is the current situation of your company in the relevant market?
  4. Tell me more about the main product/innovation from your company.
  5. How is the current situation of your product in the relevant market?

- Stage 2: SQ4 (What are the barriers faced by firms in the Netherlands in the field of renewable energy technologies during the innovation phase based on the case studies?)
  6. What factors do you think most likely to be a barrier that your company has faced when your product was first developed as a new innovation?
  7. Based on the factors listed in Exhibit 1, do you recognise any of these factors as barriers faced by your company when your product was first developed as a new innovation?
  8. How do you think these barriers influence the development of your product?

- Stage 2: SQ5 (What are the current strategies used by the firm to overcome these barriers based on the case studies?)
  9. What strategies did your company implement when your product was first developed as a new innovation?
  10. Based on the strategies listed in Exhibit 2, do you recognise any of these strategies as strategies implemented by your company when your product was first developed as a new innovation?
  11. What is the goal of each strategy you have identified?
  12. How do you think these strategies have influenced the development of your product?

- Stage 3: Discussion about other information/insight

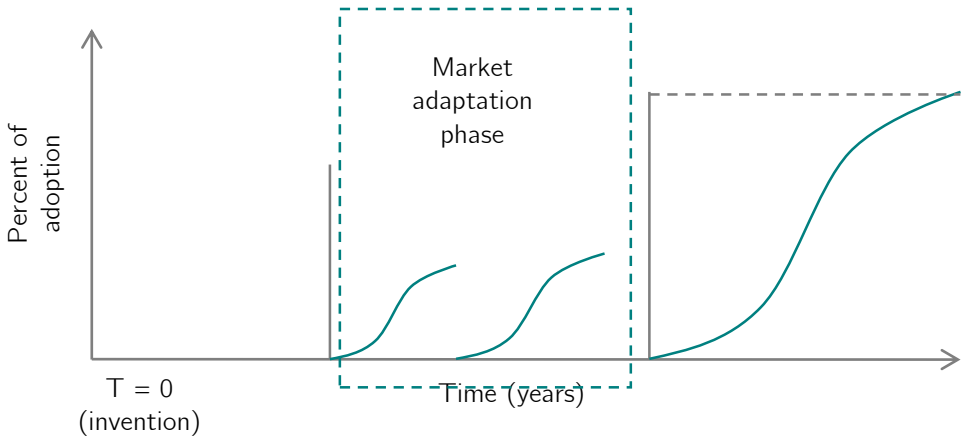
  13. How do you decide which strategy to implement in the development of your product?

  The discussion about the linkages between the barriers and strategies in the innovation phase will be conducted.

- Stage 4: Follow-up

  The interview data will be sent to the interviewees and feedback or additional information will be asked.

V: Possible framework for the market adaptation phase



Product	Infrastructure
• Lack of product performance & quality • Unaffordable product price • Lack of production system • Lack of knowledge & awareness of technology • Lack of knowledge & awareness of market • Lack of natural resources	• Lack of financial resources • Lack of complementary products & services • Lack of customers • Lack of business network • Hindering specific institutional aspects • Unideal condition of competition • Unfavourable macro-economics • Unfavourable socio-cultural aspects • Presence of accidents or events

Figure 37 Possible categorisation of factors in the market adaptation phase

Figure 37 above shows the categorisation of factors in the market adaptation phase. In the market adaptation phase, the product is first introduced to the market, resulting in early niches in the beginning and ending with a large-scale diffusion. In this phase, many factors come into play that affect the development and diffusion of the product to be successful, as the product is

being constantly improved and the infrastructure to do that is expanding. We see a couple of differences in both of the categories. Naturally, the other factors from the innovation phase are still relevant to consider in the market adaptation phase. The difference is that in this phase, these factors play a different role compared to the innovation phase as the product has been introduced to the market and adapted by customers.

We also see additions in the infrastructure category, such as complementary products and services, customers, competition, macro-economics, socio-cultural aspects, and accidents or events. As the product is gradually introduced into the market, products and services to complement the use of the main product are increasingly needed and without options for complementary, customers will be less likely to purchase the product. If there is also lack of customers or their acceptance of the product in this phase, it is more difficult to sell the product. Naturally, the diffusion of the product will be inhibited. On the contrary, if there is a lack of competition in the market, then market expansion of the product will be more likely to occur. A favourable condition of macro-economics, socio-cultural aspects, specific institutional aspects, and accidents or events is also required in this phase as they act as a landscape for the product to succeed. These factors can put a pressure to the existing regime, destabilises it, and create a window of opportunity for the new product to come in (Schot & Geels, 2008).

