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Commercialisation of Alternative Energy Technologies

A Case Study

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Abstract

Commercialisation of Alternative Energy Technologies

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Purpose:
Climate change is one of the largest threats to continued human existence, and is largely caused by the burning of fossil fuels for energy. This thesis examines the literature regarding diffusion of innovations in an attempt to understand how alternative energy technology is commercialised, and how chances of entrepreneurial success in this field can be improved.

Design/methodology/approach:
Using a case study of a 'cleantech' start-up, this thesis takes a normative approach to empirical data analysis, and explores the practical implementation of the company's strategy to commercialise their products. Five semi-structured interviews, alongside a site visit to the production facility are conducted with two executives in order to gather first-hand experience of the strategic dilemmas that have been faced, and elucidate common themes that occur in literature. As requested by the company, all names, technologies, and markets have been changed to protect commercially sensitive information.

Findings:
This research finds four key internal operational assets, which are supported by literature, that have led the company to successfully commercialise their technology. Furthermore, it finds that the ability of entrepreneurs to identify and respond strategically to new opportunities, alongside a balanced external market strategy which evaluates the target innovation system for systemic barriers to technology diffusal, are important attributes for successful commercialisation.

Practical implications:
These findings corroborate much of the existing literature, but highlight a need for government policy to incentivise consumer behaviour instead of directly sponsoring alternative energy technologies, to generate a 'market pull' which is more forgiving of systemic barriers to technology diffusion. In this way, entrepreneurs may successfully scale their products, find niche markets, and become sustainable businesses that diffuse technology across industries. Additionally, the findings from the company's experience can be used by other alternative energy entrepreneurs to help them commercialise their technologies, and expedite the change to a lower carbon energy economy.

Originality/value:
Currently literature is scarce from the perspective of the entrepreneur, instead focussing on what governments and institutions can do to support the diffusion of alternative energy innovations. Thus, this thesis seeks to better understand the intersection between entrepreneurs and the wider innovation ecosystem, and in doing so, highlight strategic variables that affect the commercialisation process using a real-world case study.

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Popular Science Summary

In capitalist socio-economic systems, entrepreneurs are often responsible for disruptive innovations, though many new companies fail to reach the sufficient economies of scale to commercialise their products. During early development, alternative energy technologies are often considered difficult to commercialise as they either have a cost that is too high, or they are not technically superior to existing technologies, and thus appear uncompetitive. However, given the seriousness and implications of climate change, it is important to support development of new technologies that can alleviate the global burden posed by the burning of fossil fuels, and hasten the change to a lower carbon energy economy. Most literature reviewed by this study takes the perspective of governments and institutions, focusing on how they, as legislators and policy makers, can support commercialisation of renewables and alternative energy technologies. Instead, this paper focusses on commercialisation of alternative energy technology from the perspective of individual entrepreneurs, and asks, what can they do themselves, to improve their chances of commercialisation success?

Commonly understood principles of innovation diffusion can help entrepreneurs to focus their commercialisation efforts, and make strategic decisions which improve their chances of commercialisation success. This study, which uses the real-world experience of a Cleantech start-up, identifies common themes to help explain how they have achieved successful commercialisation over time. It then explores their experience in several key markets to understand how different parts of an innovation ecosystem can affect entrepreneurial chances of successful commercialisation.

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To my family back in the UK, thank you for giving me every opportunity in life, and for the moral (and financial) support. I am lucky to have you all.

To the Founder and Chairman, thank you for the support you have given throughout this entire process, even when busy, and for the opportunity to study your company! I wish you every success moving forward with your technology.

And to my subject reader Annika, without your relentless demand for perfection this thesis would be a mere shadow of itself. Thank you for lending me titles from your personal library (which I promise to return!), and for pushing me to dig a little deeper with every revision.

Uppsala, 28th of June 2018

Matthew Davis

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1 Introduction

Each section has an italicised 'reader's note' under the header to help the reader explore each section of text. Some of the more in-depth sub sections also have such a paragraph. For example, this section provides an overview of the content of this thesis, and introduces the motivations of the author in conducting this study. The names of the company, employees, and contacts, used for this case study have been changed to protect commercially sensitive information.

To put it bluntly, and without unnecessary literary exaggeration, climate change is one of the biggest threats facing modern human civilisation. Climate change sceptics may misrepresent scientific uncertainty, or even historical climate shifts as proof that humans are not the cause, however, in a peer reviewed study of 10,306 scientists, 97% agree that, not only is climate change real and already occurring, but that it is anthropogenic (Cook et al, 2013). This figure also takes into account 11,944 abstracts of published research papers, and the 97% consensus has since been proven robust on several occasions. The implications and dangers of irreversible climate change are serious, with positive feedback loops causing rising sea levels, and major droughts just some of the predicted consequences (Diesendorf, 2013).

One of the major causes is the burning of fossil fuels, used for transport and electricity generation. Renewable energy technologies are widely regarded as a desirable alternative to fossil fuel based sources, but suffer from some fundamental trade-offs. One disadvantage of current generation renewable energy sources is that without a sufficient mix of technologies, renewables negatively impact the energy security of a nation due to their inconsistent performance (Helm, 2012). For example, solar photovoltaic panels are ineffective during the night or cloudy weather, and wind turbines are useless without sufficient wind. Therefore, much research has focussed on the commercialisation environment for other renewable energy technologies in order to investigate supplemental alternatives that can generate electricity on demand. Thus, if humans are to avoid global temperatures rising above the hotly debated 'point of no return', and progress beyond 'Peak Oil', one might argue that research which exemplifies paths to alternative energy sources are of critical relevance today.

