Niche strategy selection for kite-based Airborne Wind Energy technologies
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Niche strategy selection
For kite-based Airborne Wind Energy technologies

By
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in partial fulfilment of the requirements for the degree of

Master of Science
in Sustainable Energy Technology

at the Delft University of Technology,
to be defended publicly on Monday December 15, 2014 at 10:30.

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An electronic version of this thesis is available at http://repository.tudelft.nl/.
Foreword

I would like to express my gratitude to following people for their input and support, without which this thesis would not have been possible:

J.R. Ortt and L.M. Kamp for giving me the opportunity to undertake this ambitious thesis, despite that I am new to the social sciences as an engineer, and showing patience and guidance as supervisors while I learnt and improved a lot during this thesis.

The members of Kitepower group at the Delft University of Technology, particularly Dr.-Ing. R. Schmehl, for inspiring me to do this thesis (as case). And along with other leading figures in the kite-based AWE world, for making time and effort for the interviews conducted in the thesis.

I would like to thank my father for his relentless support and love during this thesis, and of course before it as well as. Without which this thesis would have not been completed, and is dedicated to my late mother.

And thanks to the many dear and special friends I have, for their support and/or distraction during this thesis, especially the many and much needed coffee/lunch breaks.

Matthew F.A. Doe

Delft University of Technology
December 2014
Executive Summary

Half a century ago the development of sustainable energy technologies started in response to environmental, political and resources crises. These crises still exist today, with increasing impacts on humanity and the planet, but the adoption of sustainable energy technologies on a significant scale is yet to occur.

Despite the best efforts of engineers, researchers and innovators to propel the development of sustainable energy technologies towards reliable and competitive market products, they still stumble upon many barriers to develop and launch their sustainable innovations onto the market. As is the case with the Airborne Wind Energy (AWE), its development knows several challenges, despite its strong potential for cheap electricity generation by tapping into more powerful and stable winds using light airborne systems. In response to this gap between technological development and market adoption, a branch of the scientific community has devoted itself to better understand the barriers and adoption process of sustainable innovations. But even with this joint effort of technological development and scientific research into innovation adoption, an entrepreneurial managerial perspective to guide the accelerated transition to a renewable energy powered society is still to be developed.

It is with this in mind that the thesis sets out to develop and provide guidance for innovative and entrepreneurial organisations, bringing sustainable innovations to market. It uses the transition theory of Strategic Niche Management (SNM), which states that (mass) market adoption can be achieved by experimentally developing the technology and market together in protected (market) spaces. In these protected spaces or niches, several experiments are setup, executed and analysed to learn and develop the innovation together with its application (markets), progressively maturing the innovation for the competitive mass market. The niches do not only shield the innovation against direct competition and fatal criticism, but also provide opportunities to start capitalising on the potential of the innovation. The experimental learning and development processes can be setup in different kinds of niches. For example, combining the innovate technology with existing technology and its infrastructure, or finding isolated or subsidized market applications. But the selection of these protected niches or niche strategies is not described in published literature, despite being historically proven that certain barriers to innovation adoption have been tackled with specific niche strategies. Hence, this thesis develops a niche strategy selection process to guide innovation actors in developing their innovations for market adoption. Focussing on the case of kite-based AWE technologies, the thesis presents most suitable niche strategies for this innovation, by using its barriers as input into the niche strategy selection process.

For the development of the niche strategy selection for kite-based AWE technologies and the corresponding process, the thesis consists of three stages. The three stages of the thesis consecutively build upon the context, research, and validation, to attain the desired end results.
The first stage of the thesis is to define the context of the thesis. It does this by describing and discussing the various options in the fields of transition theories and AWE respectively, before making a selection for SNM and kite-based AWE technologies, as the applied transition theory and case technology of the thesis. With the selected transition theory and case innovation the following stages are defined in their scope and direction, defining the context of the research done in this thesis.

The second stage is the research done into barriers, niche strategies, and the links or relations between them. The three components of barriers, niche strategies, and links, form the input, output, and algorithm of the niche strategy selection process respectively, and are based upon findings from published literature. For both the barriers and niche strategies, first the general framework or overview is determined and presented, before applying it to the case innovation of AWE technologies.

Stage 2 consists of a dedicated chapter for barriers, and a chapter for niche strategies and their links to barriers. The barrier chapter introduces the earlier reviewed barrier framework and definition, before extracting barriers to market adoption from published literature, categorizing and ranking the extracted barriers using the barrier framework. This results in a barrier ranking of the most influential barriers to market adoption in the case of AWE technologies. The chapter on niche strategies conducts a review of published literature on identified distinct niche strategies, adopting a list of ten niche strategies presented by Ortt et al. (2013). The chapter continues in a following section with the identification of the links between barriers and niche strategies. Partially building on the presented findings of Ortt et al. (2013), and partially by proposing links based on case examples, for the links missing for certain barriers, a complete matrix of links is presented. The resulting matrix of links between barriers and niche strategies allows its application to the innovation case, determining the most suitable niche strategies for AWE technologies based on its barrier ranking. The collective results from published literature forms; the general niche strategy selection process, as well as presenting the barrier ranking and niche strategy selection for AWE technologies, to be discussed and validated in stage 3.

The third stage is the validation of the literature-based findings and the developed selection process of stage 2, by presenting it to experts and interviewing them for their perspectives. By choosing to use individual structured interviews, the independent views and perspectives of the experts in kite-based AWE technologies are obtained. This allows for the interview results to strengthen the niche strategy selection process and its results for AWE technologies, and determine the consistency amongst experts. The structured results of the individual interviews are predominately used to validate the findings and selection process from the previous stage. The validation is done by comparing the original unaltered perspectives of experts, to those after presenting the findings and the selection process, as well as comparing them to interactive and further processed results. This determines whether the results of stage 2 are consistent with the perspectives of the interviewed experts, regarding effectiveness and coverage, validating the niche strategy selection and selection process for kite-based AWE technologies.
Through the three stages of research done in the thesis, the following results have come forward for the case of kite-based AWE technologies.

The barrier framework introduced in stage 2 differs from others applied to SNM and requires some explanation. It consists of two lists of factors describing the potential ‘indirect causes’ and ‘direct impacts’ of barriers, which combine to form a barrier-set that describe the barrier by its cause and impact on an innovation organization. The barrier-sets are ranked to form a barrier-ranking of influence. The original literature-based ranking of barriers of AWE technologies is altered in response to experts’ on average higher ranking of institutional barriers. Hence the barrier-set of ‘Knowledge of Technology – Institutional aspects’ has moved from 5th to 4th position. The resulting barrier ranking is representative of the general market situation of kite-based AWE technologies, although it will differ per organization due to differing stages of development and perspectives. The barrier ranking does provide an overview of the barriers to market adoption, facing kite-based AWE technologies in general, and can be used to collectively tackle certain barriers by the respective actors of the industry.

1. **Knowledge of Technology** – **Support & Investment**
   *Lack of proof of concept and performance of the technology inhibit investment and support for further development of kite-based AWE.*

2. **Vision & Image** – **Support & Investment**
   *Uncertainty regarding reliability, operation and safety of kite-based AWE amongst the general public and investors.*

3. **Macro-economic aspects** – **Customers**
   *Competition of other (renewable) energy systems inhibits market access for kite-based AWE customers.*

4. **Knowledge of Technology** – **Institutional aspects**
   *Lack of knowledge and experience inhibits access and regulation of airspace for kite-based AWE systems.*

5. **Knowledge of Technology** – **Customers**
   *Lack of experience and data regarding safety and reliability inhibits customers of kite-based AWE systems.*

6. **Knowledge of Technology** – **Technological development**
   *Technical challenges regarding control systems and materials inhibit a marketable AWE product.*

7. **Macro-economic aspects** – **Support & Investment**
   *Uncertainty about the economic performance of kite-based AWE systems undermines investment and support.*

8. **Knowledge of Technology** – **Product processes**
   *Experience and knowledge of the manufacturing and the supply chain of kite-based AWE systems is minimal.*

With the ranking of the top-8 most influential barriers determined, for the case of kite-based AWE technologies, the niche strategy selection was determined using the selection process. The ‘geographic’ niche strategy is ranked in first place, with the ‘demo, experiment and develop’ and ‘educate’ niche strategies ranked in joint second. The three strategies are also consistently mentioned in the interviews. With ‘top’ and ‘subsidized’ being ranked in fourth and fifth place, forming complementary strategies to the other three, it completes the top-5 of most suited niche strategies for kite-based AWE technologies.
1. Geographic niche strategy
2. Demo, experiment and develop niche strategy
3. Educate niche strategy
4. Top niche strategy
5. Subsidized niche strategy

The selection of niche strategies above can be used as guidance for an organization’s or the sector’s strategy to propel kite-based AWE technologies towards market adoption. Or alternatively organizations can use the niche strategy selection process to guide their strategies, using their own barrier ranking as input and following the main steps shown below, to determine their own niche strategy selection as a result.

Besides the direct results presented for kite-based AWE technologies, the thesis makes several scientific contributions to the field of transition theories and specifically to Strategic Niche Management. The revised barrier framework for categorizing barriers, has been improved, applied and validated in this thesis, forming a framework for future application in categorizing barriers and identifying new ones. It forms an alternative to other barrier identification frameworks, with more detail and structure than other frameworks. The ten niche strategies presented by Ortt et al. (2013), have been reviewed by literature and validated with the interviews, substantiating the distinct set of niche strategies for further research in its functioning and application. The presented links of Ortt et al. (2013) have been categorized and combined with proposed links for the remaining barriers, to form a complete matrix of links between barriers and niche strategies, to be investigated in other cases or for further research into the relation between barriers and niche strategies in innovation adoption.

Collectively these contributions form the core of the niche strategy selection process, the concept of which forms a managerial application of SNM, an underrepresented aspect in scientific literature on SNM. While the presented barrier ranking and niche strategy selection process form two key managerial contributions, allowing actors in the field of kite-based AWE technology to better understand and develop the market. It is one particular managerial contribution that will aid entrepreneurial and innovative actors. It is through literature and the interviews conducted with experts, that the thesis successfully presents the ranking of five niche strategies best suited to tackle the barriers of kite-based AWE technologies, thus enabling the innovation to speed up its development towards market adoption.

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Glossary

AWE - Airborne Wind Energy
AWEC - Airborne Wind Energy Convention
CAA - Civil Aviation Authority
CWT - Conventional Wind Turbine
FAA - Federal Aviation Authority
FIS - Functions of Innovation System
HAWP - High Altitude Wind Power
IS - Innovation System
MLP - Multi-Level Perspective
NS - Niche Strategy
PV - Photovoltaic
SET - Sustainable Energy Technology
SNM - Strategic Niche Management
TEP - Techno-Economic Paradigm
TM - Transition Management

List of Symbols

A - Area [m²]
D - Drag [-]
δ - Power density [kg/s³]
L - Lift [-]
P - Power [kg·m²/s³]
ρ - Density [kg/m³]
T - Traction force [kg·m/s²]
V - Velocity [m/s]
Chapter 1 - Introduction

The development of sustainable energy technologies has been ongoing for approximately half a century, yet the original goal of the large scale use of clean and renewable energy sources is still to be achieved. In response, a large effort has been made by the scientific community to identify and understand why these technologies struggle to make an impact, while entrepreneurs are still struggling to achieve market adoption with sustainable innovations.

Since the early 1970’s sustainable development has become a key topic on the global agenda, as populations and their welfare have grown exponentially while resources seemed to reach its limits [Goldsmith et al., 1972]. This, in combination with the oil crises, triggered the search for and development of sustainable energy technologies to present an alternative to fossil fuel based energy technologies. A period of further experimentation and development of both sustainable energy technologies and supporting policies followed, forming the source and inspiration for scientific research and analysis into transitions. This joint effort has eventually resulted in growing markets for sustainable energy technologies, especially in geographic areas with political or practical backing (Europe, US, Africa, and China) [US DOE EERE, 2013]. In certain countries it has even lead to a significant contribution of sustainable energy sources to the electric grid, while a better understanding of the (social and economic) mechanisms that act upon sustainable energy technologies has developed in parallel. However on a global level, modern sustainable energy sources still only contribute 1% percent to the (primary) energy consumption of the human population, despite the abundance of wind and solar energy sources [IEA, 2013].

Much of the research done on Sustainable Energy Technologies (SETs) can be divided into two general groups; technological development and (governmental) policy research and guidance. Both form two major components of the socio-technical system, and are increasingly better understood, but components like economic forces and public opinion must not be underestimated. Thus it is interesting to see that, although the socio-technical system looks towards the commercial market to truly have the desired big impact, so much of the research as gone towards technology and (public) policy development. Of course, as technologies are continuously economically scrutinized and improved, and policies are setup to trigger or push market participation in the sustainable energy market. The chances of success increase with the growing knowledge of those aspects and sciences. But commercial or entrepreneurial perspective on the adoption of sustainable energy technologies or innovations is seems to be under represented in the overall research landscape.

A field of research that has potential to represent the commercial and entrepreneurial perspective on the market’s adoption of innovations is Strategic Niche Management (SNM). Although initially presented as a policy tool, SNM is indirectly a response to a new innovation’s inability to enter the mass market. A mass market which is very much defined by the embedded existing technologies, their
paradigms and their corresponding practices and rules, thus having a dominant market position. These practices and rules can, and usually do, form barriers for the new technologies trying to enter the market. Hence the approach of Strategic Niche Management is to generate and manage protected market spaces for experimentation and growth [Kemp et al., 1998]. Creating room for the technology to develop further and the market to get accustomed, while exploiting the technology’s unique strengths. Eventually as the technology develops and its niche market forms a paradigm, built on the work of entrepreneurial actors, it alters or suits the wider market and gets adopted. Since the theory on Strategic Niche Management was initially introduced by Van de Belt and Rip (1984), it has grown further to be adapted for regime change and sustainable development. Most of the research has since focused on understanding the transition or journey from a technological niche to a market niche, and the many recorded successes and failures, according to Schot and Geels (2008). This has lead to further research into the (external) factors that influence this journey and the further process to regime change, resulting into the contextualizing of SNM through the application of Multi Level Perspective [Schot and Geels, 2008]. A first step towards moulding the (scientific) theoretical notions of SNM, and the aligning theory of Transition Management, into a practical guide or ‘competence kit’ for transition practitioners was done by Raven, van den Bosch, and Weterings (2010). They also state that, despite the large scientific effort and interest, there is a lack of practical knowledge and guidance to apply the notion of SNM in the real world successfully [Raven et al. 2010]. Learning in retrospective from historic cases of high-tech innovations, Ort and Suprapto (2011) concluded that 75% achieved large-scale adoption through experimenting in a niche (or protected) market first. Hence showing that to achieve the desired large impact of sustainable energy technologies, it will most likely have to start with adoption in a niche market. With this historic observation from the perspective of niche markets, and combining it with the theory of SNM, allows for practical guidance to be given on the basis of past experiences and lessons. This will aid the development of practical knowledge and guidance in the application SNM, as a vehicle to introduce and accelerate innovations to market. Therefore this master thesis will develop a selection process for niche strategies and expand the understanding of the effective application of SNM. Since the thesis (of the master of Sustainable Energy Technology) has an intended workload of 45 ECTS, a constraint to the scope of the thesis has to be applied, to prevent the quality of the research being undermined by excessiveness. Therefore a choice was made to focus the niche strategy selection and its corresponding process on a specific case technology.

Airborne Wind Energy is a cluster of technologies, unified by its ability to extract wind power by using airborne elements, and thus having more flexibility in operation and wind resources than conventional tower-based wind turbines. The airborne elements are not limited by the structural limitations of a tower to reach the more powerful wind resources at higher altitudes, but also require significantly less
materials for the same power rating. Yet how the wind energy is converted to (predominantly) electrical energy is what differentiates the technologies in the cluster, as different mechanisms are applied to lift the systems in the air and convert wind energy to electrical energy. The possible configurations of system components, applications and their advantages, are discussed in the dedicated chapter 4, where a selection will be made of which technology (group) will be analysed as the case of the thesis. A specific configuration of AWE technology, involving inflatable kites and the so-called yo-yo cycle, is being researched and developed at the Delft University of Technology. It is actually whilst doing a minor-project at the Kitepower research group (originally set up by the late Wubbo Ockels to develop the Laddermill at Delft University of Technology), that I became aware of the missing link between technological innovation and market shift. Despite the environmental and economic potential of AWE technologies, by harvesting more powerful winds higher up and reducing the amount of material in the system. I noticed that the research group still had to make a significant effort to get financial support. This was required to continue and accelerate the group's development of the working demonstrator, and was eventually achieved with a subsidy grant. This event raised the question with me; why is there an asymmetry between the technological development and the development of markets? Progressively as my insight grew, the focus shifted to how capitalise on the (current) technological potential as soon as possible, to trigger investment and support for further development.

**Aim & scope**

Continuing in the line of the thought and the perspective of the problem description, the aim of this Master thesis is, in the broadest sense: To accelerate technology implementation by determining which (niche) strategy is best suited to bring an sustainable energy technology to (a niche) market and thus strengthen financial and public backing for market adoption. However to achieve sufficient quality and depth of research in the thesis, in the given time frame, the scope or breadth of the thesis has to be confined and defined. Generating both an overview and the ability to retrace the reasoning behind the conclusions, several focal points and assumptions are made to specify the scope of the thesis:

As discussed in the previous paragraphs, technology implementation can be achieved by applying the theoretical framework of Strategic Niche Management. The choice for SNM is (in part) based on its potential to represent an entrepreneurial perspective on the socio-technical system, as it assumes that the actions of an actor does not alter the wider technological regime or broader market with immediate effect. This assumption aligns with the perspective of an entrepreneur or innovator who is unable to directly alter the wider technological regime single handed. But there are alternative theories on how to achieve technological transition, like Functions of Innovation Systems presented by Hekkert et al. (2007), which are discussed in chapter 3. Another assumption on the choice of the application of SNM is that it is suited for being applied for Sustainable Energy Technologies, but sufficient historical data to back the claim is currently lacking, despite being presented as suitable [R. Kemp, 1998]. But perhaps the
biggest assumption is that actively applying SNM in an entrepreneurial setting, greatly improves the chances of success with the corresponding innovation, which also lacks sufficient experience and data to truly determine its effects.

To focus the thesis, avoiding the analysis of the full breadth of SETs whilst lacking depth and time, a deliberate choice was made to use a single technology as the case study. Based on the technology’s potential and current phase of development, which allows for practical contributions to be made, the thesis focuses on the case of kite-based AWE technologies. It is assumed that there is sufficient information on the technology and its market/barriers to conduct research and analysis, despite being relatively new and with limited research done into the technology’s market adoption. And it is also assumed that the technology of Airborne Wind Energy is representative, to a reasonable degree, for the wider sector of sustainable innovations. Or phrased differently, the kite-based AWE technologies is not in such a unique innovation that the market responds completely differently to it, than it does to other innovations. And thus the historical cases also provide relevant lessons and examples for the case of kite-based AWE technologies.

From the aspect of quality, two pillars are applied to the thesis to uphold the quality of the findings and results, respecting the time constraints. The first being the careful and thorough effort made in searching and reviewing scientific literature on the barriers of AWE technologies and for the development of the niche strategy selection process. And the second pillar is formed by the meticulous interviewing of leading experts in AWE technologies, for their insights and perspectives, to strengthen and validate the literature findings and results. With these two separate pillars, it is assumed that the conclusions of the thesis and its contributions are valid, while achieving the key aim of the thesis of; guidance to market for AWE technologies by selecting niche strategies.

Research objectives
Combining the constraints and aim, previously discussed, leads to the following main research question:

**Which niche strategies are best suited for kite-based AWE technologies?** It requires the development of a selection process to determine the suitable niche strategies, for AWE technologies, to overcome the barriers to market adoption. To get the answer to the main research question in a structured and reproducible way, four research questions and two sub-questions have been formulated in table 1.1:

<table>
<thead>
<tr>
<th>Main research question:</th>
<th>Which niche strategies are best suited for kite-based AWE technologies?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research question 1.</td>
<td>Where does the technologies and market of Airborne Wind Energy currently stand?</td>
</tr>
<tr>
<td>Research question 2. a</td>
<td>How can barriers to market adoption be defined, identified, and categorized in general?</td>
</tr>
<tr>
<td>Research question b</td>
<td>What barriers are preventing the market adoption of AWE technologies?</td>
</tr>
<tr>
<td>Research question 3. a</td>
<td>What niche strategies are identified and described in published literature?</td>
</tr>
<tr>
<td>Research question b</td>
<td>Which niche strategies are suitable for the market adoption of AWE technologies?</td>
</tr>
<tr>
<td>Research question 4.</td>
<td>Which niche strategies are linked to which barriers as suitable responses?</td>
</tr>
</tbody>
</table>
The first research question is formulated to provide the reader with an up-to-date overview of the status of AWE technologies, with regards to both the technologies and the market. The overview of AWE and its latest development, also defines the context of the thesis for the later stages.

The latter three research questions focus on the niche strategy selection, with research questions 2 and 3 both split into a generic question (a) and a case specific question (b). The latter three research questions aim to develop the three components of the niche strategy selection process, building on published literature. The questions respectively research the barriers, niche strategies, and the links between them, of the niche strategy selection process. The three components respectively form the input, output, and processing, of niche strategy selection process.

The second and third research questions, each consists of a question to research the component in general, and a sub question to apply the general findings to the case of AWE, with additional case specific research. This approach of general research followed by its application to the case of AWE, is not continued in the fourth research question, as it is solely based on historic insights and no case-specific research for AWE is required. The general structure of the thesis, and how the research questions are integrated in to it, is explained in the general structure section on page 6.

Relevance
As previously discussed, the research in field of SNM up till now has predominately focussed on gaining an understanding of current and ongoing cases, and developing a concept of how to facilitate SNM from a policy perspective. So far only a few attempts have been made to close the gap and adjust the misalignment between the theoretical knowledge and its practical applications. While the perspective of entrepreneurs and corporations is also underrepresented in the field, despite their increasing importance and their relevance in bringing innovations to market having been historically proven.

Therefore the practical application of SNM in this thesis is of use for entrepreneurial actors and the science community. In response the thesis sets out the following aims for contributions to the scientific community, and practical applications for (niche) managers and other actors, thus addressing the gaps in SNM literature:

By its nature, barriers to market adoption are very case specific and difficult to objectively compare to barriers of other cases, but in order to build on the experiences of other historic cases, the barriers need to be generalized and categorized in order to compare similar barriers. Hence, a barrier framework will be presented and used in the thesis to categorize both the barriers of the case innovation of kite-based AWE technologies, as well as categorizing the barriers described in historic cases used in the development of the selection process. The barrier framework forms a scientific contribution by providing an effective means to categorize and generalize barriers while keeping the essential aspects of the barrier’s impact and cause, thus giving researchers a useful framework for further research into barriers and related topics.
To overcome the barriers face by an innovation going to market, a range of strategies have been used in the past. However these strategies are not clearly and distinctly listed or described, particularly in the context of SNM. Therefore the thesis will need to list and described the possible niche strategies, tackling the barriers to the mass market, in order to select the most suitable niche strategy. The emphasis on niche strategies is reflective of the theory of SNM, focussing on protected niche (market) spaces to experimentally develop the technology and market together. The thesis contributes by reviewing the published literature on the subject and presenting a list of distinct niche strategies to be used in the selection process, after which it will also be validated for the case innovation. The distinct and defined list of niche strategies will enable the scientific community to continue the research in the application and functioning of these strategies in the innovation adoption and transition processes.

The third contribution is the documentation of which niche strategies are suited to which barriers, building forth on the previous two contributions. As it is the core aim of the thesis to identify and select the niche strategies that can overcome barriers and progress an innovation to mass market adoption. The links between barriers and niche strategies form the most critical piece of research done for the thesis, but it is perhaps the most poorly documented aspect of niche strategies in SNM literature. Hence this overview will contribute to potential further research into the relation between barriers and niche strategies and how it functions. This leads to a greater and better understanding of how barriers to mass market adoption can be tackled, and thus accelerating the adoption of sustainable innovations.

These scientific contributions will also result in managerial contributions through application of the case innovation of kite-based AWE technologies. Through the use of the barrier framework, a barrier ranking of most influential barriers will be determined for kite-based AWE technologies, providing managers with an overview and collective perspective to discuss industry-wide approaches to tackling the barriers. And the resulting niche strategy selection for kite-based AWE technologies, using the niche strategy selection process, will allow managers of these innovations to formulate or adjust the strategies of their organizations with respect to market adoption. But the to be developed guidance tool of the niche strategy selection will be the foremost managerial contribution, enabling managers to determine the suitable niche strategies for their organizations on the basis of the barriers it experiences.

Despite being ambitious in tackling several aspects and dimensions of niche strategy selection within the case of kite-based AWE technologies, both the thesis’s contributions to scientific and managerial knowledge will hopefully lead to further development and understanding in the field of SNM, while also allowing sustainable innovations to harness their true potential, for all, sooner.

**General Structure**

The general structure of the thesis consists of three core stages, which consequently lead to the scientific and managerial contribution stipulated in the relevance section. The three core stages are; ‘context of thesis’, ‘literature-based research’, and ‘validation by experts’, and these are naturally
preceded by the introduction and concluded with the conclusion & reflection.

The three core stages of the thesis, guide the reader through the thesis, with every stage building on the work and results of the previous stage. The three core stages and all the chapters are presented in table 1.2, together with the corresponding research questions to their respective chapters:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Chapter</th>
<th>Title</th>
<th>Research question:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>Introduction</td>
<td>1. Where do the technologies and market of Airborne Wind Energy currently stand?</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Methodology</td>
<td>2a How can barriers to market adoption be defined, identified, and categorized in general?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2b What barriers are preventing the market adoption of AWE technologies?</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>Scientific Background</td>
<td>3a What niche strategies are identified and described in published literature?</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>AWE technologies &amp; market</td>
<td>3b Which niche strategies are suitable for the market adoption of AWE technologies?</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Barrier</td>
<td>4 Which niche strategies are linked to which barriers as suitable responses?</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>Niche strategies and links to barriers</td>
<td>Which niche strategies are best suited for kite-based AWE technologies?</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>Interview &amp; results</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Validation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Conclusions &amp; reflections</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>Appendix</td>
<td></td>
</tr>
</tbody>
</table>

**Stage 1** – *Defining the context of the thesis through the selection of SNM and the case of AWE technologies.*

Chapter 3; discusses several transition theories before substantiating the selection of SNM, and continues with discussing the entrepreneurial application of SNM before concluding with a summary.

Chapter 4; presents the history and key design variables of AWE technologies, before discussing several AWE systems. This leads to the selection of kite-based AWE technologies as the case innovation for the thesis, and a description of current market and developments, thus answering research question 1.

**Stage 2** – *Conducting literature-based research into the components of the niche strategy selection process.*

Chapter 5; first presents the definition of a barrier and the developed barrier framework, from an earlier literature review, and in the second part extracts barriers from literature to create a ranking of the barriers of AWE, answering questions 2.a and 2.b respectively.

Chapter 6; first develops and presents the niche strategies and their links to barriers, and then applies them to determine the suitable niche strategies for kite-based AWE technologies. First answering questions 3.a and 4, and in the second part answering the question 3.b with the niche strategy selection.

**Stage 3** – *Validating the results of stage 2 by interviewing AWE experts.*

Chapter 7; presents the interview structure and the methods for analysing the results, before presenting the results of the interviews in the second part, giving insight into the perspectives of experts.

Chapter 8; validates the components and results of niche strategy selection process, by comparing the various answers of the interviewed experts, concluding with reviewing the internal and external validity.

The thesis concludes with the conclusions on the research questions, and a reflection on the thesis and research. While builds upon the six research questions to answers the main research question in the overall conclusion in chapter 9.
Chapter 2 – Methodology

To attain the research objectives and the aim of the thesis, a structured methodology is required. A three stage methodology is presented to structure the thesis, in which the research questions will be addressed. The three stages progressively guide the thesis towards addressing the main research question in chapter 9. The stages, and the flow of results between them, are presented in figure 2.1:

Stage 1 – Context of thesis
Defining the context and circumstance of the thesis (regarding SNM and AWE).
Addresses: RQ 1: Where do the technologies and market of Airborne Wind Energy currently stand?

Stage 2 – Literature-based research
Researching and developing the niche strategy selection process from literature.
Addresses: RQ 2a: How can barriers to market adoption be defined, identified, and categorized in general?
RQ 2b: What barriers are preventing the market adoption of AWE technologies?
RQ 3a: What niche strategies are identified and described in published literature?
RQ 3b: Which niche strategies are suitable for the market adoption of AWE technologies?
RQ 4: Which niche strategies are linked to which barriers as suitable responses?

Stage 3 – Validation by experts
Interviewing experts for a second data source on AWE, to be used to validate and strengthen the niche strategy selection process for AWE.
Addresses: Reviewing RQ 2.b and RQ 3.b to determine the definitive niche strategy selection for AWE technologies, leading up to answering the main research question (in Chapter 9):
Which niche strategies are best suited for kite-based AWE technologies?

Figure 2.1: Overview of the stages and research questions of the thesis, and its interactions.

Stage 1 will describe and define the context of both the transition theory and the case technology applied in this thesis. The process of stage 1 will result in a description of the current status of AWE technologies and its market, which will frame and guide the case technology application in later stages.

Stage 2 draws on literature sources to develop the niche strategies selection process in general, before applying it to the case technology of AWE. The niche strategy selection (process), developed in this
stage, forms the core approach to addressing the main research question. But this will require further substantiation, as both SNM and AWE are relatively new fields of scientific development. The current body of literature is insufficiently substantial to validate and support the bold aim of this thesis on its own. Therefore, stage 3 is introduced, to provide additional data and insights for validating and strengthening the results of stage 2. Stage 3 will achieve this by interviewing experts in AWE individually, to extract new insights and gain their perspective on the AWE case results of stage 2. By defining the context, and developing the niche strategy selection process on the basis of the two pillars of knowledge, the selection of niche strategies for kite-based AWE technologies is attained.

**Stage 1 – Context of thesis**

The first stage of the thesis is to define the constraints and context of both the chosen transition theory and case technology. It will answer the first research question posed in the introduction, by presenting an overview of the latest developments in the field of AWE and its market. Stage 1 will start by reviewing the various possibilities, before selecting, and describing the selected context and constraints. The selection of context and constraints will be required to prevent the thesis and its results from becoming too broad and vague, and thus unrepresentative or invalid. The selected context and constraints will guide the research of the following stages and frame the rest of the thesis.

For both the transition theory and the case technology, an overview will be given for each of the various theories and options available to be applied in the thesis. These various options will then be reviewed and compared, before making the selection of the transition theory and case technology for the thesis. For the transition theories, only the most applied and described theories will be reviewed, to avoid selecting an inapplicable or under developed transition theory. The selected overview of transition theories will be presented with their history and key features, before discussing their published critique. The case technology is already defined by the broad group of AWE technologies, as predetermined in the introduction, hence the various AWE systems currently being developed will be presented for further selection. The history and key design variables will be presented beforehand, as they have a strong influence on the types of AWE systems being developed. With the two overviews of the various options for the context of the thesis, the selection of the respective transition theory and case technology can take place.

The selection of the transition theory and case technology will be done with different approaches, as different conditions apply in both selections. The different conditions reflect the aim of the thesis, as it aims to provide a practical contribution, and thus it will require a well developed and practical transition theory. While in order for the results of the thesis to be relevant, a relevant and significant cluster of the broader group of AWE technologies will need to be selected as case technology. The selection of a suitable transition theory will be done on the basis of selection criteria, which will be
focussed on matching the needs and aims of the thesis regarding transition theories. The various transitions theories will then be judged per selection criteria, before making the overall selection on the basis of all selection criteria in chapter 3.

The selection of the case technology will look at the various systems described previously, to determine which sub-group of AWE systems is the largest and most relevant of the sub-groups, in chapter 4. Through this selection, the results and contributions of the thesis are relevant and applicable for a large part of AWE community.

Once the transition theory and case technology are selected, further insight and description will be given to further explain the selected theory and case. Especially in the case of the transition theory, its critiques and the entrepreneurial perspective of the transition theory are further investigated and strengthened in chapter 3.

For the selected AWE case technology, an overview of the AWE landscape and its latest developments will be given, as well as its relation to the constraints of the thesis. This will give an up-to-date description of the developments of AWE technologies and its market, answering research question 1 in chapter 4.

It is with these more elaborate descriptions and additional insights that the context and constraints of the thesis are set out and presented to the reader, framing the literature-based research of stage 2.

**Stage 2 – Literature-based research**

The second stage of the thesis is to research and develop the three components of the niche strategy selection process, using literature sources on SNM or aligned research. The niche strategy selection process and its results will form a key part of the thesis in answering the main research question: *Which niche strategies are best suited for kite-based AWE technologies?* It is for this reason that most of the research questions posed in the introduction are answered in this stage.

First the components will each be developed in generic form, i.e. without being case related, collectively laying the foundation of the managerial tool, while answering research questions 2a, 3a, and 4. Thereafter the generic components are applied to the case of AWE technologies to determine the ranking of barriers and suitable niche strategies for the case. In the process answering the respective research questions 2.b and 3.b in chapters 5 and 6.

**Generic components**

The niche strategy selection process will consist of three generic components; the barriers, the niche strategies, and the links between barriers and niche strategies. These components reflect the input, the possible output, and the selection algorithm, of the generic selection process. Each component will be researched and developed separately, obtaining answers to questions 2.a, 3.a, and 4 respectively. The general methodology of the research and development of components is the same, and presented as such.
All components will use published literature to answer their respective research questions, making use of the comprehensive web-search service of Google Scholar. For the web search, a structured methodological approach has been devised for the search for, and the selection of, relevant articles. The web search will be done by using several search terms in combinations, to cover the breadth of the terminology while remaining focused on the subject. For example, search terms for the case technology are; ‘Airborne Wind Energy’ and ‘High Altitude Wind Power’, which are combined with the search terms for barriers; ‘barriers’, ‘hurdles’, and ‘obstacles’. The example search terms form six possible combinations, which will all be put into the search engine independently, searching per combination and processing the results. This approach allows for a comprehensive search of all terms, while guiding the search through the selection of the terms. The search terms for each web-search will be presented in the respective chapter, along with further adjustments or constraints.

With the web-search presenting all relevant articles as the results per (search term) combination, the following step will be selecting relevant articles for further processing and being read in full. The selection of articles and other published material will be required to remove articles from non-related scientific fields, due to the nature of the search engine, as well as maintaining the quality of articles’ relevance. First the total number of hits will be noted per combination, to keep track of the percentage of articles processed during each step. The next step of the selection process will be to select articles on the basis of title. This step will be limited to the first 50, 100, 200, or more hits of the search engine, under the assumption that the hits will be ranked by word-relevance, and the relevance of the hits significantly drops after a certain number of hits. If further selection of articles is required, the selection will be continued on the basis of the abstract and conclusion in consecutive steps. After this step the search and selection will be repeated for articles published after a predetermined date, by activating a filter in the search engine. This latter step will be done to concentrate (a part of) the search on recent publications, thus being able to extract and present the key latest developments in the field.

The selected articles are then read in full and the findings of interest extracted, with the findings presented and discussed in the relevant chapter.

To identify and categorize the barriers to market adoption, a framework will be adopted or developed, building on similar concepts found in literature. The concept of the barrier framework will be required to identify and categorize the barriers of a case in a generic form, so that barriers can be compared to other cases and linked to niche strategies. The concept is to categorize barriers into representative barrier-sets, maintaining the key features without case-specific information, thus answering research question 2a in chapter 5. The barrier-sets collectively form the barrier framework.

To attain a comprehensive list of niche strategies proposed or applied in cases, the extracted findings of scientific literature will be processed. The distinct and relevant niche strategies described in SNM
literature or aligned research will be searched for, extracted and discussed, before the comprehensive list of niche strategies and answer to research question 3a are presented in chapter 6.

With the possible barrier (-sets) and niche strategies defined, the links between them will be investigated by searching literature. The search will deliberately focus on past applications or historic cases, to form a proven basis for future application through the niche strategy selection process. As with the other two components, the research will be presented and discussed, before presenting a matrix of the links between barriers and niche strategies in chapter 6, which answers research question 4.

**Case application**

Once the generic components are developed in their respective chapters, they will be applied to the case of AWE technology. The application to the case will build on the available literature to determine the most influential barriers and suitable niche strategies for AWE technologies, thus answering research questions 2b and 3b.

The application of the generic niche strategy selection process will start by defining the barrier ranking of AWE technologies, which forms the input for the process. The barrier ranking will be determined from barriers presented in literature on AWE, combining several sources to attain a representative ranking. The sources will be found using the literature search methodology, presented in the ‘generic components’ methodology. The extracted barriers will be discussed and categorized using the barrier framework, to form the barrier-sets to be used in the niche strategy selection process. The barrier-sets will be ranked by adding up the identical barrier-sets of each literary source, cumulatively leading to a ranking of the most presented barriers. To rank the barrier-sets, the number of times a barrier-set is presented in a source will be noted and converted to a percentage, of the overall number of mentioned barriers, which will then be used for the ranking. If the literary source gives a ranking of its presented barriers, the ranking will be represented with a linear scale, with the highest percentage going to the highest ranked, and going down the lowest ranked barrier. Since it is possible that some sources only discuss a specific set of barriers, regarding a specific part of innovation adoption, such sources will be given a lower weighting factor to adjust for the narrow or partial focus. This allows the percentages given to barrier-sets to be summed, taking the weighting factors of the sources into account, and results in a ranking of all mentioned barriers. A top-8 of the resulting barrier ranking will be used for the rest of the thesis, the niche strategy selection process and its validation by experts. The top-8 ranked barriers is limited to eight, as it will be sufficient to cover a significant part of all mentioned barriers in AWE literature. Resulting in a barrier ranking of the most influential barriers to market adoption of AWE technologies, answers research question 2b in chapter 5.

The barrier ranking will be the input for the niche strategy selection for question 3b. The niche strategy selection process will make use of the links, extracted from historic cases of niche strategy application, to determine which niche strategies are suitable responses to the ranked barriers of AWE technologies.
As is shown in the figure 2.2, the barrier ranking will be used as input, into the link-matrix, determining the suitable niche strategies for each barrier-set. The selection process will maintain the ranking of the barrier-sets in the selected niche strategies, by giving more emphasize to higher ranked barrier-sets. Therefore, in the example of figure 2.2, niche strategy A is ranked higher due to the links with barrier-sets 1 and 3, rather than niche strategy D which is linked to barrier-sets 2 and 4. The niche strategy selection process will thus present a set of niche strategies suitable as a response to the barriers to the market adoption of AWE technologies, answering research question 3b in chapter 6.

Stage 3 – Validation by experts
To validate and strengthen the niche strategy selection, the third stage of the thesis builds upon the expertise of actors in the field of kite-based AWE technologies. The expertise is extracted through interviews with the experts, to form both a second source of authentic information, and gather their opinions on the process and results of the niche strategy selection of stage 2. This approach will allow the validation of the results of stage 2, by comparing and confirming them with the experts’ perspectives. This will lead to more valid and relevant results, than just relying on the published literature found in stage 2. But the approach will also allow the potential to strengthen or adjust the results, bringing them to a higher level with the (new) insights of the interviewed experts.

To achieve this, the third stage progresses from selecting and structuring the interviews, to analysing and presenting the results of the interviews in chapter 7. Before validating the niche strategy selection and its process, with the interview results, and concluding with a review of the internal and external validity of the overall thesis in chapter 8.

Interview
To obtain qualitative results from the interviews, which will be used to strengthen and validate the results of stage 2, the choice of the interview technique and its structure will be of importance. Several techniques are available to capture the collective knowledge and experience of experts in a certain field, although for this thesis one technique will be chosen. The choice lies predominantly between the adjusted individual interview technique and the popular Delphi technique.

The Delphi technique conducts several rounds of surveys or interviews interspersed with controlled feedback for reflection, thus working towards the primary purpose of attaining a realistic consensus of opinion amongst a group of experts. However the Delphi technique is susceptible to several disadvantages: Delphi is susceptible to the risk of sloppy execution and design, particularly through the
controlled feedback by the researcher to guide the consensus. And the experts themselves can inadvertently promote certain outcomes in the Delphi process [Gupta and Clarke, 1996]. But most of all, it is in the interest of this thesis not to attain a realistic consensus from all interviewed experts together. The thesis aims to attain pure individual data on the experts’ use and opinion of the niche strategy selection process and its results, with minimal distortion by the researcher. The individual data will allow for more analysis and (new) insights into the perspectives of the interviewed experts, and results of the niche strategy selection process, than going for a consensus amongst the interviewed experts. With the adjusted individual interview technique it will be possible to check the level of coherence amongst experts during the various stages of the niche strategy selection process, without altering or forcing opinions. Therefore, it is chosen to use adjusted individual interviews to attain the perspectives and results from the experts. This flexibility and diversity in the results of the interviews will be of great importance for the validations in chapter 8, making the most of the finite number of AWE experts.

The adjustments to the individual interviews, is largely reflected in the structure of the interview. The interview will consist of three phases, with each phase constructed by three groups of questions or assignments. The interview structure is presented for overview in abstract form in figure 2.3:

![Figure 2.3: Overview of the generic interview structure, showing the three phases and three groups of questions and tasks.](image_url)

The three groups of questions in each phase consist of a set of ‘initial’ questions, an ‘interactive’ assignment or part, and a set of ‘reflective’ questions. The ‘initial’ questions are posed in an open manner to gather the interviewee’s initial perspective and opinion, in the broadest possible sense. The ‘interactive’ assignment or part asks the interviewee to perform a task (for example, list and rank his barriers) and/or presents the literature-based results. And the ‘reflective’ questions are then posed to the interviewee to reflect on, or adjust, the literature findings or the results of the task.

The three groups of interview results, allowing the interviewee's perspective to be tracked before,
whilst using, and after presenting the literature-based results in the interview. This triple sampling of the interviewee provides much data on the expert’s perspective, which will be used to validate the literature-based results and strengthen them through new insights. These comparisons within the phase, amongst the three groups of question are dubbed ‘intra-phase comparisons’. An additional comparison is to process the results of a previous phase, using the niche strategy selection process, to compare them against the results of the following phase, which is dubbed an ‘inter-phase comparison’.

The phases of the interview structure reflect the intuitive line of the niche strategy selection process. It will start with the barrier ranking of the innovation case, followed by possible niche strategies, and ending with the links to suitable niche strategies and their selection. The interview structure will guide the interviewee through the selection process. The structure of the three phases will also ensure that the three components of the niche strategy selection process will be validated independently, rather than validating just the outcome of the selection process. The structure used in the interviews will also result in a lot of data to be analysed and processed, due to the different types of questions and tasks.

**Analysis**

Three types of analysis will be used for processing the results of the interviews. The different types of analysis will be required due to the nature of the questions or tasks in the interview, as the results from the interviews can be either concrete or elaborate in nature. The three types of analysis will be; ‘framework’, ‘reflective’, and ‘coding’, each with a specific approach to specific results.

The ‘framework’ analysis will solely be used for processing the results of tasks done during the interview. The tasks in the interview will be by design very specific and concrete, thus channelling the results of the interviewee into a predetermined framework. This will allow for the direct processing of these results, and therefore the type of analysis will be solely used for the ‘interactive’ tasks.

The ‘reflective’ analysis will be used for processing the answers to concrete questions posed in the interview. These concrete questions are (semi-) closed in nature, thus guiding the interviewees to giving brief and specific answers. These brief answers will be noted down from the audio recordings of the interviews, and then presented and if required summarized in tables in chapter 7. For certain questions, the answers of the experts will be filtered to extract specific information, for example a list of barriers.