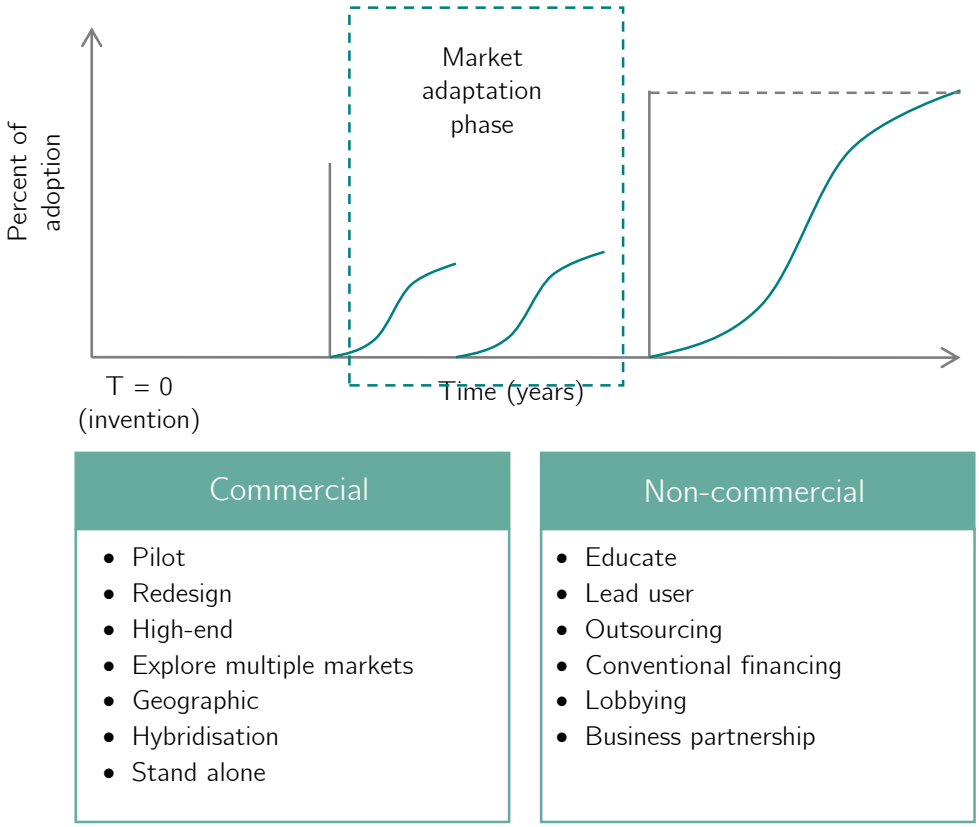


Figure 38 Possible categorisation of strategies in the market adaptation phase

Figure 38 above shows the categorisation of strategies in the market adaptation phase based on its commercial function. Note that commercial strategies are now applicable in this phase because the product has now been introduced into the market and thus, commercial activities that can generate financial gain are possible. In the market adaptation phase, the strategies implemented should focus on both commercial and non-commercial activities because this phase is all about trying to sell the product and at the same time establishing the infrastructure needed for large-scale diffusion.

Looking at the factors identified previously, we can see that product performance & quality as well as its price can act as a barrier. The strategies used in both to improve product performance/quality and price include pilot and redesign, as price and quality usually go hand-in-hand. Since the price of the new product is still not affordable and quality is low, pilot strategy can be used to demonstrate the product in a controlled way. Other than giving an opportunity for product improvements which may lead to price reduction and higher quality, it also increases awareness for the customers that the product is worth the price. This strategy could also improve the knowledge and awareness of technology and market at the same time. Redesign strategy is used by adopting the product to a simpler version that may result in a lower price and a better

quality for the new function of the product. Another strategy used in pricing is high-end strategy which can be used by attracting the top end of the market and thus, high price will not be an issue.

Strategies such as explore multiple markets and geographic can be implemented in this phase as the product has been introduced to the market, there might be an unfavourable condition of competitions, macro-economics, socio-cultural aspects, and any unexpected events in the current market or location in which the product is introduced. These two strategies can circumvent that situation and offer a new niche. When production system is not fully functional and complementary products or services are not sufficient in this phase, hybridisation strategy can be implemented as it attempts to circumvent the lack of production system and complementary products by using the product together with an old technology or using a modified existing infrastructure. Stand-alone strategy can also be used through using the product on its own or having an infrastructure specifically designed for it.

Non-commercial strategies such as outsourcing and business partnership strategy can be implemented as well to remove barrier in production system and natural resources as it aims to manufacture the product and exploiting external source to complete it. The latter strategy could also reduce the chance of competition inhibiting the product to flourish in this phase and build up business network that is necessary for the diffusion of the product. Educate strategy is also relevant in this phase as the product is commercialised, in order to advertise the product, will be required and potential customers need to be educated about the importance of the product. Similar to the innovation phase, lead user strategy can be used to improve the knowledge of technology and market as firms can gain more knowledge about the technology and gain more of an insider view from the customers' side about the product and the market.