In keeping with this overarching issue, the thesis dives deeper into the particulars of commercialising alternative energy technology by exploring the intersection between individual entrepreneur and the wider innovation system, in order to gain an understanding of the difficulties with commercialisation of innovation. The innovation ecosystem is one such important concept for analysing the competitive environment in which a start-up is positioned relative to other stakeholders (Scaringella and Radziwon, 2017). However, there is often a disconnect between the theoretical commercialisation of renewable energy technologies, which focuses on the innovation ecosystem, and practical entrepreneurial strategy. Consequently, there is a lack of empirical case studies which demonstrate the relevance of theoretical frameworks from an entrepreneurial perspective. Most current academic literature focuses on governments and institutions as the only bodies capable of supporting the high capital requirements that new technologies need to be brought to market. Though there are a few papers that recommend more investigation into the role of the entrepreneur in facilitating the transition to renewables (see Balachandra et al, 2013), most simply take this macro-scale approach to innovation diffusion. Thus, understanding how individual entrepreneurs commercialise their innovations is of foremost concern. Once this has been explored and better understood, then focus can shift to optimising this process, in order to expedite the

transition to a lower carbon energy environment. The main question that this thesis aims to answer therefore, is: *How does the intersection between the innovation ecosystem and the individual entrepreneur affect the chances of successful commercialisation of alternative energy technology?*

To begin, this thesis provides a broad literature review that is required to provide relevant background information and the theoretical conditions to which early stage technologies are subject. Thereafter, a short section on problematisation will distil the literature review into relevant research questions, and discuss how alternative energy entrepreneurs are positioned, perhaps with disruptive effects on traditional energy markets. Next, the method chapter will outline the design of this qualitative study, and the logic and considerations behind it. Consequently, a case study of an alternative energy start-up (hereafter referred to as The Company), has been generated in order to explore the intersection between the innovation ecosystem and the individual entrepreneur and thereby the challenges faced, with a wish to provide advice and discuss practical implications with a normative approach. As a point of note, when discussing alternative energy, this thesis is referring to new energy technologies that are not covered under the umbrella of renewable energy (Zehner, 2012). Following this, an assessment and comparison of the strategies observed will be debated from both academic and empirical perspectives, in order to examine how they can be deployed if successful commercialisation is the desired outcome. Finally, the conclusion presents how entrepreneurs, as actors in a wider system, can make strategic choices which will improve the likelihood of successful technology commercialisation. This will lead to two contributions, the first of which is a review of the theoretical approaches to innovation diffusion and technology commercialisation, in comparison with the wider innovation system and the individual entrepreneur therein. Secondly, and perhaps more practically, it is expected that the findings from this thesis are able to assist other alternative energy entrepreneurs in considering appropriate strategies, as well as policy makers within commercialisation of energy technologies, leading to an improved rate of technology commercialisation in the alternative energy field.

2 Literature Review

This section explores the relevant academic literature, in order to locate and position this thesis in the context of existing research.

In order to properly explore how The Company has commercialised its technology, it is imperative to firstly understand the context and interconnectedness of innovation, technology entrepreneurship, and commercialisation strategy in the alternative energy field. The literature review will begin by broadly covering the themes of innovation diffusion, and strategic marketing concepts such as technology push versus technology pull. It will then investigate more closely the links between the renewable energy sector and the innovation ecosystem in which an entrepreneur may find themselves. Subsequently, a short discussion on technology entrepreneurship aims to identify the contributory factors of success, which can aid commercialisation of alternative energy technologies. Finally, interesting aspects of the literature review are highlighted in the problematisation section, in order to draw out questions that help analyse and investigate the overarching research question.

2.1 What is innovation?

Simply defined as the commercialisation of invention, or more fully as the *"multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace"* (Baregheh et al, 2009), innovation has become a universally recognised source of economic growth, international competitive advantage, and technological advancement (Piperopoulos, 2012). In order to maintain superiority in a modern global economy, organisations engage in continual cycles of research and development, which, paired with intricate commercialisation strategies, aim to enhance idea conversion rates and ensure market success. Innovation has also been likend to an evolutionary battle between businesses, where the strongest and most profitable survive. Drucker's disputed phrase 'innovate or die', alongside Schumpeter's 'creative destruction', highlights the importance of adapting to change, lest businesses become outcompeted. Such an insular perspective of 'innovation as competition' might seem to be a cause of friction between market actors, however, it is widely accepted in post-modern capitalist economies that innovation as a collaborative mechanism drives value creation, which in turn drives wealth generation, and enriches businesses, governments and society in general (Laudicina et al, 2012). Thus, innovation remains an important cornerstone in the economic health of civilised nations, a desirable emergent property of capitalist society, and a strategically important capability for continued organisational competitiveness.

2.2 Diffusion of innovation

If innovation is perceived as mostly positive, the question remains, why do some innovations fail? The answer lies relative to the diffusion of innovation throughout society. When discussing, for example, adoption of new technologies, many authors start by referencing the well-known models of Everett Rogers (2005) and his theory of the diffusion of innovations, originally penned in 1962. In his book, Rogers suggests that an innovation must be widely adopted in order to become self-sustaining; that is,

achieve a level of adoption that supports its continued existence. Thus, a given demographic or market may be split into five different groups, each of which have differing appetites for innovation adoption. Innovators and early adopters are considered to be visionaries, who attach more value to an innovation than simply it's up front economic cost. Laggards, on the other hand, only switch to the innovation when their traditional source ceases to exist. The implication is that the more groups that adopt the innovation, the wider the diffusion and more probable its success. Importantly, failed diffusion does not mean that the innovation was adopted by no one, simply that, for whatever reason, the value proposition was not enough to achieve the critical mass necessary for mainstream adoption. Moore (1991) argues that this critical mass, the 'turning point', can also be thought of as 'crossing the chasm' of commercialisation (see Fig. 1), for which there can be any number of difficulties. How to cross this 'valley of death' for a given industry, market, or technology is the focus of much entrepreneurial academic literature, and will be explored later in the context of alternative energy technologies.