The two types of concrete answers, discussed above, can be combined to give a collective overview of the results. By noting the number of experts that mention a specific answer, of all mentioned answers, an overview of the mode or frequency of the specific answers is generated. For the rankings, for example the experts’ barrier rankings, the average ranking of each barrier is determined, resulting in the combined overall (experts) ranking. It achieves this by giving a weighted value according to the ranked position of each barrier per expert, and then adds them up per barrier. The average ranking of each barrier will then be used to determine the new overall ranking of all the mentioned barriers, or in other cases niche strategies, etc. The latter approach is termed ‘average ranking’ in this thesis.
The two approaches to generating collective overviews of the results, the mode and ‘average ranking’ approaches, are forms of data manipulation. This seems to contradict the choice for the interview technique, based on individual perspectives and minimal distortion, as the collective overviews are not verified by the interviewees, unlike with Delphi. In the case of determining the mode answer given, the manipulation is more an observation of the overall results of the question than a manipulation or processing of them. However with the ‘average ranking’ approach, the manipulation is less transparent and potentially distorting. In principle the use of ‘average ranking’ approach is valid, as it mathematical operations are, but the assumptions around it applications do pose a threat, as it assumed that the rankings from experts is linear. The assumption that the ranking is done with constant increments between all ranked barriers, might be false, as the distinction between ranked barriers might vary in the perspective of experts. For example, the difference between the highest ranked barrier and the second highest might be greater, regarding influence, than the second and third ranked barrier. So under this assumption, barriers that experts perceived to have nearly the same level of impact, will be interpreted as having distinct levels of impact. Therefore this assumption will be checked in chapter 8 against other combined results, particularly the mode of answers, to determine whether the application and results are valid.

The ‘coding’ analysis will be used to process the more elaborate answers of the interviews. These elaborate answers result from the open-questions asked during the interviews, which are deliberately open in nature to give the interviewee the opportunity to bring in new insights. However, the more elaborate answers will require more processing to extract the relevant information, thus building on the presented approach of P. Burnard (1991), the following approach will be adopted. The first stage of processing the answers, will be writing out the transcripts of the interviews from the recordings. After which, the second stage will be to highlight (or open-code) the important or interesting remarks whilst reading through the transcripts. The third stage will be to review the highlighted remarks by categorizing the remarks into coding groups, which will presented with the results in chapter 7. The fourth stage will be re-reading the transcript for missing remarks and checking whether the context of the remarks is preserved, in line with the coding groups. The fifth and final stage will be present the categorized remarks per interviewee, per question, taking care to maintain the focal point and context of the remarks. The results presented in chapter 7 will give the reader insight into the perspectives of the interviewed experts, and will form the foundation for the validation done in chapter 8.

Validation
The validation of the niche strategy selection and process will be done through comparisons of the various results, to validate the components of the selection process and its results. In addition the internal and external validities of the overall thesis will be determined by reviewing possible threats. For the validation a comparison approach will be used, making use of the structure of the interview, and
maximizing the available sources. The concept of the comparison approach is built upon the notion that three points will be sufficient to determine the collective validity of the points, as well as the relative individual validity. For example, if two sets of results show a strong coherence, but neither does with the third set, it can be argued that the third deviates from the true situation. Or if all three sets do not show coherence relative to one another, then the three sets are collectively not valid or accurate. One could illustrate this by imagining a triangle, as in figure 2.4, of which the corners are the sets of results, and the lines between the corners reflecting the strength of the coherence.

To make the comparisons effective for the validation, the selection of the sets of results for the comparison will be critical. Several options will be possible for the selection of the sets of results, using the answers of one or several questions to form a set. In general the sets of results form an ‘initial’, an ‘interactive’ and a ‘reflective’ set, using the answers of respective questions or tasks. The sets of results might come from a single phase of the interview, forming an ‘intra-phase’ comparison as discussed in the ‘stage 3 – analysis’ methodology on page 15, or come from two or more phases forming an ‘inter-phase’ comparison. The selections will be presented per validation in chapter 8, in which the answers and results (of chapter 7) will be used for the comparison.

In general, two kinds of comparisons will be made; one kind focuses on the consistency or coherence amongst the compared results, and the other focuses on deviating results from the main consensus. Which kind of comparison is used depends on what aspect needs to be validated, and will be mentioned per validation in chapter 8. For example, a comparison focusing on consistency or coherence will be used to check whether a component of the niche strategy selection process reflects the situation perceived by experts. And a comparison focusing on deviation will be used to find new perspectives or insights from the experts. Of course the two kinds of comparisons can also be used collectively if it is required by the purpose of the validation.

Internal & External validity
The validation will also focus on other threats to the validity of the thesis, besides the (independent) variable relation in the components of the niche strategy selection process and its results. In literature a distinction is made between two types of validity, regarding threats to the validation. The first is the internal validity, which reflects on the proceedings and assumptions of the research and validation within the context of the thesis. And the second is external validity, reflecting on the validity of the findings of the research outside of the researched case or study.

For this thesis, the eight threats to internal validity presented by Campbell and Stanley, 1963, and the three threats to external validity presented by Smith and Glass, 1987, will be reviewed in a dedicated section in chapter 8. The in total eleven presented threats are commonly used in social sciences for the internal and external validity, and the threats and its impacts are presented below for overview:
**Internal validity**

**History**, refers to the occurrence of events or conditions that are unrelated to the study but do reflect on the measured outcome, thus posing a threat to internal validity. These events can either be internal or external, and are more likely to occur the longer the study is conducted [Onwuegbuzie, 2000].

**Maturation**, pertains to the processes that operate within a study participant due (in part) to passage of time. These processes can alter the study participant’s intellect, knowledge, physic, and mental and emotional state, which can be incorrectly attributed to the independent variable [Onwuegbuzie, 2000].

**Testing**, also known as pretest sensitization, refers to changes that may occur in the scores of participants on the second measurement, as a result of having participated in an earlier measurement, regardless of any intervention or independent variable. Testing is more likely to prevail when; cognitive measures of factual information are utilized, and time between measures is short [Onwuegbuzie, 2000].

**Instrumentation**, occurs when scores yielded from a measure lacks the appropriate level of consistency or does not generate valid scores, as a result of inadequate content-, criterion-, and/or construct-related validity. This threat to internal validity can occur in many ways, either during the sampling, measuring, or data processing of the study [Onwuegbuzie, 2000].

**Statistical regression**, typically occurs when participants are selected on the basis of their extreme scores on a pre-intervention measure. This threat to internal validity reflects through the tendency for extreme scores to regress, or move toward, the mean on subsequent measures, which is difficult to measure post-intervention [Onwuegbuzie, 2000].

**Differential selection of participants**, also known as selection bias, refers to substantive differences between two or more of the comparison groups prior to the implementation of the intervention. This threat to internal validity, which becomes clear at the data collection stage, most often occurs when non-randomized groups are compared, but always exists to some degree [Onwuegbuzie, 2000].

**Mortality/ differential attrition**, refers to the situation when selected participants do not complete or take part in every part of the study (i.e., drop out). The bias occurs when participant attrition leads to differences between the groups that cannot be attributed to the intervention [Onwuegbuzie, 2000].

**Interaction effects**. Many of the threats to internal validity presented above can also interact with the differential selection of participants to produce an effect that resembles the intervention effect. For example, groups might significantly vary in mortality rates, due to group selection [Onwuegbuzie, 2000].
External validity

Population validity, refers to the extent to which findings are generalizable from the sample on which a study was conducted to the larger target population, as well as across different subpopulations within the larger target population. Utilizing large and random samples tend to increase the population validity of the study. However population validity is a threat in nearly all studies, requiring external replications, regardless of the level of internal validity attained in a particular study [Onwuegbuzie, 2000].

Ecological validity, refers to the extent to which the findings from a study can be generalized across contexts, variables, locations, and conditions, outside of the original context, variables, location and conditions in which the study took place [Onwuegbuzie, 2000].

External validity of operations, is a threat to external validity in almost every study. The more unique the participants, time, context, and variables, the less generally applicable the findings will be. Hence the variables must be defined and caution taken in generalizing the findings [Onwuegbuzie, 2000].
Chapter 3 – Scientific background

This chapter discusses and elaborates on the different innovation transition theories, and why Strategy Niche Management was chosen for this thesis. By discussing the different transition theories and how they are related or stand respective of one another, the choice over SNM can be substantiated. The chapter ends with a description of the notion, entrepreneurial application, and summary of the theory of SNM, giving the reader a reference for the rest of the thesis.

Technology’s introduction onto the market

From an engineer’s or inventor’s perspective, any technological innovation is developed and intended for being used by its target market to the fullest extent, especially if such an innovation as been developed to have a positive contribution to the Earth’s environment and its population. However achieving the full potential of an (technological) innovation often takes several decades, as seen with many technological transitions in the past, from the steam engine to modern day internet. So in order to speed up transitions and benefit from innovations’ sustainable and environmental potentials sooner, research on technological transitions increased in the second half of the 20th century. As the first research approach was to understand and analyse past cases of (technological) transition, several theories and approaches to transitions have sprung into existence. These have various perspectives to the transition process, varying in perspective of actors, acting level, or research aspect of transitions. All of these theories and approaches try to understand how the transition process takes place and can be steered from their perspective and focus [Lachman, 2013].

The choice for transition theories, rather than diffusion theories, is based on the nature of the innovations discussed in this thesis. Since this thesis focuses on sustainable innovations, and particularly the innovation of kite-based airborne wind power generation, there is a need to alter not only the innovation itself but also the target market(s). The co-development of the sustainable innovation and its market is required as the innovation tries to entry an existing market with incumbent technologies and strong competition, and in the case of sustainable innovations, all the advantages might not directly pay out to the user or match their values and practices. While the theory of diffusion of innovation does state that the existing values and practices of users needs to be adopted by the innovation to further strengthen its relative advantage and speed up its adoption, which conflicts with the current energy landscape actors are trying to abandon [Rogers, 2003]. Hence, diffusion theories are regarded as not suitable for the case of sustainable innovations, as in the current market the competition is too strong and indirect benefits are undervalued. Therefore the choice is made for transition theories, which do look at, or attempt to, alter existing values and practices of the market in favour of the sustainable innovations. The co-development of the technology and market is not only of interest to sustainable innovations, but also for fledgling innovations or technologies, as can be seen in many historic cases.
Overview of the transition theories

To substantiate the selection of the transition theory used in this thesis, an overview of key transition theories is presented, before comparing and discussing using a set of selection factors. The overview is based on the selection of transition theories presented in a review of Lachman (2013) of most studied and applied theories, with for each theory the origin, key features, and application described:

**Innovation systems**

Introduced in the mid 1980’s as a response to the spreading neoliberal paradigm, particularly after the fall of the Berlin Wall. The concept of ‘innovation systems’ (IS) is defined as the combination of all institutional and economic structures that affect both the direction and the speed of technological change in society, highlighting the co-evolutionary character of change process [Hekkert et al., 2007]. In the 1990’s the concept differentiated on system boundaries (national, sectorial, regional, technological), but the core idea remains to ascribe technological change to collective and individual actions relating to innovation systems [Freeman, 1998]. By breaking down the innovation system to its elements, and analysing them individually on their ability to fulfil their intended purpose, the bottlenecks in the transition process are pinpointed, while the overall IS is judged on its ability to innovate. Yet the IS approach has over time received criticism over its comprehensiveness and suitability for sustainable transitions, thus other approaches were derived from it like Functions of Innovation Systems.

**Functions of Innovation Systems**

Hekkert et al. (2007) present a further developed approach (of the framework) using the general idea of Innovation Systems. By focuses on the processes taking place in an innovation system, rather than the individuals and institutions, the dynamics of the innovation system and activities at a micro (or an entrepreneurial) level can be mapped. There are three reasons given for taking this process perspective: First of all, the perspective allows for comparison between innovation systems with different institutional setups. The second reason is that mapping the process through functions, allows the determinants of the innovation system (and their influence over time) to be systematically analysed. And the last and third reason is by using a fixed set of main functions, policies can be redirected and adjusted to improve the performance of the weaker functions [Hekkert et al. 2007]. In this way a better and more detailed analysis can be made of the innovation system, thus allowing for better policies and interventions. The overall seven functions have been categorized to map the entire innovation system, and are listed below:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function 1</td>
<td>Entrepreneurial activities</td>
</tr>
<tr>
<td>Function 2</td>
<td>Knowledge development</td>
</tr>
<tr>
<td>Function 3</td>
<td>Knowledge diffusion through networks</td>
</tr>
<tr>
<td>Function 4</td>
<td>Guidance of the search</td>
</tr>
<tr>
<td>Function 5</td>
<td>Market formation</td>
</tr>
<tr>
<td>Function 6</td>
<td>Resources mobilization</td>
</tr>
<tr>
<td>Function 7</td>
<td>Creation of legitimacy/counteract resistance to change</td>
</tr>
</tbody>
</table>
These seven functions cover the main activities of processes required for a strong innovation system. Hence through the analysis of these functions and their performance, a good insight is gained into the innovation system and where there is room for improvement.

**Socio-metabolic transitions approach**

A transition approach that centres on socio-metabolic regimes developed by Sieferle (2010) in the mid-1980’s. The approach builds upon the notion that society (which is de facto the socio-metabolic system) has environmental boundaries; if these are crossed either the system experiences structural change or it collapses. Originating from Vienna, the socio-metabolic approach states that (sustainability) transitions only come about when structural changes occur in a society’s (energy) system. The approach’s focus on macro developments that span decades to centuries, with the inclusion of nature/the environment, and its methodological core, viz. obtaining empirical information about biophysical variables, set it apart from other approaches (Fischer-Kowalski and Rotmans, 2009; Fischer-Kowalski, 2011).

**Techno-economic paradigm**

By applying the long-wave theory on Techno-Economic Paradigm (TEP), a new approach emerges to analysis (sustainability) transitions. The evolutionary-economic theory, which originated in the 1980’s, is based on the notions of co-evolution and long-wave cycles. Long wave theory states that this cyclic movement is caused by the emergence and diffusion of clusters of new technologies and associated new institutions, behaviours, etc. (in other words, a new techno-economic paradigm), and thus destabilizing the up till then reigning paradigm (Freeman and Perez, 1988; Geels, 2011). From its macro-level view and long duration of the cycles, long-wave theory focuses on entire economies and distinguishes five subsystems; science, technology, economy, politics and culture. Alignment between the subsystems resulting from co-evolution, leads in turn to bring about transition. However these transitions can only be analysed properly in hindsight using this approach.

**Transition Management**

Transition management is a concept that builds upon reflexive and participative governance, attempting to manage transformative change (i.e. its speed and direction) towards sustainable development. This is achieved through combining long-term thinking with short-term actions (thus complimenting conventional policy) in a process of searching, experimenting and learning. Gaining significant traction from 2001 onwards, it is executed on three levels (strategic, tactical, and operational). The three levels follow a cyclical path consisting of problem structuring and envisioning (strategic level), agenda building and networking (tactical level), experimenting and diffusing (operational level), and executes continuous monitoring, evaluating and adjusting on all levels [Loorbach et al., 2008]. However although promising, in practice TM has been proven difficult to apply and current literature has currently mainly focussed on niche-regime management rather than transitions itself.
Multi-Level Perspective

Originating from the Twente school’s quasi-evolutionary theory, Multi-Level Perspective is a hybrid between evolutionary approaches and interpretivism that conceptualizes a pattern of long-term change. It is centred on socio-technical regimes and consists of macro, meso and micro level, respectively landscape factors, regimes and niches [Rip and Kemp, 1998; Geels, 2002]. Transitions occur as a result of dynamics at the different levels, according to the MLP, which reinforce each other creating a ‘window of opportunity’: landscape factors destabilize regimes, while niches gather momentum to take centre stage within the system [Geels, 2006; Grin et al., 2010]. The conceptual tool of the MLP has the advantages of scope and generalizability, which aims to provide an overhead perspective of transitions in order to guide the search for patterns, and causes and impacts of different phenomena during transitions [Geels, 2011]. However one of the major weaknesses is that it uses metaphors and imprecise concepts, with the danger of creating ambiguity and categorizing phenomena too easily since concepts have vague boundaries.

Strategic Niche Management

To give a brief description for the overview, SNM has evolved out of evolutionary theories on technological change (sharing concepts with MLP) and built upon Constructive Technology Assessment. Emerging in the last decade, SNM promotes reflexive management of transition experiments in niches to break into the main-stream and achieve regime-shift [Schot and Geels, 2008]. The core idea behind SNM, like TM, is learning-by-doing and doing-by-learning to get insights from experiments for the requirements for taking over the main position in an incumbent regime [Raven and Geels, 2010]. A more detailed description and overview is given in the later paragraph on page 26.

Discussion and selection

To compare and select the transition theory to be used in the thesis, two selection criteria have been devised. The two selection criteria reflect the broader aim of the thesis; to accelerate the uptake of sustainable innovations by capitalizing on its potential sooner, and are presented in table 3.1:

With the two selection criteria, the selected transition theory should be able to support an innovator or entrepreneur in the process of achieving market adoption with a sustainable innovation.

<table>
<thead>
<tr>
<th>Selection criteria</th>
<th>Short description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Innovator’s perspective</td>
<td>The (practical) perspective of the transition theory reflects the perspective of an innovator’s or entrepreneur’s and the sphere of influence, so that the innovator can apply the resulting advice within his or her network.</td>
</tr>
<tr>
<td>2. Predictive application</td>
<td>To have an impact in future adoptions of innovations, the transition theory needs to be capable of predictive application or guidance, on the basis of its present analysis, and not solely applicable in retrospect or hindsight. Allowing the actor to respond to current situations for future success.</td>
</tr>
</tbody>
</table>
The first selection criterion achieves this by judging transition theories on their ability to share the same perspective on the socio-technological system as an entrepreneurial actor. The second selection criteria achieves it by judging transition theories on being capable of providing predictive guidance for actors to take actions to alter the future course. By selecting on the basis of these two selection criteria, a transition theory is selected suitable for innovators or entrepreneurial actors and that be applied in current or future cases.

As only the transition theories presented in the previous section are considered for selection, a pre-selection has occurred. The presented transition theories were selected by Lachman on the basis of the most used and studied theories, resulting in a favourable pre-selection of theories with sufficient amount of published material for application and research.

The comparison and selection is done by describing how the transition theories meet each of the two selection criteria. The two selection criteria separately discuss the suitability of each presented transition theory, and draw an interim conclusion before the final selection is substantiated at the end.

Starting with the innovator’s perspective selection criteria, whether the transition relates to actor’s sphere of influence, and is determined on the basis of analysis focus of transition theory on the socio-technical system. A description of the suitability to the selection criteria is given per transition theory in table 3.2:

<table>
<thead>
<tr>
<th>Transition theory:</th>
<th>Performance in respect to; innovator’s perspective selection criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation System (IS)</td>
<td>Can analyse on national to technological levels, but from system (bird’s eye) perspective and with limited capability for comparisons with other innovation systems.</td>
</tr>
<tr>
<td>Functions of Innovation System (FIS)</td>
<td>Can analyse on a micro/entrepreneurial level, by focussing on the innovation functions, but is still focused on the overall system, like IS, rather than the influence sphere of an innovator or entrepreneur.</td>
</tr>
<tr>
<td>Socio-metabolic transitions approach</td>
<td>Analyses the long-term processes and macro-level impacts on socio-technical systems, lacking the micro-level perspective and influence of an innovator or entrepreneur.</td>
</tr>
<tr>
<td>Techno-economic paradigm</td>
<td>Is focused on entire economies and how these are influence by wider socio-technical conditions over time in five subsystems.</td>
</tr>
<tr>
<td>Transition Management (TM)</td>
<td>Aimed at achieving regime-shift/transitions, although of most of literature is focused on the management of processes within the niche or regime.</td>
</tr>
<tr>
<td>Multi-Level Perspective (MLP)</td>
<td>Analysing the micro, meso, and macro levels of a socio-technical system, looking for patterns and causes in various levels leading to transitions.</td>
</tr>
<tr>
<td>Strategic Niche Management (SNM)</td>
<td>Focused on the micro or niche level, managing processes inside to achieve wider regime-shifts, building concepts of previous two transition theories.</td>
</tr>
</tbody>
</table>

The first four transition theories all have a broad perspective of the socio-technological system, very much in line with the perspective of a researcher or public-governance actor, trying to understand and steer the complex overall system of innovation and transition. The transition management (TM) theory does have a very strong micro or niche focus, with a strong managerial perspective, but in most literature focuses completely on the learning processes within the niche. It has been criticized for a lack of (managerial) tools generating a bias towards incumbent regime actors, and inhibiting (new) niche
actors [Lachman, 2013]. The Multi-Level Perspective (MLP) theory views all levels of the socio-technological system, creating a bird’s eye view of transitions to analyse the patterns and causes, which does not fully reflect the perspective of an innovator trying to trigger a transition. The Strategic Niche Management (SNM) theory builds upon the transition theories of TM and MLP, using the MLP perspective and sharing the managerial concepts of TM. It strives to achieve transition by development in niches before triggering a regime-shift, this perspective is closely aligned with that of an innovator or entrepreneur striving for eventual mass-market adoption, in contrast to the other transition theories. The second selection criteria of a transition theory’s ability to make future predictions or guidance for future adjustments, is described per transition theory in table 3.3. The descriptions are based on the functioning and application of the transition theory, with regards to the time-dimension.

<table>
<thead>
<tr>
<th>Transition theory:</th>
<th>Performance in respect to; predictive application selection criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation System (IS)</td>
<td>Identifies the current bottlenecks in the innovation system, in key components, enabling action to be taken to tackle the bottlenecks.</td>
</tr>
<tr>
<td>Functions of Innovation System (FIS)</td>
<td>Identifies the weaker processes in the innovation system, using the framework of seven key processes, allowing for corrective action to be taken.</td>
</tr>
<tr>
<td>Socio-metabolic transitions approach</td>
<td>An analytical approach to identifying the structural changes in the system and its environment, suggesting only possible application in retrospect.</td>
</tr>
<tr>
<td>Techno-economic paradigm (TEP)</td>
<td>Analysing the long-term wider macro-level processes, but is only properly applicable in hindsight.</td>
</tr>
<tr>
<td>Transition Management (TM)</td>
<td>Applies the concept of long-term thinking, short-term action, which seems suitable for application by innovators.</td>
</tr>
<tr>
<td>Multi-Level Perspective (MLP)</td>
<td>Based on the concept of aligning the macro, meso, micro level to trigger transition, but seems to require retrospective search for transition patterns.</td>
</tr>
<tr>
<td>Strategic Niche Management (SNM)</td>
<td>Analyses the socio-technical system, managing the niche and processes in response, to achieve the desired transition.</td>
</tr>
</tbody>
</table>

Both the transition theories of IS and FIS analyse the bottlenecks or weakness of the innovation system, either in the components or processes respectively, thus enabling actors to take action to adjust or correct the weaknesses in the wider innovation system. Both the socio-metabolic transitions approach and techno-economic paradigm theories strongly suggest to be looking for big (structural) changes after they have occurred. This retrospective analysis inhibits the prediction of future shifts, let alone the guidance to trigger one, thus making these transition theories unsuited for an entrepreneurial actor. A similar statement can be made for the MLP theory, although literature does suggest that it can be applied in present socio-technological systems to analysis the current opportunities to transition or its barriers. The transition theory of TM presents a very suitable case for its ability to provide predictive guidance for existing socio-technological regimes, particularly the well-described niche management processes it presents, but does suggest to be lacking a strong analytical core. Something which is addressed by the SNM theory by adopting the analytical perspective of MLP and notions of niche management of TM, building on the strengths of these two transition theories. The SNM theory is in this manner capable of giving the prospected entrepreneurial or innovative actor both analytical and responsive tools to achieve the desired transition.
On the basis of the results of the two selection criteria, it is clear that the transition theory of SNM has best match with the ambitions of the thesis to achieve sustainable transition through entrepreneurial actors. Although it has to be said that the choice for SNM will differ in other contexts, has each transition theory has its strengths and weaknesses to be respected, something highlighted by the many criticisms of all theories listed by Langman (2013). The transition theories IS and FIS also present a strong match, but lack the entrepreneurial perspective and corresponding ability to guide an entrepreneurs actions makes it less well suited. The strong match of SNM with the selection criteria, as well as building on the strengths of TM and MLP, presents a theory capable of application by innovators and entrepreneurial actors for sustainable or radical innovations transitions. This might explain the 75% of historic cases of high-tech innovations successfully entering the mass market through niche strategies [Ortt and Suprapto, 2011]. Hence for these reasons, the transition theory of SNM is adopted and applied in this thesis to achieve its aims, with further explanation of the theory in the next paragraph.

**General notion of Strategic Niche Management**

Continuing on from the developed concept of Van de Belt and Rip (1984), the published work of Schot, Hoogma, and Elzen (1994) and Kemp, Schot, and Hoogma (1998) introduced the strategic niche management perspective to address the difficulties of bridging the gap that exists between R&D and market introduction. Since then, much of the SNM research has focused on understanding the early adoption of innovations with high potential to contribute to sustainable development [Schot and Geels, 2008]. This aligns with technology actors, whom desire to solve (societal) problems or alter markets through radical innovations, and thus (try to) direct the development of technologies, etc. This notion deviates from the theory of evolutionary economics, which assumes that variation (in technology and direction) is blind. Therefore the SNM perspective is regarded as an quasi-evolutionary perspective, as the technology is directed in some extent, through anticipation of technology selection by technology actors and them shaping the selection process by special R&D programmes and demonstration projects [Schot and Geels, 2008]. These spaces in which radical innovations are tested and developed, through a process of ‘learning-by-doing’, are referred to as (technological) niches by Rip and Schot. These niches are sheltered from direct mainstream competition and nurture a specific set of interactions between (involved) actors, visions and issues. In this way niches act as ‘proto-markets’, which might develop into niche markets, building on from the collective learning experiences. This collective learning experience leads on from the created socio-technical experiments of the niches, in which various innovation actors are encouraged to collaborate and exchange information, knowledge and experience. An interactive learning process that will facilitate the incubation of the new technology [Caniels, 2008]. The process of niche formation is seen to consist of three interrelated and mutually reinforcing sub-processes, which acting together can successfully develop a (technological) niche [Kemp, Schot, and
Hoogma, 1998]. The first sub-process is the articulation of expectation and visions, the alignment of which gives direction to the learning-process, attracts attention, and legitimate (continuing) protection and nurturing. This process requires active involvement of the actors in the niche, for continuous adjustment, has the other sub-processes progress and actors join and leave. The second sub-process is the creation of constructive actor-network, which in a way forms the physical part of a niche, providing the necessary resources and exchange of knowledge. But SNM authors note that composition of network is of importance for its potential, especially the role of the users is important to the overall process [Kemp, Schot and Hoogma, 1998]. The third and last sub-process is the experimentation-based learning, through which the possibilities and constraints of the innovation, specific application domains, its acceptability, suitable policies to regulate or promote it, etc. are explored and determined. But the sub-process plays a key-role in the overall niche formation, as expectations and visions are reshaped by the new insights and knowledge.

However a niche is not isolated from its contextual regime or the overall landscape, as pleaded by Schot and Geels (2008). There are several conditional factors that need to exist to successfully develop the niche, and these factors can be split into two general groups: The first are facilitating conditional factors that cannot be manipulated in the short term, but can change over longer periods as the niche process progresses. The second are more adaptable to changes on the short term through (for example) policy intervention. This classification presented by Caniëls and Romijn (2008), is somewhat different to the regime and landscape classification from MLP commonly used, despite its parallels. The need for a different classification rose from SNM practitioners’ difficulty of categorizing conditional factors to either the regime or landscape, although in this thesis the classification of MLP will be maintained with this limitation in mind. However it is interesting to see that this more practical classification puts more emphasize on the quasi-static view niche actor have of the regime and landscape they find themselves in, highlighting that even with good actor-network, the ability of actors to quickly and radically alter the world around is limited, as perceived by entrepreneurs and innovators (despite their ambitions).

Caniëls and Romijn (2008) sum up five conditional factors that play a strong role in the niche formation process. First being the creation of sheltered spaces for incubation as emphasized by Kemp, Schot and Hoogma (1998), particularly the lack of mainstream market demands or competition and the presence of invested actors are vital. The second factor is the possibility for continuous evaluation and incremental improvement by means of broad actor interaction processes, or in other words, the technology needs to be still open for development in response to new insights of actors and the co-construction of technology and market [Elzen, Geels and Green, 2004]. Third important factor is that ‘the new technology must ... exhibit temporal increasing returns or learning economies’, in the words of Kemp, Schot and Hoogma (1998). As experimentation with the new technology progress, new scales of economy should open up, and particularly in the view of SNM, ‘learning-by-doing’ should further improvement of economic performance of the technology. The following fourth factor is that a new
technology should still be open to development in different directions, different to the originally intended purpose and allow for evolutionary variation. And the five and final strong factor presented, is that the technology should be already attractive to use for certain applications, particularly for applications in which the disadvantages matter less and the advantages are highly valued.

Overall these factors seem to focus on the technological characteristics of new technologies, however the attitudes, values and choices of actors also play a strong role in these factors, as the demands of the factors is subjective in nature, and up for judgement by the involved actors. This in turn influences the active and ongoing experimentation with new technologies by actors in the created niche spaces.

The journey from innovative idea to market adoption takes five steps in the perspective of SNM, as presented by Kemp, Schot and Hoogma (1998). The first step being the choice of (new) technology, based on the plausible promise it offers to actors and having feasible organisational features compatible with user needs and values. This choice should also have the presence of a change actor who champions the innovation and takes a lead role in its progress and development. The second step is the selection of the experiment, in which a change actor also plays a lead role, but there are several boundaries that guide the selection. The experiment is aiming for learning in small increments, while also aiming high in ambition, but not too high and thus scaring off other actors. And further it should initiate user-producer communication with a potential lead user, whilst keeping the door open for the large majority of subsequent potential adopters. However, in practice the choice of seems to be more often ad hoc and random [Caniels and Romijn, 2008]. The third step is to set up and implementation of the experiment, for which the network of actors plays a vital role. Not only must the network set itself up to maximize the exchange of knowledge and unlock the learning potential, particularly guarding against focus on technical issues (first order learning) rather the wider societal aspects and interactions, the network should also build on the existing strengths of the actors involved, and utilise their resources and skills for an easier start of the experiment rather than ‘reinventing the wheel’. This complex process requires an actor (or a select group) to take the lead in organizing and dynamically managing the required processes in this step, which would seem well suited to be done by the change actor if appropriately skilled. A network manager should maintain individual responsibility, and commitment to collective goals, for the approach and products of the network/niche [Caniels and Romijn, 2008]. The fourth step is the scaling up of the experiment, which is can done by expanding the experiment or replicating it for new applications, thus growing the momentum for the transition from pioneer market(s) to the mass market. Through which (further) learning processes are initiated on a management, organisational and institutional level, also regarded as the regime level. The fifth and final step is dismantling the protection of the niche(s), opening up the new technology to mainstream market demands and expectations. This final step might be done for one of two reasons: The first being the technology and niche has not developed to its expected potential and is not viable, so resources should no longer be wasted on maintaining the niche. Or the opposite, which is that technology and corresponding niche
have developed to point it is already to confront or emerge with the mass market.
Although many experiments strive for the latter of step five, few have been described in SNM literature
to have come that far [Caniels and Romijn, 2008]. Yet as more and more experiments are set up and the
insight into SNM expands, the understanding of how to cross the gap from new innovation to market
adoption will improve and thus the chances of a successful transition will as well.

**Entrepreneurial application of SNM**
Despite the numerous (transition) experiments applied through the notion of SNM, much of the
published literature has a strong analytical core, but lacks a managerial perspective and interpretation
[Raven et al., 2010]. Even though SNM is itself a more practical perspective on the scientific knowledge
of transitions to more sustainable socio-technological systems, there is still a gap between the scientific
perspective and the practitioners’ perspective. Naturally much of the literature is scientific in nature and
writing, but also much of the literature presents or suggests that policy-makers should be the lead-
actors in niche experiments. This seem rational from the notion that only government or public
institutions can properly represent the interests in common concerns and resources, like sustainable
use of the planet or a just distribution of societal burdens. Yet, entrepreneurs are also naturally suited
to be the promoters behind innovations for sustainable development [Gerlach, 2003]. Sustainable
innovations appeal to entrepreneurs as they can have benefits for business, humanity and the planet,
and thus can lead to a more sustainable society on a global level driven by business. The bottom-up
perspective of entrepreneurs is similarly structured as SNM and lends itself very well for it, yet the
entrepreneurial application/perspective is underrepresented in SNM literature.
In light of the lack of a managerial/entrepreneurial perspective, this thesis strives to strengthen its
representation in SNM literature, and thus further open the door to its use by entrepreneurs with
sustainable ambitions. To achieve this aim and provide some guidance for entrepreneurs, the thesis
aims to provide a managerial tool. This tool will guide entrepreneurs through the selection of suitable
niche strategies for introducing their innovation to the market. Raven (2006) reviews two patterns
which have been put forward in transition literature as typical transitions and assesses the potentials of
these patterns as strategies for dealing with the lockout of alternatives from existing regimes. The first
of the two proposed niche strategies is niche accumulation. This is a strategy based on building up the
stability and performance of radical innovations in multiple niche markets before being ready to enter
the mass market, thus leveraging the great potential for learning about the markets and the technology.
The other strategy is called niche hybridisation. This couples (less radical) innovations to the existing
regime by being an addition to the regime technology, before starting to lure mainstream actors into
using the alternative technology independently for the regime technology. Both these strategies have
their advantages and pitfalls when applied, and the strategies are not fully controlled by a single actor
but result from the interaction in the niche network.
J. Ortt, D. Langley, and N. Pals (2013) present an article with a broader set of ten niche strategies, all based on historic case-studies. Although the article is not directly linked to SNM, it does recognize the role niche strategies in innovation adoption and its link to SNM. The article's main contribution is the list of ten niche strategies, identified from a broad collection of historic case-studies, with which (if mass-market conditions are not present) the aim of mass-market adoption is (attempted to be) achieved through niche markets. With the additional comment that the found niche strategies are unclear on whether they avoid or overcome barriers to mass-market adoption. This highlights the lack of knowledge regarding niche strategies and their functioning, together with a better understanding of how these strategies guide and form niche experiments, which requires further research.

So despite lacking a strong representation of the managerial perspective in SNM literature, there has been some interesting research results in the entrepreneurial application of SNM or niche strategies, but it still leaves room for further improvement and research.

In summary, to describe the notion and perspective used in the thesis, and thus defining the context of the thesis regarding transition theories. The selection of SNM is based (in part) on its ability to reflect the perspective of an innovator and entrepreneurial actors in the socio-technological system, whilst also giving current analysis and guidance to future strategies. Enabling entrepreneurial actors to play a lead role in niches, and thus in the transition to a new technology regime, leading and guiding the three sub-processes described by Kemp, Schot and Hoogma (1998): These sub-processes are; the alignment of expectations and visions, creation of constructive actor-network, and experiment-based learning.

Creating learning-by-doing processes through which the technology and market develop in cohesion, which will hopefully proceed through the five phases described in the previous paragraph, from innovation selection to mass market entry. The formation of this process in a protective niche is subject to conditional factors from the regime and landscape levels, which according to Caniëls and Romijn (2008) can divided into two sub-groups. Whether the conditional factor can be manipulated or altered in the short-term or not, determines in which sub-group it is placed, regardless whether it originates from the regime or landscape. These distinctions are favoured by practitioners for its transparency, yet in this thesis, the MLP origin of the factor will be noted as well. But to give lead actors a tangible vision of how and where the niche process should be shaped to have best chance of success, several niche strategies are presented that have been proven in the past to overcome barriers. The niche strategies present concepts that propose niches and the focus or aims of possible experiments to be conducted within the niches, thus guiding actors around or through barriers to large market adoption. It is the selection of best suited niche strategy for a specific innovation that this thesis strives to achieve, using the described notion and perspective on SNM.
Chapter 4 – AWE Technologies

This chapter dives into the world of Airborne Wind Energy (AWE) technologies to explain it and its role in the thesis. It sets out to explain; the development history of AWE, its fundamental principles and workings behind its potential, what the different types of AWE technologies there are, how they are related, and what the current standing of the technologies’ development is. With the latter explanation answering research question 1. All to define the constraints of the technology and geography for this thesis, thus avoiding ambiguous and vague results after research into differing technologies and regions.

The history of AWE technologies

Since early recorded history mankind has harnessed wind energy to improve, broaden, and power the human endeavour. As early as 5,000 BC, wind energy has been used to propel boats up and down the Nile for transport [Energy.gov, 2014]. By 200 BC wind power was harnessed for grinding grain in the Middle East and pumping water in China, further expanding its range of applications. The technology for harnessing wind power slowly spread across the world, with merchants and crusaders bringing the technology to Europe, after seeing its extensive application in food production in the Middle East in the 11th century [Energy.gov, 2014]. From the 17th century, windmills in the Netherlands were adapted and applied on a large scale, powering entire regional (timber mill) industries and draining lakes for agricultural land. While continuing to improve the technology up to the 19th century, the introduction of steam power from coal, in that century, lead to the decline of wind power as primary power source. Yet from the late 19th century wind energy technology started to move on to the new application of generating electricity, the fruits of which can be seen on the horizon today.

The idea of using airborne devices, predominantly kites, goes back over many centuries. Yet it was not until 1827 that the first dedicated research volume on the topic was published by George Pocock, titled “The Aeropleustic Art or Navigation in the Air by the use of Kites, or Buoyant Sails”. Which he wrote jointly with his successful experiments with carriages driven by kites, he calls charvolant. But it took more than a century, dominated by fossil fuels, before the idea Airborne Wind Power was reinvigorated during the oil crisis of the 1970’s [Ahrens et al., 2013]. This interest lead to the patenting of most airborne wind power concepts by Payne and McCutchen called “Self-Erecting Windmill”, in 1975. This was soon followed up by a demonstration experiment of ‘flying electricity generators’ in Australia by Bryan Roberts in 1979. But a major influential contribution to the field was made in 1980, when Miles Loyd published his article “Crosswind Kite Power”, in which the foundations for quantitative analysis of airborne wind power systems was laid [Ahrens et al., 2013]. Still it would not be until the 2000’s when tether and control technologies have progressed far enough for further research in airborne wind energy research to accelerate again. In 1997 the late Dutch astronaut and university professor Wubbo Ockels patents the Ladder mill and started a research group at the Delft University of Technology. Then in 2001, SkySails is founded in Germany and develops the first commercial kite system for ship traction.
Following a high altitude wind power conference at AeroVironment in California in 2005, the company Makani Power was founded in 2006 in California with substantial funds of Google. That same year, Windlift in the US, NTS in Germany were founded, while the KiteGen project realizes a pumping kite system. In 2010 the first Airborne Wind Energy Conference is held in Stanford, California, and from then on there is one annual international conference, alternating its location between the US and the EU [Ahrens et al., 2013]. In 2013 Makani Power was fully acquired by Google [X], and the first monograph on ‘Airborne Wind Energy’ is published by Springer Verlag, in part cataloguing the history and development of Airborne Wind Energy.

**Fundamental principles of AWE technology**

To briefly explain the basic theories behind AWE or High Altitude Wind Power, the following section will describe what its two fundamental principles are and how it harnesses the second largest renewable energy resource on the planet [Nitsch,2007].

The renewable resource of wind power is present at nearly all levels of the atmosphere, despite that most technologies only harness the first few hundred meters from the ground up. The lesser effects of resistance from the Earth’s surface and atmospheric conditions cause the wind speeds to be higher and more consistent at higher altitudes. It is for these aspects that the flexibility of operating altitude of Airborne Wind Energy systems lends itself well for, being able to tap into such rich renewable energy sources. This will become especially apparent when one looks at the power density equation for wind power ($\delta_w$, see equation 1), and one sees that change in the wind speed ($v_w$) has a cubic effect on the power density of the wind:

**Equation 1:**

$$\delta_w = \frac{p_w}{A_{frontal}} = \frac{1}{2} \rho v_w^3$$

With $\rho$ representing the density of air, in equation 1, thus determining the wind power passing thorough a unit of frontal area. Hence a twofold increase of the wind speed leads to an eight fold increase of power per frontal area available to be harvested. Thus while the wind speeds increases with an increase in altitude up to approximately 12km above the Earth’s surface, as seen in figure 4.1, and despite the air density decreasing causing a (smaller) negative effect on the wind power density. The notion of harvesting wind power at higher altitudes (than conventional wind turbines) is a logical one.

![Figure 4.1 Wind speeds at different altitudes from 0 to 25km above ground. Source: National Weather Service](image)
To tap into this richer wind resource requires an airborne system, as a tower-structure would not be tall or strong enough to capture the wind. Thus the system need to be light enough to be able to get airborne, like planes, helicopters, zeppelins and kites, which introduces is its second fundamental principle. As not only the weight requirement for an airborne system, but also the absence of a tower and the momentum it creates on the foundations on the ground, allow AWE systems to use approximately 8 times less materials per unit power capacity than conventional wind turbines. These two fundamental principles combined explain why the Levelized Cost Of Energy is estimated to be between 10 and 50 Euro/MWh [Fagiano et al., 2010]. Making it economically competitive with fossil-fuel based utility-scale power generation from natural gas and coal. When these economies of electricity generation are reached, it would be capable of triggering the large-scale transition to renewable forms of electricity generation and the desired (societal and environmental) effects.

Working principles and design considerations
To extract power from the wind requires the application of a set of working principles, to the design of an AWE system, in order to achieve the potential presented by the fundamental principles. To highlight what design parameters strongly influence the power generation potential of such a system, the 2D crosswind power model is explained and discussed in this paragraph. Although the early applications of wind power used sails being drag ged by the wind to capture the power, quickly the sails started to move at a tangent or against the wind direction to capture more (wind) power as is the case with sailing boats and windmills. By moving the aerodynamic surface or sail in alternate direction to the wind, the sum of the two speed vectors result in a greater wind speed, as perceived by the moving surface. As the apparent wind speed over the (aerodynamic) surface is increased, so is does the power captures by it cubically as shown in equation 1.

This approach of increasing the wind speed experienced by the aerodynamic surface has been investigated and (arguably) quantified for application by AWE systems by Miles Loyd [Ahrens et al., 2013]. By flying the lifting body (inflatable kite or fixed wing) at a tangent to the wind direction, a crosswind flight path is used to capture more power from the wind. Which also the method by which conventional wind turbine harvest wind energy, by rotating at tangent to the wind direction. To give some insight how crosswind flight works and how it is related to certain design parameters, the crosswind kite power principle of Loyd and its equations are briefly described.

Figure 4.2, on the next page, shows the force and speed vectors acting on a flying body in crosswind flight in a 2D model, in which L and D represent the lifting and drag forces respectively, while the wind speed (\(V_W\)), tether reel-out speed (\(V_T\)) and crosswind speed (\(V_C\)) show how the sum of vectors result in the apparent wind speed (\(V_{app}\)).
This two dimensional model is based on certain assumptions and additional aspects. The model includes an alteration to the perceived speed by unreeling of the tether to which the lifting body is connected, as occurs with pumping kite systems (further explained in paragraph 2.3). So the lifting body drifts with the direction of the wind as the tether is unreeled to produce power on the ground, but is not necessarily dependant on the AWE system. There are four key assumptions made with this model and those are:

- Massless point model lifting body
- Massless tether, to the ground, with zero-drag
- Constant uniform wind, across flight path, in $-X_e$ direction
- Steady flight of the lifting body

Under these assumptions and additional aspects, power equation for crosswind flight derived from the following set of equations. Starting with the power generation at the ground station, which is produced from reeling the tether from a drum, hence equation 2 looks as follows:

**Equation 2:**

$$ P = T_K \cdot V_T $$

With which the power is calculated by multiplying the force on the tether with the speed the tether is reeled out. Since the reel-out speed is controlled by the ground station itself, it is the force on the tether created by aerodynamic forces which interests us.

**Equation 3:**

$$ T_K = L \sqrt{1 + \left( \frac{1}{(C_L/C_D)^2} \right)^2} $$

The tether force is the sum of lift force ($L$) and drag force ($D$) experienced by the lifting body, the sum of which is represented in the equation by the square-root component.