Socio-cultural aspects might be unfavourable which would lead to more difficulty in commercialising the product and thus, educate strategy where any actions that can increase awareness of the society about the product and its benefits to attract new customers are implemented. Lobbying strategy is naturally important in this phase, because there might be any institutional or socio-cultural aspects that inhibit the diffusion of the product and thus, this strategy is used by influencing the decisions by the government and collaborating with them. Conventional financing will be needed significantly in this phase because now products are being manufactured and financial resources are crucial to have. Note that in this phase, alternative financing and governmental funding are not as relevant as they are in the innovation phase and

this is because the product is ready to be commercialised and thus, it is not technically a new innovation anymore that governmental grants or crowdfunding would not be likely to invest as much.

VI: Possible framework for the market stabilisation phase

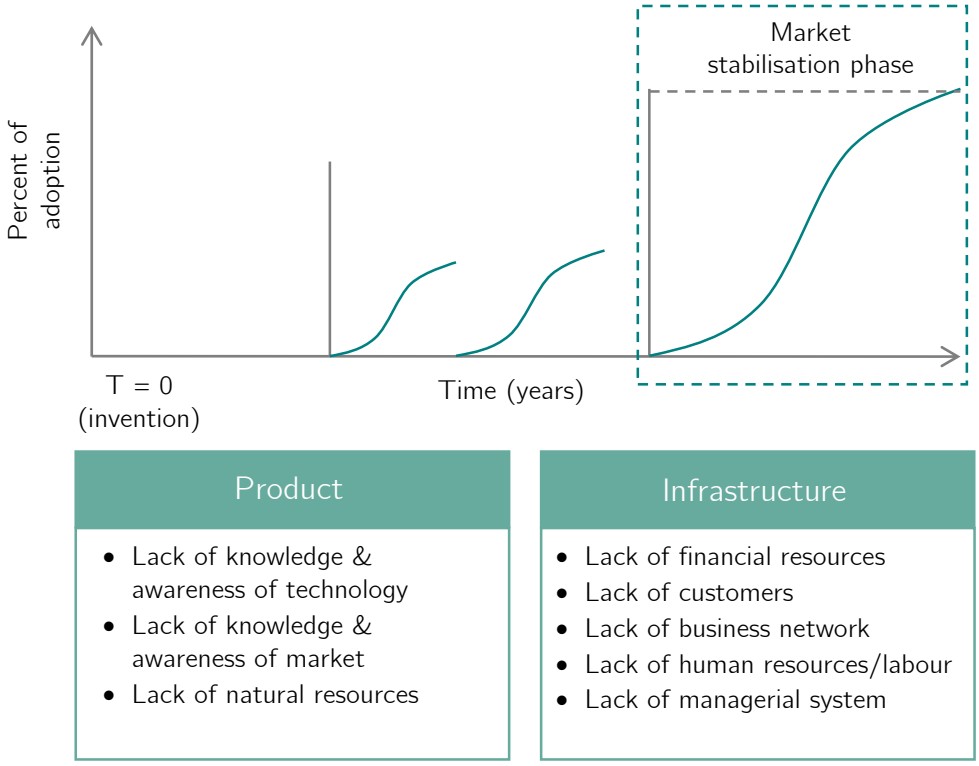


Figure 39 Possible categorisation of barriers in the market stabilisation phase

Figure 39 above shows the categorisation of factors in the market stabilisation phase. In the market stabilisation phase, the large-scale diffusion of the product takes off, following an S-shape growth curve, and substitution of the old product occurs. In this phase, most of the aspects required for the diffusion of the product to take off, such as the production system, are already established. Unlike the innovation phase where the development of new, radical innovation is crucial, incremental innovation plays a more important role in this phase (Anderson & Tushman, 1990). Changes are made and implemented to the product in order to improve the product. In this case, learning is required for incremental innovation as it enhances the firm's existing knowledge that is needed to improve the product (Benner & Tushman, 2002). Sheng & Chien

(2016) argued that learning has a more prominent effect on incremental innovation as it refines the existing knowledge. The refinement of the existing knowledge can be related to the knowledge and awareness of the technology and market. Improving the knowledge of technology would enhance the product. Improving the knowledge of market also allows the firm to improve the product by reacting to the needs of the market (Lin, McDonough, Lin, & Lin, 2013). And of course, the existence of relevant and sufficient natural resources is consistently needed throughout the diffusion pattern.

Again, In this phase, it can be considered that most of the required infrastructure are already established because the large-scale diffusion is already possible to take off. However, it is important to note that in order for the product to reach its optimal percentage of adoption (depicted as the stagnant line of the S-curve) and carry out any activities related to incremental innovation, some of the factors in the infrastructure need to be present consistently. These factors include financial resources, business network, customers, specific institutional aspects, and human resources/labour to conduct any commercialisation activity, as well as having an established managerial system to manage these resources. If there is a lack of any of the factors and capability in managing these resources, then it will be more likely for the product to fail diffusing further and the firm cannot sustain the growth in a long-term.