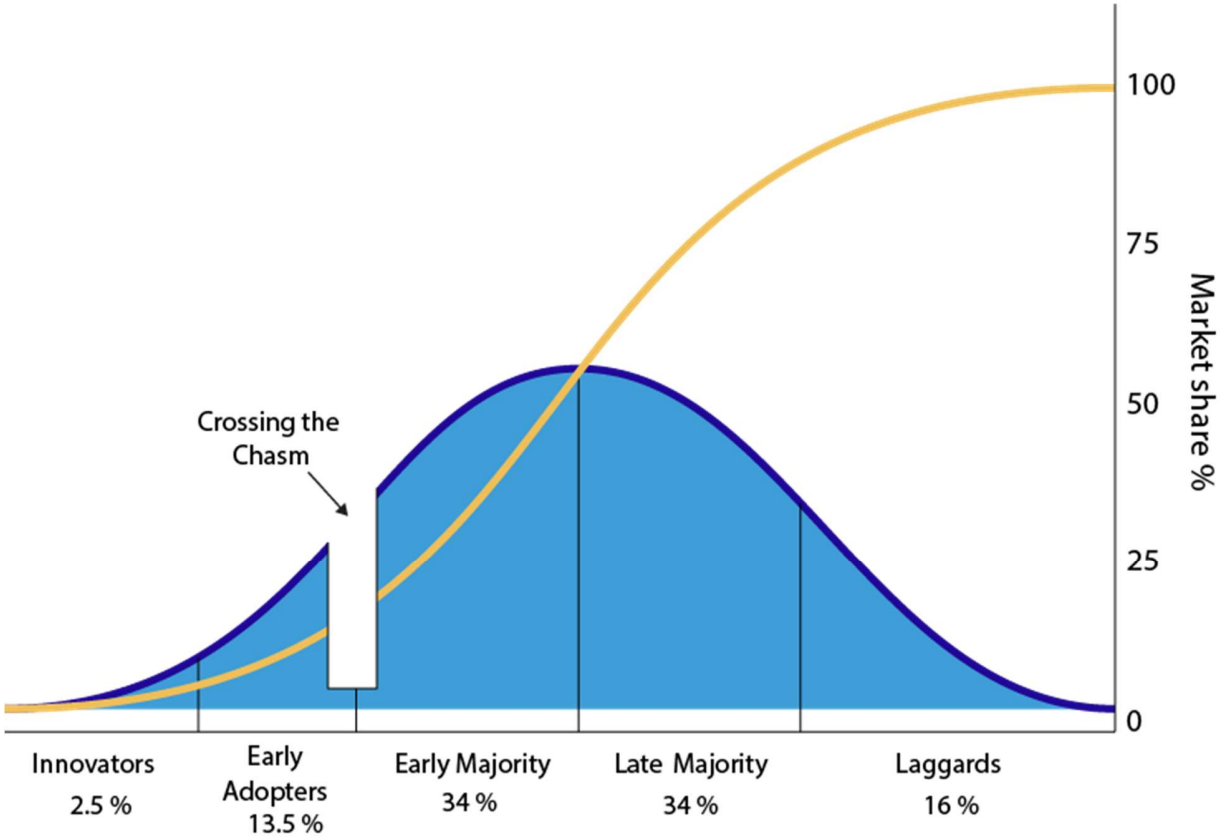

Figure 1. Diffusion of Innovation curve, including the 'valley of death', more commonly labelled as 'crossing the chasm'. Image based on Rogers (1962), and Moore (1991).

An effective strategy to 'cross the chasm' according to Moore is to find a small niche market for which the innovation can solve a problem at a reasonable price. Thus, to successfully commercialise a technology, one must adequately understand the market forces at work, as well as the general behaviour of the target demographic; this is common business practice. Unfortunately however, for a variety of reasons, many early stage technologies fail to find their niche market, and reach a stage of commercialisation. Part of the problem, for new technology at least, is that whilst early stage innovation can be achieved for relatively little cost, scaling requires a lot of investment capital in order to build

supply chains, and reach the manufacturing cost benefits of large order numbers. Thus, technology substitution by new market entrants can sometimes take longer than one might expect, even if the technology is superior in terms of performance (Adner and Kapoor, 2016).

2.3 Early stage commercialisation

It is often the role of governments to provide regulatory oversight and investment in order to incentivise private research and development (R&D). Kimura (2010) has shown that in Japan, government funding for R&D created niche markets which allowed early stage technologies to thrive in areas where private businesses would be unable to finance alone. However, despite many of the public R&D projects failing the commercialisation stage in the case study, he argues that risky but important technologies should still receive public funding because private R&D is unable to undertake such projects by itself. Additionally, research conducted by the European Commission in 2009 found that the most significant problem in R&D commercialisation was a stalemate between manufacturers and buyers. Before investing money into developing and commercialising eco-innovation technologies, manufacturers would wait until there was a demonstrated demand, however, potential buyers would also wait until there was a satisfactory product on the market before making a purchase (Hug, 2009). Thus, from a governmental perspective, there is always a risk that significant investment could still lead to failure. Thanks to governmental support in the form of subsidies, the companies interviewed in the European Commission study did not perceive risking funds on R&D expenditure as their main problem, but instead it was the risk of commercialisation failure once governmental support ended, and that the costs of scaling production volume left them exposed thus unwilling to risk continued development (see Fig 2). This is synonymous with findings from Manoukian et al (2015) and Jagoda et al (2011), who also note that private firms are unwilling to take risk of new technologies where the financial outcome is less certain, and that commercialisation goals are difficult to achieve without creating robust stakeholder partnerships.

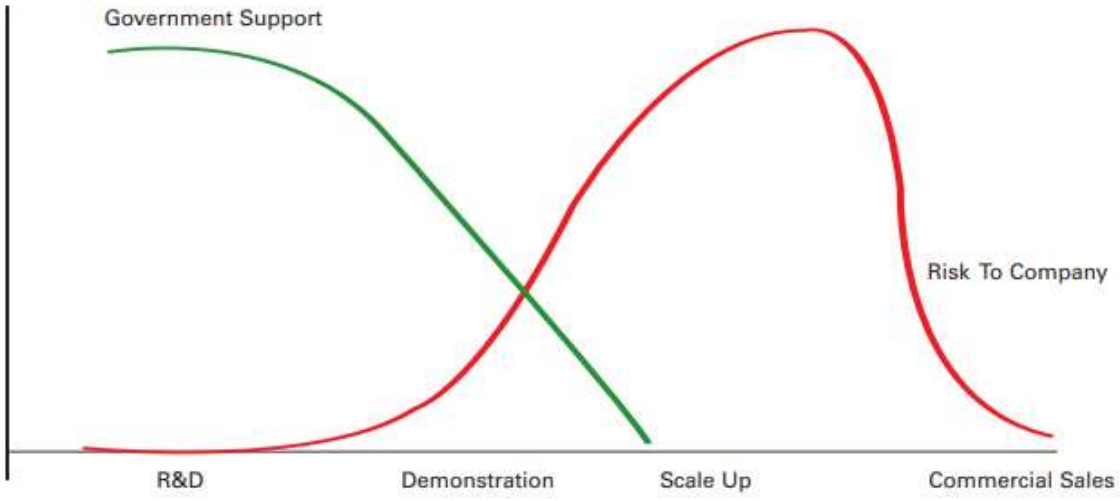

Figure 2 - Technology procurement as a commercialisation strategy (as seen in DTI, 2006).