Determining the lift force is a function of perceived speed ($V_{app}$) as well as the lift coefficient ($C_L$), as shown in equation 4 on the following page:
Equation 4: 
\[ L = \frac{1}{2} \rho V_{app}^2 C_L A_S \]

And where \( \rho \) and \( A_S \) represents the air density and lifting body surface area respectively. Where the difference lies between conventional (massless) flight and crosswind flight is the apparent wind speed \( (V_{app}) \) over the lifting body, as both the tangent (cross) speed \( V_C \), the actual wind speed \( V_w \) and the tether reel-out \( V_T \) will have to be taken into account. Hence the equation for the apparent wind speed is described as follows in equation 5:

Equation 5: 
\[ V_{app}^2 = V_C^2 + (V_W - V_T)^2 \]

Equation 6: 
\[ V_C = \frac{C_L}{C_D} (V_W - V_T) \]

With equation 6, this determines the cross speed on basis of the lift-over-drag-coefficient and effective wind speed. Combining equation 5 and 6 leads to the simplified equation 7:

Equation 7: 
\[ V_{app}^2 = \left( \left( \frac{C_L}{C_D} \right)^2 + 1 \right) (V_W - V_T)^2 \]

Now substituting equation 7 into equation 3 and in turn, equation 3 into equation 2 and 1, the power equation for crosswind flight is determined:

Equation 8: 
\[ P_{cross} = \frac{1}{2} \rho C_L A_S V_T \left( \left( \frac{C_L}{C_D} \right)^2 + 1 \right) (V_W - V_T)^2 \sqrt{1 + \frac{1}{\left( \frac{C_L}{C_D} \right)^2}} \]

Rewriting equation 8 with the ratio \( V_T/V_W \) being 1/3, which is the ratio for maximum power extraction [Loyd, 1980]. Results in equation 9:

Equation 9: 
\[ P_{cross} = \frac{2}{27} \rho C_L A_S V_W^3 \left( \frac{C_L}{C_D} \right)^2 + 1 \sqrt{1 + \frac{1}{\left( \frac{C_L}{C_D} \right)^2}} \]

From power equation for crosswind flight with tether reel-out, it is apparent that the lift-over-drag coefficient is the determining factor with regards to achieving crosswind flight. More specifically, it directly affects (in this model) the crosswind flight speed, and thus the increase in the apparent wind speed. This coefficient is determined by the shape and surface finish of the lifting body, and is a serious design consideration. As increasing the \( C_L/C_D \) exponentially increases the power output of the system, it favours fixed wind systems, which have a higher \( C_L/C_D \) than kite-based systems, thus generate more power. Yet kite-based systems are lighter, in their airborne components, and present less risk of damage during impact on the ground or other (airborne) objects. Hence, there is a design consideration between the use of fixed wing of kite-based airborne components, as discussed in the following paragraph.

It must be stated that this is a simplified model, which neglects the effects of gravity, power consumption during cyclical power generation, additional drag from the tether, other components, etc. on the power generation potential. Still it forms a sound and basic model to highlight the (main) design parameters and principles of a ground-based electricity generation system with a tethered flying lifting body. While there are other configurations and technologies for extracting power from higher altitudes,
using certain parts of the principles presented. Some systems use conventional turbine systems to generate electricity, either suspended in the air by a helium-filled structure or on a crosswind flying wing, while there are also system configurations and technologies that use drag sails to harness wind power or even auto-gyro effect for both lift and power generation. All these different systems and their working principles will be discussed in the following paragraph.

The landscape and developments of AWE technologies

In order to create overview in the large variety of different systems that harness AWE, of which a selection of examples will be presented, two differentiating features are used to form a categorization matrix to sort the different systems along these defining features. While later in this section a description of the AWE niche and its last developments will be given, answering research question 1. The first differentiating factor is whether the electricity generating component of system is airborne or not, with both options having their advantages and disadvantages. The advantage of an airborne or flying generator is that it can generally supply continuous power to the ground and power onboard control electronics. While some of the disadvantages are that the (heavy) generator has to be lifted into the air and the generated electricity has to be conducted to the ground. Whereas ground based generators have the advantages of not having to lift the generator or conduct power from the air, providing continuous power does becomes more difficult. For example, when a system uses the yoyo-principal of reeling the flying body out for power generation, and then reeling it back in while consuming a fraction of the power generated. This intermittent form of power generation can be solved by developing systems using multiple flying bodies, electric storage systems or mechanisms to transfer the mechanical power, adding complexity to the ground component of the system.

The other differentiating factor is how (a part of) the system is lifted to higher altitudes, for which four principals can be defined. These are listed in the table below with a short description of the principal:

<table>
<thead>
<tr>
<th>Lifting principal</th>
<th>Description of working principal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighter-than-air</td>
<td>Inflated structure filled with gases lighter than air to create positive buoyancy</td>
</tr>
<tr>
<td>Fixed wing</td>
<td>Rigid (wing) structure with aerodynamic profile to create lift by pressure difference</td>
</tr>
<tr>
<td>Kite-based</td>
<td>Inflatable structure with aerodynamic profile to create lift and often rigidity</td>
</tr>
<tr>
<td>Autogyro</td>
<td>Rotors rotating due to the wind, thus generating lift, similar to depowered helicopters</td>
</tr>
</tbody>
</table>

To further clarify the differences, particularly between the fixed-wing and kite-based, as both use aerodynamic profiles and Bernoulli’s principal to generate lift like conventional aircraft do. Yet fixed-wing use a rigid metallic or composite wing structure similar to conventional aircraft to achieve lift, whereas kite-based systems use a soft and light fabric-based membrane to be inflated by the flow of wind over the structure or are pre-inflated with pressurized compartments for structural rigidity and
stability. The second lifting principle of kites differs again from lighter-than-air systems, which positive buoyancy of gases like helium or hydrogen to lift the structure rather than using Bernoulli’s principal. The auto-gyro lifting principle uses rotating blades, powered by the wind, to achieve lift. Further examples of these working principals are given through the description of several prototypes and concepts described in the following section.

Makani Power / Google [X]

Although initially starting out with a pumping-kite system, Makani soon switched to a rigid-wing design that lies closer to conventional wind turbines [Ahrens et al., 2013]. The rigid wing structure flies a circular flight path at a tangent to the wind directions, mimicking the motion of the tip of the rotor blade of a conventional wind turbine. Power is generated by small onboard turbines on the wing, generating from the high wind speed of crosswind flight, which is then conducted to the ground via a tether. These turbines become propellers during launch and landing phases of the system, as well as providing (additional) control for maintaining the circular flight path. With this system configuration, continuous power can be generated, and fully autonomous flight was achieved in 2013 [Makani, 2013].

Laddermill

A system devised and patented by the late Dutch astronaut and university professor Wubbo Ockels, derives its name from the multiple kites or flying bodies climbing in altitude and descending in a circular motion. This circular motion is created by the multiple kites tethered in a loop, driving a generator on the ground connected to the loop. In this manner continuous power is generated by ground-based generator while kites ascend to the top of the loop and glide back down. Although combining a ground-based generator with the ability to continuously generate electrical power is an advantage, the complexity of controlling multiple kites in synchronised flight has inhibited the development of a prototype up till now.
SkySails

Initially SkySails Gmbh. developed a traction kite system to reduce the fuel consumption of freight ships, which is achieved by using wind power to provide additional traction for the propulsion of the ship. The kite system flies a figure eight crosswind pattern to generate the optimal pulling force with the inflatable kite. Operating a few hundred meters above the sea, the automated systems is tethered to the bow of the ship. Through the addition of this traction force, the propulsion of the main diesel engine can be reduced, saving on fuel and emissions. The first (pilot) commercial systems are in operation since 2008 [Ahrens et al., 2013]. However SkySails has also the ambition to utilise its developed automated kite technology for generating electricity through the pumping-kite concept, applying it offshore at large-scale [SkySails, 2014].

Kitepower

Originally the research group was setup at Delft University of Technology to investigate the Laddermill concept, the group focussed on developing a better understanding of the mutual interaction between the aerodynamic forces on the inflatable structure and the structure’s resulting deformations. All with the aim of developing larger and better controlled kites for large-scale application. The present Kitepower demonstrator is an single kite system in a periodic pumping mode, flying a figure eight crosswind flight path in reel-out mode (figure 4.8- left) and glides back with minimum drag during reel-in mode (figure 4.8 - right). Because of this pumping mode, the electricity generation is intermittent in
nature, as the system consumes electricity during the reel-in phase. This is resolved by storing a part of the generated electricity during the reel-out phase and controlling the ratio between reel-in and reel-out.

![Figure 4.8 Concept of pumping cycle kite system [Kitepower]](image)

**Ampyx Power**

Ampyx Power is a company based in The Hague, The Netherlands, and is developing rigid wing based system with pumping cycle. It has the same power production cycle as the kite-based pumping cycle previously described, with a reel-out and a reel-in phase seen in figure 9 below. But the main difference is the use of rigid wing plane rather than a kite to capture the power of the wind, which allows easier and more predictable control of the aircraft, and particularly has less drag during the reel-in thus reducing its power consumption. The latter is due to the fact that rigid wings have a higher L/D coefficient than kites, thus allowing the rigid wing plane to gently float down rather than being pulled in to maintain sufficient air speed, shape, and thus lift.

![Figure 4.9 Overview the pumping cycle of the Ampyx system (Ampyx Power)](image)

**KiteGen**

To overcome the intermittence of the original pumping kite system, KiteGen proposes to use kites on a large carousel, thus provide continuous electricity generation through the continuous rotation of the carousel. As the kites fly with the wind direction, thus propelling the carousel, until reaching the outer down-wind position and configuring to minimum drag setup. Then the kites are flown back to an up-wind position, propelled by the carousel, to start the next cycle. Up till now KiteGen has focussed on developing it Stem type system, which uses a single kite at the end of a boom. This pumping-cycle system, controls its kite through the two tethers and a ground-based control unit. First operational system was expected in 2012 [KiteGen, 2014].
NTS Energie- und Transportsysteme

The German based company Nature Technology Systems (NTS) developed a concept similar to KiteGen’s carousel, combining towing kites with a monorail. A circular monorail track is constructed on which cars are propelled by kites, and in turn the movement of cars power generators at either end of the track. This system configuration provides continuous power under adequate wind conditions, and is scalable from medium to large scale electricity generation [Schmehl, 2011].

Altaeros

An alternative approach to harness the higher wind speeds at higher altitudes is using lighter-than-air structures to bring a (conventional) wind turbine to a higher level. Altaeros Energies, an American based early stage company, applies this principal using an aerodynamic shaped ring which channels the airflow into the turbine in the middle. While the buoyant ring provides lift for the turbine, the tether, and itself, its shape also insures that the turbine points into the wind. Altaeros is planning a long-term demonstration project in Alaska under contract of Alaska Energy Authority, highlighting it potential of electrically powering remote and micro-grid communities [Altaeros, 2014].
Sky Windpower

Sky Windpower is a San Diego based corporation which is developing a high altitude Flying Electric Generator (FEG) based on the autogyro principal. The system consists of four rotors attached to a frame which is tethered to the ground. The system lifted to the desired altitude by powering the rotors with electricity from the grid or a stored source. Once the system has reached its desired altitude and has sufficient headwind, it tilts back and begins to float using the autogyro principal. Thus lifting the system using the power of the wind, and tapping into any surplus power to generate electricity, which is conducted to the ground via the tether.

Magenn

Magenn Power Inc. is a Canadian based company that has developed an aerial wind power generator which uses a lighter-than-air structure. The helium-filled cylindrical shaped balloon lifts the system to a higher altitude than conventional wind turbines, facing the wind broadside, and uses vanes to achieve rotation. The rotation has two effects, the first being the generation of electricity through onboard generators, which is then transmitted to the ground via the tether, and the second being the generation of the Magnus effect, thus generating additional lift and stabilizing the rotor/balloon. Although being a simpler technology compared to other AWE technologies, it is also less efficient due to its use of drag sails rather than crosswind flight/rotation. But harnessing higher wind speeds compensates the lesser efficiency, with a prototype developed in 2006 [Schmehl, 2011].

Joby Energy

The final example of AWE technology is the concept of Joby Energy, which is consists of multi-wing structure with multiple turbines. Once the turbines lift the system to an altitude with sufficient wind, a crosswind flight path is initiated to increase the wind speeds across the turbines. Due to the higher wind speeds, the need for a gearbox between the turbine and generator is eliminated, thus increasing reliability and efficiency. The generated electricity is conducted to the ground via the tether to which the system is attached. If the system is required to land, it simply powers the turbines with electricity to safely bring it back on the ground.
Not all the AWE technologies and systems that are being developed or considered, have been discussed in this section, but a selection of most diverse, influential, and discussed technologies. To create an overview of the AWE technologies that are being investigated and developed, and thus giving an impression of the distribution of research effort, the following matrix is presented in table 2 on the next page. This is done by categorizing institutions by the technology they are working on at the moment, using the two differentiating factors discussed earlier in the previous paragraphs.

Not for all possible combinations of the two differentiating feature classifications, are there examples of AWE systems with that specific configuration. As some combinations are less logical to use as a configuration than the more popular ones. For example auto-gyration with a ground-based generator would require the mechanical power of the rotation of rotors to be transferred to the ground, which would be a difficult task to achieve without a very rigid and heavy drive train. A similar argument goes for lighter-than-air system with ground-based generation. Whereas kites lifting generators into the air would counteract the safety advantage of light and soft kites if they would crash to the ground.

<table>
<thead>
<tr>
<th>Lighter-than-air</th>
<th>Kite-based</th>
<th>Fixed-wing</th>
<th>Autogyro</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Airborne generator</strong></td>
<td><strong>Ground-based generator</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>magenn</td>
<td>swiss kite power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALTAEROS energies</td>
<td>KitePower</td>
<td>windward</td>
<td>SKYING POWER</td>
</tr>
<tr>
<td></td>
<td>EnerKite</td>
<td>TWINGTEC</td>
<td>MAKANI POWER</td>
</tr>
<tr>
<td></td>
<td>KITEnergy</td>
<td>Ampyx Power</td>
<td>JOBY ENERGY</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2 Overview of active research on AWE technologies by institutions
**Description of the current developments of AWE and its market**

As is apparent from the description of the different technologies, Airborne Wind Energy is still very much in a niche in fossil-fuel driven landscape, with many variations of the AWE concept. Although there is a conventional wind power regime, or at least close to becoming a regime. It is debatable whether AWE technologies would able to fully integrate with this regime, has additional aspects like the use of air-space and corresponding legislation would require new actors and adjustments to the network to be introduced to the wind power regime.

However in the past decade the number of institutions involved with AWE technologies has grown enormously, with more and more companies being founded and research groups starting, as shown in figure 4.17. Suggesting an increasing interest, and particularly trust, in the potentials of AWE technologies.

![Figure 4.17 Number of institutions involved with AWE technologies from 2000 till 2013 [Ahrens, 2013]](image)

This growing interest and confidence means a lot for a relatively young and radical niche system. Especially as from an early phase an active effort was made, to form an all-inclusive network for the exchange of knowledge and visions. In 2005, a high altitude wind power conference is held in California. But it was not until 2009, the idea of the Airborne Wind Energy Conference (AWEC) was born and lead to the first AWEC in 2010 in Stanford, California. Since then there is an annual conference, alternating each year between the US and Europe [Ahrens et al., 2013]. During the conference in 2013 in Berlin, the speaker’s topics ranged from AWE Enterprises, Investment, Wind & Weather, Legislation, to Technology [AWEC, 2014]. Suggesting that a broad spectrum of knowledge, experiences and visions are being exchanged at such conferences within the niche network.

Perhaps more interesting is the fact that several institutions have changed their focus from one AWE technology (configuration) to another, for example Makani started with a pumping kite concept but switched to an airborne generator on a fixed wing configuration. While Kitepower group moved its focus from the previously discussed Laddermill concept to concentrate on the pumping kite concept, with KiteGen and others make a similar move [Ahrens, 2014]. This all suggests that there is a subtle selection process of technology going on within the niche.

A further selection is starting to occur, as rumours of the first commercial contracts merged in 2013.
KiteGen launched an Italian press release, stating it signed a contract with Sabic to provide its kite technology for generating power for a carbon capture project in Saudi-Arabia [Cleantech Group, 2013]. That same year, Google took full ownership of Makani Power, in which it had invested in from the start, and brought it under its secretive Google [X] arm [Ahrens, 2013]. While Altaeros launches a long-term demonstration project in Alaska in 2014 [Altaeros, 2014]. Suggesting that the first commercial demonstration is not far away, as the niche moves towards the next phase of development. At the same time, through the actor network of niche, several national air safety associations have started making steps towards legislation around the use of AWE technologies and aviation safety.

So looking at the latest trends and activities, niche of AWE is not dying down but rather living up. Although it might take some time for the next big step, the interest and trust in the technology is steadily growing.

**Technological and geographic constraint and case selection**

Although it is tempting to cover all the different technology configurations, discussed in this chapter in the rest of this thesis, including the barrier analysis and selected niche strategy, the choice was made to focus on a single technology group/configuration. The choice was made to safeguard the quality and accuracy of the barrier analysis and resulting niche strategy selection, as it is expected that the differences in technology configurations result in different sets of barriers. Particularly public perception and legislation with regards to safety and reliability will be influenced by the different technical solutions, for example soft inflatable kite versus hard rigid planes flying overhead.

Looking at the categorization of the different AWE technologies, it is clear that most institutions are developing a kite-based system with ground-based electricity generation. With institutions planning large-scale airborne wind energy systems, also focus on pumping-kite systems to develop concepts and test sub-components before scaling up through commercialization. And all this despite the advantage of higher power generation using fixed-wing flying bodies and complexity of controlling kites and other inflatable structures, which suggests that the choice of AWE systems is steered by socio-technical concerns of the wider public. Hence in light of these reasons the choice is made to constrain the technological focus of this thesis to kite-based AWE systems with ground-based power generation.

A similar constraint can be placed on geographic level as well, focusing on specific geographic location or certain types of countries for the thesis. In case of AWE and SNM it is relevant to certain factors like legislation, government policy, public interest in sustainability, energy landscape, infrastructure, etc. Looking at figure 18, it is apparent that the large majority of AWE institutions are based in Western Europe and North America, although there is a higher concentration in Europe and differences in socio-technical factors. Particularly as the population density of Europe influences the design choices of AWE systems, the choice is made to focus on Western Europe as a geographic constraint.

However, within this geographic constraint difference will still occur, while also having similarities with
other regions. This is an inevitable aspect of generalisation of global regions, therefore it is strongly
advised to maintain a critical view on the results of the barrier analysis and be aware of local aspects.

Figure 4.18 Overview of the geographic locations of the 50 institutions involved with AWE technologies in 2013 [Ahrens, 2013]
Chapter 5 – Barriers

The chapter 5 is dedicated to identifying and categorizing barriers to market adoption, for the case of AWE technologies, through the application of the generic barrier framework. Several barrier frameworks, described in literature, are reviewed and adapted to produce a generic barrier framework for categorizing barriers. A barrier framework which is then applied to case of AWE technologies, categorizing and ranking the barriers found in AWE literature. This chapter thus respectively answers research questions 2a and 2b, and develops the first component of the niche strategy selection process.

Generic barrier framework

To answer research question 2a: How can barriers to market adoption be defined, identified, and categorized in general? Several barrier frameworks are reviewed and adapted to form a generic barrier framework. The need for a generic barrier framework arises from the requirement to compare and match barriers from different cases. By comparing and matching barriers from different (historic) cases, the lessons and experience from the past can be applied to current cases with similar barriers. This forms the first component of the generic niche strategy selection process, to match the barriers from the case it is applied to with those of historic cases. Hence, the barrier framework needs to be able to extract or maintain the key features of a barrier, while removing the case-specific information, in order to match it to other cases. Therefore, presented the barrier frameworks in literature are reviewed, adopted and adapted for the thesis.

A literature search and review is conducted as described in the methodology on page 10, the steps and process of which is presented in Appendix A.1. It leads primarily to reviewing two barrier frameworks, presented by Kemp, Schot and Hoogma (1998), and the other by Ortt, Langley and Pals (2013). The latter of the two barrier frameworks is adopted and further adapted, using other literature to strengthen it and make it better suited for application to sustainable innovations. The adaptations places more emphasize on (a lack of) investment and support for sustainable innovations, and on the public image of these innovations regarding nimbyism, which often form barriers in many cases. By adopting and adapting the framework of Ortt et al. (2013), a generic barrier framework is presented to identify and categorize the key features of barriers to market adoption.

Ortt and Suprapto (2011) list twelve factors that need to be present for the large-scale market adoption of an innovation, so if one of the twelve is absent, large-scale market adoption is not possible. Hence, the twelve listed factors represent possible generic barriers to market adoption. These twelve factors are categorized into two groups by Ortt, Langley and Pals (2013), forming a group of core factors and a group of influencing factors. These two groups of six factors each, form 36 combinations that can be linked to suitable niche strategies. These two groups are adopted in this thesis with some alterations, as each group either describes the possible ‘indirect causes’ or ‘direct impacts’ of a barrier. A combination of an ‘indirect cause’ factor and a ‘direct impact’ factor forms a barrier-set, that describes a barrier’s key
features. The groups of ‘indirect cause’ and ‘direct impact’ factors are listed in tables 5.1 and 5.2:

Table 5.1: List of indirect causes from the barrier framework, and their descriptions, adopted from Ortt et al. (2013).

<table>
<thead>
<tr>
<th>Indirect cause</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of technology</td>
<td>Lack of knowledge required to develop, produce and control technology</td>
</tr>
<tr>
<td>Knowledge of application</td>
<td>Lack of knowledge of possible uses or application of prospective technology</td>
</tr>
<tr>
<td>Resources</td>
<td>Lack of skilled labour, materials, space, financial, etc. for product or service</td>
</tr>
<tr>
<td>Socio-cultural aspects</td>
<td>Impact of norms, values and context from society on technology application</td>
</tr>
<tr>
<td>Macro-economic aspects</td>
<td>Competition for resources, markets and innovation from the wider landscape</td>
</tr>
<tr>
<td>Vision &amp; Image</td>
<td>Perception of actors and the broader public of the technology and its potential</td>
</tr>
</tbody>
</table>

Table 5.2: List of direct impacts from the barrier framework, and their descriptions, adopted from Ortt et al. (2013).

<table>
<thead>
<tr>
<th>Direct Impact</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological development</td>
<td>Lack of research and development of prospective technology/product</td>
</tr>
<tr>
<td>Production process</td>
<td>Incomplete production chain for the prospective technology/product</td>
</tr>
<tr>
<td>Complementary products &amp; services</td>
<td>Lack of supporting infrastructure, technologies or services</td>
</tr>
<tr>
<td>Support &amp; investments</td>
<td>Lack of local/partner support or (financial) investment for producer/consumer</td>
</tr>
<tr>
<td>Customers</td>
<td>Lack of customer (market, size, awareness)</td>
</tr>
<tr>
<td>Institutional aspects</td>
<td>Impact of laws, regulations, standards, etc. either positive or negative.</td>
</tr>
</tbody>
</table>

As an example of the barrier categorization; if an innovation cannot get investment or funding, due to investors wanting to see a proof of concept first, the corresponding barrier-set would be; Knowledge of Technology – Support & Investment. Clarifying the functioning and application of the barrier framework to categorize barriers into barrier-sets, using the ‘indirect cause’ and ‘direct impact’ factors.

**Barriers of AWE technologies**

To find barriers presented in literature on AWE technologies, a scientific web-research is done as described in the methodology on page 10. The search was conducted with the following two sets of terms: ‘HAWP’, ‘AWE’, ‘airborne wind’, ‘high altitude wind’ and ‘barrier’, ‘hurdle’. The articles selected from the search are presented with a brief description and their contribution to the barrier analysis, as well as the addition of the report of the non-profit organisation Near Zero found outside of the search.

The report of Near Zero is the result of surveying 31 experts in AWE on how to develop the technologies and what the barriers are faced by AWE technologies. It forms a key source for the barrier ranking, as it surveys many experts from various AWE organizations across the world to rank the barriers faced by AWE. Hence the report was suggested by the Kitepower group at Delft University of Technology.

A market report of the renowned GL Garrad Hassan on the High Altitude Wind Power industry was published in 2011. It presents an insight into the potential of HAWP, and the current standing (at the time) of the developing technologies and the companies. But it is the insight on technical, legal and market challenges that report provides, which is of interest for the barrier analysis of AWE.

A comprehensive book on Airborne Wind Energy by Ahrens et al. was published in late 2013, covering almost all aspects of the technology, as well as several insights into the market of AWE. It presents a dedicated chapter on financing strategies for AWE technologies, which was presented at an AWE conference, in which several barriers are mentioned specific to the financing of AWE technologies.

M. G. Bronstein (2010) presents an assessment on the commercialization potential of HAWP in the U.S.,
which includes technical and non-technical barriers. Although it does not present a list or ranking of barriers, many are addressed and discussed in the paper.

The final written source used is the article of N.A. Megahed (2014), in which landscape assessment is applied to AWE technologies. The methods used, were developed for the location planning of conventional wind farms, and focusing on the alteration in the value of the landscape as perceived by local actors.

Each of the selected sources presents several barriers, often with a description of the context of the barrier, aiding the categorization. The following section presents an overview of the barriers found in the written sources, and these will be described, and categorized using the barrier framework.

**Extracted barriers**

**Nero Zero**

In a survey conducted amongst 31 AWE experts, 10 barriers to development of AWE technology were presented, and were ranked from the highest barrier to the lowest by each expert. The results were combined by counting the number of experts that ranked a specific barrier on ranking position (so 12 experts ranked 'reliability' the highest barrier, and 6 experts ranked it the second-highest barrier, etc.).

The overall combined results of the ten ranked barriers are shown in figure 5.1 below:

![Figure 5.1: Barrier ranking of the Near Zero survey](Near Zero, 2013)

Only a brief description of the context of the barriers is given in most cases, but not why the specific set of ten barriers has been chosen in a pre-survey discussion. With this limited information and further personal interpretation, the ten barriers are categorized into barrier-sets using the barrier framework. This results in several barrier-sets per barrier, and these are ranked and added up using the original presented ranking of the survey. A ranking of the 9 barrier-sets results from this process and is presented below, with a description of the barriers each barrier-set represents:

1. **Knowledge of technology - Technology development**

   The highest ranked barrier according to the survey is the required further development of AWE technology. As there are still technical challenges regarding; reliable operation, (flight) control systems, suitable materials for the tether, and in the case of flying generators, the transmission of the generated electricity (not the case for kite-based AWE technology). A lack of technical knowledge regarding these challenges inhibits the design and manufacture of reliable and proven AWE systems, also resulting in other barriers mentioned below.
2. Vision and Image - Support and Investments
Since there are only a few working prototypes, none of which have so far gone through long periods of operational testing, there is a lot of uncertainty amongst the general public and investors. Particularly regarding how reliable these systems are and what the risk of accidents is. Hence the perception of AWE technology holds back its experimentation and application.

3. Macro-economic aspects - Customers
The lack of long running demonstration experiments also leaves uncertainty about the economics of operating an AWE system, particularly regarding to its capacity factor and maintenance costs and intervals. This withholds customers from installing AWE systems since the operational economic costs are unknown, and more proven alternatives are available.

4. Macro-economic aspects - Support and investments
Uncertainty about the economic performance of (current) operational AWE technologies, also undermines the willingness of investors and others to support and investment in these technologies and their organisations.

5. Knowledge of technology - Institutional aspects
The lack of technical knowledge on the safety and reliability of AWE systems inhibits the formulation of adequate legislation for AWE technologies, particularly regarding air space use and regulations. Hence AWE systems are in a legal void regarding use of air space and safety regulations, inhibiting easy application within the existing air space (legislation).

6. Vision and Image - Customers
The perception of AWE systems also plays a role with the customers of these system, as many questions regarding the operation and safety of AWE systems are still to be answered. Hence, customers might be reluctant to purchase an AWE system until these questions have been sufficiently answered.

7. Resources - Support and Investments
A property of AWE technology is that it has a larger ground footprint has conventional wind turbines due to the flying tether overhead. Whether this footprint should be fully owned by the operator of the system or used in agreement with the (original) owner is not clear at this moment. However, land can be a scarce resource, particularly near density urban centres. So support and investment can be inhibited if this resource has to be shared or purchased at a high cost.

8. Knowledge of technology - Product processes
Most of the research and development has gone towards development of small-scale (prototype/demonstration) systems, while there are plans for large utility-scale systems. While these large systems are not currently being developed and tested, the debate whether AWE technology can be scaled to larger scales is still ongoing. Particularly in the case of kite-based HAWP technology, whether the kites can designed and manufactured to larger scale without too much compromise.

9. Knowledge of technology - Complimentary products or services
The last barrier of the ranking, both the wind resource as the pumping-cycle systems are intermittent in their electrical power production, raising questions regarding its integration with the grid. It is a topic that affects nearly all renewable sources, but should be less of an issue with AWE as the wind resource is more stable and the pumping-cycle fluctuations can be absorbed by the system.
Based on analysis and insight of experts at GL Garrad Hassan, a market report on the application of HAWP systems has been published in 2011. It presents a list of areas for further development and research as well as a list of barriers, the latter of which is categorized using the former as guidance. The listed barriers are presented below, with the corresponding barrier-set directly underneath and a description of the barrier(s). In the report no ranking is given of the influence of the listed barriers.

**Airspace access:**
Knowledge of Technology - Institutional aspects
The safety and reliability of AWE systems, or rather lack of guarantees and solutions to insure it, poses a barrier for AWE systems to gain access to airspace on a regulatory basis. As airspace and airborne vehicle safety is tightly regulated for safety and public concerns, hence AWE technologies much prove their safe operation and insurances to gain access.

**Operational safety:**
Knowledge of Technology - Customers
A similar issue plays with the (potential) customers of AWE technologies, as they are (very likely) responsible for the safe operation of the system and any possible damage it might cause. Hence customers might not be willing to purchase an AWE system, if there are uncertainties about its safety.

**Environmental impact & concept of operation viability:**
Knowledge of Technology - Support and Investment
In order to further develop and deploy AWE systems, support and investment of the wider public and investors is important. But this requires a good concept of the workings and operation of AWE technologies, leading to an understanding with the public of how the system generates its economic potential, deals with operational risks and its (lesser) environmental impact. Two barriers mentioned in the report fall into this category.

**Economic viability:**
Macro-economic aspects - Customers
For customers to investment, purchase or lease an AWE system, the economic viability is of great importance. Hence adequate knowledge of the economic performance of such a system and the wider energy market is required.

**Energy production scaling potential:**
Knowledge of Technology - Product processes
Most AWE systems are being developed at smaller prototypical scale, despite ambitions for utility scale application. Hence it is currently unproven whether these systems can be scaled up to larger scales of energy production and have the desired large contribution to the energy landscape.

**Harnessing rivers of wind**
Assessing the commercial potential of HAWP technologies, the article describes many and relatively specific barriers to HAWP commercialization. These have been extracted and categorized on their description and context, but no distinct list or overview is given of the barriers, nor is a ranking given. Hence, the barrier-sets are presented with a description of the barrier, presented in the article, below.
Focussed on systems operating a 10,000m altitude, concerns are raised over the weight and drag of the tether of such a system. As it presents an engineering challenge regarding materials, drag and costs.

Two aspects of public support for HAWP systems are mentioned, the public support for strong legislation regarding curbing carbon emissions and promoting renewable energy sources, which affects the wider energy market or landscape. As well as public support regarding the safe operation of HAWP systems above public and private land, which is the barrier extracted.

Since the economic downturn, venture capital firms have become more risk averse, thus investing less in more risky technical innovations, like HAWP technologies. While HAWP technologies are also competing with similar renewable technologies like conventional wind turbines for funding.

Customers, whether utility companies or small energy-cooperatives, will require confidence in the operational and economic viability of HAWP systems in order to start placing orders.

Customers should understand and be able to compare the electric energy production of HAWP systems with competing technologies, like PV solar and conventional wind power, to determine the best suited for their needs.

In the initial stages of deployment (of prototypes), the systems will (probably) need more frequent maintenance and repairs than fully matured technologies, thus inhibiting investors and customers. While potentially large airborne platform can also pose a safety risk to personnel and property near a HAWP system, thus reducing backing from the local public and investors.

Although wind resources are more stable and stronger at higher altitudes, they can shift paths and locations, thus impacting on the electricity production of the HAWP system and its economic revenue.

Renewable energy sources and the wider energy landscape has become a political topic, affecting public subsidies, carbon emission policy and renewable energy quotas. All of which also effects the development and implementation of HAWP technologies. While application of HAWP systems at 10,000m presents the risk of mid-air collision and the required aviation legislation.

Investors and developers of HAWP technologies might be at odds regarding when the technology is developed enough to be commercially applied, influencing funding decisions and risk of accidents through technical shortcomings.

Policies regarding renewable energy sources and the fossil fuel landscape might be influenced by the social impact the respective energy source has on jobs, the economy or culture, thus socio-cultural values of an energy source does influence its application in that region.
Macro-economic aspects - Technological development

Seen as the development of HAWP technologies is for a (large) part dependent on subsidies from government and other public bodies, financial deficits of those bodies will have a negative influence on the R&D budgets of HAWP technologies.

**Landscape and visual impact**

It describes essentially three barriers without ranking, based on a comparison between conventional wind power and HAWP regarding visual and landscape impact, but these are specifically described or presented. Hence, the barrier-set is presented with a description of the extracted barrier.

**Vision and Image - Support and Investment**

The idea of flying cables and systems in the sky might reduce the visual sight of a wind energy system, it can result in local actors not backing HAWP technologies because of safety concerns.

**Knowledge of Technology - Customers**

The application of HAWP might be held back by the fact that it is more susceptible to severe weather conditions like lightning and wind gusts. Until proven otherwise, customers for HAWP technologies might not invest or purchase.

**Resources - Customers**

The land footprint of HAWP is larger than wind turbines, despite the foundation being smaller for a similar power-rated system, but the land underneath the flying part of the system might not be viable for alternative uses. Hence it is possible that customers of HAWP systems will have to purchase, rent or arrange agreements of the airspace above large areas of land, for the system’s operation.

**Airborne Wind Energy**

The chapter mentions a few barriers regarding the financing of AWE technologies, both for the development phase and the commercialization phase, based on insights of experts in the field of AWE. These barriers are not distinctly presented, so the description is used to determine the barrier-set.

**Vision and Image - Support and Investment**

Even when demonstration projects have proven that AWE technology is ready for commercialization, there might still be inertia from the general public and investors to the application of AWE, while the technology might suffer from an out-dated image or prejudice, as well as there being further technical challenges to further improve the performance.

**Knowledge of Technology - Support and Investment**

A lack of sufficient data from the few demonstration projects and complete understanding of new innovations within AWE systems, leads to the lack of an in-depth insight into the risks and opportunities of AWE technologies.

**Knowledge of Application - Support and Investment**

An absence of knowledge regarding the applications and business models of AWE technologies, will widen the ‘valley of death’ for AWE technologies. As either the technologies might deliver a return in time or investors can see how it will make that return, thus running out of funding before sufficient revenues have been generated.
Although a limited number of articles have been processed, and their barriers extracted, a large number of barriers have been described and categorized. With the diversity of sources, the extracted barriers should be sufficient to proceed to the following stage.

**Barrier ranking based on literature**

Now that all the barriers have been extracted and categorized from the selected literature sources, the barrier-sets and rankings will be compiled, as described in the methodology on page 12, to form the final ranking on the basis of literature.

The barriers presented in the publications of Near Zero, GL Garrad Hassan and M. G. Bronstein (2010), cover the full breadth of the possible barriers of AWE technologies. While the two other sources, of Ahrens et al. (2013) and N.A. Megahed (2014), only presented barriers with a specific focus on financial and local/environmental barriers respectively. Hence the latter two get a correction factor to represent the narrower focus with regards to overall spectrum of possible barriers. The exact value of the correction factor has very little effect on the barrier ranking, but it is important to reflect the respective focus of the sources and their barriers, to avoid emphasizing certain barriers more than others. In view of all the found sources, financial barriers seem to play an influential but small role, hence it is given a correction factor of 0.1. While the influence of alterations in landscape value by local actors is regarded as a smaller barrier focus, thus a lesser correction factor is given of 0.05. The correction factors are displayed per source in the top row of figure 5.2.

The barriers of each literature source are either ranked or given equal weighing factor per barrier, but with some sources, two barriers are identified with the same barrier-set, then the weighing factors added up. These distributions of rankings, or weighing factors or points are converted to percentages and presented in figure 5.2, as described in methodology chapter (2). For example; if a ranking is given of nine barriers, the highest ranked barrier would get 9 points, the second 8, etc., until one point the lowest ranked barrier. Then the percentages are determined by dividing the awarded points per barrier-set by the total sum of points given per source. If equal points (or weighing factors) are given to barriers, the percentage is determined by dividing the awarded points per barrier-set by the sum of all points awarded per source, thus each barrier-set gets an equal percentage unless it represents multiple barriers. This is done accordingly for the five selected sources in figure 5.2.

Once the correction factors of each source has been determined, and the distribution of percentages over the barrier-sets per source, the overall ranking can be determined. This is done by multiplying each percentage distribution of each source with the corresponding correction factor and adding up all the percentages per barrier-set. The resulting percentages, reflecting the extracted barriers of selected literature, are presented in the column on the far-right in figure 5.2. The darkest coloured cell indicates the highest percentage, and thus the highest ranked barrier-set of the literature sources combined, thus the overall literature-based ranking can be determined from figure 5.2:
The percentages in the column on the right show the percentage of weighing factors or points that each extracted barrier-set has received. The top-8 highest ranked barriers, coloured in darker shades of blue, form more than 78% of all the weighing factors given, leaving less than 22% to the other 8 barrier-sets, hence top-8 is listed below, the eight most influential barriers according to literature sources, forms the literature-based barrier ranking of AWE technologies:

1. Knowledge of Technology – Support & Investment
2. Vision & Image – Support & Investment
3. Macro-economic aspects – Customers
4. Knowledge of Technology – Customers
5. Knowledge of Technology – Institutional aspects
6. Knowledge of Technology – Technological development
7. Macro-economic aspects – Support & Investment
8. Knowledge of Technology – Product processes

**Market situation description**

Taking all the described barriers and insights of the literature sources in to account, a general description of the market situation can be made for AWE technologies. Despite it delving into the detail of the literature sources, it does give an indication of the barriers and challenges that face AWE technologies in general, and answer research question 2b: *What barriers are preventing the market*
adoption of AWE technologies?

Drawing on the literature-based barrier ranking, the absence of fully proven technology, impacts on the confidence of investors, institutions and customers to back the technology. These actors would like to see the technology to have been tested or demonstrated to the full extend for long periods, to remove any doubts about the reliability, performance and safety of an AWE system. These doubts also play a role amongst the general public and other actors, as the image of the technology is not really guided or developed. Leaving it open of uncertainties to arise, particularly about the safety, environmental impact, and performance of AWE systems. This could particularly impact on investors and actors living close-by to the installed AWE systems, as financial backing or local support/acceptance could be missing for (local) AWE projects to succeed. This while the economic competition from the wider energy regime provides a challenge from above, as both fossil-based and renewable energy technologies form strong competition as alternatives for electricity production, thus being challenged on the economic level as well as by local opposition. While the technology itself requires further developed in the aspects of autonomous control and materials, to achieve the desired performance, yet this requires a push in these fields of research. Combining this brief market insight and its sources with the presented barrier ranking, results in a barrier ranking with brief descriptions of the (market situation) challenges behind each barrier, and answers the research question (2b):

1. Knowledge of Technology – Support & Investment
   *Technical challenges inhibit investment and support for further development of kite-based AWE.*

2. Vision & Image – Support & Investment
   *Uncertainty regarding reliability, operation and safety of kite-based AWE amongst the general public and investors.*

3. Macro-economic aspects – Customers
   *Competition of other (renewable) energy systems inhibits a strong market for kite-based AWE customers.*

4. Knowledge of Technology – Customers
   *Lack of experience regarding safety and reliability inhibits customers of kite-based AWE systems.*

5. Knowledge of Technology – Institutional aspects
   *Lack of knowledge and experience inhibits access and regulation of airspace for kite-based AWE systems.*

6. Knowledge of Technology – Technological development
   *Technical challenges regarding control systems and materials inhibit a safe, reliable and marketable AWE product.*

7. Macro-economic aspects – Support & Investment
   *Uncertainty about the economic performance of kite-based AWE systems undermines potential investment and support.*

8. Knowledge of Technology – Product processes
   *Experience and knowledge of the manufacturing of kite-based AWE systems is lacking or minimal.*
Chapter 6 – Niche strategies and links to barriers

This chapter answers three of the six research questions posed in the introduction, regarding niche strategies and their links. Research question 3a will be answered in the ‘Niche strategies’ section, by presenting a generic list of distinct niche strategies found in literature. Research question 4 will be answered in the ‘Overall link matrix’ section, and presents a matrix of the generic links. Research question 3b, the last in this chapter, will be answered in the ‘Interim conclusion’ section, by presenting a ranking of niche strategies suitable for AWE technologies based on literature. In this manner, the chapter first presents two generic components of the niche strategy selection process, building on the available published literature. Before applying the components, together with the AWE barrier ranking of chapter 5, to determine the suitable niche strategies for AWE technologies.

Niche Strategies

Before searching and assessing literature sources on niche strategies, the following (sub) question has to be addressed: What is the definition of niche strategy? In the SNM research community, niche strategy is not a broadly adopted term, and many alternative terms for it seem to exist. Therefore to avoid a misguided search or an incomplete selection, a clear definition is required for the search, selection, and review of the findings on niche strategies from scientific literature.

Although Ortt, Langley, and Pals (2013) clearly use the term ‘niche strategy’, no definition is given. But a definition of the used term ‘niche application’ is given as: A relatively small group of customers with specific wants and demands regarding a product. A term and definition much more focused on the target market of an innovation than the process of SNM, with a similar context given to that of the marketing definition of a niche discussed later on.

Raven (2006) presents the term ‘transition strategies’ and describes it as; not a planned formal strategy to achieve the desired goal, but a process of learning and continuous adjustment to the intentions of actors involved to achieve the desired goal. A description very much in line with the experimental and learning processes of SNM, but could be seen as more of a statement than a definition.

Smith and Raven (2012) states that a defining characteristic of niches; is that they afford temporary ‘protective space’ for the configuration and development of innovations. Also a key notion of SNM, that innovations need a ‘protective space’ during the early stages of their development and market introduction, as is the case with sustainable energy technologies within the existing energy regime.

In the marketing sciences, the term niche strategy has not got a clear and comprehensive definition either. Although focused on marketing strategies, it broadly describes a niche strategy as: A strategy to focus on a smaller segment of market for a product, tailored to the needs and demands of that specific market. Generating better profits or returns through better matching the product to the customer.

So there are many terms aligned or similar to ‘niche strategy’ both in and outside the field of SNM, yet no clear definition for niche strategy is given to guide the following sections. Hence the following
definition is proposed to be adopted and used in this thesis: *A niche strategy is a coordinating process, in which one or a set of experiments are setup, executed, and assessed in a protected niche of the market segment. In order to achieve the wider adoption of the new innovation, through co-development of innovation and market in a niche.*

The proposed definition draws upon the notion of SNM, as presented in chapter 3, and builds upon the presented terms and definitions or Ortt et al. (2013), Raven (2006), and Smith and Raven (2012). It is important to distinguish the proposed definition of ‘niche strategy’ from the definition and concept used in marketing sciences, as there are different contexts that play a role. The marketing sciences definition of ‘niche strategy’ very much focuses on adapting an existing technology to cater an existing consumer base or niche, whereas SNM uses the niche to develop the (immature) innovation/technology and market. These different uses of the niche, is what differentiates SNM from the marketing notion of product introduction, despite similarities in application. As with SNM both the technology and market are too immature to cater for (full) market adoption, thus requiring the protection of the niche to experiment and develop further. While in traditional marketing notion of product introduction, the product and market are assumed to have a good fit and ready for adoption without (socio-technical) barriers. Hence the proposed definition is used, be it with possibly its own short comings, for the following section to guide the search and selection of niche strategies or aligned notions from literature.

**Search and selection of literature sources on niche strategies**

The literature search was conducted as described in the methodology chapter (2), to search for (distinct) niche strategies, using Google Scholar. The search terms were selected to be very effective and yet try to cover the broad spectrum of terms, hence the following terms where used:

niche + strategy* + innovation; niche + strategy* + sustain*; niche + strategy* + transition.

The term niche strategy* was combined with the terms innovation, sustain*, and transition, to direct the search towards niche strategies within the context of SNM. Hence the three latter (search) terms were selected on their relation to SNM theories and cases, despite probably not covering all notions or applications of SNM, nor being very selective or specific in the search in their own right.