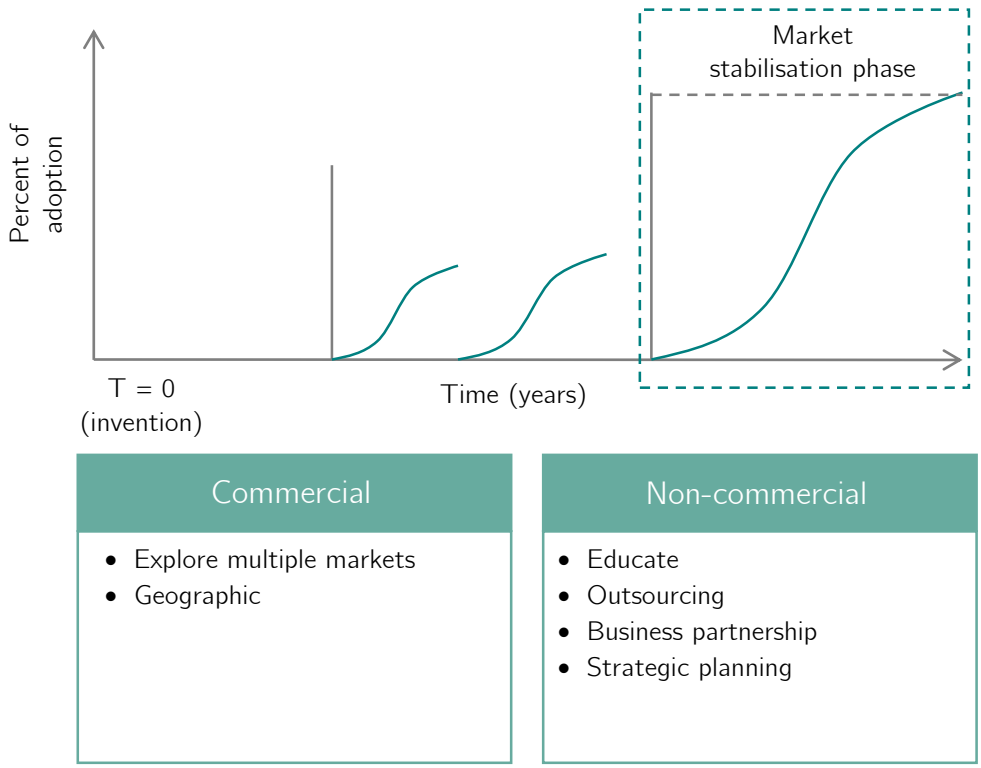


Figure 40 Possible categorisation of strategies in the market stabilisation phase

Figure 40 above shows the categorisation of strategies in the market stabilisation phase based on its commercial function. In the market adaptation phase, the strategies implemented should focus on both commercial and non-commercial activities because similarly to the market adaptation phase, this phase is all about trying to sell the product and at the same time maintaining the infrastructure for the large-scale diffusion that is taking off.

Looking from a commercial point of view, explore multiple markets can be used by commercialising the product in other market segments. In this phase, the lack of knowledge & awareness of the market and customers can reveal and inhibit the large-scale diffusion. This strategy can circumvent those barriers by looking for potentials of commercialisation in other markets in which there is more intelligence can be found about the market or customers are abundant. Geographic strategy follows the same logic as it can circumvent these barriers by diversifying geographical locations for product commercialisation. In this phase, learning is important for the firm to stay competitive and improve the new product and thus, outsourcing strategy can be used to obtain the required knowledge. Similar to the strategies in the innovation phase, the strategy is implemented to learn the knowledge from an external source or partners

that the firm itself cannot internally produce. However, learning in this phase aims to build the incremental innovation on the product rather than radical innovation.

Another important aspect in this phase is to maintain the relationships with business network to improve any aspect in the value chain and with customers to obtain their feedback regarding the product. This can be done through business partnership strategy by maintaining the relationship and commitment with the business network. As for the customers, educate strategy can be implemented to create a long-term and loyal customer, and thus, the product can be improved. In this phase, this strategy is not only about increasing awareness to the customer about the benefits of the product, but rather to also gain their feedback. Strategic planning strategy can be used in this phase to manage human resources and improve managerial system to oversee all aspects of the diffusion of the product. This can include allocation of resources (be it natural or financial) and asset protection, human resources management to maintain and improve the firm's individuals' skills and personal development, and any day-to-day operation. This is crucial in this phase in order to be able to manage the firm's resources so that the business can be as sustainable as possible and ensure competitive advantage for the firm.