Further research has also shown that governments can improve chances of successful innovation diffusion and commercialisation through policy and environmental legislation which provides stable markets for an industry to develop (Aslani, 2015), thus providing businesses with confidence of future revenue.

One other potential strategy for technological advancement is the practice of technology procurement, whereby governments themselves define highly innovative technology requirements. However, due to a lack of a wider commercial market, the government almost always serves as the sole purchaser of the resulting products (ten Cate et al, 1998). Additionally, this practice is inherently cost inhibitive, usually involving low scale production and specialised use cases, thus making it difficult and an unpopular use of taxpayers' money. The question must then be asked, if it is not economically viable for governments to sponsor the complete commercialisation and diffusion of alternative energy technologies, and cost prohibitive for private interests, what strategic approaches can private business take in order to minimise the risk of commercialisation failure?

2.4 Commercialisation Strategy

Innovation activity has traditionally followed a linear model of innovation, whereby organisations could adopt either a 'technology push' or 'market pull' approach (Brem, 2008). This means that companies either tried to find a market gap for which their invention is desirable, or they attempted to create a solution to fill an identified market gap by research and development activity. From this perspective, it is interesting to compare the current desire for renewable energy solutions in the context of climate change. Presently in most civilised environments, electricity is cheap and widely available, and the effects of climate change are subtle, thus your average consumer has no immediate economic incentive to invest in more expensive alternative technologies. Indeed, the market selection process actually inhibits consumer choices, and thus demand, as incumbent suppliers are not only dominant, but reliant on cheap energy for their profits (Jacobsson & Johnson, 1998). More expensive early stage technology such as renewables, only serves to reduce margins, unless they can sell the energy at a higher rate to compensate for their loss. In order to change both consumer and manufacturer behaviour therefore, governments must engage with policy frameworks such as industry subsidies and tax relief in order to create technology push (Hoffmann, 2014). The interactions of actors in this network are complex and will be discussed further later on (see Innovation Systems). However, once a technology reaches a certain stage of development, it may become attractive enough to address a market pull. Eng and Quaia (2009) discuss, in their paper, a theoretical framework which looks at strategies for improving product adoption, particularly in uncertain environments. In it, a key factor for adoption is knowledge around a given technology, and we can see evidence of this influencing renewable technology adoption in the current energy markets. With widespread awareness and concern for the environment at large, more consumers are choosing suppliers that offer electricity sourced from renewable means, thus creating somewhat of a market demand for renewable energy despite it being slightly more expensive (Sundt & Rehdanz, 2015). Walsh (2011) refers to this knowledge on a societal level as 'market sophistication', and expands the traditional push versus pull concept into a four-category framework for renewable energy technologies (see Fig 3).

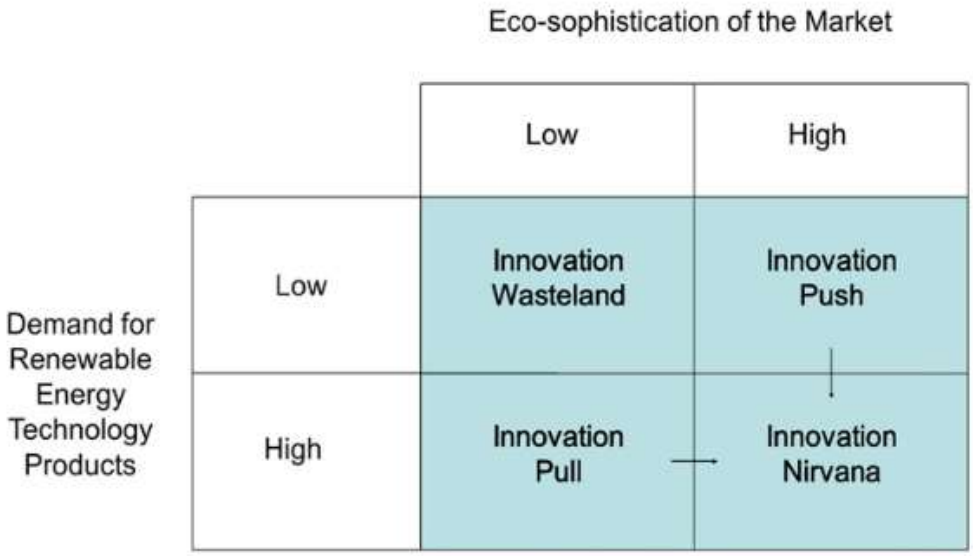

Figure 3. - Renewable Energy Commercialisation Environments, as seen in Walsh (2009).

Acknowledging and proporting the importance of small or medium enterprises (SMEs) to the diffusion of renewable energy technologies, Walsh uses this framework to categorise the market dynamics in a given commercialisation environment. Higher market sophistication, it is argued, leads to higher awareness of other technological advantages, and less focus on the traditional neoclassical cost benefit value proposition. Gabriel and Kirkwood (2016) also find that certain business models work better in certain regions due to differing levels of governmental interest in renewable, governance, and policy support, alongside the relative ease of doing business. Additionally, organisations may improve their chances of successful commercialisation in a given market through tailored use of the suggested commercialisation strategies (see table 1), which take into account the systemic innovation ecosystem and the sources of finance.

Table 1 - Commercialisation environment and related strategies for renewable energy technologies (RET), as seen in Walsh (2009). Commercial risk is a combination of cost risk, product risk, and market risk to the entrepreneur.