After the first 50 search results, the presented results only contained one or two words of the search term, and shown little relevance with the topic, hence the selection stopped at 50. An additional search was done for articles and books published since 2010, using the same approach and search terms. Through the overall search process, a total of seven articles were selected, downloaded and read for further analysis, two of which present interesting and relevant descriptions, a further three provide additional insights. One selected article (Dalgic and Leeuw, 1994) is solely focused on the marketing interpretation of niche strategies. The marketing perspective under-represents the experimental processes in the niche and lacks distinct strategies, despite giving a general overview of the process of niche creation, thus this articles is rejected. Caniêls and Romijn, (2008) was also not selected, although
it provides a good oversight of the field of SNM, but does not specify or discuss distinct niche strategies. The contributions of the five selected articles are presented, along with those of the article of Ortt, Langley and Pals (2013) on niche strategies, in the following paragraph.

Results of selected articles
From each article the extracted information, insight, and further background is presented and briefly discussed. Starting with the two articles with the strongest contributions to this review:

Raven (2006) presents a paper which discusses two patterns, put forward in transition literature as typical in transitions, and assesses their potential as strategies for dealing with lockout of alternatives. These two strategies have been doubted; ‘niche accumulation’ and ‘niche hybridisation’. The first is a strategy that argues for the application of a technology in different niche markets so that the technology/market combination becomes robust. As the innovation moves from one niche market to another (‘niche branching’), the fit between technology and markets improves and increases the innovation’s internal momentum. This triggers a new regime to emerge as it becomes embedded in social and institutional networks, allowing it to be able to better compete with the old technology on mainstream markets. Examples of cases, where this pattern has been identified; are the development of Combined Heat and Power technologies in the Netherlands, the case of biomass combustion in Denmark, as well as solar panels and wind turbines in general. Raven (2006) argues that the rationale of a niche accumulation strategy is that it offers great potential for learning about technology and markets. In the process the technology can be adapted to better suit the market and become more robust, while developers can get feedback from customers. However selecting markets using traditional market research techniques is hampered by the lack information of the insight possible customers have over the technology’s potential. Hence Lynn et al. (1996) argues that there is a need for a ‘probe and learn’ strategy, suggesting markets should be selected on their learning potential rather than economic potential. Another important side-note to the strategy is that there is a limit to how many niche markets can be targeted, due to a limitation of resources and their effective use.

The other strategy is to integrate the new technology with the old into a hybrid design. Usually by introducing the new technology as an add-on onto the old technology within the existing regime, before developing into the dominant design and taking over the regime. According to Raven (2006), the rationale of it is that the technology’s development can thus circumvent the harsh competition against the existing regime, particularly in cases where ‘hard’ infrastructure is an important aspect of the functioning of the regime. Hoogma (2000) describes the hybridisation strategy as a ‘fit-and-stretch pattern’, the innovation starts out as a close fit to the existing regime. But gradually stretches into a radical innovation, either by altering the technology, market, or both. Examples of the hybridisation pattern are given in the cases of; gas turbines for electricity generation, steam propulsion for ships and more recently electric cars [Raven, 2006]. However there is a potential pitfall with this strategy, which is that the existing regime might actively cooperate and/or adsorbs the innovation into the old technology
without changing the regime, as was the case with co-firing biomass in the Netherlands [Raven, 2006]. Raven (2006) also discusses the viability of selecting a strategy, and assumes that a strategy can only be selected after experimentation or on the basis of analysing historic experiments (in other regions). According to Raven (2006), an emergent strategy thus depends on the historical and context conditions of an innovation’s journey thus far, as they define the space for a single actor to manoeuvre strategically, and what strategy is viable for him or her.

Smith and Raven (2012), reviews existing notions of protection and protective spaces, and propose two additions. One addition is focused on the development phases of a niche or protected space, while the other is intended to strengthen the managerial structure within the niche. Starting with the former, Smith and Raven (2012) state that besides the processes of shielding and nurturing taking place in a niche, there is also a process of empowerment. Briefly explaining the phases of shielding and nurturing; the creation of a niche or protective space starts with finding or creating a natural or artificial protection of a market segment. While the guidance of the niche creation is created in cooperation with the engaged actors, who guide and in part guarantee the shielding/protect of the niche market during the experiment’s time span. Once the niche has been adequately shielded, the nurturing of the innovation and the corresponding learning process can start. This is done through the exchange of knowledge, experience and economic transactions, both the innovation and market further develop and strengthen. Smith and Raven (2012) argue that there is an additional phase, in which the innovation becomes empowered enough to breakdown or leave the protection of the niche. This can either be a process in which the innovation becomes competitive with the current regime, or that the innovation has the changed regime to its favour. Although would be logical to see these processes as consecutive phases of a niche, it is also stated that these phases can happen all at once.

The second addition Smith and Raven (2012) propose that the internal relations between the actors in the niche are challenging the productive coordination of the niche. Based on empirical results, difficulties arise in objectively measuring the sustainability, niche performance, and status of the regime, hence the ‘agency’ of managerial actors in the niche need to combine and analyse the internal focus and relations to the wider perspective of the socio-technical landscape. This is especially relevant during the empowerment phase, when the innovation start to cross the borders of protection, and is exposed to the wider regime and any misalignments there might be between the niche and regime.

Nill and Kemp (2009) present and cite some interesting criticisms on SNM and strategy selection, which are adopted to further strengthen the context of the reviewed niche strategies. Berkhout et al. (2004) states that SNM is too much a bottom-up approach, which is supported by the fact that some good niche strategies (e.g. Swiss electric cars) were not good enough to reach a successful technological transition, causing doubt about the potential of SNM as a standalone tool for transition. Nill and Kemp
(2009) state that there is a lack of empirical experience with the selection of SNM experiments. Hence it should be brought to mind that SNM and its strategies are not always sufficient to achieve the desired transition and that there is a lack of empirical data on selecting niche strategies/experiments.

Coenen, Raven and Verbong (2010) wrote a paper with the objective of gaining a better understanding of the conditions under which actors that participate in SNM can leverage the ‘regional advantages’. The ‘regional advantages’ that might take place in these localities for niche experimentation and upscaling. Stating that specific attention for explaining locations is not explicitly present in SNM, the paper does conclude that taking proximity dimensions seriously in SNM helps to unpack processes of upscaling and aggregation. However it also concludes that there is a bias in proximity literature towards advantages of proximity while neglecting potential disadvantages for innovation, aggregation and upscaling.

Smith, Kern, Raven and Verhees (2014) investigates the social construction of ‘protection’, using the case of PV in the United Kingdom, in an attempt to redress the balance between research on innovation development in the niche and the development of the niche protection itself. They observe that creating favourable conditions in an unfavourable context underscores the need for attention to the socio-political processes that narrow the techno-economical development of the innovation. These can also be termed ‘outward-oriented activities’, such as interpreting, representing, and negotiating the innovation in the wider social world, which is absent in earlier theorisation of niche development.

The second observation is that the both the ‘inward-oriented’ and ‘outward-oriented’ processes constitutes and characterises the niche, although the distinction is in practice much more overlapping. Hence Smith, Kern, Raven and Verhees (2014) conclude that a niche can be conceived as the combination of internal developments specific to the innovation and external representations meaningful to the wider social context.

Review and adoption of niche strategies
On reflection of the found articles and their extracted contributions, it can be said that the possible niche strategies or experiments for applying SNM is one the less well investigated areas in the scientific literature, as also represented by the criticism of Nill and Kemp (2009) that there is lack of empirical data on niche selection in SNM literature. However the few extracted articles and contributions are discussed in the following section, before being used to review and strengthen the ten niche strategies presented by Ortt et al. (2013).

Raven (2006) presents two patterns of niche development that have become widely adopted, and gives several case examples of the found patterns, however the link between the described patterns and cases is not further explained and the further distinction is absent. So, although the patterns presented are retraceable in many cases of (sustainable) innovations, further clarification and distinction could drastically help both researchers and users of SNM.

Although taking a different perspective and not strictly focussed on possible niche strategies, Smith and
Raven (2012) do present a strong and logical view on the different processes around a niche's development. The processes of 'shielding', 'nurturing' and 'empowerment' are important for the creation, development and competitiveness of a niche and its innovation, respectively, and should be guided by a managing 'agency'. These findings combine with the findings of Smith, Kern, Raven and Verhees (2014) and those of Coenen, Raven and Verbong (2010), to provide a good insight and possible guide to the creation and management of a niche, and are of use to any practitioner of a niche strategy. On reflection of these articles and sources, the paper of Ortt, Langley and Pals (2013) presents perhaps the most complete overview of niche strategies, backed up by case examples,. After giving a brief overview of the ten presented strategies presented by Ortt et al. (2013), the ten strategies are reviewed with extracted insights from literature sources discussed above, thus leading to the final overview of niche strategies and additional information on their development.

On the basis of the analysis of historical cases of high-tech productions and their introduction into the market, Ortt et al. (2013) identified ten niche strategies. Two of the ten niche strategies identified are the niche accumulation and niche hybridisation, as also presented by Raven (2006). The other eight identified niche strategies, although not presented in other articles as distinct strategies, are mentioned in an indirect manner in literature. Something that can probably be credited to the logical nature of most of these strategies, besides the many historical cases they are based on. But using the findings from the literature search above, it is tempting to integrate them with the ten niche strategies of Ortt et al. (2013). For example, integrating the findings of Smith and Raven (2012) by tagging the niche strategies as 'shielding', 'nurturing' or 'empowerment' oriented processes. But this would not further strengthen the ten niche strategies, as each strategy in essences is capable of 'shielding', 'nurturing' and 'empowering' a niche, and is not described or found in cases to focus on a single phase. Generalising or combing also not seems to contribute to strengthening of the strategies either, as the presented strategies are deemed to have sufficient distinction and affirmation to stand individually.

However there are a few interesting perspectives to be considered over the ten niche strategies presented below. First of all, despite that a distinct can be made between the niche strategies, there appears to be a certain level of overlap and similarities between the strategies. This does open up the possibility in practice of combining or simultaneously using these strategies into a niche development plan. Second, that the tenth and final strategies listed below could be regarded as more of a strategy of strategies. As it argues for innovation application in several niches simultaneously, while each application in turn would require a niche strategy. Still the strengths of the accumulation niche strategy stand with the analysis of historic cases. The ten niche strategies as presented by Ortt, Langley and Pals (2013) are listed in table 6.1, on page 62, and answers the research question of: What niche strategies are identified and described in published literature? With a brief description of the niche strategy, and a historic example of a technology or product that has applied that strategy, given in table 6.1:
Table 6.1: Ten niche strategies as presented by Ortt et al. (2013) and adopted for this thesis.

<table>
<thead>
<tr>
<th>Niche Strategy</th>
<th>Case technology/product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demo, experiment and develop niche strategy</td>
<td>Telegraph</td>
</tr>
<tr>
<td>A niche strategy adopted to demonstrate the innovation in public in a controlled way so the limited quality of performance is not a problem. It allows the innovation to demonstrate its potential, thus generating interest with possible users and backers by increasing their understanding of the technology. While feedback from public can also be a learning experience for the actors involved, and for the development of the innovation.</td>
<td></td>
</tr>
<tr>
<td>Top niche strategy</td>
<td>Dynema</td>
</tr>
<tr>
<td>A niche strategy by which small production runs or hand-made products can be made (to order) for a specific top-end of the market. Thus alleviating the pressure of economies of scale, or skimming the market by supplying top-end first and thus funding the next segment. The article states that a lack of knowledge of technology and resources, which impact through price and quality, can be addressed by this niche strategy.</td>
<td></td>
</tr>
<tr>
<td>Subsidized niche strategy</td>
<td>Clean Energy technologies</td>
</tr>
<tr>
<td>A niche strategy where the use of an innovation, by a particular segment of users, is considered of importance or relevance to society. And hence, the use of which is supported or promoted by subsidized to lower the costs of use for the particular user. The niche strategy is presented as adoptable when the market situation is inhibited when the price is affected by a lack of resources or the production process is undermined.</td>
<td></td>
</tr>
<tr>
<td>Redesign niche strategy</td>
<td>Personal computers</td>
</tr>
<tr>
<td>By redesigning the innovation (product or service), allows to overcome resistance from institutional aspects, customers, backers, or lack of knowledge or resources, if suited alternatives for these barriers are present.</td>
<td></td>
</tr>
<tr>
<td>Dedicated system or stand alone niche strategy</td>
<td>Telephony</td>
</tr>
<tr>
<td>A niche strategy to tackle a lack of (predominantly) infrastructure for the corresponding innovation. The origin of the barrier might be a simple lack of infrastructure as innovation has not had time to develop the infrastructure or use pre-existing infrastructure, or can be caused by a lack of support to fund a large investment in the required infrastructure with the high risks and costs as reasons.</td>
<td></td>
</tr>
<tr>
<td>Hybridization or adopter niche strategy</td>
<td>Electric-hybrid cars</td>
</tr>
<tr>
<td>As described by Raven (2006), a niche strategy to enter the market is to introduce the innovation as an additional feature or add-on for the regime’s technology, thus the conflict between new and old is less and the innovation can make use of the existing infrastructure through either the regime technology or an adapter or convertor. There is the risk of remaining in the current regime by lacking distinction from it or absorption by it.</td>
<td></td>
</tr>
<tr>
<td>Educate niche strategy</td>
<td>Semiconductor and transistor technology</td>
</tr>
<tr>
<td>To address a lack of knowledge and understanding amongst customers, backers and suppliers, a niche strategy with a focus on education is presented. This can be to share and exchange knowledge through forums or conferences, to stimulate the development of knowledge at universities and similar research centres.</td>
<td></td>
</tr>
<tr>
<td>Geographic niche strategy</td>
<td>Dynamite</td>
</tr>
<tr>
<td>A change in or specific protection by a geographic area is a way to circumvent institutional aspects, a lack of resources, suppliers or customers, or past-events that have had a negative impact on the innovation’s image. The niche strategy can thus tackle a diverse range of barrier-sets, by finding or relocating niche experiments.</td>
<td></td>
</tr>
<tr>
<td>Lead user niche strategy</td>
<td>Certain high-end sports equipment</td>
</tr>
<tr>
<td>A niche strategy which finds innovators or lead users to co-develop and experiment with the innovation, thus furthering its development and corresponding knowledge. It is particularly suitable for adoption when a lack of application knowledge is hampering the innovation, but also when its image or macro-economic aspects denied a larger group of users.</td>
<td></td>
</tr>
<tr>
<td>Explore multiple markets niche strategy</td>
<td>Memory metal</td>
</tr>
<tr>
<td>The final niche strategy presented by Ortt et al. (2013) is a broader strategy of deploying the innovation in multiple applications simultaneously to build on and others strengths has the niches progresses. Particularly tackling a lack of knowledge of application, but with various direct impacts, it seems the best suited strategy of this indirect cause.</td>
<td></td>
</tr>
</tbody>
</table>
Linking barriers to niche strategies

Now that the niche strategies have been identified, categorized and described in the previous section, the following step can be made to link them to the barriers. Ideally this would be done, during this stage of the thesis, using literature sources to build up a strong and widely supported overview of the links. However a quick search on Google Scholar (using the terms barrier, strategy, niche, and link), and the search experience of the niche strategies, shows that there is very little written about the subject. Only one relevant article was found during the web search, and the fact that only a few articles were found on niche strategies, it is assumed that no further articles and research has be done into the links other than that of Ortt et al (2013).

Hence an alternative plan is set up to achieve the desired outcome of linking the barriers to the appropriate niche strategies. Using the links presented by Ortt et al. (2013) between market situations and appropriate niche strategies, a translation will be made to the links between barrier-sets and niche strategies. However not all barrier-sets are linked, so some barrier-sets will received proposed links that will be based on a case example, as discussed at the relevant point later on.

Interpretation & categorization
One point to bear in mind is that the market situations, as presented by Ortt et al. (2013), need to be translated to one or several barrier-sets of the barrier framework. This translation creates an opportunity for subjective interpretation to alter the perceived situation, and is one of many steps/translations from an actor’s experience of barriers to a selected niche strategy. However, this is a necessity of the proposed process of niche strategy selection, as it heavily relies on the categorization of both the barriers and niche strategies. Hence, as interpretation will always affect the process, the links between barriers and niche strategies will be well described and try to follow intuitive paths. This should produce a transparent and reproducible selection process, using the links between the barrier-sets and niche strategies as a component. Starting with the work of Ortt et al., translating the market situation descriptions per niche strategy to barrier-sets, linking them to suitable niche strategies.

Links from J.R. Ortt et al. (2013)
The article of Ortt, Langley and Pals (2013) presents ten niche strategies, each with description of market situations for which that strategy can be applied, based on historic cases. The description of market situation, in some cases, already uses the factors also presented by Ortt et al. (2013), but does not list a set of barrier-sets to describe the market situations. Hence each market situation description will be interpreted and given several barrier-sets to reflect the description, as presented in table 6.2. Starting with the first niche strategy presented, demo, experiment and develop niche strategy, the description strongly points out its suitability for addressing a lack of technological knowledge. It achieves this by demonstrating the technology or innovation to the general public or interested actors in the protected and controlled manner, reducing the impact of the less developed aspects of the
innovation. Reflecting that the lack of technological knowledge impacting on customers, investors and the broader public, thus inhibiting adoption of the innovation, the presented barrier-sets are selected. The top niche strategy is described to be suited for addressing situations where a lack of technological knowledge or resources impacts the price and quality of the innovation, partially impacting on the further development towards the (mass) production process. Hence it is interpreted as the impacting on the customers and the production process, resulting in the presented barrier-sets, and is addressed by focussing on the higher end of the market, with greater spending power, with smaller or specialized production runs.

The subsidized niche strategy can be adopted if a lack of technological knowledge or resources affect the product or production process, and impact the price and development of the innovation. Particularly as the innovation is considered as relevant or important for society, hence justifying the subsidization using public money. This situation is represented by the presented barrier-sets, with the causes of knowledge of technology and resources impacting in several ways, but ultimately as a under developed or expensive product or service.

The redesign niche strategy is described to be suited when the economic performance, institutional aspect or a lack of customers or support, impacts the adoption of the innovation. This can be caused by a lack of knowledge regarding application or technology, resources or socio-cultural aspects, hence the presented barrier-sets where chosen. The niche strategy addresses this by altering the design of the innovation to circumvent these barriers.

The dedicated system or standalone niche strategy addresses a lack of supporting infrastructure or strong competition in the wider market by focussing on a standalone or isolated application market. Hence overcoming or circumventing a lack of technological knowledge impacting on the complementary services and products, and/or lack application knowledge or macro-economic factors inhibiting wider support and investment, which are the chosen barrier-sets.

Dealing with a similar situation, the hybridization or adopter niche strategy is presented as a suitable response. By letting the innovation supplement existing technologies, it can befit from existing infrastructure, services and the economic regime, until the regime and/or technology has altered to the point it can sustain itself and go mass-market independently. Mentioned in several articles as suited to addresses a lack of complementary products and services, the presented barriers are focussed on this direct impact.

The educate niche strategy is presented by Ortt et al. (2013) as suitable when a lack of knowledge of technology or aligned resources exists. This impacts businesses and organizations by the absence of a (niche) market, as customers and backers are unaware, under- or misinformed of the technological potential of the innovation. Hence the presented barriers are chosen to reflect this market situation, and can be addressed by the strategy through educating and spreading the knowledge with the relevant institutions.
The geographic niche strategy, is perhaps one of the more intuitive strategies, is presented by Ortt et al. (2013) has a suitable strategy for several market situations. The barriers and market situations are tied to local market conditions like available infrastructure, legislation, and users, which can be circumvented by moving to another regional market. Ortt et al. (2013) also presents several sets of factors which have been translated to the barrier-sets presented in table 6.2.

The lead-user niche strategy is focused on finding or involving innovators or lead users in the co-development and application of an innovation, by creating a ‘learning-by-doing’ experiment for specific applications usually. It can be adopted to address a lack of application knowledge or the innovation reputation requires a lead user or champion to promote its use or application.

The explore multiple markets niche strategy is presented by Ortt et al. (2013) as suitable to explore different applications of the innovations. Directly tackling a lack of knowledge of application, which can impact an organization or business in several ways, based on which the presented barrier-sets are selected.

<table>
<thead>
<tr>
<th>Niche Strategies</th>
<th>Market situation suitable for adopting niche strategy</th>
<th>Barrier-sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demo, experiment and develop niche strategy</td>
<td>Knowledge of the technology is lacking and that affects the availability of the product itself because the functionality is not provided with sufficient quality.</td>
<td>Knowledge of Technology – Customers Knowledge of Technology – Support &amp; Investment</td>
</tr>
<tr>
<td>Top niche strategy</td>
<td>Knowledge of the technology is lacking and that affects the availability of the product for a reasonable price. Knowledge of the technology is lacking and that affects the production system with which controlled production of products with a constant and good enough quality and reasonable price is possible. Resources for the product or the production are lacking or very expensive and that affects the product’s price.</td>
<td>Knowledge of Technology – Customers Knowledge of Technology – Production process Resources – Customers Resources – Production process</td>
</tr>
<tr>
<td>Subsidized niche strategy</td>
<td>Knowledge of the technology is lacking and that affects the availability of the product or the production system and that in turn affects the availability of the product for a reasonable price. Resources for the product or the production are lacking or very expensive and that affects the product’s price.</td>
<td>Knowledge of Technology – Production process Knowledge of Technology – Technological Development Resources – Customers Resources – Technological Development</td>
</tr>
<tr>
<td>Redesign niche strategy</td>
<td>Knowledge of the technology is lacking and that affects the availability of the product or the production system and that in turn affects the availability of the product for a reasonable price. Resources for the product or the production are lacking or very expensive and that affects the product’s price. Knowledge of the application of the product is missing or socio cultural aspects affect the availability of appropriate institutional aspects (laws, rules and standards) and thereby hamper diffusion.</td>
<td>Knowledge of Technology – Technological Development Knowledge of Application – Institutional aspects Resources – Customers Socio Cultural aspects – Support &amp; Investment</td>
</tr>
</tbody>
</table>
Socio-cultural aspects affect the availability of suppliers or customers.

<table>
<thead>
<tr>
<th>Dedicated system or standalone niche strategy</th>
<th>Knowledge of the technology is lacking and that affects the availability of complementary products and services.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybridization or adopter niche strategy</td>
<td>Knowledge of the technology is lacking and that affects the availability of complementary products and services. Resources are lacking and that affects the availability of complementary products and services.</td>
</tr>
<tr>
<td>Educate niche strategy</td>
<td>Knowledge of the technology is lacking and that affects the availability of suppliers or customers.</td>
</tr>
<tr>
<td>Geographic niche strategy</td>
<td>Knowledge of the technology or its application is lacking and that affect the availability of appropriate institutional aspects (laws, rules and standards). Resources are lacking affecting the availability of the product or complementary products and services. Socio-cultural aspects or macro-economic aspects affect the availability of suppliers, customers and appropriate institutional aspects. Accidents and unexpected events affect the availability appropriate institutional aspects.</td>
</tr>
<tr>
<td>Lead user niche strategy</td>
<td>Knowledge of the application of the product is missing and that affects a clear view on customer applications, specific product requirements and customer segments by suppliers. Socio-cultural aspects, Macro-Economic aspects or accidents and unexpected events affect the availability of suppliers or customers.</td>
</tr>
<tr>
<td>Explore multiple markets niche strategy</td>
<td>Knowledge of the application of the product is missing and that affects the availability of a clear view on applications, usage patterns and product benefits by customers.</td>
</tr>
</tbody>
</table>

Knowledge of Technology – Complementary Products & Services
Knowledge of Application – Support & Investment
Macro Economic aspects – Support & Investment

Knowledge of Technology – Complementary Products & Services
Knowledge of Application - Complementary Products & Services
Resources - Complementary Products & Services
Knowledge of Technology – Customers
Knowledge of Technology – Support & Investment
Resources – Technological Development
Knowledge of Technology – Institutional aspects
Macro Economic aspects – Support & Investment
Vision & Image – Support & Investment
Vision & Image – Customers
Resources – Complementary Products & Services
Knowledge of Application – Technological Development
Knowledge of Application – Customers
Macro Economic aspects – Support & Investment
Vision & Image – Support & Investment
Knowledge of Application – Production process
Knowledge of Application – Support & Investment
Knowledge of Application – Customers

Links from own reading of remaining links
The reverse linking of niche strategies to barrier-sets, according the market situation description of Ortt et al. (2013), leaves 16 barrier-sets without a niche strategy to be adopted. Ortt et al. (2013) states that no all combinations of factors in their article are relevant, as certain combinations of direct impacts and indirect causes are not relevant or possible. However 16 of 36 barrier-sets are a significant share of the barrier-sets, and the relevance of barrier-sets is subject to interpretation by users. Further research into historic cases and experimentation with selecting niche strategies on the basis of barrier-sets should further substantiate the relevance of barrier-sets and their links, but this is not possible within the time constraint of the thesis. Hence, in this paragraph, proposed links will be presented for the remaining 16 barrier-sets to complete the matrix of links, in order to provide an answer when one of the 16 unlinked
barrier-sets is selected and ranking, due to either an alternative interpretation or broader identification of barriers. Each barrier-set will be given a brief description of a corresponding market situation as well as being coupled to a case example of an innovation, thus providing an intuitive connection between barrier and niche strategy by the presented cases, despite a lack of time for detailed examination.

**Macro-economic aspects – Institutional aspects**

An example market situation of this barrier-set is global competition on the wider regime level leading to legislation and regulation of the innovation. A case example of this is the legislation in US in the 1970’s regarding supersonic aircraft, which only allowed 16 Concorde supersonic aircraft access to 13 designated entry points in the US, and any new aircraft had to meet stricter FAA noise emission standards. A decision viewed as a highly political compromise, and arguably made to protect the interests of US aerospace industry [Ross, 1978]. Hence the following niche strategies are proposed as suitable response to such a market situation:

*Top niche strategy, redesign niche strategy*

**Macro-economic aspects – Customers**

Strong competition from the wider technological regime impacts on the size of the customer market, by either a better product or/and lower price. Perhaps a barrier-set interpretable on different levels, from the general higher prices of new innovations to more case specific situation in which the innovation struggles with macro-economic aspects. As an adoptable response, the following niche strategies are proposed:

*Subsidized niche strategy, top niche strategy, redesign niche strategy*

**Macro-economic aspects – Complementary Products & Services**

Economic forces prevent the availability of the required infrastructure and services for the innovation, an example case could be argued around the proposed route for the Superbus for the Zuiderzeelijn. The Superbus is a new form sustainable high speed transport, with a radical rethink of the vehicles, infrastructure and logistics, and to achieve the 250km/h maximum speed, special dedicated infrastructure is required to separate the streamlined electric buses from conventional traffic on long distances. But in the case of the Zuiderzeelijn, it could be argued that uncertainty and competition of (cheaper) rail-based options, prevented the investment in Superbus infrastructure for the route, in light of this case and barrier-set the following niche strategies are proposed:

*Hybridization or adopter niche strategy, lead-user niche strategy, dedicated system or standalone niche strategy, Geographic niche strategy.*

**Macro-economic aspects – Production Process**

Limitations regarding suppliers, production capacity or knowledge of production due to macro-economic competition from other technologies or economic circumstances inhibit the innovation’s
production. A case where these conditions were overcome is the DeHavilland DH.98 Mosquito during the Second World War. A lack of sufficient resources and production capacity of metal alloys, limited the production of fighter and bomber aircraft in the United Kingdom [Howsawi et al., 2011]. Hence the design, development and production of a largely plywood aircraft, which was the fastest military aircraft at the time, alleviated the shortage of aircraft from the limited metal aircraft production. Hence the following niche strategies are proposed for this barrier-set: 
Top niche strategy, redesign niche strategy, lead-user niche strategy.

Macro-economic aspects – Technological development
Wider economic competition gives prioritization to the development of other technologies than the innovation. This can be seen with the amount of subsidies granted to existing technologies compared to new innovations, which is particularly due to risk avoidance, it results however in less technological development of new innovations in competition with existing technologies. In response to this the following niche strategies are proposed: 
Geographic niche strategy, educate niche strategy, lead-user niche strategy, demo, experiment and develop niche strategy.

Vision & Image – Institutional aspects
The reputation of the innovation leads to negative, or alternatively a lack of, legislation, preventing its use within the institution’s jurisdictional space. An early mention example case is the Nobel’s production of Dynamite, which after some accidents, causing changes in the innovation’s perception and corresponding legislation, moved the production to the UK [Brown, 1998]. Hence the following niche strategies are proposed as adoptable for this barrier-set: 
Geographic niche strategy, redesign niche strategy, educate niche strategy.

Vision & Image – Complementary Products & Services
The (radical) image of the innovation inhibits the creation or use of the required infrastructure and services. A case of where an innovation is confronted by this barrier-set is magnetic levitation technology (Maglev), which is a new alternative form of (very) high-speed public transport. However it has not commercialized, despite a half century of development, due to high costs of the infrastructure and inflexibility to connect with other infrastructure [Nash, 2009]. So the new and radical image, in spite of several test tracks, inhibit the creation of the required infrastructure for Maglev services, thus the following niche strategies are proposed to be adopted as a response to this barrier-set: 
Geographic niche strategy, redesign niche strategy, hybridization or adopter niche strategy.

Vision & Image – Production Process
The innovation’s reputation inhibits the availability of suppliers and the production process, as public pressure forces suppliers to be involved with the industry or making it uneconomical. A case example is
Siemens stopping its nuclear power arm of the business, in light of the Fukushima nuclear disaster and the closure of German nuclear plants [Joskow and Parsons, 2012]. Hence the following niche strategies can adopted to overcome this barrier-set:

*Redesign niche strategy, educate niche strategy, lead-user niche strategy.*

**Vision & Image – Technological Development**

Due to the innovation’s reputation or perception the development of the innovation is inhibited. It can be argued that once an innovation’s reputation or image has become negative in the public’s eyes, like other discussed cases as nuclear power and hypothetically genetically modified crops, it prevents further technological development of the innovation. The following niche strategies are proposed as adoptable responses to this barrier-set:

*Educate niche strategy, lead-user niche strategy.*

**Resources – Institutional aspects**

An example market situation of this barrier-set is the influence of geo-politics on the availability and price of resources and markets. For example, 97% of the global supply of rare-earth metals comes from China, which has made large cuts to the amounts allowed for export, causing prices to increase sharply and triggering uncertainty on the world market [Massari and Ruberti, 2012]. In other words, the global competition for resources leads in some cases to legislation, to protect national interests, which impacts on the availability of these resources. The following niche strategies are proposed as suitable responses:

*Redesign niche strategy, top niche strategy, geographic niche strategy.*

**Resources – Support & Investment**

Lack of resources inhibits the required support and/or investment for the innovation. A very direct example of this is the impact of the financial crisis in 2008 on investments in innovation in Europe [Archibugi and Filippetti, 2011]. Has financial resources quickly dwindled, it limited availability affected the amount of investment and support (sustainable) innovations received, however as other cases can also be described by this barrier-set, thus the following niche strategies are therefore proposed:

*Redesign niche strategy, geographic niche strategy, subsidized niche strategy, top niche strategy.*

**Socio-cultural aspects – Institutional aspects**

Legislation based on socio-cultural values inhibits an innovation from entering a market, an example case of this is the differences in cultures between the United States and European Union regarding dealing with scientific uncertainty. This is reflected in the different regulatory approaches to genetically modified food crops, with EU having banned them for consumers’ consumption and US growing them commercially [Strauss, 2008]. Based on this case of the barrier-set, the following niche strategies are proposed for adoption in such a market situation:

*Geographic niche strategy, redesign niche strategy, educate niche strategy.*
Socio-cultural aspects – Customers

Values and norms of customers inhibits the creation of a market for the innovation. One could argue this to be the case with genetically modified food, as the public raises ethical concerns about its development, production, and use [Frewer et al., 1997]. While it is interesting to note that this had more of an impact in Europe than the United States, suggesting socio-cultural influences. The following niche strategies are proposed:

Geographic niche strategy, redesign niche strategy, educate niche strategy, lead-user niche strategy.

Socio-cultural aspects – Production Process

The production process of the innovation is impacted upon by the breach of socio-cultural values during or by the production process. An example of this barrier-set is animal testing, often forming part of cosmetic and medical development and production, while the public opposition against the use of animal testing varies from country to country, there is no consistent relationship to scientific knowledge [Pifer et al. 1994]. Public attitudes to animal testing as production process varies per country or region, although there is a movement to develop and use alternatives to animal testing in line with socio-cultural values. The following niche strategies are proposed to be usable responses to this barrier-set:

Redesign niche strategy, geographic niche strategy, educate niche strategy.

Socio-cultural aspects – Technological Development

Values and norms of customers inhibits the technological development and research into the innovation. One example case of this is genetically modified food, as the public raises ethical concerns about its development, production, and use [Frewer et al., 1997]. While it is interesting to note that this had more of a (regulation) impact in Europe than the United States, hence the following niche strategies are proposed:

Redesign niche strategy, geographic niche strategy, educate niche strategy.

With the proposed niche strategies for the remaining 16 barrier-sets, all barrier-sets have been linked to niche strategies that are deemed a suitable approach to the barrier-set. For most of the 16 barrier-sets an example case of the (barrier) situation is given, to give an intuitive feel to the barrier-set and how the proposed niche strategies can alleviate it. This forms the argumentation behind the link between the barrier-set and corresponding niche strategies, with further validation following in chapter 8.

Overall link matrix

By combining the links based on the niche strategies by Ortt et al. (2013) and the intuitive links of the remaining 16 barrier-sets, a complete matrix linking the barrier-sets with niche strategies presented in table 6.3. The coloured cells each represent a link between the respective barrier-set and niche strategy in the matrix on page 71. The matrix of links presented in table 6.3 answers research question 4; which niche strategies are linked to which barriers as suitable responses?
<table>
<thead>
<tr>
<th>Barrier-set:</th>
<th>Niche strategies:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect cause</td>
<td>Direct impact</td>
</tr>
<tr>
<td>Knowledge of Technology</td>
<td>Institutional aspects</td>
</tr>
<tr>
<td></td>
<td>Customers</td>
</tr>
<tr>
<td></td>
<td>Complementary Products and Services</td>
</tr>
<tr>
<td></td>
<td>Production Process</td>
</tr>
<tr>
<td></td>
<td>Technological Development</td>
</tr>
<tr>
<td></td>
<td>Support &amp; Investment</td>
</tr>
<tr>
<td>Knowledge of Application</td>
<td>Institutional aspects</td>
</tr>
<tr>
<td></td>
<td>Customers</td>
</tr>
<tr>
<td></td>
<td>Complementary Products and Services</td>
</tr>
<tr>
<td></td>
<td>Production Process</td>
</tr>
<tr>
<td></td>
<td>Technological Development</td>
</tr>
<tr>
<td></td>
<td>Support &amp; Investment</td>
</tr>
<tr>
<td>Macro-economic aspects</td>
<td>Institutional aspects</td>
</tr>
<tr>
<td></td>
<td>Customers</td>
</tr>
<tr>
<td></td>
<td>Complementary Products and Services</td>
</tr>
<tr>
<td></td>
<td>Production Process</td>
</tr>
<tr>
<td></td>
<td>Technological Development</td>
</tr>
<tr>
<td></td>
<td>Support &amp; Investment</td>
</tr>
<tr>
<td>Vision &amp; Image</td>
<td>Institutional aspects</td>
</tr>
<tr>
<td></td>
<td>Customers</td>
</tr>
<tr>
<td></td>
<td>Complementary Products and Services</td>
</tr>
<tr>
<td></td>
<td>Production Process</td>
</tr>
<tr>
<td></td>
<td>Technological Development</td>
</tr>
<tr>
<td></td>
<td>Support &amp; Investment</td>
</tr>
<tr>
<td>Resources</td>
<td>Institutional aspects</td>
</tr>
<tr>
<td></td>
<td>Customers</td>
</tr>
<tr>
<td></td>
<td>Complementary Products and Services</td>
</tr>
<tr>
<td></td>
<td>Production Process</td>
</tr>
<tr>
<td></td>
<td>Technological Development</td>
</tr>
<tr>
<td></td>
<td>Support &amp; Investment</td>
</tr>
<tr>
<td>Socio-cultural aspects</td>
<td>Institutional aspects</td>
</tr>
<tr>
<td></td>
<td>Customers</td>
</tr>
<tr>
<td></td>
<td>Complementary Products and Services</td>
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<tr>
<td></td>
<td>Production Process</td>
</tr>
<tr>
<td></td>
<td>Technological Development</td>
</tr>
<tr>
<td></td>
<td>Support &amp; Investment</td>
</tr>
</tbody>
</table>
However it is interesting to note, that the identified links in table 6.3 have come forward thorough two different approaches. The links interpreted from the descriptions of Ortt et al. (2013), are derived from the barrier-set (or factors) identified with niche strategies in historic cases. Hence, the links are made from the niche strategies to the barrier-sets, or from the top-down. Whereas with the remaining 16 barrier-sets, the reverse approach had to be adopted, linking from barrier-sets to corresponding niche strategies or bottom-up. The biggest difference in the approaches is the different argumentations for the links, as the top-down approach is based on the historic cases investigated by Ortt et al. (2013), whereas the bottom-up approach is based on intuitive interpretation of a case example. Hence the results are presented in the link matrix table with two different shades of blue, dark blue for the top-down approach results and a lighter shade of blue for the bottom-up approach. Through the application of both approaches, all 36 barrier-sets have (proposed) links to corresponding niche strategies, thus improving the robustness (to different interpretations) of the niche strategy selection process.

Niche strategy selection for AWE

This chapter has developed a list of niche strategies and matrix of the links between barrier-sets and niche strategies, which form the latter two components of the niche strategy selection process, and answers research questions 3a and 4 respectively. The two components are combined with the barrier ranking of chapter 5 to determine the suitable niche strategies for AWE technologies, answering research question 3b: Which niche strategies are suitable for the market adoption of AWE technologies?

The textbox on the right shows the niche strategy ranking for AWE technologies, ranked to suitability as response to the barrier ranking of chapter 5. With the selected niche strategies resulting from the application of the niche strategy selection process.

The basic working of the niche strategy selection process, developed from literature in stages 1 and 2 is explained below in figure 6.1 with an example of the process and its steps.

**Figure 6.1: Overview of an example of the niche strategy selection process.**

**INPUT: Barrier ranking:**
- 1. Knowledge of Technology – Support & Investment
- 2. Knowledge of Technology – Institutional aspects
- 3. Vision & Image – Technological development

**Output: Niche strategy selection process:**
- 1. Demo, experiment and develop niche strategy (3 points)
- 1. Educate niche strategy (5 points)
- 1. Geographic niche strategy (2 points)
- 1. Explore multiple niches niche strategy (1 point)
- 1. Lead-user niche strategy (1 point)

The barrier ranking, consisting of ranked barrier-sets, is used as input to reflect the market situation of the innovation. The barrier-sets are then linked to the corresponding niche strategies, and giving points in the inverse order to the ranking. The points are added up to determine the ranking of the niche strategies, best suited for the market situation.
Chapter 7: Interview structure & results

To bolster the findings so far, regarding barriers, niche strategies, and their links, a selected group of experts in the field of kite-based AWE technologies have been interviewed. The results of which will serve two purposes, to potentially further expand the findings with new insights, and foremost to validate the findings from literature. The results of the interviews are presented in this chapter, partially processed and summarized, to give insight of what has been said and done during the interviews with minimum distortion. Giving the reader a comprehensible and clear insight into the perspective of the interviewed experts, before the results and perspectives are used in the validation chapter (8).

Interview structure & analysis

As discussed in the methodology chapter, on page 13, it was decided to use adjusted individual interviews as interview technique, hence this section will explain how the interview technique is applied and analysed. The general structure, introduced in the methodology chapter, will be further elaborated on regarding its application in this thesis, and the goals of the interview linked to the questions and assignments. The three types of analysis, introduced in the methodology to process the results and answers of the interviews, will also be further elaborated on and linked to the questions of the interview. With in the final paragraph the selection of experts in the field of kite-based AWE, to be interviewed, is presented and discussed. Giving the introduction and framework for the interview results presented in the next section.

Interview structure & questions

Four goals have been set out to be achieved by interviewing with experts in the field of kite-based AWE technologies. The first goal is to determine the experts’ views and expertise, serving both as a quality measurement and a potential source of additional information. The second goal is to let the expert rank his own barriers using the presented barrier framework, to validate the barrier framework and indirectly providing data for the validation of the other components of the selection process. The third goal is to inquire to the expert’s opinion and level of agreement on the presented literature findings, both directly validating the findings and forcing the expert to review his own perspective on the matter. The final goal set out for the interviews, is to survey the expert’s opinion of the use and trustworthiness of the overall selection process, from barrier categorization to niche strategy selection, giving insight to the contribution of the selection process to an organization.

The four goals presented above are combined with the general structure, presented in the methodology on page 13, to form the interview structure and questions. The general structure of the interview consists of three phases, with each phase comprising of three steps. Each step is either a set of initial questions, an interactive component, or a set of reflective questions on the presented literature findings. The resulting structure and formulated questions and exercises are presented in figure 7.1 on page 74, showing the phases and steps (SX) of the interview and corresponding questions.
Fig. 7.1: Interview structure and question sheet

Phase 1 - Barriers & ranking

Q1: In your opinion, what is the status of the market for AWE technologies?
Q2: What withholds or barricades the commercialization of AWE technologies?
Q3: Which 3 barriers do you deem the most influential in blocking market adoption?

Ex1: Present and explain the barrier framework and its categorization
Ex2: Allow the expert to determine, construct and rank the barriers to AWE technologies (rank top 5 of barriers)
Ex3: Present and explain the method of the barrier ranking from written sources

Q4: With what barriers would you agree and which would you discard from the written sources ranking?
Q5: Is the market situation, in your view, adequately described by the ranking?
Q6: What could be further improvements on the ranking?

Phase 2 - Niche strategies

Q1: What strategy or approach would like you to see or expect to tackle the barriers to commercialization of AWE technologies?
Q2: Are you familiar with Strategic Niche Management?

Ex1: Present the reviewed Niche Strategies

Q3: Are the niche strategies well defined to their intent and application?
Q4: Are, in your opinion, all possible strategies covered?
Q5: Can niche strategies be regarded as single independent entities, or can they be combined?

Phase 3 - Links between barriers and niche strategies & Selection process

Q1: What niche strategies would form a suitable reply to the ranked barriers?
Q2: How do you see the niche strategy circumvent, overcome or tackle the barriers?

Ex1: Present links between barriers and niche strategies to experts and the wider selection process
Ex2: Present the selected niche strategies, from literature-based ranking, for kite-based AWE technologies

Q3: Do the selected niche strategies meet expectations, and not why?
Q4: On a scale from 1 to 10, how much trust would you put in the selection results?
Q5: In which part of the selection process do you have the least confidence and in which part the most?
Q6: Do you think that the selection process contributes to the commercialization strategy of your organization?
The three phases reflect the three key components of the niche strategy selection process, being; the barrier ranking; the niche strategies; and the links between barriers and niche strategies and resulting niche strategy selection. The third and last phase has an expanded third step to reflect and review the overall niche strategy selection process, at the end of the interview. The three steps of each phase allow for the expert’s opinion and expertise to be determined, before, during, and at the end of each phase in the interview, measuring the consistency of the experts’ perspectives and any possible learning curve. The presented interview structure and formulated questions and exercises, in figure 7.1, attain the four goals with specifically developed components of the interview, an overview of the four goals and corresponding components is presented in table 7.1 and further explanation given below:

<table>
<thead>
<tr>
<th>Goal:</th>
<th>Responding components of the interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>To determine the expert’s view and expertise of the AWE market situation</td>
<td>Phase 1 – Step 1 &amp; in part step 3; Phase 2 – Step 1 &amp; in part step 3</td>
</tr>
<tr>
<td>To let the expert rank his own barriers using the presented barrier framework</td>
<td>Phase 1 – Step 2 (with additional insight and context given in phase 1 – steps 1 &amp; 3)</td>
</tr>
<tr>
<td>To inquire to the expert’s opinion and level of agreement on the presented findings</td>
<td>Phase 1 – Step 3; Phase 2 – Step 3; Phase 3 – Step 3 (context given by all steps 1 &amp; 2)</td>
</tr>
<tr>
<td>To survey the expert’s opinion of the use and trustworthiness of the overall selection process</td>
<td>Phase 3 – Step 3</td>
</tr>
</tbody>
</table>

The first goal of determining the expert’s view and expertise of the kite-based AWE market is predominately attained by the initial questions posed in the first steps of phases 1 and 2. Due to the open nature of the posed questions, the uninfluenced and unrestricted perspective of experts is attained, to check the expertise of the experts and possibly gain additional insights. The second goal of letting experts ranked their own barriers using the barrier framework is directly attained by the interactive exercise 2 given in phase 1, providing direct data of experts using the barrier framework and their rankings. The third goal of inquiring to the experts’ opinions and levels of agreement to the presented literature findings is attained by the reviewing closing questions of all three phases. These results will be used to validate and confirm the literature findings of chapters 5 and 6, using the experts’ reflections and comments, also drawing on the answers and results of steps 1 and 2 of all phases. The fourth and final goal of inquiring to the experts’ opinions of the use and trustworthiness of the niche strategy selection and process, is attained by the reflective questions of the third phase. Giving feedback on the usefulness and level of trust experts have in the concept of the niche strategy selection process and its application to the case of kite-based AWE technologies.