RET commercialisation environment	**Innovation type**	**Commercial risk**	**Commercialisation choice**	**Commercialisation strategies**
Innovation Wasteland	Disruptive	High	Dependent (Collaboration)	Government Incentives External R&D contracts Utility funding
Innovation Push	Discontinuous	Moderate		Outsourcing Licensing
Innovation Pull				Joint Venture

				Strategic Alliance
Innovation Nirvana	Sequential	Low	Independent	Venture capital Equity financing Acquisition

Whilst the environmental landscapes of each market are undoubtedly more complicated than this framework may suggest, these categories work well for the context of alternative energy technologies, and provide a useful tool to begin analysis and entry into unknown markets.

As we move closer to the current trends in innovation and management practice, in order to remain competitive, the process of innovation becomes much more cyclical, and with shorter development timescales required. In their paper on manufacturing strategy in emerging industries, Lubik et al (2012) found that future commercialisation success will most likely occur from a combination of 'technology push' and 'market pull' factors, where the most successful companies are those that are able to implement these approaches flexibly, depending on the market. Hence, in order to understand how SMEs can play a key role in innovation diffusal and successful technology commercialisation, it is important to review how these factors are influenced by the macro scale system within which they reside.

2.5 Innovation Systems

As mentioned previously, taking into account the complexity involved in market interactions between a diverse group of actors, it becomes logical to adopt an innovation systems approach which helps to identify key stakeholder groups in the innovation process, and thereby opportunities to influence success. Jacobsson and Johnson (2000) propose that the diffusion of renewable energy technologies can be studied through a combination of two opposing perspectives; the neoclassical economic, and that of the individual firm. They suggest that the individual entrepreneur has more power over innovation diffusal than simply aiming for an attractive cost-benefit unit price. Instead, systemic variables are more important determinants for commercialisation success, and should be prioritised.

The system, it is argued, is represented by three main groups; Actors and markets, Networks, and Institutions. Negro et al (2012) expand this list into further categories and compare it to a wide body of other literature in the renewable energy technology context. However, for the purposes of this thesis, their analysis has been simplified, merged into the original categories (see table 2), and collated into examples of systemic variables which lead to a new technology being repelled.

Table 2 - Examples of systemic variables leading to a new technology being repelled (from Jacobsson & Johnson, 2000, and Negro et al, 2012)

Actors and markets	Poorly articulated/lack of demand Established technology characterised by increasing returns Local search processes Market control by incumbents Lack of capabilities/capacities Lack of skilled staff

Networks	Poor connectivity Wrong guidance with respect to future markets Too weak and too strong interaction problems
Institutions (Hard & Soft)	Legislative failures Failures in the educational system Skewed capital market Underdeveloped organisational and political power of new entrants Poor knowledge infrastructure Lack of supporting physical infrastructure

In their conclusions, Negro et al. note a bias in that current research focuses more on institutional aspects, as opposed to the individual entrepreneurial perspective. This is due to governments playing an overly dominant role in stimulating or directing these transformations to bring about societal change, because new technologies tend to be associated initially with either a high price or low utility. This raises the question of whether or not alternative energy technologies can actually be successfully commercialised without sufficient political will. Indeed, Foxon et al (2005) imply that policy incentives are necessary to create and support early niche markets, and improve the risk/reward ratio for private businesses. Balachandra et al (2010) however, propose a combined public-private sector approach for successful diffusion of sustainable energy technologies by making entrepreneurs the target of diffusion efforts instead of 'millions of end-users'. Indeed, the majority of literature found for this thesis conforms to a macro level view to alternative energy technology diffusion, choosing to focus on government policy and incentivisation rather than, for example, how grass-roots initiatives can be more effective. This split between incumbents doing business as usual, and entrepreneurs looking to commercialise early stage technology, means that smaller companies are often left out of policy or framework funding processes. Therefore, by providing innovative financial support mechanisms, incentive schemes, and marketing mechanisms to make alternative energy technologies profitable, it is argued that entrepreneurs will autonomously make the necessary commercialisation moves to bring a product to the mass market through a gradual process of increasing returns. Whilst this might seem a little idealistic, it does suggest that entrepreneurs will continue to be incentivised to attempt commercialisation of alternative energy technologies. Nevertheless, it is important that organisations look at the system as a whole before deciding on a commercialisation strategy, or entrance into a market (Artinger & Powell, 2015). Just as markets can fail, so too can the networks and institutions fail to support the emergence of new technologies (Jacobsson & Johnson, 2000), thus entrepreneurs must be aware of more than just their competitive advantage in order to capitalise on systemic opportunities. This does not mean that entrepreneurs are purely at the mercy of the innovation system however, strategic choices can greatly influence the outcome of success. Upper echelons theory suggests, rather obviously, that executives' experiences, values, and personalities greatly influence their interpretations of the situations they face and, in turn, affect their choices (Hambrick, 2007). Thus, applying these conclusions to early start-ups would suggest organisational success can be linked equally to the actions of the entrepreneur, rather than solely the configuration of the resident innovation system and its externalities. Indeed, Hemert et al (2011) highlight the academic change in understanding innovation systems, from traditional market based views of industry, to innovation networks of individuals that span multiple industries. Thus entrepreneurial actions, such as knowledge transfer between actors within the system, become more important than the structure of the system itself. To better understand innovation processes, and thereby

how to improve the rate of successful commercialisation, it is argued that greater focus should be placed on the socio-technical perspective and the role of business networks. Consequently, it is important to explore what additional factors lead to commercialisation success from an entrepreneurial perspective.

2.6 What is Entrepreneurship?

It is claimed that Jean-Baptiste Say first presented the French term 'entrepreneur' in his early works (1803), after reading Adam Smith's 'The Wealth of Nations (1776). In his book *'A Treatise on Political Economy'*, he presents the entrepreneur as an 'adventurer' who burdens himself with the immediate responsibility and risk of a business, upon his own or borrowed capital (Say, 2001). Later, Schumpeter (1942) used the term entrepreneur as the enabler of economic growth through creative destruction. The modern study of the entrepreneur however, or entrepreneurship as defined by Lazear (2005), is more specific; *"the process of assembling necessary factors of production consisting of human, physical, and information resources and doing so in an efficient manner"*. Incidentally there are many similar definitions provided by authors from a wide body of literature (Gartner, 1988; Hindle & Yencken, 2004; Braunerhjelm, 2010). Thus for the purposes of this thesis, the definition of an entrepreneur is simply the person capable of seeking out and actively embracing opportunities where these factors may combine to deliver increased value. Widely recognised as a valuable outcome of capitalist free market dynamics, entrepreneurs continually seek out value creating opportunities despite the risk of failure. In this way, they continually disrupt the balance of competition, thus preventing undesirable monopolies from stagnating an economy, and creating a wide ranging and diverse source of products and services. Entrepreneurship therefore, is considered the engine of innovation (Drucker, 2002), and can come in many forms.

The linkages between the innovation system and the individual entrepreneur can be described as the process of entrepreneurship. It is in this understanding of how entrepreneurs function in the wider ecosystem, that this thesis looks to identify relevant literature which describes attributes that have led to higher levels of success. Gartner (1988) argues that asking 'Who is an Entrepreneur' however, is the wrong question, and that instead of focussing on personality traits and characteristics of entrepreneurs, it is more productive to look for common behaviours as the key to understanding entrepreneurship. Thus research should look to capture and analyse what an entrepreneur does in the process of building and running an organisation, rather than who the entrepreneur is, because this avoids the causal assumption that unsuccessful entrepreneurs do not share the same personality traits as those who achieve success.

McKenzie et al (2007) however, critique Gartner's perspective as narrowing and de-contextualising the field of entrepreneurship, and since the original article, many other authors have also continued to explore alternative views. Low (2001) recognises that individuals differ with respect to their abilities to identify and exploit opportunities, and concludes that exploring the link between micro-level entrepreneurial action and macro-level economic progress is a highly valuable contribution to the field of entrepreneurial study. Therefore, this research, looks to explore what combination of traits and behaviours are identified in literature, in order to categorise commonalities of success; what do entrepreneurs do that leads to a successful outcome, and why do they take the actions they do as opposed to those they do not?

Common aspects of entrepreneurial success, as identified in literature, may be referred to as factors of success (as in Song et al, 2008, or Kirchberger & Pohl, 2016), but are better explained as operational or entrepreneurial attributes; that is, qualities and capabilities that are shared by entrepreneurs who have been successful. These attributes, which have been established over time through entrepreneurial experience, are based on personal interpretations of strategic information, and subsequent outcomes of decisions. If certain entrepreneurial actions have led to failure however, then the blame is often placed on insufficient experience (Artinger & Powell, 2015). For example, one might take a strategic action which has worked previously, and is appropriate given the current information, but still fail due to unpredictable external market behaviour. To that end, it is useful to look at decisions taken by the entrepreneurs involved in alternative energy commercialisation, in isolation to the situational conditions of the innovation system at large. Thus, in an effort to clarify and separate the academic view of entrepreneurial success, the next section begins by examining literature which seeks to understand the act of entrepreneurialism, and to review it for contributory elements of successful commercialisation.

2.7 What drives an entrepreneur?

Research has shown that people are attracted to becoming entrepreneurs based on their self-perceived traits and the task demands of the entrepreneurial endeavour. Zhao et al (2010) find that people who become entrepreneurs are more likely to be successful if they have personality traits that are aligned with the behaviours necessary for entrepreneurial tasks. In particular, conscientiousness, openness to experience, emotional stability, and extraversion are each positively related to entrepreneurial firm performance. Thus people who are comfortable networking, multi-tasking, and empathising with their customers for example, are more likely to be successful entrepreneurs than those who do not. This makes sense as, in early start-ups, entrepreneurs are often under many discrepant pressures related to the immediate responsibility and risk of running a business. There are many concepts which aim to explain the ability of entrepreneurs to multitask and prioritise in a given environment. Dynamic capabilities (Teece, 2009), and entrepreneurial ambidexterity (Bryant, 2009) are two such concepts which focus on creating an agile organisation that can respond quickly to changes and challenges in the market. From an entrepreneurial perspective, the important factor for success at this early stage, as discussed by Nambisan & Baron (2013), is the combination of entrepreneurial self-regulatory processes, categorised as self-control, grit, and metacognition (see Fig 4). Through mastery of these skills, it is argued, the chances of venture success are improved. Likewise, just as innovation has a number of different phases, successful entrepreneurs are able to apply a different mix of tacit and codified knowledge inputs for each phase of opportunity development, to convert them into commercial successes (Hindle & Yencken, 2004). In order to navigate the tensions of renewable energy ecosystems therefore, entrepreneurs must carefully consider the extent to which their skills and self-regulatory predispositions match the unique demands of each market and their respective opportunities.

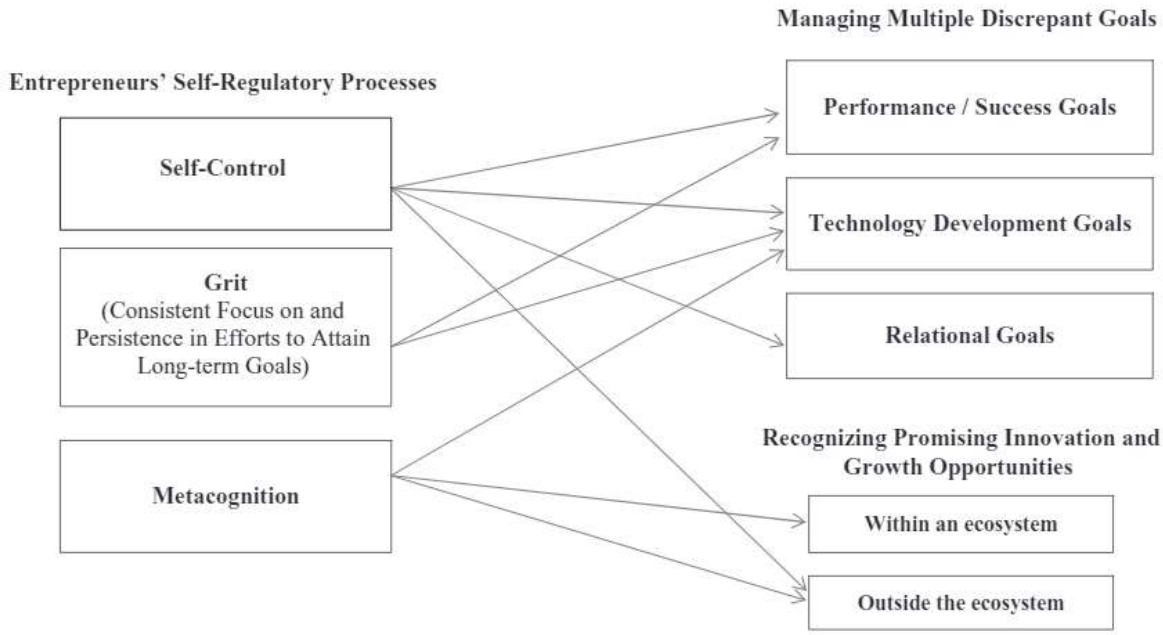

Figure 4 - Entrepreneurs' self-regulatory processes and success in managing dual roles in innovation ecosystems (from Nambisan & Baron, 2013).