Through the structure and questions of the interview, the four goals set out can be attained. Using the three phases, with each three steps, in various ways to strengthen and validate the niche strategy selection process, as presented and discussed in chapter 8. The slides presented during the interview, with the literature findings and niche strategy selection, can be found in appendix A.2.
Interview analysis

An equally important aspect of the interview is the processing of the results of the interview, of which the exact methodology of processing of the results, using three types of analysis, is discussed in the methodology chapter on page 13. For transparency, about which components are processed by which method of analysis, this paragraph will present an overview of the applied types of analysis, and the reasoning behind their application, to specific results.

In the methodology chapter, on page 13, three types of analysis are introduced and described. The ‘framework analysis’, ‘reflective analysis’, and ‘coding analysis’ reflect the different questions and exercises posed in the adjusted individual interviews. The way the questions are formulated result in different response, from extensive and detailed answers to a short ‘yes’ or ‘no’, hence these answers are processed with different types of analysis, as discussed in the methodology chapter on page 13. In table 7.2 an overview is presented of the three types of analysis, and for which questions and exercises these are applied, per phase.

<table>
<thead>
<tr>
<th>Questions and exercises to be processed</th>
<th>Analysis option:</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>‘Framework analysis’</td>
<td>Ex2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>‘Reflective analysis’</td>
<td>Q3; Q4</td>
<td>Q3; Q4; Q5</td>
<td>Q1; Q3; Q4</td>
</tr>
<tr>
<td></td>
<td>‘Coding analysis’</td>
<td>Q1; Q2; Q5; Q6</td>
<td>Q1; Q2</td>
<td>Q2; Q5; Q6</td>
</tr>
</tbody>
</table>

The ‘framework analysis’ is solely applied to the results of exercise 2 of phase 1, as these results are concrete and direct in nature, thus requiring little processing. The ‘reflective analysis’ is applied to short and concise answers expected to given in reply to the questions presented above, in table 7.2, most of which are reflective questions. The ‘coding analysis’ is applied to longer and more detailed answers expected to be given to the questions listed above in the bottom row of table 7.2, which are both initial and reflective questions, the answers will be analysis, and relevant remarks extracted using coding groups. With the three types of analysis all results and answers of the interviews can be processed, for a clear and concise overview of the perspectives of the interviewed experts.

Expert selection

The size and relevance of the group of kite-based AWE experts to be interviewed is also of importance for the quality of the interview results. Hence the experts invited for the interviews are selected on the basis of the relevance and expertise of the actors in the field of kite-based AWE. Of proximately 50 institutions that are active in the overall field of AWE technologies, 11 experts on kite-based AWE technologies have been selected, with the relevance and expertise being determined on the basis of the aspects of; organisation, role in with the organisation, and additional notes. These aspects, along with the aspects of research funding and location, show the heterogeneous background of the 11 selected experts, as can been seen in the overview of the selected experts in table 7.3 on the next page:
Table 7.3: Selected experts and the reasons therefore.

<table>
<thead>
<tr>
<th>Expert</th>
<th>Organisation</th>
<th>Research funding</th>
<th>Role</th>
<th>Location</th>
<th>Additional notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr.-ing. R. Schmehl</td>
<td>Kitepower TU Delft</td>
<td>University</td>
<td>Associate professor</td>
<td>Delft, NL</td>
<td>One of the main editors of AWE (book)</td>
</tr>
<tr>
<td>S. Brabeck</td>
<td>SkySails GmbH.</td>
<td>Private</td>
<td>Chief Technical Officer</td>
<td>Hamburg, DE</td>
<td>Key speaker at AWEC 2013 on “AWE Enterprises &amp; Prototypes”</td>
</tr>
<tr>
<td>A. Bormann</td>
<td>Enerkite GmbH.</td>
<td>Private</td>
<td>Chairman</td>
<td>Berlin, DE</td>
<td>Demonstrated pumping-kite system at AWEC 2013</td>
</tr>
<tr>
<td>M. Milanese</td>
<td>Kitenergy srl.</td>
<td>Private</td>
<td>Technical director &amp; founder</td>
<td>Torino, IT</td>
<td></td>
</tr>
<tr>
<td>M. Ippolito</td>
<td>KiteGen</td>
<td>Private</td>
<td>President</td>
<td>Torino, IT</td>
<td></td>
</tr>
<tr>
<td>C. Grete</td>
<td>Skigh Energy</td>
<td>University</td>
<td>Former founder</td>
<td>Delft, NL</td>
<td>Start-up focussed on developing countries</td>
</tr>
<tr>
<td>Dr. R. Luchsinger</td>
<td>Twingtech</td>
<td>Private</td>
<td>Managing director</td>
<td>Dübendorf, CH</td>
<td>Researching inflated wings</td>
</tr>
<tr>
<td>B. Hampton</td>
<td>Kite Power Solutions Ltd.</td>
<td>Private</td>
<td>Founder</td>
<td>Chelmsford, UK</td>
<td></td>
</tr>
<tr>
<td>C. Perassi</td>
<td>Wind Operations Worldwide</td>
<td>Private</td>
<td>Board of Directors</td>
<td>Milano, IT</td>
<td>Financial holding company in AWE</td>
</tr>
<tr>
<td>M. ter Horst</td>
<td>e-kite</td>
<td>Private</td>
<td>Commercial director</td>
<td>Barneveld, NL</td>
<td></td>
</tr>
</tbody>
</table>

The heterogeneous background of the experts is reflected in the various roles the experts have within the organisations and the locations of the organisations. Still the experts play key and important role in the organisations, thus emphasizing their relevance to the interview, and all fit within geographic constraint chosen in chapter 4. All the eleven selected experts presented in table 7.3 are approached for the interview, of which ten responded, and of those six were interviewed. The results of these interviews, conducted and processed as discussed, are presented in the following section.

Results

Discussing the results of the interviews in this section, first of all, the general or main results are presented from each question per interviewee. Followed by presenting any new findings and additional comments in later paragraph, as judged by the researcher to expand or strengthen the literature findings, forming interesting insights or context to the wider topic of niche strategies and AWE. The answers given by the interviewees and results of the exercises are processed as previously discussed to present a most truthful representation of the perspectives voiced during the interviews. This giving the reader insight into the perspectives of the interviewees, thus allowing the reader follow and pass judgement on the further processing of the results in chapter 8. The answers and results are presented in order of the questions of the interview, maintaining the intuitive line of the interview and niche strategy selection process.

Sadly, the interview with U. Ahrens has been omitted from the main results, except for P1-Q3 and P1-Ex2 which have concise results, due to the many errors and miscommunication that occurred during the interview, under time pressure, resulting in a strong bias towards his company and marketing niches.
Main results

Phase 1 – Question 1: ‘What is the status of the market for AWE technologies?’

The answers to this question were analysed using the following coding: Status of technology regarding the market; time to first commercial product onto market; description of challenges to market entry.

**B. Hampton:** States that there is currently no commercial AWE entity with a marketable solution, and it will take at least a minimum of five years before the first commercial AWE systems get introduced. This is due to, not only the current technical challenges, but also the process of gaining access to air space via the air authorities. And lack of proof of technology and legislation regarding air space, act as two halves of an interacting problem.

**C. Grete:** AWE technology is still very much at the research and development stage and not yet in touch with the market, according to C. Grete. Although no figure is given for the time to market, but it is stated that most groups are at prototype stage and a limited few are starting pilot projects.

**M. Conorgiu:** States that despite the huge potential, there are no commercial products on the market. In the case of KiteGen, it will take a couple of years to go to market, as the company already has a commitment to purchase for its development partner. Although there are many “bureaucratic” challenges, ranging from access to air space, local planning permission, grid compliance and national subsidies for renewable energy, this would be overcome in a rational world, once an AWE system reached its disruptive economic potential, but the world is not always rational.

**R. Schmehl:** In general, thinks that the AWE technology is still quite some steps away from a true market introduction. There are prototypes around, but none those have the reliability of a wind power system, which is what potential customers expect. The kite-based technologies have still a serious technical gap, regarding robustness issues, besides certification and regulation issues.

**S. Brabeck:** States that the utilities are waiting for a ready-to-us product, which is the main challenge of the AWE industry. The first 1 MW scale prototype is expected in two to three years. There is also very strong competition from land-based CWT’s, hence SkySails is focussing on offshore, which is in AWE’s advantage.

**Digest:** The general consensus is that the technology is two to five years from market introduction and currently at the prototype or R&D stage. Although different detailed barriers are mentioned, two general themes come forward; technology development & proving towards a reliable and safety product, and funding & legislation to enable the development and application of kite-based AWE systems.
**Phase 1 – Question 2: ‘What withholds the commercialization of AWE technologies?’**

The answers to this question were analysed using the following coding: *Barriers mentioned; barrier impact on market and technology development; ranking (if mentioned).*

**B. Hampton:** States that air space access, military approval (with regards to radar signature), and public acceptance are the three non-technical barriers, in that order, inhibiting the commercialization. Technical barriers are not ranked as high, under the assumption that these can be easily solved within the company with enough time and money.

**C. Grete:** Sees a self enforcing cycle of technology development or proofing and investment, as investors see a high risk with AWE technologies and are waiting others to make the leap. This hampers the further development and proofing of the technology, thus enforcing the cycle regarding risk, as well as that there is an absence of a legal framework with authorities.

**M. Conorgiu:** Safety and reliability are mentioned as barriers, creating local, investor and legislative opposition, although KiteGen tackles this through technical solutions, the first few years will require continuous development to improve reliability. Another barrier is lobbying from the wider energy regime through laws and regulations, in response to the disruptive potential of AWE, although most European grids prioritize renewably generated electricity, thus creating a directly accessible market.

**R. Schmehl:** States that reliability of the system, regarding safe and economic operation, and material durability are the primary (technical) barriers facing AWE technologies. The non-technical barriers mentioned are (the lack of information about) environmental impact, public perception and regulations and creation of air space for AWE. The later is addressed by the German AWE interest group, while the technical barriers will be tackled by technical solutions.

**S. Brabeck:** States the funding gap between a good concept and product development is a barrier, as to development and test an autonomous prototype requires 10 to 20 million Euros from investors. Also the market faces strong competition as utilities and others are looking for well-proven and cheap (renewable) energy production, as well as investors raising questions regarding land-use.

**Digest:** Many different barriers are mentioned, often due the interviewee perspective from his own technology, but the development of reliable and proven technology seems a dominant theme. The lack of technical knowledge and proof seems to impact on many aspects, from institutions to customers and from investors to the general public.

**Phase 1- Question 3: ‘Which 3 barriers are most influential in blocking market adoption?’**

Analysing the results, the table 7.4, on the next page, shows which barriers have been mentioned by which interviewee, after being categorized, with a description of categories on the right:
### Table 7.4: Categorized barriers per interviewee

<table>
<thead>
<tr>
<th>Expert:</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Hampton</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Grete</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. Corongiu</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R. Schmehl</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. Brabeck</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U. Ahrens</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Totals:** 5 2 3 1 1 2 2 1

x – mentioned barrier in a category

The totals on bottom show the number of times a categorized barrier is mentioned in all interviews, giving an overview of which categorized barriers are mentioned the most.

### Phase 1 – Exercise 2 – ‘Ranking 5 barriers with the barrier framework’

The results of the ranked barriers, by the experts using the barrier framework, are presented in the following matrix per interviewee, with the ranking indicated with numbers per row (table 7.5):

### Table 7.5: Matrix of barrier ranking results per interviewee.

<table>
<thead>
<tr>
<th>Knowledge of Technology</th>
<th>Knowledge of Application</th>
<th>Macro-Economic aspects</th>
<th>Vision &amp; Image</th>
<th>Resources</th>
<th>Socio-cultural aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Experts:**

<table>
<thead>
<tr>
<th>Experts</th>
<th>Knowledge of Technology</th>
<th>Knowledge of Application</th>
<th>Macro-Economic aspects</th>
<th>Vision &amp; Image</th>
<th>Resources</th>
<th>Socio-cultural aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Hampton</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>C. Grete</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>M. Corongiu</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>R. Schmehl</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>S. Brabeck*</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>U. Ahrens</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

* Used the framework in an alternative fashion, due to different interview approach (phone & mail), admitted due similarities.

### Phase 1 – Question 4: ‘With which barriers would you agree from the written sources ranking?’

The results of the expert’s review of the presented barrier ranking are shown in table 7.6, on the next page, in which the alterations have being indicated and highlighted with arrows. Of each expert the respective re-ranking of barriers is shown by listing barriers with their original ranking position, for example; ranked in second place is barrier 5, which originally was ranked fifth in literature. Also the overall revised ranking presented, which is a results of the equal combination of the 5 expert reviews, and some additional comments to barriers in the notes.
Table 7.6: Overview of the expert’s review of the presented barrier ranking based on literature.

<table>
<thead>
<tr>
<th>Barrier</th>
<th>B. Hampton</th>
<th>C. Grete</th>
<th>M. Corongiu</th>
<th>R. Schmehl</th>
<th>S. Brabeck</th>
<th>Combined:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Barrier 1</td>
<td>Barrier 1</td>
<td>Barrier 1</td>
<td>Barrier 1</td>
<td>Barrier 1</td>
<td>Barrier 1</td>
<td>Barrier 1</td>
</tr>
<tr>
<td>2 Barrier 5 ▲</td>
<td>Barrier 2</td>
<td>Barrier 2</td>
<td>Barrier 2</td>
<td>Barrier 2</td>
<td>Barrier 2</td>
<td>Barrier 2</td>
</tr>
<tr>
<td>3 Barrier 2 ▼</td>
<td>Barrier 3</td>
<td>Barrier 3</td>
<td>Barrier 3</td>
<td>Barrier 3</td>
<td>Barrier 3</td>
<td>Barrier 3</td>
</tr>
<tr>
<td>4 Barrier 4</td>
<td>Barrier 5 ▲</td>
<td>Barrier 4</td>
<td>Barrier 4</td>
<td>Barrier 4</td>
<td>Barrier 4</td>
<td>Barrier 4</td>
</tr>
<tr>
<td>5 Barrier 6 ▲</td>
<td>Barrier 7 ▲</td>
<td>Barrier 5</td>
<td>Barrier 5</td>
<td>Barrier 5</td>
<td>Barrier 5</td>
<td>Barrier 5</td>
</tr>
<tr>
<td>6 Barrier 7 ▲</td>
<td>Barrier 6</td>
<td>Barrier 6</td>
<td>Barrier 6</td>
<td>Barrier 6</td>
<td>Barrier 6</td>
<td>Barrier 6</td>
</tr>
<tr>
<td>7 Barrier 8 ▲</td>
<td>Barrier 4 ▼</td>
<td>Barrier 7</td>
<td>Barrier 7</td>
<td>Barrier 7</td>
<td>Barrier 7</td>
<td>Barrier 7</td>
</tr>
<tr>
<td>8 Barrier 3 ▼</td>
<td>Barrier -</td>
<td>Barrier -</td>
<td>Barrier -</td>
<td>Barrier -</td>
<td>Barrier -</td>
<td>Barrier -</td>
</tr>
</tbody>
</table>

1. For general public not, but yes for investors.
2. Is dependent on performance of the technology, with it doesn’t reach potential then yes, otherwise no.
3. Is dependent on the scale of the technology, for small-scale yes.
4. Not a barrier, just requires system assembly of existing technologies.
5. Just for the materials.

Phase 1 – Question 5: ‘Is the market situation adequately described by the ranking?’

Analysing the often relatively short answers, the following opinions were voiced:

**B. Hampton:** Thinks it is complete, although for his funded organization he would rank it differently.

**C. Grete:** Missing service and maintenance aspects, as well as greater distinction for customers.

**M. Corongiu:** Thinks it is OK, but for KiteGen institutional aspects and technology are most relevant.

**R. Schmehl:** Finds it well ranked and fully agrees, although some barriers might not apply for small-AWE systems.

**S. Braback:** Finds it describes the market situation OK.

Phase 1 – Question 6: ‘What could be further improvements on the ranking?’

Analysing the often relatively short answers, the following opinions were voiced:

**B. Hampton:** Thinks that the ranking is about right for the general situation.

**C. Grete:** Thinks that an additional category, time required to overcome barrier, would be useful.

**M. Corongiu:** Would rank it differently for his organization, as it has a commitment to purchase.

**R. Schmehl** Finds it still a bite unclear, usually deals with specific problems, but thinks it covers all.

**S. Brabeck** Finds it OK, and would not alter it, although the first four are of equal weight.

Phase 2 – Question 1: ‘What strategy would you expect to tackle the barriers to commercialization?’

The answers to this question have been analysed using the following coding: Mentioned strategies (incl. brief description); relation to which barriers.

**B. Hampton:** States that they are building a good relationship with UK air authorities (CAA), but are developing their own safety standards before going to the CAA. Also would like to see collaboration amongst AWE groups when it comes to the international authorities, to gain air access, as well as research into radar signatures of AWE systems. To tackle the barriers of public perception and environmental impact is to start the dialogue early with the relevant actors.
C. Grete: Thinks that forming groups to collectively present AWE, as an industry rather than individuals, will aid the discussion around air space classification and funding. As well as that AWE groups should do more empirical research to provide more data, which can be shared amongst groups to speed up technical development, or even more direct collaboration. And start searching for early adopters, to show investors there is interest, and a market for the technology.

M. Corongiu: States that pushing ahead with the developing and testing the AWE systems is the most efficient approach, as once the strong potential (both potential and reliability) of the technology is proven, a lot of barriers will reduce or disappear. As well as spreading the knowledge about AWE technologies amongst the public and investors, to alter perception of AWE technologies.

R. Schmehl: Is of the opinion that there is a lack of collaboration amongst the 50 AWE groups, particularly when it comes to dealing with the aviation authorities regarding classification and air access. As well as lobbying for public funding for further development, as the latter requires to be better informed of the technologies, to remove the high level of scepticism. And further he would like to see the AWE cluster to invest in the R&D of key technologies, like materials, to further its development.

S. Brabeck: AWE technologies are at an economic advantage in offshore application, in comparison to CWT’s due to the lighter foundation requirements, thus forming a niche market in the perspective of SkySails. This economic viability not only attracts investors and users, but also mitigates land use and regulation issues. Once this niche market is successful, according to the interviewee, small-scale systems could move on land for application in remote locations.

Digest: The consensus seems to lay around a broad collaboration on tackling regulation and air access, while also developing the technology further to proof the concept and thus attract investors and adopters, as main strategies. However which one has higher priority does differ, as well as several other strategies being mentioned to tackle aligned or other barriers. The main strategies discussed are; collaborative approach to air authorities, further research and data/resource sharing amongst groups, and spreading information on AWE for public perception and investors.

Phase 2 – Question 2: ‘Are you familiar with Strategic Niche Management?’

Analysing the often relatively short answers, the following (summarized) opinions were voiced:

B. Hampton: Strategic Niche Management,.. no, sorry, no.
C. Grete: Very much, although not very much. But I had the course of Linda Kamp, along with Jaco Quist, but it has been three years.
M. Corongiu: No, I’m not familiar.
R. Schmehl: No, not the theory, but I have read about it.
S. Brabeck: Strategic... Niche management?
Digest: Three of the five selected experts have not heard of Strategic Niche Management, with the other two having heard of it and stating that they know some of the basic theory.

Phase 2 – Question 3: ‘Are the niche strategies well defined to their intent and application?’

Analysing the often relatively very short answers, the following (summarized) opinions were voiced:

**Experts:** Summarised responses:

- B. Hampton: Yeah, yeah, totally.
- C. Grete: They make sense.
- M. Corongiu: Yes, there are clear.
- R. Schmehl: I cannot say, whether this is complete. I can definitely recognise the individual strategies, although I also see some overlaps. I think it is a good list.
- S. Brabeck: Yes, they are well defined.

The general consensus seems to be that the strategies are well defined to their intent and application.

Phase 2 – Question 4: ‘Are all possible strategies covered?’

Analysing the often relatively very short answers, the following (summarized) opinions were voiced:

**Experts:** Summarised responses:

- B. Hampton: It covers the majority,
- C. Grete: Cannot judge now, perhaps later, after going through business models.
- M. Corongiu: Do not have much knowledge about it, but seems complete.
- R. Schmehl: Thinks it is nice wide spread list of niche strategies, but lacks adequate insight.
- S. Brabeck: Yes, I think it is complete.

Even though the experts are not very confident, the reactions are generally positive, although there is room for improvement.

Phase 2 – Question 5: ‘Can niche strategies be regarded as single independent entities or can they be combined?’

Analysing the often relatively very short answers, the following (summarized) opinions were voiced:

**Experts:** Summarised responses:

- B. Hampton: Definitely can be combined.
- C. Grete: They can certainly be combined.
- M. Corongiu: Can be combined.
- R. Schmehl: Thought there might be overlaps, probably covers everything.
- S. Brabeck: Yes, a combination is possible.

The general consensus seems to be that the strategies can be combined into a (business) strategy.

Phase 3 – Question 1: ‘What niche strategies would form a suitable reply to the barriers?’

The results, extracted from the answers, show which strategies were selected or otherwise rejected:

The experts had the slide with the ten niche strategies open during this question, and were asked to select which strategies they deemed suitable in response to the barriers. In some interviews, the expert also stated which niche strategies he deemed unsuitable, these are represented in the table with a ‘no’.
Table 7.7: Overview of the mentioned strategies of the presented literature findings, per interviewee.

<table>
<thead>
<tr>
<th>Experts</th>
<th>Demo</th>
<th>Top</th>
<th>Subsidized</th>
<th>Redesign</th>
<th>Dedicated</th>
<th>Hybrid</th>
<th>Educate</th>
<th>Geographic</th>
<th>Lead-user</th>
<th>Multiple markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bill Hampton</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Christoph Grete</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Marcello Corongiu</td>
<td>x</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>x</td>
<td>x</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Roland Schmehl</td>
<td>x</td>
<td>x</td>
<td>no</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Stephan Brabeck</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Totals</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Phase 3 – Question 2: ‘How do you see the niche strategy circumvent, overcome or tackle the barriers?’**

The answers to this question have been analysed using the following coding: *Strategy & barrier(s) combination; how to tackle the barrier(s).*

**B. Hampton:** States the Geographic niche strategy is good to avoid many barriers, if possible, particularly regarding legislation and regulation. While the Demo strategy is well suited to create awareness amongst investors and broader public, in a controlled manner, thus removing any misconceptions or uncertainties and creating more backing. The Educate strategy is less suited for this.

**C. Grete:** The suggested application of the education, he regards as to help the investment versus development cycle, as groups build one and others contributions through open-source knowledge, although in-house development and knowledge is still required. While the lead-user strategy might make investors see revenues from customers, thus providing practical applications and so boosting further investment on the back of investor confidence.

**M. Corongiu:** States that the Demo strategy would tackle institutional and public perception barriers, through spreading the knowledge regarding reliability and performance. While the Geographic strategy tackles institutional and public perception barriers, by moving the technologies to another area where these barriers are no present or to a lesser extent.

**R. Schmehl:** States that the Education strategy is good to tackle the information barrier, by generating and spreading knowledge. The Top niche strategy would tackle the economic viability barrier, through targeting a group for which economic performance is a lesser priority. Regards the Demo strategy as a standard approach for all strategies, as well as for AWE technologies, and most groups have lead-users as they are looking for launch customers, as required for further funding.
S. Brabeck: Finds the Lead-user strategy suited to focus and orient the development of AWE technologies on practical business applications, presumably to overcome funding and perception barriers. With Geographic niche strategy providing economic niche market for economic competitiveness, avoiding both institutional and market barriers.

**Phase 3 – Questions 3: ‘Do the selected niche strategies meet expectations, or perhaps not?’**

Analysing the often relatively short answers, the following (summarized) opinions were voiced:

<table>
<thead>
<tr>
<th>Experts</th>
<th>Summarised responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Hampton</td>
<td>Geo, yes; educate, remove; lead-user, yes; demo, yes, on 2; dedicated, not sure.</td>
</tr>
<tr>
<td>C. Grete</td>
<td>Applied the geographic niche to the small-scale system with Skigh Energy.</td>
</tr>
<tr>
<td>M. Corongiu</td>
<td>Geo, agree; Demo, agree; Lead-user, not; Educate, done for 10 years; Dedicated, not</td>
</tr>
<tr>
<td>R. Schmehl</td>
<td>Interesting it matches the path line of the Kitepower (Skigh Energy)</td>
</tr>
<tr>
<td>S. Brabeck</td>
<td>Agree with ranking; Geographic, educate, lead-user: good; Demo and Standalone: OK</td>
</tr>
</tbody>
</table>

The general consensus seems to be that ranking is largely correct, although some alterations are suggested per interviewee.

**Phase 3 – Questions 4: ‘How much trust would you put in the result of the selection and the process?’**

The following grades were given as answers by the interviewees, in table 7.8. The experts were asked to grade the process of selecting niche strategies, from barrier ranking to the selection, and the results of niche strategy selection itself for kite-based AWE technologies separately.

<table>
<thead>
<tr>
<th>Experts</th>
<th>Grade process</th>
<th>Grade results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bill Hampton</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Christoph Grete</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Marcello Corongiu</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Roland Schmehl</td>
<td>7.5</td>
<td>8</td>
</tr>
<tr>
<td>Stephan Brabeck</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Averages</td>
<td>7.1</td>
<td>7.2</td>
</tr>
</tbody>
</table>

**Phase 3 – Question 5: ‘In which part of the selection process do you have the least confidence and in which part the most?’**

The answers have been analysed using the following coding: The part with the most trust; the part with the least trust; explanation of the reasons why.

**B. Hampton:** Finds the method correct and can’t improve the process on the spot, but does not make a clear statement on the results. Thinks that using a niche is definitely a way to open the market, even though AWE technologies are not really a niche product in his opinion.

**C. Grete:** Has the least trust in the niche strategy ranking, even though he has the most trust in the links between barriers and niche strategies, on which the ranking is based. Process yes, results less.
**M. Corongiu:** Is quite confident in the selection of the barriers and less confident in the selection of niche strategies for kite-based AWE technologies.

**R. Schmehl:** Finds the barriers more clearly and distinctly described than the niche strategies, thus has more trust in the barrier part of the process.

**S. Brabeck:** Finds it generally OK, with barrier framework perhaps a bite too detailed, but the outcome reflects his own impression.

**Digest:** no real consensus has appeared from the answers given, nor any strong rejection of any part of the overall selection process (barrier framework & selection, niche strategies, links, or niche strategy selection).

**Phase 3 – Question 6: ‘Does the selection process contribute to the strategy of your organisation?’**

The answers have been analysed using the following coding: **Agreement; explanation.**

**B. Hampton:** Can contribution, does not directly alter current strategy, but could influence it.

**C. Grete:** Finds it worth keeping in mind and to go through the process, but less sure about the (niche strategy selection) results.

**M. Corongiu:** Simply states that it may help in formulating a strategy for his organization.

**R. Schmehl:** Would grade it with an 8.5, has the Delft Kitepower currently does not make use of the knowledge regarding niche strategies and recognizes the need for a niche strategy.

**S. Brabeck:** States that it can contribute, as SkySails has done a similar approach based on empirical research, and is good to have an overview of all possible niche strategies. So he thinks that SkySails would use such a process, and generally finds it OK.

**Digest:** There seems to be a consensus, that it can contribute, but the experts not very sure or confident were it would be adopted outright or is very reliable.

**New findings and additional comments**

Several interesting comments and answers were made during the interviews, some can contribute to strengthening the presented findings, and some provide different context or insight that might form a new spur of research. Hence per interviewee these comments are presented and discussed.

**U. Ahrens:** Stated that for the AWE system of NTS X-Wind there is no suitable niche strategy, as this particularly system is large-scale and aimed at utilities, this was perhaps due to the expert using the marketing definition of niche strategy. However NTS has recently gone on a road show to present their AWE system and raise funding amongst investors, as well as participating in the German AWE interest group tackling legislation issues, and naming the fax machine as an historic example of the application of the geographic niche
strategy, suggesting that the organization does (indirectly) use and understand niche strategies.

S. Brabeck: Suggested that AWE should be applied where CWT’s cannot, such as offshore in deep-waters and hurricane prone areas, thus creating an initial niche market to start the commercialization. A good example of the application of geographic niche strategy.

R. Schmehl: Made some interesting remarks regarding interdependence amongst AWE groups and the supply chain, particularly that as material durability is an issue, hence AWE industry should (collectively) invest in the material research and development of its suppliers.

M. Corongiu: Expects that the difference in weight between airborne generators and ground-based ones will also result in a difference in the perceived safety of the respective systems, particularly with local actors active under the flight path during the early phase of the technology.

C. Grete: Noted that an absence of maintenance and service companies, both as a barrier, and in the presented barrier ranking. As well as lack of greater diversity of customer types reflecting different business and revenue models, in the barrier framework.

B. Hampton: Mentioned a possible alternative (niche) strategy, by which to two or more (innovative) technologies are combined to single product as the ‘A+B strategy’, for example tidal and wind energy at sea. Although the expert was not enthusiastic about it himself.

Reflection on interviews
Reviewing the presented results, through the three phase structure of the interview, sufficient data has been extracted to attain the goals set out. Through the different approaches to questions, both the broader narrative and specific categorized answers were given during the interviews. By using the different types of analysis to obtain a proper understanding, a good insight into the perspective of the experts in kite-based AWE technologies is given. Sadly, only 6 of the 11 experts have been interviewed, with others citing; a lack of time (2), business confidentiality (1), no longer working for the organization (1), or no response (1). Yet the diversity in backgrounds, organizations, and locations of the experts, provides a broad picture of the kite-based AWE sector, thus avoiding a too specific focus on a single system or region. The results will be processed and analysed in the following chapter for the (selection process) validation. With this interview structure and questions, the goals of interviews is achieved with the desired quality and quantity. In chapter 8 and the methodology, further explanation will be given of how the results of the interviews are processed and compared, for the validation and strengthening of the niche strategy selection and corresponding process.
Chapter 8 – Validation

With the literature findings and the results of the interviews complete, the validation of the niche strategy selection process will commence in this chapter. This chapter is solely dedicated to confirming whether the developed Niche Strategy (NS) selection, and process, are applicable and correct for kite-based AWE technologies. The findings from literature and the developed NS selection process are presented, applied and reviewed during the interviews with experts, as presented in chapter 7. By integrating the NS selection process into the interviews and the validation, the NS selection process and its results can be validated through the interview results and validation comparisons.

The interview structure allows each component of the NS selection process to be validated separately, with multiple results and answers from the interviews to do so. Since the NS selection process consists of several consecutive steps, each step has to be valid in order for the overall process and results to be valid. Therefore the following structure is applied in this chapter for the validation, as presented in table 8.1. Consecutively building up the validation of the NS selection process, step by step, to deliver a valid selection of suitable niche strategies for kite-based AWE technologies.

The (general) methodology of the validation process is described in the methodology chapter (2) on page 16, and only the choices and context of the process are specified in this chapter. The structure of the validation is presented in this paragraph, for transparency and overview, with table 8.1 shows an overview of the validation structure, with sections, paragraphs and purpose indicated per column:

<table>
<thead>
<tr>
<th>Section</th>
<th>Paragraph</th>
<th>Purpose of validation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Experts)</td>
<td>V0</td>
<td>Validity of experts’ opinions and perspectives.</td>
</tr>
<tr>
<td>Barrier framework</td>
<td>V1A</td>
<td>To validate the categorization effectiveness of the barrier framework.</td>
</tr>
<tr>
<td></td>
<td>V1B</td>
<td>Whether barrier framework is complete and representative of barriers.</td>
</tr>
<tr>
<td></td>
<td>V1C</td>
<td>Accuracy and comprehensiveness of literature-based barrier ranking.</td>
</tr>
<tr>
<td>Niche Strategies (NS)</td>
<td>V2A</td>
<td>Comprehensiveness of the presented list of niche strategies.</td>
</tr>
<tr>
<td></td>
<td>V2B</td>
<td>Practical categorization and usability of the niche strategies.</td>
</tr>
<tr>
<td>Links &amp; NS Selection</td>
<td>V3A</td>
<td>Effectiveness of links regarding AWE technologies to select suitable NS.</td>
</tr>
<tr>
<td></td>
<td>V3B</td>
<td>(Individual) accuracy of niche strategy selection.</td>
</tr>
<tr>
<td></td>
<td>V3C</td>
<td>Usability of the niche strategy selection process and its selection.</td>
</tr>
</tbody>
</table>

The structure of the validation chapter starts with the validation of the expertise of the interviewees (V0), since the experts’ interview answers form a large part of the comparisons made for the validations, the relevance and quality of the experts’ expertise are critical for the validations.

The validation continues with the barrier framework, starting with validating the effectiveness of the categorization of barriers into barrier-sets, as presented in chapter 5 (V1A), the barrier framework is also validated on whether it is complete in its reflection of barriers (V1B). Collectively validating whether barrier framework is reliable and accurate or not, before concluding with the validation of the accuracy and comprehensiveness of the barrier ranking for kite-based AWE technologies (V1C).
The niche strategies will be validated on whether all possible niche strategies are represented by the list of ten from literature, and thus whether it is a complete list (V2A), with a second validation on whether the niche strategies are categorized well enough to be used effectively (V2B). Collectively validating the niche strategies’ definitions and application for the case of kite-based AWE technologies.

With the previous two components validated, in the previous two paragraphs, the links between the barriers and the niche strategies will be validated. The validation will focus on the effectiveness of links for the kite-based AWE technologies case (V3A), and the NS selection itself will be validated on its accuracy of selecting the correct niche strategies (V3B). For the validation of both the accuracy of the overall selection process and the selection for the case, the individual barrier rankings and the collective ranking of experts will be used. Also the usability of the NS selection will be validated, to determine whether actors can and want to use the NS selection process to guide their innovations to market (V3C).

Preceding the concluding section, the threats to the internal and external validity of the research are discussed in a dedicated section. The concluding section will discuss the validity of the NS selection and process overall, and drawing a conclusion, ending the chapter with the definitive barrier ranking and NS selection, for kite-based AWE technologies.

**Validation of interviewee’s expertise [V0]**

The validation of the interviewed experts will focus on their level and consistency of their expertise. Viewing the results of questions 1 and 2 of phase 1, in chapter 7 on page 78, in comparison with the literature findings of chapters 5 and 6, and particularly the market situation description of chapter 5 on page 54. The experts’ perspectives are consistent in their descriptions of the kite-based AWE market. This is well illustrated by the consistency of the description of the status of AWE technologies, and its barriers, both amongst experts themselves and in literature, therefore the conclusion is; that the expertise of the interviewed experts is good and valid.

**Validation of barrier framework and ranking**

**V1A: Categorization effectiveness of the barrier framework.**

To determine whether the categorization of barriers using the barrier framework is valid, specifically whether the barriers are effectively represented by the barrier-sets. The validation will compare the results of *questions 3 and 4, and exercise 2* of phase 1 of the interview, and the comparison is done as described in the methodology, looking for consistencies between the sets of results.

The original results of the selected questions and exercise are presented in chapter 7, but a synopsis is presented in tables 8.2 and 8.3 on the next page. Table 8.2 shows the results of *question 3* in the second-left column, and the *top 5 ranked barriers according the experts* in the five columns from the right, with the ranked barrier-sets in table 8.2 listed from left to right, from highest barrier to lowest respectively. The description of the barriers, listed in the second left column, is presented in the textbox below it on the page 90. The results of *question 4* are presented in table 8.3, and shows the alterations.
of each expert to the presented literature based barrier ranking, listing the revised (ranking) position of
the original barrier-set. For example, a barrier-set originally ranking in second place/row, is re-ranked by
an expert to third position, as seen with Mr. B. Hampton. The original barrier ranking is presented in the
column on the far left, while the combined effect of the alterations is presented in the far right column.

Table 8.2: Overview of interview results of ‘initial’ question 3 and ‘interactive’ exercise 2 sources [P1-Q3 and P1-Ex2]

<table>
<thead>
<tr>
<th>Expert:</th>
<th>P1-Q3 barriers</th>
<th>P1-Ex2: Experts’ barrier ranking using the barrier framework, consisting of barrier-sets: indirect cause-direct impact</th>
</tr>
</thead>
</table>

Table 8.3: Overview of literature-based barrier ranking and ‘confirmation’ alteration per interviewee.

<table>
<thead>
<tr>
<th>Literature-based barrier ranking</th>
<th>BH</th>
<th>CG</th>
<th>MC</th>
<th>RS</th>
<th>SB</th>
<th>Σ:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of Technology – Support &amp; Investment</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Vision &amp; Image – Support &amp; Investment</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Macro-economic aspects – Customers</td>
<td>3</td>
<td>8</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Knowledge of Technology – Customers</td>
<td>4</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Knowledge of Technology – Institutional aspects</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Knowledge of Technology – Technological development</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Macro-economic aspects – Support &amp; Investment</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Knowledge of Technology – Product processes</td>
<td>8</td>
<td>7</td>
<td>X</td>
<td>X</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

For all three sets, the individual answers have been combined to create a cumulative average
reflecting the answers of the experts. For question 3 the count of the frequency of the mentions of
barriers, and ranking the results as a top 5 (in the bottom row). A ‘ranked average’ is determined from
the barrier rankings created by the experts (P1-Ex2), as presented in the methodology on page 10, as
well as for the results of question 4, in the far-right column of table 8.3. The assumption made in the
methodology, that there is consistent distinction between the barriers in the experts’ rankings, is valid,
as the results of Q3 and Q4 present a similar order of barrier-sets as that the combined experts’ barrier
rankings of exercise 2 (table 8.2), therefore the rankings can be combined using ‘ranked averages’.
Comparing the three sets of results above, per interviewee as well as the combined results, two findings
come forward. The first finding is that the emphasis on institutional, support & investment and
 technological barriers from the results of question 3, is well represented in both the individual and the
combined results of the experts’ barrier rankings (table 8.2). Suggesting that the experts are capable of
using the barrier framework effectively to reflect their perspective on barriers. However the second findings is that this consistency, found between question 3 and exercise 2, is not reflected in the individual alterations to the presented barrier ranking based on literature (table 8.3). It is possible this is due to the experts learning about the barriers of the wider kite-based AWE sector, when presented with them and their descriptions. Or perhaps due to the fact that the presented barrier ranking based on literature is effectively a combined result, which experts find difficult to reconcile with their individual perspective. However, this inconsistency is not reflected in the combined results of questions 3 and 4 and exercise 2. Here the emphasis on institutional, support & investment and technological barriers is reflected in all the combined results of the three sets.

Reflection on the findings presented above, shows the experts are capable of expressing their individual perspectives using the barrier framework. Yet, in general, the experts seem to accept the presented barrier ranking largely as is, which as a barrier ranking is effectively consistent with the combined results of the experts. Therefore, the categorization of the barrier framework is deemed effective in achieving the representative reflection of the market situation of kite-based AWE technologies.

**V1B: Completeness and coverage of the barrier framework for kite-based AWE technologies.**

To validate whether the barrier framework is comprehensive enough to cover the barriers for kite-based AWE technologies, the validation will compare the results of questions 2, 5 and 6, and exercise 2 of phase 1, on deviating results or barriers, as described in the methodology.

As the results of exercise 2 are already presented in table 8.2 on the previous page, a synopsis is given of the results of questions 2, 5 and 6, presented in chapter 7. The relatively short results of questions 5 and 6 are presented in table 8.4, with the deviating answers or results underlined in the text:

<table>
<thead>
<tr>
<th>Experts</th>
<th>Results of question 5: Is the market situation adequately described by the ranking?</th>
<th>Results of question 6: What could be further improvements on the ranking?</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Hampton</td>
<td>Thinks it is complete, although for his funded organization would rank it differently.</td>
<td>Thinks that the ranking is about right for the general situation.</td>
</tr>
<tr>
<td>C. Grete</td>
<td>Missing service and maintenance aspects, as well as greater distinction for customers.</td>
<td>Thinks that an additional category, time required to overcome barrier, would be useful.</td>
</tr>
<tr>
<td>M. Corongiu</td>
<td>Thinks it is OK, but for KiteGen institutional aspects and technology are most relevant.</td>
<td>Would rank it differently for his organization, as it has a commitment to purchase.</td>
</tr>
<tr>
<td>R. Schmehl</td>
<td>Finds it well ranked and fully agrees, although some barriers might not apply for small AWE systems.</td>
<td>Finds it still a bit unclear, usually deals with specific problems, but thinks it covers all.</td>
</tr>
<tr>
<td>S. Brabeck</td>
<td>Finds it describes the market situation OK.</td>
<td>Finds it OK, and would not alter it, although the first four are of equal weight.</td>
</tr>
</tbody>
</table>

The general consensus for questions 5 and 6 is that (revised) barrier ranking based on literature is complete, although most interviewees state that the ranking would be different for their organization.

Also a few comments, regarding improving the barrier framework, were made in the answers to questions 5 and 6. Mr. Grete states that greater distinction between different kinds of customers would be desirable, in perspective of different business models, as well as giving an indication of the time required to overcome the barriers. These comments do not directly reflect on the comprehensiveness of the barrier framework, but are of interest as opportunities for further research.
Processing the results of question 2, the general consensus appears to be that three barriers form the main barriers (see the footnote). However, a few deviating barriers or remarks are mentioned by the experts. Mr. Hampton states that the radar signature of kites might prevent military approval, while Mr. Corongiu points out the disruptive potential of AWE, which might cause the current energy regime to prevent a market introduction through legislation and wider bureaucracy. And Mr. Brabeck remarks that there is strong competition from other (well-proven and cheap) renewable energy production systems, like for example; photovoltaic systems and conventional wind turbines.

Comparing the three sets of results of the interview, with the answers of questions 5 and 6 forming a single set, two findings come forward from the comparison of the mentioned barriers. The first finding is that a total of four barriers are mentioned that deviate from the general consensus on the barriers of kite-based AWE technologies. These four deviating barriers are presented in table 8.5, with a short description, which expert mentioned it, and in which question:

<table>
<thead>
<tr>
<th>Deviating barrier</th>
<th>Expert</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaining military approval of air access, due to radar signature.</td>
<td>B. Hampton</td>
<td>Question 2</td>
</tr>
<tr>
<td>Missing services and maintenance for AWE systems</td>
<td>C. Grete</td>
<td>Question 5</td>
</tr>
<tr>
<td>Disruptive potential of AWE will cause defensive response of wider (fossil) energy regime.</td>
<td>M. Corongiu</td>
<td>Question 2</td>
</tr>
<tr>
<td>Strong (economic) competition of other (renewable) energy sources.</td>
<td>S. Brabeck</td>
<td>Question 2</td>
</tr>
</tbody>
</table>

No radically deviating barrier(-sets) where found in the results of exercise 2 of phase 1, as the rankings made by experts appears to focus on the main barriers.