Furthermore, there is also something to be said for the motivations of the entrepreneur. Binder and Belz (2015) break the concept of entrepreneurship into separate types; conventional, social, and environmental, with each type of entrepreneur aiming for alternative, but not necessarily dissimilar, goals (see Fig 5). As concepts of sustainable entrepreneurship, these orientations or alignments, also allow for different motivations; not only for becoming an entrepreneur, but also for strategic decision making, thus defining alternative measures of success. When it comes to technology entrepreneurship and alternative energy specifically, one can argue that the goals of the entrepreneur aren't simply economic, but a reflection of their personal values and interests.

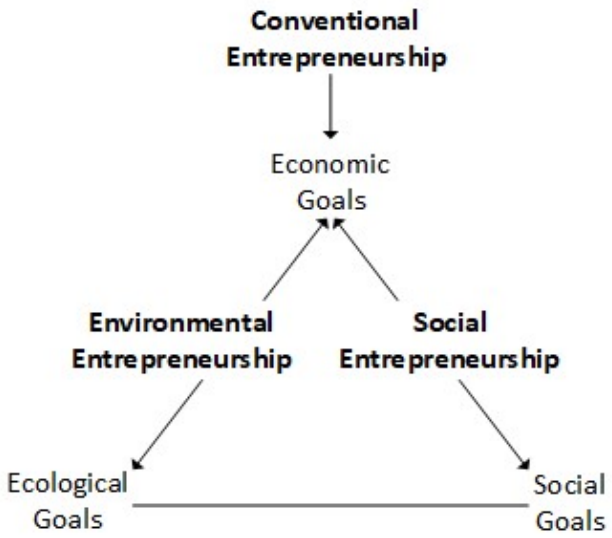

Figure 5 - Related concepts of sustainable entrepreneurship (from Binder and Belz, 2015)

Just as environmental entrepreneurs are driven by ecological goals such as preventing climate change, technology entrepreneurs are distinguished from mainstream entrepreneurs due to their focus and passions for opportunities fostered through innovations in science and engineering (Beckman et al, 2012). However, whilst commercial success may sometimes not be the entrepreneur's key motivation or desired outcome, as discussed previously it is necessary for the entrepreneur to scale up their business to ensure goals are achieved to their fullest potential. Thus, commercialisation becomes passively incentivised through the evolutionary means of marketplace survival. For alternative energy technologies, this marketplace orientation gives way to a separate definition. 'Cleantech' organisations aim to compete favourably on price and performance, whilst reducing pollution, waste, and the use of natural resources (Avdeitchikova & Coenen, 2015), hence their goals are a good example of the combination between traditional and alternative forms of entrepreneurship.

Naturally therefore, the next section will briefly explore how entrepreneurial firms can maximise their potential for successful commercialisation through strategic means.

2.8 Entrepreneurial firm success

Start-ups, or 'entrepreneurial firms', are categorised as early stage businesses that usually start from a weak market position, with few resources. As challengers to the status quo, they must usually interact with established external resource holders (suppliers, creditors, customers etc.) who are invested in and advantaged by the incumbent structure of the resident innovation system (Avdeitchikova & Coenen, 2015). As a result, strategic choices are increasingly important as they are likely to be costly, and the consequences of repeated failure can be more severe than on well-funded larger firms. Katila et al discuss (2012) how entrepreneurial firms can change their strategic approach depending on whether they are entering a new or existing market, and surmise some interesting conclusions. In established markets, it is better for entrepreneurial firms to be skilful, and pursue strategies that avoid competitive conflict with

larger rivals who are better equipped to finance counter moves. This can be linked to the prior findings of creating a personal market niche and should be addressed through adopting an exploitative strategic approach. However, it is in new markets where entrepreneurial firms may find the most success, as the market and customer landscape is undefined; from this perspective, an explorative strategy is the most effective. Coincidently, the theme of ambidexterity appears again, in that firms that are able to quickly explore the landscape and avoid overstaying in any unprofitable segment generally perform well. For small/medium enterprises (SMEs), Hemert et al. (2011) also find that using and maintaining an appropriate balance between exploration and exploitation networks is also of vital importance.

Even with strong strategic direction however, new technology ventures can fail. In their study of 11,259 new technology ventures based in the USA, Song et al (2008) found that only 36% were still in business after 4 years (with more than 5 full-time employees), and only 21.9% after 5 years. From a meta-analysis of academic literature, focussing on success factors, they found that new technology ventures are more successful when the organisation has particular capabilities and traits, such as market scope, ability to integrate supply chains, founder's industry experience, or the existence of patent protection. These so called 'factors' ensure that barriers to aspects of doing business are kept minimal, and thus were positively correlated with entrepreneurial commercialisation success. Kirchberger & Pohl (2016) also find similar 'factors' for success in their literature review of technology commercialisation, including industry closeness, resource availability, and property rights. For example, closeness to industry can mean that supply chains are geographically close to minimise transport costs, or to improve communication channels such that any problems are quickly resolved. Resource availability has similar connotations in that problems or issues that arise can be dealt with quickly, or that strategic manoeuvres are able to be implemented because access to funding is readily available. Property rights refers to patent protection, as this increases the attractiveness of licensing a technology, but they also find that CEO ownership of the technology increases commercialisation success, due the improved strategic position this creates. Furthermore, in a study of UK innovation for new and renewable energy technologies, Foxon et al (2005) also find that patents or intellectual property rights are essential for young companies in securing private equity finance. The relationship between the entrepreneurial team is also an important aspect, such that a diverse team with a plethe Chairmana of suitable knowledge and experience is generally associated with high performance. These common aspects all play into the wider literature and suggests that less waste, a strong industry network, and protection of intellectual assets are key attributes for entrepreneurial success.