The second finding is that the four mentioned deviating barriers, are not clearly reflected in the other results, only a few of the deviating barriers are partially reflected in the experts’ rankings of exercise 2, by the barrier-sets with the ‘institutional aspects’ factor. The deviating barriers mentioned in question 2 are not at all mentioned in the results of questions 5 and 6, neither by the same expert or others, and vice versa. This finding seems to suggest that, despite several barriers being mentioned, these are not important enough to be consistently mentioned in all sets of results, so the deviating barriers found are either represented by a more general barrier (set), or ranked lower than other barriers in the ranking.

In light of these two findings, the following conclusion is drawn on the comprehensiveness of the barrier framework, and also whether the literature based barrier ranking of kite-based AWE technologies is complete. Four deviating barriers have been mentioned during the interviews, and many of the barriers are covered by broader barrier (-sets). Like the ‘military approval’ and ‘resistance from the energy regime’ barriers are represented by barrier-sets with the ‘institutional aspects’ as direct impact. But in general, these deviating barriers are actually not consistently mentioned or ranked across all sets of results. This suggests that these are of lesser importance than other barriers, or they are partially represented by them, to be represented individually. Concluding that the barrier framework and barrier ranking, is largely comprehensive in covering the influential barriers of kite-based AWE technologies.
**V1C: Accuracy and comprehensiveness of literature-based barrier ranking.**

To validate whether the experts’ revised barrier rankings is accurate and comprehensive in representing the market situation of kite-based AWE technologies, the following sets of results are used for the comparison: The answers of question 3 act as the ‘initial’ set of results, listing the experts’ uninfluenced barriers. The results of exercise 2 are the ‘interactive’ experts’ translation of barriers using the barrier framework. And the results of questions 4, 5 and 6 form the ‘reflective’ set, reflecting on the present literature based barrier ranking. These results are presented in tables 8.2, 8.3, and 8.4 in the previous two validation sub-sections, and chapter 7, will be referred to for this validation.

Comparing the three sets of results, both on consistency and deviations, three findings come forward:

The first finding is that looking at the combined results of each set, five barriers are consistently represented in each set. These five barriers in random order are: **air space regulations**, **finding funding**, **informing investors and public**, **development of technology**, and **regime competition**.

The second finding, as stated in the answers on questions 5 and 6, is that the general consensus on the revised barrier ranking being largely complete and representative. Although there is one exception, with Mr. Grete stating he is missing ‘a lack of services and maintenance for AWE systems’ as a barrier in the ranking. But the interviewee does not reflect this barrier in his answers to other questions, perhaps due to lesser importance compared to other barriers. The third finding states there is a lot of variation in the individual results of experts in both the ‘initial’ and ‘interactive’ results sets, but this variation is not reflected in the experts’ alterations, to the presented literature based barrier ranking. As discussed in V1A, this might be due to a learning experience, a lack of overview on the part of individual, or a tendency to accept the literature based results, in neither case does it affect the combined results or general consensus on the revised barrier ranking of table 8.3.

Building on the validations of V1A and V1B, together with the three findings from the comparison, the following conclusion is made: The revised barrier ranking (as presented on page 54) is deemed to be an accurate and comprehensive representation of the market situation of kite-based AWE technologies. As five major barriers are consistently represented throughout, and the consensus amongst the interviewed experts on the final revised barrier ranking is strong.

**Validation of Niche Strategies**

**V2A: Comprehensiveness of presented list of niche strategies.**

Validating whether the presented list of niche strategies is complete, in perspective of kite-based AWE technologies, the validation will compare the results of questions 1 and 4 of phase 2, and of question 1 of phase 3. The comparison is executed as described in the methodology, on page 16, looking for deviations amongst the sets of results.

With the original results presented in chapter 7, a synopsis is given of the three sets of results. From the answers to question 1 (phase 2), the barriers named by the experts were extracted per individual, and
listed in table 8.6. In the column on the far right, the niche strategies corresponding to the mentioned strategies are presented, with the corresponding niche strategies selected by the researcher.

Table 8.6: Extracted mentioned barriers from the results of question 1 of phase 2, and corresponding niche strategies.

<table>
<thead>
<tr>
<th>Expert:</th>
<th>Mentioned initial strategies by the interviewed experts</th>
<th>Niche strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Hampton</td>
<td>- Building relations with the air authorities</td>
<td>Demo</td>
</tr>
<tr>
<td></td>
<td>- Collaboration amongst AWE groups for air access regulation</td>
<td>Educate</td>
</tr>
<tr>
<td></td>
<td>- Early dialogue with actors for public perception and impact</td>
<td>Demo</td>
</tr>
<tr>
<td>C. Grete</td>
<td>- Collectively present AWE tech. for air space classification and funding</td>
<td>Demo</td>
</tr>
<tr>
<td></td>
<td>- Do more empirical research and share it amongst AWE groups</td>
<td>Educate</td>
</tr>
<tr>
<td></td>
<td>- Start searching for early adopters</td>
<td>Demo</td>
</tr>
<tr>
<td>M. Corongiu</td>
<td>- Push ahead with development and testing of AWE technologies</td>
<td>‘classic’</td>
</tr>
<tr>
<td></td>
<td>- Spreading awareness of AWE amongst investors and the public</td>
<td>Demo</td>
</tr>
<tr>
<td>R. Schmehl</td>
<td>- More collaboration amongst AWE groups for air access and public funding</td>
<td>Educate</td>
</tr>
<tr>
<td></td>
<td>- AWE groups collectively investing in supporting industries</td>
<td>-</td>
</tr>
<tr>
<td>S. Brabeck</td>
<td>- Finding niche market based on geographic location</td>
<td>Geographic</td>
</tr>
<tr>
<td></td>
<td>- Followed by moving to the next (niche) market.</td>
<td>Multiple markets</td>
</tr>
</tbody>
</table>

For most mentioned strategies corresponding niche strategies could be found, using the broader definition of the ‘demo’ strategy, with the exception of two. Of the two exceptions, one is regarded as a ‘classic’ strategy, relying on the technology to proof itself, and the other is completely original.

Processing the brief answers to question 4 of phase 2, the degree to which the experts find that all strategies are covered is summarized as follows: 2, find the list complete; 2, find it covers the majority; and one interviewee does not comment. Although the answers are not given with much confidence, they are positive to the coverage of the ten niche strategies presented.

The niche strategies selected by the experts, as suitable replies to the discussed barriers of AWE, are presented in table 8.7, with ‘1’ indicating a selected niche strategy, and ‘no’ a rejected niche strategy.

Table 8.7: Overview of expert selected niche strategies as a suitable reply to barriers of kite-based AWE technologies in question 1 of phase 3.

<table>
<thead>
<tr>
<th>Expert:</th>
<th>Demo</th>
<th>Top</th>
<th>Subsidized</th>
<th>Redesign</th>
<th>Dedicated</th>
<th>Hybrid</th>
<th>Educate</th>
<th>Geographic</th>
<th>Lead-user</th>
<th>Multiple</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.H.</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>C.G.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.C.</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>R.S.</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.B.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Comparing the three sets of results, presented above, three findings were found in the process: The first most apparent finding is the shift in the diversity of niche strategies between the results of table 8.6 and table 8.7. In table 8.6, with the results of question 1 (phase 2), many strategies are mentioned but cluster around a few (corresponding) niche strategies, yet in table 8.7, the selected niche strategies are more diverse, or have a greater spread, than those in table 8.6. This suggests that the experts have under gone a learning experience, after being presented with the ten niche strategies. The second finding is the uncategorized strategy of ‘AWE investing in supporting industries’ is not reflected or mentioned in the other results, perhaps this is because it is debatable as a niche strategy or too specific, but it is certainly a lead for further research. The final finding is that the experts seem to adopt the
presented list of niche strategies without criticism, both in *question 4* of phase 2 and *question 1* of phase 3. In neither case have any comments been made as to missing or unlisted niche strategies, while the ten niche strategies are used in the answers of *question 1* of phase 3.

In conclusion, in the case of kite-based AWE technologies, the presented ten niche strategies are regarded as covering the majority of possible strategies. Although the experts are somewhat uncertain on whether the list is complete, and the strategy of ‘AWE investing in support industries’ requires further investigation.

**V2B: Validating whether the definition, description and the application of the niche strategies is clear:**

Validating whether the presented list of niche strategies is sufficiently described to be used by actors from the kite-based AWE technologies sector. The validation uses the results of *questions 1* and 3 (of phase 2), and *question 2* (of phase 3) in comparisons, following described the methodology, focussing on consistencies amongst the sets of results.

All the (original) results, used in the comparison, are presented in chapter 7, but a summarized overview is giving of the latter two, with the results of *question 1* of phase 2 presented in table 8.6 above.

*Question 3* (of phase 2) asks whether the niche strategies are well defined in respect of their intent and application, and the answers given are very brief in nature. Four of the five interviewed experts find them well defined, with only one interviewee being more hesitant but finding it a good list.

Processing the results of *question 2* (phase 3) into table 8.8, where experts explain how the niche strategies overcome the barriers, all interviewed experts discuss two or three of the ten niche strategies with a correct description of how the niche strategies can overcome the barriers. However, not all the niche strategies are discussed, as there is a focus on kite-based AWE technologies, the niche strategies that are not discussed are presented in the far right column, with the discussed niche strategies presented per interviewee in the middle.

<table>
<thead>
<tr>
<th>Discussed Niche Strategy</th>
<th>Interviewee</th>
<th>Niche strategies not discussed:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geographic niche strategy</strong></td>
<td>BH</td>
<td>Dedicated niche strategy</td>
</tr>
<tr>
<td><strong>Demo, experiment and develop niche strategy</strong></td>
<td>CG</td>
<td>Hybrid niche strategy</td>
</tr>
<tr>
<td><strong>Educate niche strategy</strong></td>
<td>MC</td>
<td>Multiple markets niche strategy</td>
</tr>
<tr>
<td><strong>Lead-user niche strategy</strong></td>
<td>RS</td>
<td>Redesign niche strategy</td>
</tr>
<tr>
<td><strong>Top niche strategy</strong></td>
<td>SB</td>
<td>Subsidized niche strategy</td>
</tr>
</tbody>
</table>

From the comparison of three sets of results, against one another, two findings come forward: The first finding being that, not only do the experts find the niche strategies well defined, they can apply them correctly as well. This is apparent from comparing the results of *question 4* of phase 2 against those of *question 1* of phase 3, with clear explanations given in the latter. The second finding is that about half of niche strategies described in *question 1* of phase 3, were also mentioned in *question 1* of phase 2. As
the descriptions of the strategies remain consistent in both results, this suggests that niche strategies were easily adopted befitting of existing strategies.

In light of these findings, the following conclusion is drawn from them; the niche strategies are well enough defined to be easily and quickly adopted by the relevant actors. Demonstrated by the experts of kite-based AWE technologies, who quickly and accurately adopt the niche strategies for application to the (case) innovation.

**Validation of links & Niche strategy selection**

**V3A: Effectiveness of the links between the barriers and niche strategies regarding AWE technologies.**

The effectiveness of the links between barriers and niche strategies is validated. More specifically, whether in the case of kite-based AWE technologies, the links select suitable niche strategies on the basis of the barriers. For this validation the results of question 1 (phase 2), questions 1 and 2 (phase 3), and question 4 (ph. 1) are used, forming the respective ‘initial’, ‘interactive’ and ‘reflective’ result sets.

The results of question 1 of phase 2 are already presented in table 8.6 on page 94, for the other results a synopsis is given per results set, starting with the processed results of question 4 of phase 1. The individual adjustments to the barrier ranking, as presented table 8.3 on page 90, are processed using the niche strategy selection process, as shown and explained in the figure 6.1 in chapter 6 on page 72.

The resulting niche strategies selections are presented in table 8.9, per interviewee, as well as the combined niche strategy selection, using the combined barrier ranking of table 8.3.

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Niche strategy ranking results:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.</td>
</tr>
<tr>
<td>B. Hampton</td>
<td>Geographic</td>
</tr>
<tr>
<td>C. Grete</td>
<td>Geographic</td>
</tr>
<tr>
<td>M. Corongiu</td>
<td>Demo</td>
</tr>
<tr>
<td>R. Schmehl</td>
<td>Geographic</td>
</tr>
<tr>
<td>S. Brabeck</td>
<td>Geographic</td>
</tr>
<tr>
<td>Combined:</td>
<td>Geographic</td>
</tr>
</tbody>
</table>

Using the (combined) barrier rankings from table 8.3 and applying the niche strategy selection process to it, gives the (combined) niche strategy selections which can validate the effectiveness of the process.

Results of questions 1 and 2 are combined, to form the ‘interactive’ set of results, as experts select strategies. The niche strategies mentioned or discussed in these questions, are presented in table 8.10 per interviewee, with the cumulative sum of mentions is presented in the bottom row per question:

<table>
<thead>
<tr>
<th>Experts</th>
<th>Demo</th>
<th>Top</th>
<th>Subsidized</th>
<th>Redesign</th>
<th>Dedicated</th>
<th>Hybrid</th>
<th>Educate</th>
<th>Geographic</th>
<th>Lead-user</th>
<th>Multiple.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Hampton</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Grete</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. Corongiu</td>
<td>XX</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>X</td>
<td>XX</td>
<td>no</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>R. Schmehl</td>
<td>XX</td>
<td>XX</td>
<td>no</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>S. Brabeck</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>5(3)</td>
<td>2(1)</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3(2)</td>
<td>4(3)</td>
<td>3(1)</td>
<td>1</td>
</tr>
</tbody>
</table>
Comparing the sets of results, on both consistency and deviations, three findings come forward. Starting with the first finding, the ‘demo’ and ‘educate’ niche strategies are well represented throughout all three sets of results. These two strategies attained a high ranking in both the ‘interactive’ and ‘reflective’ results, table 8.9 and 8.10 respectively, whilst being predominantly categorized in table 8.6 on page 94. A following finding is that the ‘geographic’, ‘top’ and ‘lead-user’ are also well represented in tables 8.9 and 8.10, suggesting a strong match between the niche strategies selected by the experts and those selected on the basis of the experts’ barrier rankings. This strong match is also well reflected by the comparison of the combined results, with four of five barriers being ranked highly. Yet as a third finding, the individual niche strategy selections in table 8.9, are not that well reflected by the expert selected niche strategies of table 8.10.

With these findings and the validation of the barrier ranking and niche strategies in previous sections, the following conclusion is drawn from them: Even though some inconsistencies exists between the links and experts, most links are generally validated by the comparisons and experts own answers in question 2 of phase 3. Therefore, the links between barriers and corresponding niche strategies are deemed to be predominantly effective, in the case of kite-based AWE technologies.

**V3B: Accuracy of the niche strategy selection process.**

To validate whether the niche strategy selection is accurate, in the case of kite-based AWE technologies, the results of question 1 of phase 2 and questions 1, 2 and 3 of phase 3 are used for the validation. Comparing the results of NS selection against experts own selections, and their opinion on the selection, the comparison looks for consistency in the selection of niche strategies to determine the accuracy of the process.

All results, with exception of the answers of question 3 of phase 3, have been presented in tables 8.6 and 8.10. The brief answers to question 3 of phase 3 are presented in table 8.11. With the comments of experts on individual niche strategies also presented in respective columns.

<table>
<thead>
<tr>
<th>Interviewees</th>
<th>Niche strategies and summarized responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Hampton</td>
<td>‘Geographic’ Yes; ‘Educate’ Remove; ‘Lead-user’ Yes; ‘Demo’ Yes on 2nd place; ‘Dedicated’ Not sure</td>
</tr>
<tr>
<td>C. Grete</td>
<td>Applied the geographic niche to the small-scale system with Skigh Energy</td>
</tr>
<tr>
<td>M. Corongiu</td>
<td>Agree; Done for 10 years; Not; Agree; Not</td>
</tr>
<tr>
<td>R. Schmehl</td>
<td>Interesting it matches the path line of the Kitepower (Skigh Energy)</td>
</tr>
<tr>
<td>S. Brabeck</td>
<td>Good; Good; Good; Ok; Ok</td>
</tr>
</tbody>
</table>

Through the comparison of the results, listed above, three findings are found in the process. The first finding is that in questions 1 and 2, four of five niche strategies are selected by both the experts and the NS selection process itself. This indicates a strong and correct match for the selection for kite-based AWE technologies. The second finding is that the experts remain largely consistent with their own selection, when reviewing the presented NS selection, which comes forward by comparing table 8.11 with table 8.10, with similar individual patterns appearing per expert. The third and final finding is that
the ‘geographic’ niche strategy is ranked higher in both the results of questions 1 and 2, as question 3 of phase 3. But this strategy is only mentioned once in table 8.6 on page 94. This suggests that a learning experience has occurred amongst most experts, regarding the ‘geographic’ niche strategy.

Drawing a conclusion on these findings, regarding the accuracy of the NS selection process. The conclusion is that, in the case of kite-based AWE technologies, as both the experts’ own selections as the process’ selection are largely consistent, the NS selection process can very credibly create an accurate niche strategy selection.

**V3C: Usability of the niche strategy selection process and its results.**

To validate whether the NS selection process and the selection results are usable, and specifically whether innovation actors find the process and its results usable to guide their strategies. For the validation the results, of question 1 of phase 2, and questions 3, 4, 5, and 6 of phase 3, are compared for consistency.

The results of question 1 (phase 2) and 3 (phase 3) are represented in tables 8.6 and 8.11 respectively, as part of previous validations. The results of question 4 (phase 3) are presented in table 8.12, showing the grades given by experts for the selection process and the selection results respectively, the grades reflect the amount of trust experts have, going from 1 to a maximum of 10.

**Table 8.12: Overview of the grades given by the interviewed experts for the (niche strategy selection) process and results.**

<table>
<thead>
<tr>
<th>Experts</th>
<th>Grade process</th>
<th>Grade results</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Hampton</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>C. Grete</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>M. Corongiu</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>R. Schmehl</td>
<td>7.5</td>
<td>8</td>
</tr>
<tr>
<td>S. Brabeck</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Averages</td>
<td>7.1</td>
<td>7.2</td>
</tr>
</tbody>
</table>

The results of question 5, as presented chapter 7, have been processed, listing which parts of the selection process has the most, and which the least, confidence of the experts. The mentioned parts, or corresponding comments, are presented in table 8.13 per interviewee:

**Table 8.13: Listing of parts with the most and least confident parts.**

<table>
<thead>
<tr>
<th>Experts</th>
<th>Most confidence in:</th>
<th>Least confidence in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.H.</td>
<td>The method is correct, cannot be improved on the spot</td>
<td>He does not make a clear statement on the results.</td>
</tr>
<tr>
<td>C.G.</td>
<td>The links between barriers and niche strategies (process)</td>
<td>The niche strategy ranking, thus less in the results</td>
</tr>
<tr>
<td>M.C.</td>
<td>Quite confident in the selection of barriers</td>
<td>The selection of niche strategies.</td>
</tr>
<tr>
<td>R.S.</td>
<td>The barriers due to clear and distinct descriptions</td>
<td>The niche strategies</td>
</tr>
<tr>
<td>S.B.</td>
<td>The outcome, it reflects his own impression</td>
<td>Barrier framework, perhaps a bite too detailed.</td>
</tr>
</tbody>
</table>

**Question 6 of phase 3**, asks whether the selection process contributes to the expert’s organization, which leads to a general consensus stating that the NS selection and process can contribute to their organization, although experts do not express this with much confidence.

From the comparison of the results, three findings have been found regarding actor usability: The first finding is that a learning experience seems to have taken place around the presentation of the NS selection, with the experts giving different results to question 1 of phase 2 compared to question 3 of
phase 3. The second finding is the match of the confidence with which experts review the presented NS selection in question 3 of phase 3, and the consensus in question 6, which suggests that the experts have a clear vision or idea of how the niche strategies can be applied to their organization. The third and final finding is that the experts have slightly more confidence in the barrier ranking and its process, than the NS selection. Yet the experts grade the results slightly higher than the process on average, thus suggesting that experts’ confidence is actually quite consistent over both the NS process and selection. In light of these findings and the previous validations, the following conclusion is drawn: Although the concept of niche strategies was new to many experts, leading to perhaps less confidence in this aspect of the process. The interviewed experts do state to have more than satisfactory confidence in the selection process and the selection results, with these being graded on average with a 7.1 and 7.2 respectively. This confidence is also reflected by the experts stating that the NS selection process is usable for guiding their organizations’ strategies. Therefore, in reflection of the results, the niche strategy selection and process are deemed to be usable, in the case of kite-based AWE technologies.

Concluding on this validation paragraph, regarding the niche strategy selection and its process. The links between barriers and niche strategies are deemed to be largely effective, in the case of kite-based AWE technologies. The links also form the core of the NS selection process, which has been validated as accurate in selecting suitable niche strategies for the case, while the NS selection process, and the corresponding results from it, are regarded by the experts as useful to their organizations. Thus in view of these validations, the niche strategy selection and corresponding process are regarded as being effective and useful, guiding innovation actors to shape their market adoption strategy for kite-based AWE technologies.

**Reviewing internal and external validity**

To determine whether the causal interaction between the perceived barriers and suitable NS selection has been validly researched, and whether it is applicable to a broader context, this paragraph reviews the internal and external validity of the research. With the internal validity reviewing the research and analysis processes, and with the external validity seeing whether the results can be applied to the whole of the kite-based AWE field, as well as possible other (sustainable) innovations. The review discusses eleven threats to the internal and external validity, listed below, with further explanation in chapter 2 on page 17.

**Internal threats to validity, according to Campbell and Stanley, 1963.**

- **History** - The threat of the occurrence of an event during the study that influences the outcome.
- **Maturation** - Changes in the study participant, in time, that falsely seem like an independent variable.
- **Testing** - Changes in the study participants’ scores on the second measurement, due to test-effect.
- **Instrumentation** - The threat of inconsistent measurements, due to poor measurement design/execution.
- **Statistical regression** - Selected extreme population might regress to average during intervention, upsetting selection.
- **Selection bias** - Substantive differences between comparison group pre-intervention, offsetting comparison.
- **Mortality** - Loss of study participants, due to various reasons, during intervention or influencing control groups.
- **Interaction effects** - The threat to selectional differences between comparison groups, resembling intervention effect.
External threats to validity, according to Smith and Glass, 1997.

*Population validity* - The extent to which the findings can be generalized to the larger target population.

*Ecological validity* - The extent to which the findings can be generalized across contexts and environments.

*External validity of operations* - The context of the variables might be specific to participant group or research environment.

In two sub-sections, the internal and external validity will be discussed separately, with the overall conclusion of this review made in the concluding section at the end of the chapter.

**Internal validity**

The influence of internal or external events on the research has either been minimized or deliberately triggered. The research, and in particular the interviews, were conducted during a short time-frame. This limited the effects of history and maturation, as the chance of such an (external) event is occurring limited during the 2 hours of the interview, or such an event significantly influencing literature. However, there was a form of deliberate maturation during the interviews, as the interviewee underwent an interactive interview, the results of which can measure the maturation (of the expert’s understanding). One could regard this as a testing effect, although no aspects of the interview was repeated or presented beforehand, in this way no test learning effects could take place. While care has been taken to conduct the interviews and literature research with a high level of consistency, to avoid differences from the research execution in the results, it does not form a granteen of validity. However multiple sampling methods during the interviews and transparent literature searches, do limit the threats from instrumentation, although it cannot be fully removed. The only selection was of the technological and geographic constraints, but neither where selected on basis of extremes regarding the target group, hence the threat of statistical regression is minimized in this thesis. Nor have any comparison groups been made, as all comparison were done either on an individual level or collectively, removing any differential selection bias amongst (interview) participants. And all the participants of the interview completed the entire interview, so mortality is limited as a threat to internal validity. Although only carefully selected data was used from Mr. Ahrens, which is dealt with by thorough data analysis. And so is the threat of interaction effects, as no comparison groups were made or selected. Therefore, reviewing the eight possible threats, the internal validity is regarded as sufficient.

**External validity**

The focussed selection of experts was made within the technological and geographic constraints of the thesis. The selection also focussed on the expertise of the experts, within the field, of which about half were interviewed, but otherwise no further selection or differentiations were made. So within the technological, geographic and expertise constraints, of the expert selection, the population validity is good. However the first two constraints do affect the ecological validity, particularly when looking beyond AWE technologies. In theory any ecological differences should be reflected in the barrier ranking and thus not directly influence the selection process, but the selection has (only) been validated.
for the case of kite-based AWE technologies, so beyond this case further research is required for ecological validity. The research has deliberately been given a very specific case focus, with the development stage, geographic distribution and technology tightly constrained by the case of kite-based AWE technologies, hence further research is required into the variable(s) and the causal interaction for application outside of this case, for external validity of operations. Therefore the external validity is limited to the case of kite-based AWE technologies.

Conclusion on validation
By combining the validation of each component, for kite-based AWE technologies, the overall validity of the niche strategy selection and process is proven. The internal and external validity will be concluded, before presenting the final barrier ranking and its corresponding niche strategy selection (ranking).

Each component, discussed in the previous paragraphs, forms a link in the chain of the niche strategy selection process and its corresponding results, therefore, the conclusion on each component will be briefly presented, before finishing with the overall conclusion on the validation of the NS selection.

But starting with the validity of the statements and answers given by the interviewed experts, which are extensively used in (cross) comparisons with other results for the validation. The level and consistency of the interviewees expertise is regarded as good in comparison to the literature findings. Therefore, the expertise of the experts, in the field of kite-based AWE technologies, is regarded as valid and trustworthy.

Using the results of the interviews, the barrier framework is validated, on its categorization of barriers and coverage of them. Through the comparison of several sets of results, the categorization of the barriers using the barrier framework is regarded as effective, and the coverage of barriers, by both the barrier framework and ranking, is regarded as largely comprehensive. Hence, the barrier framework is validated as being effective and comprehensive in representing the barriers of the case, supporting the validation of barrier ranking, for kite-based AWE technologies, as being accurate and comprehensive in its representation.

With the answers, to several questions regarding the coverage of the presented niche strategies, a comparison was made with the initial strategies of the experts. From this it is concluded that the ten presented niche strategies cover the majority of the possible strategies, and these niche strategies are well enough defined and described to be applied by relevant actors, as confirmed and proven by the interviewed experts. Therefore the ten niche strategies are regarded as satisfactory in definition and coverage for application in the case of kite-based AWE technologies.

Continuing with the comparison of experts’ selection of suitable niche strategies and the links found in literature. The links between the barriers and suitable niche strategies are determined to be predominantly effective in linking the correct strategies within the context of kite-based AWE technologies. And further comparison validates that the niche strategy selection, resulting from the
process, is very credible in its accuracy in selecting suitable niche strategies. The third validation states that both the NS selection and its process, for the case of kite-based AWE technologies, is usable by relevant actors.

In light of these validations, the NS selection process and corresponding selection are deemed to be primarily valid for its application for kite-based AWE technologies, and thus suitable for guiding innovators to accelerate their kite-based AWE innovations to (mass) market.

Great care has been taken to secure the internal validity of the research and its results, and most threats are deemed to have been adequately addressed for the results to be valid. However no threats have or can be fully removed, thus healthy level of scepticism is required towards the results. For the external validity, the constraints of the research put a narrow focus on its application, the findings of the research are regarded as valid for the case kite-based AWE technologies within Europe. But for the broader field of AWE technologies, or other (sustainable) innovations, further research is required, particularly on the barrier ranking, the comprehensiveness of the niche strategies and especially the links between them, for each innovation.

Now that the results of the interviews have been analysed, and the NS selection process and its results validated. The final barrier ranking and corresponding niche strategy ranking can be determined and presented. The final barrier ranking is based on both the combined experts’ barrier rankings, and the alterations made to the literature-based barrier ranking presented during the interviews. The later was largely regarded as accurate, only requiring a higher ranking of institutional barriers as suggested in the alterations, hence the presented final barrier ranking below does not differ much for the literature-based ranking.

Using the final barrier ranking as input into the validated NS selection process, the following ranking of niche strategies has been generated of the top 5 most suited niche strategies. With the ‘geographic’ niche strategy ranked in first place, and ‘demo, experiment and develop’, and ‘educate’ niche strategies jointly ranked in second place. The ‘top’ and ‘subsidized’ niche strategies take fourth and fifth place. The five niche strategies can form the basis or inspiration of a (business) strategy for an organization active with kite-based AWE technologies. A (business) strategy to tackle or overcome the barriers to mass market adoption of the technology.

### Final barrier ranking for kite-based AWE technologies

1. **Knowledge of Technology** – **Support & Investment**
2. **Vision & Image** – **Support & Investment**
3. **Macro-economic aspects** – **Customers**
4. **Knowledge of Technology** – **Institutional aspects**
5. **Knowledge of Technology** – **Customers**
6. **Knowledge of Technology** – **Technological development**
7. **Macro-economic aspects** – **Support & Investment**
8. **Knowledge of Technology** – **Product processes**

### Niche strategy ranking

1. Geographic niche strategy
2. Demo, experiment and develop niche strategy
3. Educate niche strategy
4. Top niche strategy
5. Subsidized niche strategy
Chapter 9 – Conclusion & Reflection

Conclusion
Achieving significant market adoption with a sustainable innovation is very often a long process, taking several decades after its conception. Yet in a world that is increasingly confronted with the limits to its resources, time is perhaps the most precious resource of all. Therefore this thesis sets out to speed up the uptake of sustainable innovations, within a feasible scope, by focusing on the case of kite-based Airborne Wind Energy (AWE) technologies and applying the theories of Strategic Niche Management to it. The aim of the thesis is to develop a niche strategy selection process, to determine the best suited niche strategies for kite-based AWE technologies, guiding its further development to market.

Six research questions have been formulated to build up to the answer of the main research question: Which niche strategies are best suited for kite-based AWE technologies? The conclusions to each of the six research questions (four prime, and two sub) are presented below, with a brief description of the findings. This builds up to answering the main research question in the overall conclusion at the end of the conclusion section.

Where does the technology and market of AWE currently stand?
Since 1827, when the first dedicated research volume on the use of airborne devices for propulsion was published, development has followed a slow exponential curve, with significant steps being made in the past 40 years and increasing pace. Approximately 50 businesses and institutions are currently active in the field of Airborne Wind Energy, developing many different AWE systems which can be placed into eight categories, based on four lifting principles and two kinds of power generation. This thesis focuses on kite-based lifting systems with ground-based generation as the technology case, as discussed in chapter 4. A few organizations are starting or are running pilot projects, while most are developing a prototype for proof of concept, but there have also been several commercial activities in recent years. SkySails has been marketing an automated towing kite for marine applications for several years, and Kitenergy has received a letter of intent to purchase from its corporate partner, while in 2013 Makani was fully acquired by Google. So the first businesses and organizations are starting to look at market introduction, into a market that is still very much fossil-fuel dominated, while also facing competition from other renewable energy systems. This highlights the current need for guidance in bridging the gap between R&D and market adoption. The thesis provides this through the niche strategy selection, aiding organizations in overcoming barriers and unlocking the full potential of AWE.

How can barriers to market adoption be defined, identified, and categorized in general?
To compare the barriers of different cases, and apply the lessons from the past, a generic barrier framework is required to identify and categorize the key features of a barrier without case-specific information. Through a literature search several barrier frameworks linked to SNM have been found. These were compared and reviewed, particularly the lists of generic barriers presented by Kemp, Schot.
and Hoogma. (1998) and the framework of Ortt, Langley and Pals. (2013), before adopting the latter framework with some alterations. Ortt et al. (2013) presents a framework consisting of two sets of six factors, with one set forming the core factors and the other the influencing factors. All twelve factors need to be addressed for large-scale (direct) market adoption to happen, so if one or more factors are not addressed direct market adoption is not possible, and a niche strategy is required. Ortt et al. (2013) propose that both the not addressed core factors and influencing factors need to be known for a more detailed representation of the market situation or barriers, thus enabling a suitable niche strategy to be selected. This concept is adopted with some alterations to the two sets of factors to better suite sustainable innovations, and adds the idea of combining the (individual) factors from the two sets, for identifying and categorizing barriers to market adoption. It is presented in this thesis as a combination of an 'indirect cause' factor with a ‘direct impact’ factor to form a barrier-set, which represents the key features of a barrier without case-specific information. The barrier framework is further explained and the sets of factors presented in chapter 5. The generic barrier framework adapted from Ortt et al. (2013), allows the barriers from different cases to be matched by their key features. This enables suitable niche strategies to be adopted from successful historic cases with similar barriers, to achieve market adoption.

**What barriers are preventing the market adoption of AWE technologies?**

To attain an overview of the barriers to the market adoption of AWE technologies, and provide input for the niche strategy selection process, literature research was conducted to extract identified barriers from various sources. The barriers were extracted from literature sources and categorized into barrier-sets, before combining the barrier-sets to form a barrier ranking based on literature. This literature-based barrier ranking is presented in chapter 5, showing the top 8 most influential barrier-sets for AWE. The literature-based barrier ranking was validated and strengthened through interviews with experts in kite-based AWE technologies, resulting in a small adjustment of the ranking. The final and validated barrier ranking of kite-based AWE technologies is listed below:

1. Knowledge of Technology – Support & Investment
2. Vision & Image – Support & Investment
3. Macro-economic aspects – Customers
4. Knowledge of Technology – Institutional aspects
5. Knowledge of Technology – Customers
6. Knowledge of Technology – Technological developments
7. Macro-economic aspects – Support & Investment
8. Knowledge of Technology – Production processes

The barrier-sets presented above, show that kite-based AWE technologies predominantly lack the technological knowledge or proof to convince investors, users, and aviation institutions of the technology’s potentials and safe operation. This prevents sufficient funds and customers from being available and gaining a license to fly in controlled air space, which inhibits the (full) market adoption of
kite-based AWE, despite its potentials. With this ranking, suitable niche strategies can be selected to overcome the barriers, and accelerate the market adoption of kite-based AWE technologies.

**What niche strategies are identified and described in published literature?**
To attain an overview of the possible niche strategies, to be adopted in response to the barriers, a literature search is conducted to find distinct niche strategies.

In the relatively young field of SNM, no comprehensive definition for niche strategy is given in literature. Hence the following definition is proposed for this thesis, building on descriptions in literature: *A niche strategy is a coordinating process, in which one or a set of experiments are setup, executed, and assessed in a protected niche of the market segment. In order to achieve the wider adoption of a new innovation, through the co-development of innovation and market.* With this definition as guidance, a web-search for relevant literature was conducted, resulting in the analysis of a total of six articles, amongst which that of Ortt et al. (2013). Making use of the limited published research into niche strategies, the ten niche strategies presented by Ortt et al. (2013) form the most comprehensive list. This has been reviewed, using the other literary sources, before being adopted and presented with descriptions in chapter 6 on page 65. The ten niche strategies provide actors with an overview of possible niche strategies to choose from, or be inspired by, to tackle barriers to market adoption.

**Which niche strategies are linked to which barriers as suitable responses?**
A fundamental part of the thesis, and the niche strategy selection process, are the links between barriers and niche strategies. This allows suitable niche strategies to be selected through the barrier-sets, based on historic cases and examples. The ten niche strategies are linked to 20 barrier-sets, of the overall 36 (6 indirect causes x 6 direct impacts), based on the given market descriptions of Ortt et al. (2013). This leaves the 16 remaining barrier-sets without corresponding niche strategies. For the sixteen remaining barrier-sets a description of the market situation is presented and an example-case found, which were then used to determine the suitable niche strategies. The resulting overview of the barrier-sets and corresponding niche strategies is presented in a matrix on page 71 in chapter 6. The links between barriers and niche strategies direct the selection of niche strategies in this thesis, and progressively improve the chances of a successful transition by building on historic cases.

**Which niche strategies are suitable for the market adoption of AWE technologies?**
With the three components (the barrier framework, niche strategies and their links) of the niche strategies selection process defined, the suited niche strategies for kite-based AWE technologies are determined. By using the barrier ranking as input and linking the barrier-sets to suitable niche strategies, a ranking of suitable niche strategies is determined on the basis of the applied barrier ranking. The resulting ranking of five suitable niche strategies, listed on the next page, enabling kite-based AWE technologies to overcome the barriers to market adoption. Thus achieve the aim of the thesis, while providing guidance for the (business) strategies of kite-based AWE organizations.
**Niche strategies selected for kite-based AWE technologies:**

1. Geographic niche strategy
2. Demo, experiment, and develop niche strategy
3. Educate niche strategy
4. Top niche strategy
5. Subsidized niche strategy

**Overall conclusion**

Applying the theory of Strategic Niche Management from an entrepreneurial perspective to the field of kite-based AWE technologies, has led to an innovative niche strategy selection process and resulting niche strategy selection for the technology. Using the niche strategy selection process with the final barrier ranking as input, presents a top 5 ranking of suitable niche strategies, and directly answers the main research question: *Which niche strategy are best suited for kite-based AWE technologies?*

The ‘geographic’ niche strategy is ranked in first place, with the niche strategies of ‘demo, experiment and develop’, and ‘educate’ ranked in joint second place, and the ‘top’ and ‘subsidized’ niche strategies ranked respectively as fourth and fifth most suitable. The five selected niche strategies form the core result of the niche strategy selection process, which are both regarded as being of value to organizations active with kite-based AWE technologies, by the interviewed experts.

By taking entrepreneurial or innovative actors through the selection process, mapping barriers and selecting niche strategies, gives them a tool, overview, and guidance in accelerating their innovations to (mass) market. The niche strategy selection presents the possible niches and experiments to step-by-step unlock the (technological and economic) potential of the innovation, thus funding the further development towards achieving its full potential and market adoption. The approach can potentially break through the slow spiral of a lack of funding resulting in a lack of further development and vice versa, which some organizations currently face. And by selecting niche strategies based on historic cases, it is hoped that past mistakes can be avoided, and the path to market adoption accelerated by better (business) strategies.

It is in this way that the broader ambition of this thesis is achieved, to accelerate the transition and capitalisation of sustainable innovations by tapping into their potential. In spite of the limited published research into niche strategies and managerial perspectives of SNM, it is the concept of niche strategy selection, designed to achieve faster and more efficient transitions, that the thesis proudly presents.

With further research into the relations and variables between barriers and niche strategies, the field of SNM can be developed further to a more influential transition theory. Building on the presented links of the selection process, and with the presented application to kite-based AWE technologies, a new branch of SNM research can be developed. A new branch of SNM to better understand and guide the use of resources in achieving more effective and faster technology transitions to a better world.
Reflection
Reflecting back on the thesis, this section discusses the results and findings, before making proposals for further research. First the scientific contributions and managerial applications of the thesis are presented, followed by a discussion of their limitations, concluding with proposals for further research.

Scientific Contributions
The NS selection process developed in this thesis, for kite-based AWE technologies, and the notions and components which were reviewed or developed for it, has lead to three contributions to the scientific community. These three are discussed below per contribution, to highlight their impact and potential:

The barrier framework is critical for the overall process to correctly interpret the barriers to large-scale market adoption, so the barrier framework was developed to be as reliable as possible regarding its comprehensiveness, categorization, and distinction of barriers. Reviewing several literature sources on the barrier frameworks, resulted in a revised barrier framework as described in chapter 5. It was validated on its categorization effectiveness and comprehensiveness, in the case of kite-based AWE technologies through interviews with experts. Leading to a reliable barrier framework to categorize barriers, and represent the market situation with effective barrier-sets, giving the scientific community a universal framework to identify or categorize barriers to large-scale market adoption. The barrier framework will aid in the further development and understanding of transition theories, by being able to compare the barriers of historic cases through categorization with ‘indirect cause’ and ‘direct impact’ factors, thus generalizing cases’ barriers and providing transparency into past challenges and lessons.

The niche strategies form the outcome of the niche strategy selection process, and need to be comprehensive and clear in their application to be useful. Two sub-contributions are made, from the work done in the thesis on niche strategies. The first being a proposed definition given for the term niche strategy within the context of SNM, since in published literature no clear or comprehensive definition was given for the term. The second being the review of the ten niche strategies adopted from Ortt, Langley, and Pals (2013), with it being reviewed against other literature sources and validated during the interviews by experts on comprehensiveness and application, to form a comprehensive and tested set of ten niche strategies. The sub-contributions collectively provide a starting point for further research into niche strategies in transition science, by presenting a validated application and definition.

The links between barriers and suitable niche strategies form a critical component of the NS selection process and thesis, and despite being a valuable component of the selection process, very limited research is published on the links. From published literature only 20 barrier-sets were linked to niche strategies, with the remaining 16 barriers linked through case examples, and validated by the interviews with kite-based AWE experts. This forms the first comprehensive overview of the links between barrier-sets and niche strategies, covering all possible barrier-sets of the barrier framework. The comprehensive
overview of the links provides a starting point for further research into both the application and functioning of niche strategies in response to barriers, for a better understanding of the relation and the key variables affecting the relation between barriers and niche strategies and how it can be applied.

These three scientific contributions combine to form the core of the niche strategy selection process, which itself is a concept to form a managerial/entrepreneurial application of SNM. This tackles the lack of managerial perspective in SNM literature, as noted by Raven et al. (2010), by the application of SNM in an entrepreneurial/managerial setting. The work done on the niche strategy selection process will potentially lead to a managerial tool over time, as well as a better understanding of how and which niche strategies can tackle specific barriers. This forms the initial step of a new branch of Strategic Niche Management, in its entrepreneurial/business application, to accelerate innovations to market.

Managerial Applications
The results and findings of the thesis also have applications for managers and actors in the innovation space, and although the thesis overall has a strong managerial or entrepreneurial focus, three specific managerial contributions are presented and discussed in the following three paragraphs:

The developed niche strategy selection process contributes directly to managers, who are trying to shape their strategies to successfully tackle the barriers to market, by allowing the manager to apply the process for selecting suitable niche strategies. The resulting selection gives managers the potential to creating business models and strategies for their organizations with a greater chance of success, by building on historic cases of technological innovations and the SNM theory. The overall niche strategy selection process guides and structures the managers’ approach to identifying barriers and finding suitable niche strategies for their (entrepreneurial) organizations, providing clarity and an overview of the options. So not only are the results of niche strategy selection process useful for managers, but the process itself helps and structures a manager’s thoughts in selecting and developing future strategies of the organization. This is acknowledged by the interviewed experts who grade the usefulness of the niche strategy selection process with a 7.1 on average, affirming that the process is of use to managers.

The results of niche strategy selection for kite-based AWE technologies forms a specific managerial contribution, presenting a ranking of five niche strategies to be directly applied by the relevant kite-based AWE actors. The five ranked niche strategies are to be integrated into a business strategy for a kite-based AWE system, helping organizations to overcome the generic barriers of the case innovation, by giving a more structured approach to tackling the barriers and capitalizing on the innovation’s potential. The specific contribution of niche strategy selection for kite-based AWE technologies is also confirmed by the experts during the interview, in which they grade the results of the niche strategy selection with a 7.2 on average. Therefore the selected niche strategies can directly aid the adoption and development of kite-based AWE technologies, through giving (business) strategy guidance.
The barrier ranking for kite-based AWE technologies forms the third direct managerial contribution. Although perhaps not as significant a contribution as the previous two, and with a barrier ranking already presented for AWE technologies in general by the Near Zero (2012) survey. The presented barrier ranking, on page 102, is specific to kite-based AWE technologies, and can contribute by giving managers of relevant organizations a collective reference to discuss the market situation and collectively formulate strategies and co-operations to tackle these barriers. This combined effort of the kite-based AWE industry to make better use of resources and potentials to overcome barriers, is much desired by the interviewed experts, but has only been partially achieved so far and could be expanded.

**Limitations**

Reflecting on the thesis, a total of ten limitations have been identified and are discussed below:

- Only five interviews were used in full for the validation, of the eleven experts approached for an interview. This limits the diversity of experts’ perspectives and the strength of collective agreements, thus threatening the comprehensiveness and consistency validations of the results respectively.
- The choice for interviewing experts in kite-based AWE was made under the assumption that they know best which strategies work for the case innovation. However, regarding the distinction and comprehensiveness of the niche strategies, interviewing experts in business development or innovation commercialization might result in more precise and comprehensive answers. Also the assumption is made that the kite-based AWE experts can correctly predict which strategies will work for the case innovation, which might be contradicted by other experts or future developments of the innovation.
- Since the interviews were all conducted in a single session, with topics discussed in rapid succession, this does not give experts time to reflect on their answers. This perhaps forces a consistency in their answers and results, despite the interview being structured for openness and minimal influence.
- The barrier framework is susceptible to misuse or miscomprehension of the barrier categorization, which has consequences throughout the niche strategy selection process, as actors might accidentally select the wrong, or very similar but different, barrier-sets to represent the market situation. This risk concurs with the sensitivity of the selection process, and alters the niche strategy ranking as a result.
- It is assumed that the barriers are distinguishable and independent, and thus can be categorized and processed independently. But a possible perspective is that the barriers might be interrelated or interdependent, thus strengthening one another and possibly inhibiting the niche strategy.
- Although experts are confident that the presented niche strategies can be combined, no research was done into the interdependence of the niche strategies. As some combinations might cancel one another out, or not be possible, while other combinations might lead to a mutually strengthening effect.
- It is assumed that using historic cases and expert perspectives, collectively form a valid basis to make future predictions to which niche strategies will tackle the barriers. However, a hindsight bias might occur, as the basis of the selection process is built upon selected past experiences and cases.
● No assessment was done whether the links between barriers and niche strategies are case specific or generally applicable, so it remains uncertain whether the match between a case’s barrier and niche strategy is applicable to other cases, although some are indirectly validated for the kite-based AWE case.

● Sixteen of the 36 barrier-sets where not covered by the historic cases, presented by Ortt et al. (2013), and for those sixteen barrier-sets the links are proposed based on the market situation description. However these proposed links are not directly validated, under time constraints, although they are indirectly validated in the kite-based AWE technologies case, the evidence of these links remains weak.

● A limitation to the niche strategy selection process is that it is a static analysis, thus neglecting the dynamic behaviour within and outside the niche. Although repeated application of the niche strategy selection process results in a quasi-static analysis, by reassessing the best suited niche strategies at set time intervals, the actions taken during the time interval will be blind to the dynamic (market) situation.

Further research
Three proposals for the further research are made, which cover the majority of the ten limitations previously discussed, are presented below:

● The first proposal is to conduct more interviews or use alternative forms of testing, to tackle; the lack of conducted interviews, a selection bias from interviewing kite-based AWE experts, and susceptibility of the barrier framework to misinterpretation, which are the first, second, and fourth limitations. One could interview experts in business development or innovation commercialization, to attain a broader perhaps more comprehensive perspective on the functioning of the niche strategy selection process and its results. Alternatively one could possibly use business simulation games, to test the niche strategy selection process under controlled conditions and in less time than a full-scale experiment. All of the above is to collect more and diverse data to strengthen and validate the niche strategy selection process and the barrier framework’s selectivity, through analysing individual results and comparing them.

● The second proposal is for further research into barriers, niche strategies and the relations between them; to tackle the lack of understanding of possible barrier interdependence and niche strategy interdependence, as well as the individual validity and the case-sensitivity of the links between barriers and niche strategies, which are the fifth, sixth, eighth, and ninth limitations. These limitations can be individually tackled through (historic) case research, or collectively by applying the niche strategy selection process to current cases or simulations to progressively strengthen against these limitations. Either way, attaining a greater understanding of the functioning and preconditions of barriers, niche strategies and the links, will greatly improve the successful application of niche strategies and SNM.

● The third proposal is the application and understanding of niche strategies and the selection process beyond the case of kite-based AWE technologies. Therefore it is proposed that one investigates the niche strategy selection process for other (sustainable) innovations, to strengthen the results and/or in support of the other two proposals. Thus gathering more diverse results from other innovations, for the strengthening of the selection process, and the further understanding of niche strategies and SNM.
Bibliography:


Appendix

Appendix A.1: The identification and categorization of barriers
For the proper application of Strategic Niche Management, it is important to have a thorough understanding of what is preventing a sustainable innovation from entering the market and having significant uptake. Hence a comprehensive analysis of the barriers preventing market uptake is necessary before a niche market can be selected to overcome or avoid these barriers.

In the current field of research much of the effort has gone into analysing case-specific barriers and their causes and effects. But less effort has gone into forming a clear and applicable framework, with a sustainable innovation and entrepreneurial perspective. The latter is required for entrepreneurs to be able to take action and bring sustainable innovations to (a niche) market, after understanding the barriers against large-scale adoption and identifying what niche markets might viable for the innovation with the appropriate strategy. This is achieved by using the framework to map the barriers, and check for missing ones, giving an overview of the current socio-technical system and possible niche strategies avoiding or overcoming the barriers, hence a literature review has been done to provide the required comprehensive framework.

The goal of this literature review is; to provide a framework of barriers with this perspective by reviewing two selected frameworks of barriers and scrutinizing them against findings from a literary web-search. This leads to a framework of barriers, which consists of a set categorization terms that allow barriers (in generic form) to described on a basis of cause and impact through the combination of terms from the two sets. Thus allowing to place barriers in their respective combination and describing what factors are inhibiting large scale adoption of a sustainable innovation, while simultaneously sketching an overview of the market situation. Which is done out of the perspective of entrepreneurs, trying the capitalize the potential of the sustainable innovation, as further research aims to support them adapt to the barriers in their potential market. Which leads to the main research question; do the current frameworks suffice in covering and describing barriers of the market entry of sustainable innovation? The methodology of answering this question and the reasoning behind the two selected frameworks is given in section 1. With section 2 discussing the selection and processing of articles found by the web-search. Section 3 focuses on the extraction of information and examples from the selected articles. Section 4 reviews the frameworks and presents the final framework that comes forth of the review. Section 5 concludes, reviews and recommends the overall process of this literature review and future improvements.

Section 1: Methodology & search
Starting with the current frameworks related to strategic niche management, articles of Kemp, Schot and Hoogma (1998) and Ortt, Langley and Pals (2013), form the base sources. The article of Kemp, Schot, and Hoogma (1998) was selected as it presents a set of factors that impede the development and
use of sustainable innovations in the transport sector, and seems to be the first of such an analysis in the field of SNM. The article of Ortt, Langley and Pals (2013) presents 10 generic niche strategies, based historic cases of niche markets, found through combinations of causal and resulting factors leading to describing 36 market situations. These market situations suffered of barriers that prevented large-scale adopting of technical innovations, and hence provide a well documented framework of barriers, which is hence used in this review. From these articles the described frameworks will be extracted, to then be scrutinized and if possible improved or expanded, by reviewing them against the results of a compact (web-) search for scientific articles on barriers and their categorization.

To guide this search for barriers, and alternative frameworks, a review protocol has been developed to safeguard the (scientific) quality and reproducibility of the literature review. As well as being the guiding protocol for delivering a relevant framework for barriers for further application in my thesis. The relevant framework will be the result of extracting and (if possible) combining the frameworks from the selected articles, followed by reviewing them against several relevant articles to find room for expansion or clarification. Particularly the search for articles and the following study selection will be a critical part of the review, thus the following approach has been set up to deliver the required quality.

The following figure A.1 gives a brief overview of the overall process of this review:

Figure A.1 Overview of process steps to reviewing and developing a barrier framework

- Step 1: Extraction of frameworks for Kemp et al. (1998) and Ortt et al. (2013).
- Step 2: Web-search for articles on barriers and frameworks
- Step 3: Selection on relevance of article based on the title
- Step 4: Selection on articles based on abstract
- Step 5: Selection for extraction after reading entire articles
- Step 6: Selection of extracted barriers and frameworks against initial frameworks
- Step 7: Integration of selected barriers and frameworks into final framework

To briefly expand on the definition of barriers used in this review: A barrier is an observed obstacle by an actor in the techno-system, inhibiting further progress. Usually this observed obstacle is often based on a specific problem, and thus hard to describe as a generic barrier, highlighting the complex form of barriers. Its complexity is often due to misalignments in a combination of (certain) factors. All of these factors are required to be aligned in order to allow for direct mass market introduction, which is often not the case [Ortt & Suprapto, 2011]. Hence in this review a barrier is regarded as a misalignment in one or, the combination of, several factors of importance to the market introduction of an sustainable technical innovation.
To align the search for articles with the desired context of the results, the search will done using the following search terms; barrier*, factor*, hurdle*, obstacle*, in combination with innovati* or technology*strategy*. The first four search terms cover different expressions for barriers, while the latter two search terms present terminology for innovation and technology development. With the * broaden the search in the search engine to plural or adjective forms of the search terms, for example strategy, strategies, and strategic. In addition, the search terms will be combined with the option to filter on the publication date, to extract the latest articles. Which has the aim of filtering out the latest findings, developments, and definitions and getting a current perspective on the subject. An additional approach could be to search for citations of the two base articles, to investigate what other researchers have done to continue building on the two base-articles with regards to barriers.

The choice is deliberately made to avoid directly searching for sustainability for two reasons. First simply being that there multiple terms that describe, reflect or represent sustainable technologies, for example; eco-friendly, cleantech, renewable, etc. Hence to absorb all these terms into the search would expand the search from 8 combinations to 32 or more combinations. The second argument is that barriers against new technologies in general, will also impact sustainable technologies as a barriers and therefore will also have to be absorbed in the search. Hence the choice was made to keep the search broad and adjust for it in the selection process.

To select articles for further analysis of content, which will proceed in three phases, the articles relevance to sustainable technology and/or an entrepreneurial perspective will be assessed. Despite that these terms conjure up strong images and personal definitions, they are actually quite opaque. Hence the initial phase (step 3) will constitute reading the title to subjectively determine its relevance with the mentioned terms, while the statistics of rejected and accepted articles are documented. This approach prevents the exclusion of articles due to different terminology or the inclusion of articles that use the terms but in a different context/application. The following phase (step 4) will be reading the abstract to determine its connection with the mentioned terms, and for each article a brief argumentation for inclusion or exclusion will be given by the reviewer. In the final phase (step 5) the same procedure has the previous phase will be applied but after reading the entry article.

To reflect on how comprehensive the final resulting framework is, the following procedure is put into place to judge the breadth and quality of the research. To judge this, the number of articles found, the number and quality of articles processed, and the number of additional results are added to the initial framework, will be documented and assessed. By looking at the ratio between the number of articles and new results added, the effectiveness of a further search can be judged, while the quality of articles will indicate the scope of research committed to defining and categorizing barriers.

Due to the subjective nature of the topic of barriers to commercialization, as how barriers are perceived by actors differs and leads to differing terms and description, the quality assessment of the articles is relatively more challenging. However an assessment will be made of the used research methodology
and its alignment with the research questions of each article that was selected in the second phase, which will be achieved by applying the checklist proposed by Popay, Rogers and Williams (1998). After reading the complete articles from the selection, either the presented alternative frameworks or the barriers that are not covered in the framework of the base-articles are extracted. The alternative frameworks or not covered barriers are the two expected types of results, from the article search, relevant for the review of the frameworks.

If alternative frameworks are found and presented, it will be scrutinized by its relevance with market introduction and sustainable innovations. If found to be relevant the frameworks will be extracted and absorbed into the review, together with an argumentation of its relevance by the reviewer (step 6).

Barriers found that are not covered or properly described, within the initial frameworks of the base-articles, will also be scrutinized on basis of relevance to market introduction, the initial framework, and sustainable innovations. If the barriers found stand up to scrutiny, then they will be absorbed into the review. However the second result of the search is far more subjective than the first. As the differentiation whether the barrier is covered by the initial framework or not is rather opaque, due to flexibility in the interpretation of the framework. Hence the barriers extracted will included a thorough description for later review by others, in regards to whether it is covered or not be the framework. And in case of uncertainty, the barrier will be extracted regardless, to prevent exclusion and as an exercise of applying the framework.

Following the extraction of results, in the form of alternative frameworks and not covered barriers, these will have to be correlated and integrated with the initial framework to form the final comprehensive framework (step 7). Using the initial framework as a starting point for both comparison and a basic framework to which the additional results will be integrated, each result will be first compared with framework to understand how it differs from the initial framework, leading to a brief description what aspects or factors are affected. Once all the results have been processed in this manner, and in the case of not covered barriers additionally checked on their fit the initial framework, the initial framework will be reviewed. Regarding which factors or aspects have a scoop for further improvement, by surveying which factors and aspects differ from the found results.

The final step is to integrate the found results into the initial framework by adapting or expanding the framework to become a more comprehensive and reviewed framework for later application in barrier analysis.

Section 2: Article selection & quality assessment
Before doing the web-search for additional articles, the base articles were read and relevant information was extracted.

Starting with the articles of Kemp, Schot and Hoogma (1998), which presents strategic niche management as a perspective for regime shifts to sustainability. It is specifically focussed on the case of
clean road vehicles, but without analysing historic cases in depth, it lists seven factors that affect development and use of new transport technologies. The nature of these factors are listed in the following table A.1:

Table A.1: List factors presented by Kemp et al.

**Technological**

**Government policy and regulatory**

**Cultural and psychological**

**Demand**

**Production**

**Infrastructure and maintenance**

**Undesirable societal and environmental effects of new technologies**

And are described as not being independent causes of barriers, but by being interrelated and often reinforcing each other to form barriers, and thus collectively impact the technical regime inhibiting radical change. Although the factors seem to cover most of the technical regime’s aspects, it seems more applicable as checklist for the coverage of all the aspects than a comprehensive framework for identifying causes, effects and impacts.

The framework described in the article of Ortt, Langley and Pals (2013), is constructed from a different approach. It describes the factors required for large-scale diffusion of technology in the market space, stating that if one or more of these factors is missing, large-scale diffusion is not possible. This framework introduces a dual level and top-down approach, making a distinction between six defined core-factors and six influencing factors, with the combinations presenting specific barrier cases. The both sets of factors are presented in table A.2 (on the next page):

Seen as the base articles both present a different tact to categorizing barriers with a framework of factors, with one approach being from the bottom-up and the other from the top-down, combining the two would seem be a way to get to a more comprehensive framework. However as will be described later on, every framework struggles to properly describe the interdependence and causality of barriers in its categorization of them. Thus in order to save time and effort, the two initial frameworks will not be combined until additional frameworks and/or barriers are found, so that a later stage a better effort can be made to result in a more comprehensive and stronger final framework. Comparing the newly found frameworks from the selected articles, will be done against both frameworks separately. This should not impact the result, as both frameworks seem has a similar coverage of barriers and are already quite good.
Table A.2: Overview of core and influencing factors as presented by Orrt et al (2013)

<table>
<thead>
<tr>
<th>Core-factors</th>
<th>Influencing factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New high-tech product</strong></td>
<td>Knowledge of technology</td>
</tr>
<tr>
<td><strong>Production system</strong></td>
<td>Knowledge of application</td>
</tr>
<tr>
<td><strong>Complementary products and services</strong></td>
<td>Natural resources and labour</td>
</tr>
<tr>
<td><strong>Supplies (network of organizations)</strong></td>
<td>Socio-cultural aspects</td>
</tr>
<tr>
<td><strong>Customers</strong></td>
<td>Macro-economic aspects</td>
</tr>
<tr>
<td><strong>Institutional aspects (laws, rules and standards)</strong></td>
<td>Accidents or events</td>
</tr>
</tbody>
</table>
the 133 articles, selected from the total 2380 processed results, were processed further on the basis of their abstract or other comparable summary of content (step 4). For each article a brief argumentation was given why the article was accepted or rejected for the following stage (step 5) of the selection process, with the overview to be found in table A.7 on page A.23.

The final stage was to read the 30 articles completely, but sadly in the case of 4 articles accesses to the full article was inhibited, hence these articles were not processed. The remaining 26 articles were read in full, and the extracted frameworks and barriers are described and discussed in section 3.

Quality assessment:
To assess whether the search and selection of articles has sufficient quality and breadth, the relations between the different phases of the search and selection process are reviewed. On average, over all eight search terms, 1.1% of the results produced by the web search where processed. And of the processed articles 1.3% where accepted to be read in full, on average. These percentages might seem low, but do suggest that search was broad whilst still producing a significant number of articles to read. Whether it would be better to process more results from the search is debatable, especially when more time was available for the selection. But as the web search was done in the generic setting, which presents the most relevant (based on word count) results first, it is assumed that number of relevant articles per number of results will drop further as more results are processed. Of course there is some variation between the search terms, and a second search using more precious or targeted search terms would definitely be recommendable in retrospect.

To make efficient use of time and effort, only the sources from which information is extracted will be reviewed regarding quality of the source. This will be done by applying a checklist for checking the quality of sources used in a literature review, presented by Popay, Rogers, and Williams (1998), which is presented in table 4 along with a brief description of checkpoint.

Table A.4: Checklist and description of Popay et al. (1998)

<table>
<thead>
<tr>
<th>Primary marker</th>
<th>Is the research aiming to explore the subjective interpretation of experiences?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context sensitive</td>
<td>Does the design of the research allow for flexibility/sensitivity during the study?</td>
</tr>
<tr>
<td>Sampling strategy</td>
<td>Has sampling been shaped by theory with attention to diverse contexts, etc.?</td>
</tr>
<tr>
<td>Data quality</td>
<td>Are different sources of knowledge/understanding being explored?</td>
</tr>
<tr>
<td>Theoretical adequacy</td>
<td>Do researchers explain the process from data to interpretation?</td>
</tr>
<tr>
<td>Generalizability</td>
<td>Do claims on general application follow logically/theoretically from the data?</td>
</tr>
</tbody>
</table>

From the 116 articles which were selected on basis of their titles, further selection on basis of abstract and extracted barriers and frameworks, 8 articles were found to have barriers and framework which contribute to the final framework. These 8 articles are checked on their quality and are discussed individually in the following paragraphs:
Doranova and Miedzinski (2013), draws on Eco-Innovation Observatory thematic report ‘Eco-Innovation in emerging markets’ (2012). This report is a compilation of other reports and case studies, mainly from government and corporate sources, but lacks a transparent methodology to its compilation. Why and how sources are selected is unclear, but seems to be based on a broad base of sources. Although from a trustworthy source, the lack of a methodology is worrying, but still the broad base of sources makes it a reasonable source.

Richter (2013), is based on a series of interviews with selected actors, and is in line with relevant research theories. Despite dealing with a subjective topic, the use of interviews and their setup allowed for flexibility in interpretation. The sampling strategy of interviewees is clearly described and sound, thus also insuring diversity of sources. Overall I’m confident that this article is a good scientific source, in line with the checklist.

Galia and Legios (2002), uses data from a survey conducted by the industrial statistical department of the French Ministry of Economics, Finance, and Industry, and is supplemented by additional sources. Still much of the flexibility of interpretation, sampling, and quality lies with the strength of the data from the survey. Knowing that care has been taken with the survey, I deem this source as a descent source of the literature review.

Padel (2001), reviews a large number of studies on organic farmers, which are then compare to the adoption model. Although taking critical view on the many studies and the adoption model itself. The correlation between the model and the study’s findings seem to be determined by the researcher herself, as here is not a clear description how the studies are selected and extracted. Seen as the relevant information is based on multiple studies, rather the conclusion of the article itself, the source is deem reasonable of quality.

Huangli and Chi (2013), itself is based on results of survey among high-tech industry in China. However the extracted framework of Piatier (1984), which is referred to by Huang et al., originates from a matrix-structure used in a survey in selected European countries. The five-groups presented represent predominantly actors and certain perceived emotions in the process. What the origin of the structure is not clearly defined, although of course structured to the research purpose of the survey. It might be one of the research projects in the field, but it is non transparent and thus regarded as of questionable quality. Which also reflects on the quality of the selected article.

Stephens (2013), builds on previous research on non-cost barriers, but fails to clear state what the sources are and how the selection and extraction was done. This severely impacts the quality of the article, despite being of a reputable source, and hence is regarded as disputable.

Goodier and Chmutina (2013), analysis four case studies, which were selected on their geographic spread and the different financial and technical approaches of the case projects. The case studies are described a extensive web search and interviews, using a analysis tools for the semi-structured interviews. Despite the limited number of sources, much effort seems to have gone into the extraction,
thus the quality of the article is deemed good.

Wüsthenagen, Wolsink and Bürer (2007), combines several papers to present an overview and an introduction. However it does specify how the papers are selected or information is extracted, stating that there is a limited source of relevant papers. Still sources are compared and summarized to get an overview, with argumentation of additional sources. So in light of this, the source is regarded as reasonable.

Overall the sources are of reasonable quality, there is a lot of non transparency regarding selection and extraction of sources, which might be due to the relatively high share of sources lacking an academic background. But seen as the information extracted from these sources is often a small part of the overall article, and very often a further development based on other sources, I feel that in the circumstances the quality is sufficient to achieve the desired result.

**Section 3: Data extraction and analysis**

From the 25 articles that were read after the article selection process, several new (or poorly represented) barriers and alternative frameworks were found. By extracting and analysis each found barrier or framework could provide an opportunity to broaden or strengthen the final barrier analysis framework of this literature review. In total eight articles of the 25 articles read present new barriers or frameworks which have been extracted, after selection against the existing frameworks, several other articles highlight interesting points or perspectives but are not directly relevant to the framework review. Each found barrier or framework is described with some context to fully grasp the situation in which the barrier or framework exists, before being processed further into the final framework. In the following table 5 the eight selected articles and brief description of their extracts is given:

<table>
<thead>
<tr>
<th>Authors</th>
<th>Date</th>
<th>Brief description of extractions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doranova &amp; Miedzinski</td>
<td>2013</td>
<td>Framework on direct impact on business in eco-innovations and corresponding barriers.</td>
</tr>
<tr>
<td>Richter</td>
<td>2013</td>
<td>Barriers of lack of (public) backing through politicians and partners</td>
</tr>
<tr>
<td>Galia &amp; Legios</td>
<td>2002</td>
<td>Framework with greater distinction between economic barriers.</td>
</tr>
<tr>
<td>Padel</td>
<td>2001</td>
<td>Barrier of a divide between adopters and non-adopters regarding information and skills.</td>
</tr>
<tr>
<td>Stephens</td>
<td>2013</td>
<td>Barrier of lack of diversity in models or variations of the product</td>
</tr>
<tr>
<td>Goodier &amp; Chmutina</td>
<td>2013</td>
<td>Barrier of lack of partner commitment to a project or product</td>
</tr>
<tr>
<td>Wüsthenagen, Wolsink and Bürer</td>
<td>2007</td>
<td>Framework with different actor groups and their acceptance of renewable energy innovations.</td>
</tr>
</tbody>
</table>
Starting with a note paper of Doranova and Miedzinski (2013), in which an analysis is made of the barriers from eco-innovation in emerging and developing countries, it presents both an alternative framework and underrepresented barriers. The framework categorizes the direct impact of barriers on businesses trying to get eco-innovation on the market in emerging and developing countries, for which the four categories of barriers have been listed: Economic barriers, Institutional barriers, technological & knowledge-based barriers, and other barriers.

The category of economic barriers covers the economic aspects or incentives of government policies, the access to investment capital, lack of consumer demand, and lack of good intellectual property protection which is discussed later on. Thus covering barriers concerned with capital requirements and assets of the business as well as possible revenue sources.

Institutional barriers covers the impact of governmental and other public bodies on the business through either polices for eco-innovations or other markets and regulations.

Technological and knowledge-based barriers covers mainly the lack of resources required, either in the form of complementary infrastructure, skilled personnel, or the ability to adapt the technology to local needs (lack of technical knowledge). This category could be regarded as broad, and in certain perspectives might be used to cover every barrier, but being specifically tailored technological and knowledge-based resources scarcity limits its scoop.

The final category of other barriers seems to be a safety net for barriers that are not covered, but the examples given by the authors are collated in the aspect of cultural and psychological perceived barriers. For example lack of awareness of eco-innovations or cultural differences between the local market and foreign businesses.

The appealing aspect of this framework is that it takes the perspective of an entrepreneur or business, thus directly applicable for this actor group. Although it does neglect the actual cause or source of the barriers and does not discuss the interdependence and domino-effect that barriers have. And there is not reference or explanation why or on what basis the authors chose this framework. The entrepreneurial perspective on barriers is also of importance for the final framework, as this perspective will form a main source of information for the barrier analysis in subsequent thesis and other research. And despite not being very detailed or dealing with interdependence or causality, the perspective and responding categorization will be integrated into the final framework.

Certain barriers presented by Doranova and Miedzinski (2013), provide a new and interesting perspective that does not seem to be covered or well represented by the initial framework, perhaps due to its focus on emerging and developing countries. A lack of financial resources for R&D and other investments is mentioned as a barrier, but does not seem to be well covered by the initial framework, and strongly impacts the ability of the business to innovate, start, and expand into the market. Further
barriers of interest are trade barriers against global trade limiting access to both goods and financial resources, and (the perceived) lack of intellectual property protect as a direct risk the potential to commercialize an (sustainable) innovation. These barriers will certainly need to be covered in the future framework to both broaden and strengthen it, thus allowing application in both developed and developing countries and coverage of more aspects.

The article of Richter (2013), delves into how German municipal utilities invest and innovative with offshore wind energy in terms of business models. One of the interesting barriers or actually driver found in the articles is that due to the public nature of utilities, local politicians enforce their political agenda’s through the supervisory board of the utility company, thus drive the push for renewable energy. However the lack of politicians with a similar function in businesses with sustainable innovations or similar agenda’s could act as an barrier rather a driver. Not because the missing driving force. But the possibility that the business’s ambition conflicts with that of the politician’s, which is perceived as another barrier and covered by the initial framework. The other barrier described is the experience and reputation of cooperation partners as perceived by investors with high stake, and thus running high financial risks if partners fail. This barrier has two perspectives, one from the investor how wants trustworthy partners, and the perspective of the partner how needs to be perceived as experienced and has a good reputation. Dependant on the role of the innovator, whether as supplier of system components or as lead-technological developer or perhaps investor, the effect of the barrier is either not getting a contract or struggling to find adequate supplier or other complementary services for the technological system respectively.

Both the described barriers are unique and to a certain level specific, as there extracted from specific cases, however they still represent an important aspect in the actor-network of a sustainable innovation. Both that the evolvement of certain actors can significantly steer the direction of the socio-technical system and that if actors in the network have a lack of trust or commitment it can seriously slow the pace of the sustainable innovation’s development and deployment. Hence these, perhaps often overlooked, barriers with a strong impact should definitively represented in the final framework.

Galia and Legios (2002) present the framework used in a technical industry survey on barriers to innovation inside French companies. The results of the survey are represented in percentages of the innovation projects that were either postponed or abandoned. The framework consists of nine categories, which are: Economic risks, costs of innovation, lack of financial resources, resistance within the organisation, lack of skilled personnel, lack of information on technologies, lack of information on markets, institutional barriers, and lack of consumer response. The framework from the Community Innovation Survey 2 (of the industrial statistics department of the French Ministry of Economics, Finance and Industry) uses greater distinction between economic barriers (the first three mentioned). The three barrier of; economic risks, costs of innovation, and lack of financial resources were also the barriers with
the highest percentages in the survey, while the distinction seems to run parallel to three aspects of investment decisions (risks, size, and financing costs).

Seen as the greater distinction between economic barriers was also the top 3 reasons shown in the survey results, highlights that economic barriers play a strong role and take on different backgrounds. Although no further analysis is given and the categorization is suggestive due to the nature of the research, additional distinction in economic barriers with regards to investment decisions will be represented in the final framework.

In the article of Padel (2001) on the innovation diffusion of organic farming, an interesting barrier comes to light regarding innovation adopters. Although described as a barrier for farmers converting to organic farming, broader application to innovations that replace or displace other technologies is possible. Although organic farmers seem to open to one another, in sharing information, an outsider might struggle to join the (close knit) community and access knowledge of technology or application. But this divide between groups of adopters and non-adopters might be caused or fortified by the invasive nature of a new innovation to the (local) system, or perhaps even result in the perception that the new innovation is innovative. The entrenchment of the community between adopters and non-adopters, due to lack of transparency and neutral product introduction, can inhibit further adoption. This interesting social barrier seems only applicable to innovations that directly replace another technology and thus compete for backers and adopters. But it also shows that the way the public, consumers, or other actors view the technology as an opportunity or threat is of importance to its adoption and should be accounted for in the final framework.

Huangli and Chi (2013) describes in his article on barriers and their impact on innovation performance of Chinese industries, the framework developed by Piatier. The framework consists of five groups of barriers; research & development policies, general, economic, and social policies, action by national private sector and universities, innovation climate, and foreign countries. And covers both internal as external barriers to innovation for a business, organization, or industry. It is one of the first and comprehensive research projects done on innovation barriers [Huangli, 2013], and had been developed further since.

Reflecting from the initial framework, there is significant differences between the categorization used in the frameworks, and the framework of Piatier does not seem correlate to a specific perspective or aspects of the barriers. Despite being one of the first comprehensive research projects on the subject, it seems to have been improved and surpassed by the initial frameworks. The categorization groups are very different to other frameworks, but it seems that this framework has little to offer to the final framework of this literature review.
In an article of the Stephens (2013) on the non-cost barriers to consumer adoption of new light-duty vehicle technologies, the lack of alternatives of the same innovation is presented as a barrier to consumers, which might be specific to technological innovation in a wider product system. But consumers willing to adopt the new innovation will want to do so in a combination of other technologies and features specific to the individual consumer, which is might not be offered on the market (yet). Thus a lack of diversity of models/products offered is a barrier opposed to the value of having diversity of models/products offered [Greene, 2001]. This is regarded as a barrier which is easily overlooked during analysis, hence should definitely be representable in the final framework.

Goodier and Chmutina (2013) present a multiple case-study analysis of non-technical barriers impacting on urban energy systems. In which a case-study presented the case that a key-stakeholder unexpectedly changed its position and involvement in the respective project, resulting in a financial gap in the project’s finances. The dynamics of the actors involved in such innovative projects allow for sudden changes in direction and can lead to project failures and its consequences. Whether this effect is an resultant or cause of other barriers is not quite clear, but on its own it can impact the progress and time-line of an innovation system. Such an impact can have serious consequences for the innovation and should definitely be described by the final framework to insure coverage during a barrier analysis.

Wüstehagen, Wolsink and Bürer (2007) present an article on the social acceptance of renewable energy innovations presents a framework for the categorizing three dimensions of social-acceptance. Although not covering all possible barriers in the framework. It focuses on cultural and psychological aspect of barriers, hence taken aboard for further review. Split in three dimensions; market acceptance, community acceptance, socio-political acceptance. The market acceptance dimension covers acceptance of actors directly involved from an economic perspective. While community acceptance covers the acceptance of the communities near to renewable energy innovations, through the stages of development and operation of renewable energy innovations. Final socio-political acceptance actually covers the acceptance of the innovation itself from a technical perspective of all actors (public, key stakeholders, policy makers, etc.).

This split in forms of acceptance seems to follow the different actor groups involved with the acceptance of renewable energy innovations, and hence forms a relevant and useful comparison for the final framework. Safe guarding the representation the cultural and psychological aspects of the three dimensions mentioned in the final framework.

In the following section these extracted frameworks and barriers will be combined to form the final framework, to be presented by this review, building on the initial framework.
Section 4: Framework review & development
The purpose of the final framework is to guide and accelerate the barrier analysis of a sustainable innovation. Thus providing a comprehensive overview and insight, for driving actors behind the innovation, of what is withholding the technology from gaining traction on the market. Hence the final framework is orientated on the perspective of its prospective users; innovators, innovation entrepreneurs, business consultants, and researchers with a similar perspective, to streamline its use in a prospective barrier analysis.

The two initial frameworks presented at the beginning will form the foundation on which the further developed and scrutinized final framework will be based. However the initial frameworks do have their differences in approach and setup. The framework presented by Ort, Langley and Pals (2013), makes a distinction between indirect cause and direct impact and is constructed from the top-down by looking at missing factors for mass market uptake. It is these features that make it suited as a base for to build the sustainable innovation oriented final framework on. The distinction between direct and indirect factors, will allow users to more easily identify barriers by their direct impact on the business or innovation and tracing it back to the underlying cause(s). The other feature of top-down construction is that it is based on historic cases, allows for both relevance and room for further expansion. Hence this initial framework will be used as the base for the final framework, as it is features are suited for the purpose of the final framework. While the other initial framework will be used as a control for covering breadth of diversity of barriers.

To clarify the definitions and resulting distinction of direct impact and indirect cause, the following definitions will given to explain the roll these play in the framework. The perceived impact on segments of a business or innovation by barriers, fall under direct impact, and allow users to quick categorize where the business is affected. This is especially relevant has barriers can be internal or external to a business or innovation and be technical, social or economical in nature. However for the cause of the impact, one will have to look further in a much more opaque area of indirect causes. Since the actual and precious cause of a specific barrier would dedicated research on its own, the categories represent the approximate area from which the cause of the barrier originates. It should be understood that the combination of direct impact and indirect cause is what represents a barrier type, and that the combination describes the core properties of the barrier type. This means that one direct impact can have six different indirect causes, or one indirect causes can result in seven direct impacts. Resulting from combining the found frameworks and barriers with the initial framework in the described format, following framework as come forward (see table A.6) and will be further discussed.
Table A.6: Final framework categories and causality

<table>
<thead>
<tr>
<th>Direct impact</th>
<th>Indirect cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological development</td>
<td>Knowledge of technology</td>
</tr>
<tr>
<td>Production process</td>
<td>Knowledge of application</td>
</tr>
<tr>
<td>Complementary products &amp; services</td>
<td>Resources</td>
</tr>
<tr>
<td>Support &amp; investments</td>
<td>Socio-cultural aspects</td>
</tr>
<tr>
<td>Customers</td>
<td>Macro-economic aspects</td>
</tr>
<tr>
<td>Institutional aspects</td>
<td>Vision &amp; image</td>
</tr>
</tbody>
</table>

The framework was developed by taking the found barriers and trying to find a suitable combination in the initial framework, if this was not possible then a new factor (or an alternative name for a factor) was conceived to (better) cover the barrier. Once done, the new framework and initial framework was compared to the found alternative frameworks to see whether there was any further room for improvement. Both processes were repeated till the resulting framework adequately covered the barriers.

To further clarify and improve the use of the framework, a brief description and confines of each category will be given, starting with the direct impact categories:

Technological development – represents impacts on the research and development of technology or directly corresponding products. It is strictly confined to the development of the prospective technology, either inside or outside to the corresponding business or organisation, inhibiting initial or further development of an innovation.

Production process – covers the manufacturing, supply chain, retail, logistics of getting an innovation in the form of a product or service to market. Largely internal to a business or organisation, a lack of suppliers of system components can also be a barrier, thus no strictly confined to internal limitations, the confines are the required processes for the product or service to exist. This category is also more or less the replacement of the former production system factor of the initial framework, which emphasizes the technology required to produce the product or service.

Complementary products & services – directly adopted from the initial framework, represents products or services that are either required for or strengthen the core innovative product or service. This ranges from maintenance and infrastructure to additional features to be added to core innovation. But confined outside the direct process, development and presentation of the core-innovation.

Support & Investments – is a new completely new addition to the framework, inspired by found barriers. It covers two groups of actors who back a business or innovation. The first is the (local) community or society who can be powered, as often the case renewable energy technologies, to block or back
progress without (directly) being a customer. The second being investors in the business, venture, or even development, who control a vital resource for the pace of development and can have access to strengthening networks as partners. This category covers the top three barriers found in the article of Galia and Legros (2002), which according to the survey have a strong impact, thus justifying a separate category.

Customers – is relatively clear category adopted from the initial framework. However not only are size of the customer market and customer’s knowledge of the innovation important, the realisation different innovations cater to different sorts of customers, like businesses, public bodies, or consumers, as well as all sorts simultaneously.

Institutional aspects – another adoption from the initial framework regards the impact of laws, regulations, standards, etc. This impact can either be positive or negative, and is often governed by a public organisation or institute.

Continuing with the indirect cause categories:

Knowledge of technology – covers the knowledge required to develop, produce, replicate, and control an innovative technology, and it application in a product or service.

Knowledge of application – represents the knowledge required to apply the innovative technology in an effective, economical-feasible, or creative way to generate value from it in a practical application.

Resources – covers all the required resources required to produce, develop, and guide an innovative product or service. This ranges from skilled labour, materials, to space, all required to achieve the desired product or service. But excludes financial resources since lack of these is often due to macro-economic conditions than a lack of money.

Socio-cultural aspects - has been directly adopted from the initial framework, and represents the norms and values of a particular culture. These might norms and values not covered by laws or rules, but play a strong role in the societal debate about a new technology.

Macro-economical aspects – also directly adopted, refers to wider economic system in which the innovation operates. The wider economic system can compete with the innovation on resources, attracting finance, or technology entrenchment. While also affecting the market side of the business, organisation, or research.

Vision & image – perhaps the most vague and a new category, but it covers the how other actors in the innovation system respond to the innovation. Referring to both how the innovation is presented to and perceived by actors (investors, partners, communities, governments, etc.) and how these actor then align their opinions with regards to the innovation. This category is introduced to better cover the NIMBY-effect and the barrier that a project-partner backs out of a project mid-way due to change of vision, as presented by Goodier and Chmutina (2013).
Certain categories were removed and replaced from the initial framework, with technological development replacing new high-tech products to redefine and better present the confines to the design and development side of the product or service. While accidents and events was removed, since such events have a underlying cause that triggered the event, hence the category is liable to misuse. In the sense of a category to cover poorly described barriers with description that lack either depth or aren’t covered by one of the categories, with latter abusing the category as a bin for ‘other’. Suppliers is superseded by production process in case of product related supplier and complementary products and services if not. This also highlights the shady boundary behind what is and what is not part of a product or service. For instance, does charging infrastructure from part of an electric vehicle product?

The final framework shows a lot of similarities with the initial framework of Ortt, Langley and Pals (2013), since much of the original framework covered many barriers in the desired approach and perspective. Still the final framework has been strengthened by additional barriers and frameworks found through the article search and selection, and using the other initial framework of R. Kemp et al., 1998, to additionally check for quality of breadth. All seven presented factors are represented in the final framework, although the factor of undesirable societal and environmental effects of new technologies is less clearly represented. This factor finds it causes in lack of knowledge of technology, lack of knowledge of application, and macro-economic effects, while these impact through support & investments and institutional aspects, as community, governing organisations, and/or investors block an innovation due to negative side-effects. It is the ability to further distinguish and accommodate cases like this that reassure that final framework is an improvement and more comprehensive. A similar case can be made for the seven functions of innovation systems (FIS), which is an alternative approach to technology adoption and market transitions. The FIS approach be can summarised from its early description in this chapter, as searching for the main bottlenecks in an innovation system (the system of actors, connections and artefacts), by analysis the dynamics of the processes or functions in the system. Hence in a way it is looking for barriers that prevent the further development of technology and market. However what barriers are accounted for depends on the system boundaries, whether the external effects of regime and landscape level are represented by the 7 functions. So several analyses of the functions at different levels (of system scale) will have to be done, to get the full picture of all barriers on the different levels. Despite this complexity, the main concern for FIS as an actor barrier analysis framework is the lack of distinction between cause and effect, as well as not distinguishing the differences between the niche, regime and landscape levels. Hence, despite being an interesting approach to identifying and categorizing barriers of a niche innovation, it does not seem fit to provide the required level of detail for actors to properly response. Hence for this thesis, the reviewed framework is chosen over the FIS approach framework to categorize barriers and map the market situation with sufficient detail to created an adequate response.
Section 5: Conclusion, Review & Recommendations

In review, the two initial frameworks from the selected base articles, both form a decent framework to cover most barriers incurred by technical innovations trying to get to market. Particularly the approach and structure of the framework presented by Ortt, Langley and Pals (2013) is useful to use for a barrier analysis for a specific technical innovation. However both frameworks lack or under represent, in the reviewer’s opinion, two categories of barriers. The first being the lack of investment support as a direct impact barrier, acting on the development of an innovation and the ability for a business to grow, despite being generally regarded as a main barrier by business [Galía, 2004]. And the second being the side effects, in absence of a better term, of sustainable energy innovations and their impact on local communities and the innovation’s public image. Hence, answering the main research question, the initial frameworks are not sufficient to provide a comprehensive cover of barriers incurred by sustainable innovations.

Therefore, in order to attain an adequate and comprehensive result for further use, the initial frameworks were expanded and integrated into the final framework presented in this review. It is still largely based on the framework presented by Ortt, Langley and Pals (2013), but also builds on additional insights and information found in the literature search. Resulting in a more comprehensive and better suited framework for analysing barriers faced by sustainable innovations from an entrepreneurial perspective.

In retrospect on the review, the web-search could have been done with more specific or targeted search terms to gain more relevant results and better extracts, either as an additional search/iteration or on its own. Besides that, the quality of the found articles is reasonable but questionable, which perhaps could be prevented by a stricter selection of the source. Particularly the absence of academic or (more) scientific articles is noticeable in the results, which suffers of a lot articles with poor methodology and poor explanation of choices.

Therefore I would like to recommend the literature search to be more specific and include better safeguards for the (scientific) quality of the articles found. And further to recommend a better case-based framework, to include detailed examples, to strengthen and improve its quality and usability. Which in this review was not viable due to time constraints and hence the applied approach was chosen.

To summarize the chapter, research in technological transitions started to boost transition to sustainable technologies in the second half of the 20th century. Two main directions in transition science formed, diffusion and transition theories. With the latter being adopted for this thesis, as the it better addresses the need to reshape the current (energy) regime. Of the many transition theories discussed in this chapter, the choice was made for Strategic Niche Management to used in this thesis. As the quasi-static, intervening and micro-scale perspective nature of SNM, makes it best suited for entrepreneurial guiding perspective this thesis has. The general notion of SNM in the thesis largely
adopts the notions presented in the few articles on SNM in scientific literature. The reviewed and further developed barrier framework presented in the latter half of the chapter, is largely based on the adopted framework of Ortt et al. (2013). By both categorizing the cause and impact of the barrier, and better categorization is hoped to be achieve to cover the complexity of the barrier. While still having independent and concise categories to form 36 possible combinations, to allow transparent use by actors. Now that the technological and theoretical confines have be set and described, the following chapter will describe the methodology of the research component of the thesis.
References of appendix A.1:


Table A.7: Overview of selected and rejected articles from literature search.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Date</th>
<th>Title</th>
<th>Selection Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Morrison, et al.</td>
<td>2000</td>
<td>Determinants of User Innovation and Innovation Sharing in a Local Market</td>
<td>ACCEPTED - Article on user innovations of library software, not directly related to search, but potential for new findings on underlit subject</td>
</tr>
<tr>
<td>A. Verbruggen, et al.</td>
<td>2010</td>
<td>Renewable energy costs, potentials, barriers: Conceptual issues</td>
<td>ACCEPTED - Article on the renewable energy transition, focusing on the interrelations between drivers and naming barriers.</td>
</tr>
<tr>
<td>A. Marcus</td>
<td>1981</td>
<td>Policy Uncertainty and Technological Innovation</td>
<td>ACCEPTED - Focus relationship between government policy and investment in innovations, a potential underlit aspect</td>
</tr>
<tr>
<td>C. Christensen, R. Rosenbloom</td>
<td>1995</td>
<td>Explaining the attacker’s advantage: Technological paradigms, organizational dynamics, and the value network</td>
<td>ACCEPTED - Looking into whether value chain is critical to potential of new innovative entrants in the market</td>
</tr>
<tr>
<td>M. Poliakoff, et al.</td>
<td>2002</td>
<td>Green Chemistry: Science and Politics of Change</td>
<td>ACCEPTED - Transition to green chemistry, clearing discussing potential barriers</td>
</tr>
<tr>
<td>A. Hargadon, Y. Douglas</td>
<td>2001</td>
<td>When Innovations Meet Institutions: Edison and the Design of the Electric Light</td>
<td>ACCEPTED - Niche advantage through innovation design</td>
</tr>
<tr>
<td>R. Wustenhagen, et al.</td>
<td>2007</td>
<td>Social acceptance of renewable energy innovation: An introduction to the concept</td>
<td>ACCEPTED - Constraining factor of social acceptance of renewable energy technologies</td>
</tr>
<tr>
<td>W. Holzl, J. Janger</td>
<td>2013</td>
<td>Does the analysis of innovation barriers perceived by high growth firms provide information on innovation policy priorities?</td>
<td>ACCEPTED - high growth firms perceived barriers to innovation in Europe</td>
</tr>
<tr>
<td>Xueli Huang, Renyong Chi</td>
<td>2013</td>
<td>Innovation in China’s high-tech industries: barriers and their impact on innovation performance</td>
<td>ACCEPTED - Focus both internal and external perceived barriers for high-tech innovation in China (survey)</td>
</tr>
<tr>
<td>M. Richter</td>
<td>2013</td>
<td>Business model innovation for sustainable energy: how German municipal utilities invest in offshore wind energy</td>
<td>ACCEPTED - Analysis of business model innovation for off-shore wind energy in Germany</td>
</tr>
<tr>
<td>A. Doranova, M. Miedzinski</td>
<td>2013</td>
<td>EU-SOUTH COOPERATION PERSPECTIVES IN ECO-INNOVATION</td>
<td>ACCEPTED - Barriers to European eco-innovations in emerging countries</td>
</tr>
<tr>
<td>T. Stevens</td>
<td>2013</td>
<td>Non-Cost Barriers to Consumer Adoption of New Light-Duty Vehicle Technologies</td>
<td>ACCEPTED - non-cost barriers of light duty vehicles, reliance with sustainability and innovation acceptance barriers</td>
</tr>
<tr>
<td>C. Goodier, K. Chmutina</td>
<td>2013</td>
<td>Non-technical barriers for challenging lock-in to urban energy systems: learning from international case studies</td>
<td>ACCEPTED - Case-based list of non-technical barriers in the renewable energy system</td>
</tr>
<tr>
<td>J. Wenting, W. Zhong</td>
<td>2012</td>
<td>Research on the Driving Factors of Renewable Energy Technology Innovation Based on SD Model</td>
<td>ACCEPTED - Describing the influencing factors of early stage development of renewable energy technologies</td>
</tr>
<tr>
<td>J. Han et al.</td>
<td>2001</td>
<td>Entry Barriers: A Dull-, One-, or Two-Edged Sword for Incumbents? Unraveling the Paradox from a Contingency Perspective</td>
<td>ACCEPTED - Analysis on the effectiveness of entry barriers from incumbents</td>
</tr>
<tr>
<td>E. Montaguti</td>
<td>2002</td>
<td>Entry strategy for radical product innovations: A conceptual model and propositional inventory</td>
<td>ACCEPTED - Relevance with research although not directly mentioning barriers, it looks into increasing the the speed of adoption of a new radical innovation</td>
</tr>
<tr>
<td>H. Aiking, et al.</td>
<td>2006</td>
<td>Sustainable Protein Production and Consumption: Pigs or Peas?: Pigs Or Peas?</td>
<td>ACCEPTED - requirements for a transition to natural protein sources replacing meat</td>
</tr>
<tr>
<td>S. Erzurumlu, Y. Erzurumlu</td>
<td>2013</td>
<td>Development and deployment drivers of clean technology innovations</td>
<td>ACCEPTED - Drivers for development and deployment of cleantech, could highlight potential barriers as well as providing framework of drivers and thus reverse view of barriers</td>
</tr>
<tr>
<td>F. Galia, D. Legros</td>
<td>2004</td>
<td>Complementarities between obstacles to innovation: evidence from France</td>
<td>ACCEPTED - List of barriers to innovation for French firms</td>
</tr>
<tr>
<td>K. Smith et al.</td>
<td>2012</td>
<td>Transitions to renewable energy systems: the innovation and policy issues</td>
<td>ACCEPTED: Required changes to allow for a RET transition</td>
</tr>
<tr>
<td>L. Jing et al.</td>
<td>2007</td>
<td>Research on Financing Barrier of Retrofit for Energy Saving of Existing Buildings and Corresponding Countermeasures</td>
<td>ACCEPTED - Barriers on building renewable retrofitting in China</td>
</tr>
<tr>
<td>B. Eaton, R. Lipsey</td>
<td>1980</td>
<td>Exit Barriers are Entry Barriers: The Durability of Capital as a Barrier to Entry</td>
<td>ACCEPTED - Capital as an entry barrier for new comers and market leaders</td>
</tr>
<tr>
<td>G. Miller</td>
<td>2008</td>
<td>Public Acceptance: The Greatest Barrier to Widespread Water Reuse</td>
<td>ACCEPTED - relevant in aspects of sustainability but especially look a detail at public acceptance</td>
</tr>
<tr>
<td>M. Richter</td>
<td>2013</td>
<td>Business model innovation for sustainable energy: German utilities and renewable energy</td>
<td>ACCEPTED - Business models in response to sustainable energy in Germany</td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
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<tr>
<td>M. Suzuki et al.</td>
<td>2013</td>
<td>Addressing key issues in technology innovation and transfer of clean energy technologies: a focus on enhancing the enabling environment in the developing countries</td>
<td>ACCEPTED - Barriers in developing countries</td>
</tr>
<tr>
<td>J. Eide</td>
<td>2013</td>
<td>Rethinking CCS – Strategies for Technology Development in Times of Uncertainty</td>
<td>ACCEPTED - Barriers of CCS</td>
</tr>
<tr>
<td>Roland Berger</td>
<td>2009</td>
<td>ELECTRIC MOBILITY: THE BUSINESS MODEL IS KEY TO SUCCESS</td>
<td>ACCEPTED - Focused on business models will play a key role for forming an EV market with different players</td>
</tr>
<tr>
<td>P. Attewell</td>
<td>1992</td>
<td>Technology Diffusion and Organizational Learning: The Case of Business Computing</td>
<td>ACCEPTED - Focus on adoption barriers from a lack of knowledge</td>
</tr>
<tr>
<td>R. Haas</td>
<td>2004</td>
<td>How to promote renewable energy systems successfully and effectively</td>
<td>ACCEPTED - Collection of opinions from Energy Conference</td>
</tr>
<tr>
<td>D. Jones-Evans</td>
<td>1996</td>
<td>Technical Entrepreneurship, Strategy and Experience</td>
<td>ACCEPTED - Focus on the entrepreneurial skills of technical entrepreneurs and their strategies</td>
</tr>
<tr>
<td>K. Helmet et al.</td>
<td>2005</td>
<td>Environmental Innovations: Institutional Impacts on Co-operations for Sustainable Development</td>
<td>REJECTED - focused on barriers to co-operation in innovation development, thus regarded as to specific on the impact of co-operations</td>
</tr>
<tr>
<td>R. Grol, M. Wensing</td>
<td>2004</td>
<td>What drives change? Barriers to and incentives for achieving evidence-based practice</td>
<td>REJECTED - Medical oriented paper on patient care, thus no relation to technical innovation or sustainability</td>
</tr>
<tr>
<td>D. Dougherty</td>
<td>1992</td>
<td>Interpretive Barriers to Successful Product Innovation in Large Firms</td>
<td>REJECTED - Article on barriers during the technical innovation phase within organisations, rejected because lack of entrepreneurial perspective and sustainable context</td>
</tr>
<tr>
<td>W. Abernathy</td>
<td>1985</td>
<td>Innovation: Mapping the winds of creative destruction</td>
<td>REJECTED - Focus competitive impact on the market from innovations, while our research is focused on entrepreneurial side of the relation</td>
</tr>
<tr>
<td>M. Gort, S. Klepper</td>
<td>1982</td>
<td>Time paths in the diffusion of product innovations</td>
<td>REJECTED - No relation with niche management nor sustainability, and build on Nelson and Winter thus probably neglecting critical barriers.</td>
</tr>
<tr>
<td>C. Perez, L. Soete</td>
<td>2007</td>
<td>Catching up in technology: entry barriers and windows of opportunity</td>
<td>REJECTED – Barriers to technological industrialisation of developing countries, no relation to innovation or sustainability</td>
</tr>
<tr>
<td>J. Markard, B. Truffer</td>
<td>2008</td>
<td>Technological innovation systems and the multi-level perspective: Towards an integrated framework</td>
<td>REJECTED - unrelated to barriers (framework), but of potential interest for inspiration for combining frameworks</td>
</tr>
<tr>
<td>C. Banbury, W. Mitchell</td>
<td>2007</td>
<td>The effect of introducing important incremental innovations on market share and business survival</td>
<td>REJECTED - Focus relation between market share and adopting innovation by incumbent industries</td>
</tr>
<tr>
<td>S. Breschi, F. Malerba, L. Orsenigo</td>
<td>2001</td>
<td>Technological regimes and Schumpeterian patterns of innovation</td>
<td>REJECTED - Industry wide focus on innovation patterns for cumulative efforts (several) technological regimes, bares very little relation with the research</td>
</tr>
<tr>
<td>B. Chakravarthy</td>
<td>1997</td>
<td>A New Strategy Framework for Coping with Turbulence</td>
<td>REJECTED - Market strategy focused, bares little relation with research</td>
</tr>
<tr>
<td>T. Petersen</td>
<td>2010</td>
<td>How to Overcome Barriers to Innovation: An Empirical Analysis of the Relationship between Personal Power Bases and Behavior in Different Barrier Situations</td>
<td>REJECTED - Innovators response to barriers within the organization</td>
</tr>
<tr>
<td>G. Ramnath</td>
<td>2012</td>
<td>Innovation in Emerging Market Micro, Small and Medium Enterprises: Barriers and Access to Resources</td>
<td>REJECTED - Focus on impacts of the global economy on resources for SME’s, no related to sustainability, nor to technical innovation, or market-specific barriers</td>
</tr>
<tr>
<td>N. Thompson, E. Stam</td>
<td>2010</td>
<td>Macroeconomic Dynamics and Innovation: SME innovation in the Netherlands, 1999-2009</td>
<td>REJECTED - Policy adjustments for macro-economic effects on innovative SME’s</td>
</tr>
<tr>
<td>C. Cattano</td>
<td>2010</td>
<td>Identifying Barriers to Address During the Delivery of Sustainable Building Renovation Projects</td>
<td>REJECTED - Focus practical barriers of delivering sustainable building renovations, thus unrelated to innovation, or market entry barriers</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Year</td>
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<tr>
<td>P. Blanchard, J-P Huiban, A. Musolesi, P. Sevestre</td>
<td>2012</td>
<td>Where there is a will, is there a way? Assessing the impact of obstacles to innovation</td>
<td>REJECTED - Focus innovation within a firm, poorly related to technical innovation, sustainability, and market entry</td>
</tr>
<tr>
<td>R. Rohrbeck, L. Konnertz, S. Knab</td>
<td>2013</td>
<td>Collaborative Business Modelling for Systemic and Sustainability Innovations</td>
<td>REJECTED - Focused on strategy and business modelling, no related of mention of barriers</td>
</tr>
<tr>
<td>S. Avdeitchikova, L. Coenen,</td>
<td>2013</td>
<td>Commercializing clean technology innovations - the emergence of new business in an agency-structure perspective</td>
<td>REJECTED - Analysis of cleantech commercial activity on an agency-structure level, bares no mention of barriers to market entry</td>
</tr>
<tr>
<td>A. Triguero, L. Moreno-Mondejar, M. Davia</td>
<td>2013</td>
<td>Drivers of different types of eco-innovation in European SMEs</td>
<td>REJECTED - Analysis of different kinds of eco-innovations and key actors, but no mention of barriers</td>
</tr>
<tr>
<td>R. Michaelides, S. Morton, W. Liu</td>
<td>2012</td>
<td>A framework for evaluating the benefits of collaborative technologies in engineering innovation networks</td>
<td>REJECTED - Focused on internal innovation through collaborative networks, no relation to barriers, or sustainability</td>
</tr>
<tr>
<td>M. LaBelle, M. Morwitch</td>
<td>2013</td>
<td>The Breakout of Energy Innovation: Accelerating to a New Low Carbon Energy System</td>
<td>REJECTED - Focused on how circumvent the technology lock-out, thus no new barriers or analysis mentioned</td>
</tr>
<tr>
<td>M. Smith et al.</td>
<td>2008</td>
<td>FACTORS INFLUENCING AN ORGANISATION’S ABILITY TO MANAGE INNOVATION: A STRUCTURED LITERATURE REVIEW AND CONCEPTUAL MODEL</td>
<td>REJECTED - Focused on internal innovation management, no relation with market entry, or sustainability or mention technological innovation</td>
</tr>
<tr>
<td>N. Janz, G. Ebling, S. Gottschalk, B. Peters, T. Schmidt</td>
<td>2001</td>
<td>Innovation Activities in the German Economy</td>
<td>REJECTED - No mention of new analysis on barriers, or focus on sustainability</td>
</tr>
<tr>
<td>E. Shiu, C. Cheng</td>
<td>2011</td>
<td>Proposing an expanded theoretical framework of innovation adoption linking to consumer innovativeness and creativity and their driving factors</td>
<td>REJECTED - No information on barriers to market entry or adoption, nor on sustainability</td>
</tr>
<tr>
<td>T. Mueller-Prothmann, E. Behnken, S. Borovac</td>
<td>2008</td>
<td>'Innovation Management Devils' - A Disruptive Factor Based Analysis of Innovation Processes</td>
<td>REJECTED - Focused on innovation strategy for corporations, lack of relation with research with regards to market-entry or sustainability</td>
</tr>
<tr>
<td>L. Qiqi</td>
<td>2013</td>
<td>Study on the evaluation of technology innovation performance of equipment manufacturing industry base on Shaanxi’s data</td>
<td>REJECTED - main focus on internal barriers to innovation in manufacturing industry, thus not relevant</td>
</tr>
<tr>
<td>R. Kemp</td>
<td>2000</td>
<td>Incremental Steps and their Limits</td>
<td>REJECTED - Focus policy framework for incurring radical innovation in the sustainable space (Kemp), lack of relation with entrepreneurial perspective, and focus on barriers</td>
</tr>
<tr>
<td>A. Cabagnols,</td>
<td>2006</td>
<td>Factors of Entry and Persistence In Innovation: A Competence Based Approach</td>
<td>REJECTED - Seems to be focus on internal innovation management, thus lack of relation with research</td>
</tr>
<tr>
<td>S. Wan-song, D. Yi-min, Z. Yan</td>
<td>2006</td>
<td>The Study of the Independent Innovation System in the High-tech Region</td>
<td>REJECTED - Focus on innovation management unrelated to sustainability or entrepreneurship and no specific mention of technological innovation</td>
</tr>
<tr>
<td>C. Yalan</td>
<td>2010</td>
<td>Study on the Independent Innovation Capability of Innovative Pilot Enterprises: A Case in Fujian Province of China</td>
<td>REJECTED - Internal innovation management from a local government perspective, no relation with research</td>
</tr>
<tr>
<td>G. Colarelli O’Connor</td>
<td>2003</td>
<td>Market Learning and Radical Innovation: A Cross Case Comparison of Eight Radical Innovation Projects</td>
<td>REJECTED - The role customer input in steering innovation, no relation with barriers or sustainability</td>
</tr>
<tr>
<td>R. Tiwari, S. Buse</td>
<td>2007</td>
<td>Barriers to innovation in SMEs: Can the internationalization of R&amp;D mitigate their effects?</td>
<td>REJECTED - Focus internal innovation management under influence of the global economy</td>
</tr>
<tr>
<td>N. O'Regan, A. Ghobadian, M. Sims</td>
<td>2006</td>
<td>Fast tracking innovation in manufacturing SMEs</td>
<td>REJECTED - Focus internal innovation management for fast-tracking effective innovations in SME's</td>
</tr>
<tr>
<td>R. Tietz, P. Morrison, C. Luthje, C. Herstatt</td>
<td>2005</td>
<td>The process of user-innovation: a case study in a consumer goods setting</td>
<td>REJECTED - Focus internal innovation management in the early stages of novel products</td>
</tr>
<tr>
<td>M. Porta, B. House, L. Buckley, A. Blitz</td>
<td>1975</td>
<td>Value 2.0: eight new rules for creating and capturing value from innovative technologies</td>
<td>REJECTED - Value creation from innovation, not in scope of research</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Year</td>
<td>Title</td>
<td>Rejection Reason</td>
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<tr>
<td>A. Herrmann, T. Tomczak, R. Befurt,</td>
<td>1998</td>
<td>Determinants of radical product innovations</td>
<td>REJECTED - Internal innovation management of the adoption of radical innovations</td>
</tr>
<tr>
<td>R.R. Brown, M. A. Farrell</td>
<td>2009</td>
<td>Delivering sustainable urban water management: a review of the hurdles we face</td>
<td>REJECTED - no relation with (tech.) innovation and it implementation but rather with policy implementation</td>
</tr>
<tr>
<td>E. Mills</td>
<td>2003</td>
<td>The insurance and risk management industries: new players in the delivery of energy-efficient and renewable energy products and services</td>
<td>REJECTED - Business model insurer involvement, no relation with research</td>
</tr>
<tr>
<td>S. Martin, J. T. Scott</td>
<td>2000</td>
<td>The nature of innovation market failure and the design of public support for private innovation</td>
<td>REJECTED - Focus on public policy for innovation, no relation with sustainability, or specific barriers analysis in relation with entrepreneurial innovation deployment</td>
</tr>
<tr>
<td>S. B. Moore, S. L. Manring</td>
<td>2009</td>
<td>Strategy development in small and medium sized enterprises for sustainability and increased value creation</td>
<td>REJECTED - Focus on sustainable SME’s support policy, no relation to research scoop</td>
</tr>
<tr>
<td>W. Luetkenhorst</td>
<td>2004</td>
<td>Corporate social responsibility and the development agenda</td>
<td>REJECTED - review of trends in CSR and its application to SME’s, no mention of barriers or technical innovation</td>
</tr>
<tr>
<td>R. K. Pillania</td>
<td>2006</td>
<td>Leveraging knowledge for sustainable competitiveness in SMEs</td>
<td>REJECTED - Focused on knowledge leverage at SME level, no relation with research regarding; specific technological innovation, sustainability, and barriers</td>
</tr>
<tr>
<td>B. Chu</td>
<td>2013</td>
<td>Fostering Technology Transfer, Innovation, and Entrepreneurship from the Perspective of a Public University</td>
<td>REJECTED - Focused on technology transfer from a university, no mention of adoption barriers on market level or sustainability</td>
</tr>
<tr>
<td>A. Ganter, A. Hecker,</td>
<td>2013</td>
<td>Configurational paths to organizational innovation: qualitative comparative analyses of antecedents and contingencies</td>
<td>REJECTED - Internal Innovation management, out of research scoop</td>
</tr>
<tr>
<td>C. Ghisetti, A. Marzucchi, S. Montresor</td>
<td>2013</td>
<td>Does external knowledge affect environmental innovations? An empirical investigation of eleven European countries.</td>
<td>REJECTED - seems not bare any relation with research scoop in terms of barriers to market adoption</td>
</tr>
<tr>
<td>M. Klumpp, S. Bioly, S. Zelewski</td>
<td>2013</td>
<td>Integrating sustainability and technology innovation in logistics management</td>
<td>REJECTED - Chapter focused on relation between technology and sustainability in logistics industry</td>
</tr>
<tr>
<td>R. Tripathi, R. Kumar Shastri, S. Agarwal</td>
<td>2013</td>
<td>Survival and Growth Strategies for Small- and Medium-Scale Enterprises in India: A Key for Sustainable Development</td>
<td>REJECTED - (management) policy for strengthening the position of Indian Manufacturing SME’s through sustainable development and tech. innovation, no relation on barriers for adoption</td>
</tr>
<tr>
<td>C. Edquist</td>
<td></td>
<td>Systems of Innovation - Perspectives and Challenges</td>
<td>REJECTED - Untransparent book with lack of new research</td>
</tr>
<tr>
<td>D. Davis, M. Morris, J. Allen</td>
<td>1991</td>
<td>Perceived Environmental Turbulence and Its Effect on Selected Entrepreneurship, Marketing, and Organizational Characteristics in Industrial Firms</td>
<td>REJECTED - Focused on entrepreneurship management, no relation with barriers, tech. innovation, or sustainability</td>
</tr>
<tr>
<td>J. Edler, L. Georgiou</td>
<td>2007</td>
<td>Public procurement and innovation - Resurrecting the demand side</td>
<td>REJECTED - focused on public procurement as driver for innovation, outside of scoop of research</td>
</tr>
<tr>
<td>M. Van der Walt</td>
<td>2006</td>
<td>A framework for knowledge innovation.</td>
<td>REJECTED - innovation management, no relation to adoption barriers or sustainability</td>
</tr>
<tr>
<td>H. Min, W. P. Galle</td>
<td>1997</td>
<td>Green Purchasing Strategies: Trends and Implications</td>
<td>REJECTED - no relation to innovation or adoption barriers, but focused on sustainable procurement strategies</td>
</tr>
<tr>
<td>NREL</td>
<td>2010</td>
<td>Green Light-Emitting Diode Makes Highly Efficient White Light</td>
<td>REJECTED - no relation to entrepreneurship or adoption barriers at all</td>
</tr>
<tr>
<td>H. Pacini, A. Betinardi Strapasson</td>
<td>2012</td>
<td>Innovation subject to sustainability: the European policy on biofuels and its effects on innovation in the Brazilian bioethanol industry</td>
<td>REJECTED - no relation to adoption barriers</td>
</tr>
<tr>
<td>J. Weerawardena, G. Sullivan Mort</td>
<td>2006</td>
<td>Investigating social entrepreneurship: A multidimensional model</td>
<td>REJECTED - focused on the differences of social entrepreneurship compared generic entrepreneurship, no relation to research scoop</td>
</tr>
<tr>
<td>Title</td>
<td>Year</td>
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<tr>
<td>Small and medium-size enterprises: Access to finance as a growth constraint</td>
<td>2006</td>
<td></td>
<td>REJECTED - Financing of SME's in developing countries</td>
</tr>
<tr>
<td>Governance for sustainability: towards a 'thick' analysis of environmental decisionmaking</td>
<td>2003</td>
<td></td>
<td>REJECTED - Focus on environmental decision making, no relation with adoption barriers, or entrepreneurship</td>
</tr>
<tr>
<td>The Meaning of “Social Entrepreneurship”</td>
<td>1998</td>
<td></td>
<td>REJECTED -Purely discusses the meaning and purpose of social entrepreneurship, thus no connection with research scoop</td>
</tr>
<tr>
<td>Make and buy in innovation strategies: evidence from Belgian manufacturing firms</td>
<td>1999</td>
<td></td>
<td>REJECTED - Innovation management at firm-level, no relation with technology transition or sustainability</td>
</tr>
<tr>
<td>Determinants of Innovation in Organizations</td>
<td>1969</td>
<td></td>
<td>REJECTED - Innovation in public agencies, no relevance with entrepreneurs</td>
</tr>
<tr>
<td>The Challenge of Innovation Implementation</td>
<td>1996</td>
<td></td>
<td>REJECTED - Innovation management at organizational level</td>
</tr>
<tr>
<td>Strategic Innovation in Established Companies</td>
<td>1998</td>
<td></td>
<td>REJECTED - Innovation management at organizational level</td>
</tr>
<tr>
<td>Is environmental innovation embedded within high-performance organisational changes? The role of human resource management and complementarity in green business strategies</td>
<td>2013</td>
<td></td>
<td>REJECTED - Innovation management at organizational level</td>
</tr>
<tr>
<td>Emergence of Innovation – Eleven Strategies to Increase Innovative Capability</td>
<td>2013</td>
<td></td>
<td>REJECTED - Innovation management at organizational level</td>
</tr>
<tr>
<td>Chapter 37 Technological change and technology strategy</td>
<td>1995</td>
<td></td>
<td>REJECTED - generic handbook on technology development</td>
</tr>
<tr>
<td>The Strategic Management of Technology</td>
<td>1985</td>
<td></td>
<td>REJECTED - No relation with innovation adoption, sustainability, or entrepreneurship</td>
</tr>
<tr>
<td>Rational Analysis on Green Barrier and its Development Trend</td>
<td>2005</td>
<td></td>
<td>REJECTED - No mention or hit of adoption barriers or sustainability in abstract</td>
</tr>
<tr>
<td>Addressing first- and second-order barriers to change: Strategies for technology integration</td>
<td>1999</td>
<td></td>
<td>REJECTED - focused on barriers teaching with technology</td>
</tr>
<tr>
<td>Green Trade Barrier and the Choice of Chinese Strategy</td>
<td>2008</td>
<td></td>
<td>REJECTED - Lack of relation with entrepreneurial level of research and clear focus on tech. adoption</td>
</tr>
<tr>
<td>Sustainable Development of Foreign Trade, Strategic Choice of Evading Green Trade Barrier</td>
<td>2005</td>
<td></td>
<td>REJECTED - Lack of relation with entrepreneurial level of research and clear focus on tech. adoption</td>
</tr>
<tr>
<td>The R&amp;D-marketing interface in high-technology firms</td>
<td>1985</td>
<td></td>
<td>REJECTED - Innovation management at organizational level</td>
</tr>
<tr>
<td>R&amp;D strategy for building effective entry barrier</td>
<td>2012</td>
<td></td>
<td>REJECTED - Innovation management at organizational level especially focus on IP use</td>
</tr>
<tr>
<td>An ISM approach for the barrier analysis in implementing green supply chain management</td>
<td>2013</td>
<td></td>
<td>REJECTED - focused on implementing sustainable supply chain strategies</td>
</tr>
<tr>
<td>Study on Regional Synergetic Development of Low Carbon Technology</td>
<td>2013</td>
<td></td>
<td>REJECTED - lack of relation with research scoop</td>
</tr>
<tr>
<td>Barrier Identification and Removal Based on Process Analysis</td>
<td>2013</td>
<td></td>
<td>REJECTED - Innovation management at organizational level</td>
</tr>
<tr>
<td>Renewable Energy Financial Management in the EU’s Enlargement Strategy and Environmental Crises</td>
<td>2013</td>
<td></td>
<td>REJECTED - Not related to research scoop</td>
</tr>
<tr>
<td>Strategy and Sustainable Business Development: Dynamic Hazard or Dynamic Mania? Lessons Learned from a Crisis</td>
<td>2013</td>
<td></td>
<td>REJECTED - lack of relation with research scoop</td>
</tr>
<tr>
<td>Environment-strategy relationship and its performance implications: An empirical study of the chinese electronics industry</td>
<td>1994</td>
<td></td>
<td>REJECTED - no relation with adoption barriers, or sustainability</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Year</td>
<td>Title</td>
<td>Comments</td>
</tr>
<tr>
<td>-----------------------------------------</td>
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<td>----------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>J. Edmonds, M. Wise</td>
<td>1997</td>
<td>Exploring a Technology Strategy For Stabilizing Atmospheric CO2</td>
<td>REJECTED - no relation with adoption barriers, or technological innovation</td>
</tr>
<tr>
<td>Z. Tao, C. Ri Hao</td>
<td>2013</td>
<td>Research on Green Marketing Strategy in Enterprises Based on Low Carbon (LC) Environment</td>
<td>REJECTED - no relation with adoption barriers, or technological innovation, but focus on consumer response to environmental pollution and resources scarcity</td>
</tr>
<tr>
<td>Y. Yong Xi, L. Shoude, L. Mengya</td>
<td>2013</td>
<td>Firms Pollution Abatement R&amp;D Investment Strategy on Tradable Emissions Permits</td>
<td>REJECTED - focused on the effect on option value of investing in anti-pollution technology in a competitive space</td>
</tr>
<tr>
<td>R. Cui, L. Cui, L. Li</td>
<td>2014</td>
<td>The new energy industries' core competencies strategy based on knowledge innovation management</td>
<td>REJECTED - lack of relation with adoption barriers, and is focus on internal innovation management</td>
</tr>
<tr>
<td>H. Li</td>
<td>2013</td>
<td>An Integrated Strategy for Sustainable Underground Urbanization</td>
<td>REJECTED - focused on strategy to sustainably use underground resources in big cities, no relation with adoption barriers, or entrepreneur innovation</td>
</tr>
<tr>
<td>C-J Yang</td>
<td>2010</td>
<td>Launching strategy for electric vehicles: Lessons from China and Taiwan</td>
<td>REJECTED - Focused on policy barriers</td>
</tr>
<tr>
<td>P-L Chang, C-T Tsai</td>
<td>2002</td>
<td>Finding the niche position — competition strategy of Taiwan's IC design industry</td>
<td>REJECTED - Focused on Taiwan's IC industry and how it captured the second market position by being a quick follower, thus no relation to innovation adoption or sustainability</td>
</tr>
<tr>
<td>C. M. McDermott, G. Colarelli O'Connor</td>
<td>2003</td>
<td>Managing radical innovation: an overview of emergent strategy issues</td>
<td>REJECTED - No relation to entrepreneurial perspective or sustainability</td>
</tr>
<tr>
<td>V. Murthy</td>
<td>2009</td>
<td>Emergent combinations of frameworks, theories, and grounded action: one solution to overcoming the hurdles to innovation as a growth strategy</td>
<td>REJECTED - No relation to entrepreneurial perspective or sustainability</td>
</tr>
<tr>
<td>C. Easingwood, C. Beard</td>
<td>1989</td>
<td>High technology launch strategies in the U.K.</td>
<td>REJECTED - No focus on adoption barriers but purely strategies</td>
</tr>
<tr>
<td>X. Zhang, G.Q.P. Shen, J. Feng, Y. Wu</td>
<td>2013</td>
<td>Delivering a low-carbon community in China: Technology vs. strategy?</td>
<td>REJECTED - No mention of barrier analysis or an entrepreneurial perspective</td>
</tr>
<tr>
<td>B. Kaur</td>
<td>2013</td>
<td>Strategies for the marketing of innovative Products: a case study of biotech sector in India</td>
<td>REJECTED - Poor relation with adoption barriers, no relation with sustainability in generally accepted terms</td>
</tr>
<tr>
<td>M. Mendez-Fuente, et al.</td>
<td>2013</td>
<td>Hurdles for an ubiquitous electric vehicle: The experiences of ELEVTRA Project</td>
<td>REJECTED - Focused on the experience of a project to overcome knowledge barriers regarding maintenance and production</td>
</tr>
<tr>
<td>US Embassy Copenhagen - Denmark</td>
<td>2012</td>
<td>SUSTAINABILITY AND TECHNOLOGY COMMERCIALIZATION CONFERENCE</td>
<td>REJECTED - Generic view on barriers from climate change, resource-scarcity, etc. No relation to adoption barriers, technological innovation</td>
</tr>
<tr>
<td>Li Juan, F. Fong, L. Baofa</td>
<td>2011</td>
<td>The obstacle and strategy of distributed energy in development for Chongqing industrial park</td>
<td>REJECTED - Focus specifically on a policy perspective of implementing distributed energy system in a specific industrial park</td>
</tr>
<tr>
<td>F. Wirl</td>
<td>2014</td>
<td>Taxes versus permits as incentive for the intertemporal supply of a clean technology by a monopoly</td>
<td>REJECTED - Focused purely on policy to create a market space for clean technology</td>
</tr>
<tr>
<td>J. Loras, J. Vizcaino</td>
<td>1967</td>
<td>Is technical training an obstacle to entrepreneurship?</td>
<td>REJECTED - Focus on whether engineering students can become entrepreneurs</td>
</tr>
<tr>
<td>E. Setiawati, S. Notodamro, P. Soewondo, A. Jatnika Effendi, B. Widjanarko Otok</td>
<td>2013</td>
<td>Infrastructure Development Strategy for Sustainable Wastewater System by using SEM Method (Case Study Setiabudi and Tebet Districts, South Jakarta)</td>
<td>REJECTED - Policy perspective on the role of government on water management in Indonesia and analysis of barriers</td>
</tr>
<tr>
<td>P. Kyle, et al.</td>
<td>2013</td>
<td>Influence of climate change mitigation technology on global demands of water for electricity generation</td>
<td>REJECTED - No relation with adoption barriers, but focused on technical impact of climate mitigation on water use of energy industry</td>
</tr>
</tbody>
</table>
Appendix A.2 Presented interview slides

Barrier framework

<table>
<thead>
<tr>
<th>Indirect Cause</th>
<th>Direct Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of technology</td>
<td>Technological development</td>
</tr>
<tr>
<td>Lack of knowledge</td>
<td>Lack of research and development of</td>
</tr>
<tr>
<td>required to develop,...</td>
<td>the prospective technology/product.</td>
</tr>
<tr>
<td>Knowledge of application</td>
<td>Production process</td>
</tr>
<tr>
<td>Lack of knowledge</td>
<td>Incomplete production chain for the</td>
</tr>
<tr>
<td>of possible uses or</td>
<td>prospective technology/product.</td>
</tr>
<tr>
<td>application of</td>
<td>Complementary products &amp; services</td>
</tr>
<tr>
<td>prospective technology.</td>
<td>Lack of supporting infrastructure,</td>
</tr>
<tr>
<td></td>
<td>technologies or services</td>
</tr>
<tr>
<td>Resources</td>
<td>Support &amp; investments</td>
</tr>
<tr>
<td>Lack of skilled labour,</td>
<td>Lack of local/potential support or</td>
</tr>
<tr>
<td>materials, space,</td>
<td>financial investment for future</td>
</tr>
<tr>
<td>financial, etc. for</td>
<td>production/consumer.</td>
</tr>
<tr>
<td>product or service.</td>
<td>Customers</td>
</tr>
<tr>
<td></td>
<td>Lack of customer (market, size,</td>
</tr>
<tr>
<td>Socio-cultural aspects</td>
<td>awareness)</td>
</tr>
<tr>
<td>Impact of norms, values</td>
<td></td>
</tr>
<tr>
<td>and context from society</td>
<td>on technology.</td>
</tr>
<tr>
<td>Macro-economic aspects</td>
<td>Vision &amp; Image</td>
</tr>
<tr>
<td>Competition for</td>
<td>Recognition of actors and the broader</td>
</tr>
<tr>
<td>resources, markets and</td>
<td>public of the technology and its</td>
</tr>
<tr>
<td>innovation from the</td>
<td>potential.</td>
</tr>
<tr>
<td>wider landscape.</td>
<td></td>
</tr>
</tbody>
</table>

Barrier ranking based literature findings

1. Knowledge of Technology - Support & Investment
   Technical challenges in initial investment and support for further development of kite-based AWE.

2. Vision & Image - Support & Investment
   Uncertainty regarding reliability, operation and safety of kite-based AWE amongst the general public and investors.

3. Macro-economic aspects - Customers
   Competition of other (renewable) energy systems inhibits a strong market for kite-based AWE customers.

4. Knowledge of Technology - Customers
   Lack of experience regarding safety and reliability inhibits customers of kite-based AWE systems.

5. Knowledge of Technology - Institutional aspects
   Lack of knowledge and experience inhibits access and regulation of airspace for kite-based AWE systems.

6. Knowledge of Technology - Technological development
   Technical challenges regarding control systems and materials inhibit a safe, reliable and marketable AWE product.

7. Macro-economic aspects - Support & Investment
   Uncertainty about the economic performance of kite-based AWE systems undermines potential investment and support.

8. Knowledge of Technology - Product processes
   Experience and knowledge of the manufacturing of kite-based AWE systems is lacking or minimal.
**Niche Strategy:**
A niche strategy is a coordinating process, in which one or a set of experiments are setup, executed, and assessed in a protected niche of the market segment. In order to achieve the wider adoption of the new innovation, through co-development of innovation and market.

---

**Ten niche strategies**

**Demo, experiment and develop niche strategy**
Demonstrating the innovation to the public to spread information and gain feedback.
- **Telegraphy**

**Top niche strategy**
Small production for the high-end of the market, alleviating the pressures of economies of scale.
- **Dyneema®**

**Subsidized niche strategy**
Lower the cost of the innovation for a particular user, which is important or relevant for the wider society.
- **Clean energy technologies**

**Redesign niche strategy**
Redesign the innovation to overcome resistance from legislation, customers, backers, lack of knowledge or resources.
- **Personal computers**

**Dedicated system or standalone niche strategy**
Overcoming a lack of wider infrastructure or direct competition by providing for local and specific needs.
- **Telephony**

**Hybridization or adopter niche strategy**
Overcoming a lack of infrastructure by combining with existing technology regimes.
- **Electric-hybrids**

**Educate niche strategy**
Addressing a lack of knowledge and support by creating and sharing knowledge at universities and research laboratories.
- **Semiconductors & transistors**

**Geographic niche strategy**
Using a chance of geographic location to circumvent institutional, resources, and market barriers as well as others.
- **Dynamite**

**Lead user niche strategy**
Collaborating with lead users or early customers to co-develop and experiment with the innovation.
- **High-end sports equipment**

**Explore multiple markets niche strategy**
To spread the resources over several niche experiments/markets and potentially find a suitable application.
- **Memory metal**
Links between barriers and niche strategies

<table>
<thead>
<tr>
<th>Niches</th>
<th>Knowledge of Technology</th>
<th>Knowledge of Application</th>
<th>Macro-Economic aspects</th>
<th>Vision &amp; Image</th>
<th>Resources</th>
<th>Socio-cultural aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated system of adopter</td>
<td>Support &amp; Development</td>
<td>Product Process</td>
<td>Institutional aspects</td>
<td>Technical Development</td>
<td>Support &amp; Investment</td>
<td>Institutional aspects</td>
</tr>
<tr>
<td>Geographic</td>
<td>Support &amp; Development</td>
<td>Product Process</td>
<td>Institutional aspects</td>
<td>Technical Development</td>
<td>Support &amp; Investment</td>
<td>Institutional aspects</td>
</tr>
</tbody>
</table>

Selecting and ranking niche strategies for AWE

<table>
<thead>
<tr>
<th>Niches</th>
<th>Demo, experiment &amp; develop</th>
<th>Top</th>
<th>Subsidized</th>
<th>Redesign</th>
<th>Dedicated system or stand-alone</th>
<th>Hybridization or adopter</th>
<th>Educate</th>
<th>Geographic</th>
<th>Lead-user</th>
<th>Explore multiple markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of Technology</td>
<td>Support &amp; Investment</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Macro-economic aspects</td>
<td>Customers</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Knowledge of Technology</td>
<td>Customers</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Knowledge of Technology</td>
<td>Technological developments</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Macro-economic aspects</td>
<td>Support &amp; Investment</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Total: 13 6 4 3 8 / 13 17 13 /
Percentage: 16.9% 7.8% 5.2% 3.9% 10.4% 0.0% 16.9% 22.1% 16.9% 0.0%

1. Geographic niche strategy 22.1%
2. Educate niche strategy 16.9%
3. Lead user niche strategy 16.9%
4. Demo, experiment and develop niche strategy 16.9%
5. Dedicated system or standalone niche strategy 16.4%
Appendix A.3: Additional graphs

For additional clarification or explanation, additional graphs are provided to compliment the results and findings of the thesis.

Figure A.2 shows the distribution of percentages of barrier-sets per literature sources, collectively forming the literature-based barrier ranking. The distribution shows that the top-8 barrier-sets each consists of the percentage combination of at least two literature sources, especially the barrier-sets with the highest percentages, proving that the ranking is not solely based on or influenced by a single dominant literature source.

Figure A.3 shows the alterations five experts have made during the interview to the literature-based barrier ranking, highlighting the fact that on average experts rank the barrier-sets in the same order as literature-based barrier ranking. Although barrier-sets 4 and 5 are radically re-ranked by a few experts, resulting in the eventual swap with barrier-set 4 going to 5th place and barrier-set 5 to 4th. To explain the graph, for example 4 experts have ranked 2nd barrier-set in 2nd place, and one ranked it in 3rd place.
Figure A.4 shows how the niche strategy selection was determined using the revised barrier ranking as input, with the resulting niche strategy selection and ranking shown in the bottom row. The figure particularly shows how the niche strategy selection process works for the case of kite-based AWE technologies, with the links between barriers and niche strategies forming the core.

Per barrier-set the linked niche strategies are determined, and giving points according to the barrier ranking. So the corresponding niche strategies of the highest ranking barrier-sets receive 8 points, which is inverse to the ranking of the top-8 barrier-sets, as seen in figure A.4.

<table>
<thead>
<tr>
<th>1. Knowledge of Technology – Support &amp; Investment</th>
<th>Demo, experiment and develop</th>
<th>Top</th>
<th>Subsidized</th>
<th>Redesign</th>
<th>Dedicated system of sanitation</th>
<th>Hybridization or adaptor</th>
<th>Educate</th>
<th>Geographic</th>
<th>Lead user</th>
<th>Explore multiple markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Vision &amp; Image – Support &amp; Investment</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Macro-economic aspects – Customers</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Knowledge of Technology – Customers</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Knowledge of Technology – Institutional aspects</td>
<td></td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Knowledge of Technology – Technological developments</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Macro-economic aspects – Support &amp; Investment</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Knowledge of Technology – Production processes</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| TOTAL:                                           |                             | 12  | 11         | 10       | 9                | 2                    | 0      | 12         | 12       | 7                       | 0
| Percentage:                                      |                             | 16.00% | 14.67% | 13.33% | 12.00% | 2.67% | 0.00% | 16.00% | 16.00% | 9.33% | 0.00% |
| Ranking:                                         |                             | 1st  | 4th       | 5th      | 5th           | 1st                | 1st    | 1st       | 1st      |                         |

Figure A.4: Overview of the niche strategy selection process using the revised barrier ranking.
Appendix A.4: Nomenclature
A list of the common terms and wording used in this thesis:

Airborne Wind Energy: A system (generally) generating electricity from wind power resources by using airborne components in wind or air flow.

Barrier: An observed obstacle by an actor in the socio-techno-system, inhibiting further progress to market adoption, caused by the misalignment of one or several factors, important for market introduction of sustainable technical innovations.

Barrier framework: Framework to categorize, generically describe, and list barriers to large-scale (mass) market adoption of radical innovations, using two list of six factors to describe the ‘indirect cause’ and ‘direct impact’ a barrier has on the socio-technical system.

Barrier ranking: Ranking of barriers on basis of their influence on the socio-technical system, consisting of barrier-sets listed in the ranking order.

Barrier-set: A set of two factors from the two lists of the barrier framework, to describe a barrier by its ‘indirect cause’ and ‘direct impact’ on the socio-technical systems. Multiple barrier-sets can be used to describe a single barrier if required.

Kite-based AWE technologies: A sub-group of Airborne Wind Energy technologies using inflatable kites or similar structures to access wind resources at altitude.

Niche strategy: A coordinating process, in which one or a set of experiments are setup, executed, and assessed in a protected niche of the market segment. In order to achieve the wider adoption of the new innovation, through co-development of innovation and market.

Niche strategy selection: A selection niche strategies regarded as a suitable response to the barrier ranking of an innovation or market situation. Determined by using the barrier ranking as input for niche strategy selection process.

Niche strategy selection process: The process of selecting niche strategies suitable to tackle or overcome barriers to market adoption faced by the case innovation. Is conducted by determining which niche strategies suit the individual barrier-sets ranked in the barrier ranking, after which the results are combined to result in a ranking of niche strategies and thus selection.
# Appendix A.5: List of interviewed experts

<table>
<thead>
<tr>
<th>Expert</th>
<th>Organization</th>
<th>Reason</th>
<th>Date of the interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Hampton</td>
<td>Kite Power Solutions Ltd.</td>
<td>Fledgling British kite-based HAWP company, founded by Bill Hampton. Building on experience in kite-surfing and display kites.</td>
<td>19th of August 2014</td>
</tr>
<tr>
<td>C. Grete</td>
<td>Skigh Energy</td>
<td>Former start-up using the technology from Delft University of Technology, to deploy small-scale kite systems off grid in developing countries. Ceased operations after market research, and is now employed at Kitepower 2.0.</td>
<td>12th of August 2014</td>
</tr>
<tr>
<td>M. Corongiu</td>
<td>Kitenergy srl.</td>
<td>Programme manager of a leading Italian firm in kite-based HAWP technology, based in Turin area. Currently developing and testing a small scale kite-based prototype.</td>
<td>29th of August 2014</td>
</tr>
<tr>
<td>Dr. -ing. R. Schmehl</td>
<td>Kitepower TU Delft</td>
<td>Associate professor responsible for Kite Power research at the TU Delft, focused on kite aero-elastic interaction. One of the editors of the AWE (book) and located in Delft, The Netherlands.</td>
<td>5th of August 2014</td>
</tr>
<tr>
<td>S. Brabeck</td>
<td>SkySails GmbH.</td>
<td>Prominent Hamburg-based company with first commercialization of traction kites for commercial shipping. A key speaker at AWEC 2013 on “AWE Enterprises &amp; Prototypes”</td>
<td>5th of August 2014</td>
</tr>
<tr>
<td>U. Ahrens</td>
<td>NTS X-wind GmbH.</td>
<td>One of the editors of the AWE (book), and founder of Nature Technology Systems(X-wind) based in Berlin area. Developing a large scale application kite-based HAWP technology.</td>
<td>11th of August 2014</td>
</tr>
</tbody>
</table>