The renewable energy field is particularly interesting, because in many cases renewable energy does not compete directly with the incumbent fossil fuel industry. Depending on the market sophistication, alternative energy sources are often competing against second generation renewable energy sources such as wind or solar, which offer a similar value proposition and are widely available for an affordable price. New market exploration therefore, or niche market development, becomes the strategy with the highest likelihood of success. Avdeitchikova & Coenen (2015) advocate taking a 'multi-level' view of the socio-technical system, which differentiates between the transitional evolution of innovation landscapes, regimes, and niches. They rationalise that commercialisation strategies need to take account of the particular stage of the institutional transition and the particular opportunities and challenges that follow from this, for an entrepreneur involved in commercialising 'cleantech' to be successful. Thus, to better identify a niche opportunity, the entrepreneur must become intimately familiar with the target market

innovation system, and can thereby ‘nurture’ their niche in order to induce favourable market transformation.

2.9 Problematisation

Following on from the literature review, the interplay between successful commercialisation of technology, innovation systems, and entrepreneurship has now been explored from multiple stakeholder perspectives. A clear pattern of macro scale research has been found, which misses the link between individual entrepreneurial strategy and alternative energy technology commercialisation in a given innovation system. Some authors such as Farney & Calderon (2015), and Montiel & Ceranic (2015) attempt to bridge this gap by discussing how entrepreneurship can affect societal change, however, there is still a large focus on the understanding entrepreneurialism on a metalevel, thus the opportunity to improve this process is missed. Avedeitchikova & Coenen (2015) however, take an interesting view and highlight that there is a fundamental uncertainty about the complex and multidimensional shifts considered necessary to adapt societies and economies to sustainable modes of production and consumption, which makes the commercialisation process for cleantech, and thereby alternative energy technologies, fundamentally different from that of other technological innovations. Thus, the intersection between the entrepreneur and the wider innovation system requires entrepreneurs to have an understanding of the social and economic systems at work, in order to overcome barriers to commercialisation. This section therefore, will summarise and clarify which areas of academic debate are of further interest for this thesis.

Firstly, the major problem that this area of literature aims to address, is a seemingly large deficit in the real-world commercialisation of renewable energy technologies. It is accepted that technologies such as solar PV and commercial wind turbines are growing in installed capacity, but in comparison to traditional means of energy generation based on fossil fuels, there is still much room for improvement. There is plenty of scope for other technologies to have a large impact on the market, however, time is fast running out. By capturing the case of The Company therefore, this thesis explores the challenges of real world commercialisation of alternative energy technology, in an effort to showcase how entrepreneurs navigate real strategic issues. Looking at the theory around particular traits, behaviours or goals of the entrepreneur, one can see an academic argument for certain operational capabilities arising from certain personal assets, even if there is inherent weakness in the causal assumption that personal traits lead to business success. However, to map the complex interactions and unique market performance metrics of start-ups to their individual components of success seems disingenuous given how broad ranging the topic of commercialisation strategy is. This is not to suggest that these attributes are the sole determinants of commercialisation success, merely that the literature on the topic suggests that in the broadest sense, start-ups which demonstrate these capabilities, traits, or behavioural characteristics are associated with improved success rates. Consequently, this research starts by asking what combination of entrepreneurial or operational attributes have led to successful commercialisation, and how so, in an effort to explore and identify desirable qualities.

Secondly, it is noted from the literature review that a large body of texts support the view that diffusion of innovation, and particularly innovations that have high research and developments costs, require governments and institutions to subsidise their commercialisation. This is attributed to their high purchase price or low utility compared with existing technology. Another question that guides this research

therefore, is whether or not alternative energy technologies can even be commercialised successfully without governmental support, and if yes, how?

Finally, with regard to the innovation system at large, many frameworks have been reviewed to explore how small or medium enterprises are situated to disrupt traditional energy markets. From this review, academics recommend that start-ups consider their exploratory or exploitative strategy with respect to the unique requirements of a given innovation system, and gauge their commercialisation efforts depending on the level of external market variables for technology repulsion. Thus, in order to provide a more practical, normative contribution, this thesis will analyse The Company's experience in several of their key markets to explore the question, how do innovation system variables contribute to technology diffusion and successful commercialisation?

The following section, provides an overview of the research design for this thesis, which aims to answer the overarching question: *How does the intersection between the innovation ecosystem and the individual entrepreneur affect the chances of successful commercialisation of alternative energy technology?*

3 Methodology

This section gives an overview of the approach taken for the study conducted in this thesis, in order to demonstrate and justify the chosen method of study and data collection.

There are many methods at the disposal of researchers that can be used to attempt to explain phenomena, or observe and analyse the world at large. In any case, research is generally conducted in order to gain knowledge, whether through verification of existing speculation, or completely new lines of inquiry. Generally, there are two main research strategies taken by academics of social science. Quantitative methods entail the collection of numerical or statistical data to try to measure causality, or correlation, with an expectation to generalise or replicate results. Qualitative methods however, emphasise context or process, gathered through empirical observation or personal engagement. Consequently, they attempt to construct a narrative to explain phenomena, and propose or destroy theories as a result. According to Bryman & Bell (2011, p.4), these methods are not neutral tools; they are *"linked to the ways in which social scientists envision the connection between different viewpoints about the nature of social reality, and how it should be examined."* Thus, the outcome of research is heavily dependent on the suitability of research method chosen, as well as the proclivities of the researcher conducting the study. For this thesis however, the methods drawn upon are purely qualitative in nature, and are so chosen due to the desire to understand the complex nature of human experience in relation to an external environment, through the eyes of the researcher. Additionally, taking a self-reflexive approach (Alvesson, 2011), the author of this thesis is inspired to systematically contextualise the knowledge created, in order to neutralise any inherent bias from his previous experiences or from subjective meta-analyses of prior information gathered from the literature review.

Whilst one could fill more than several pages on the topic of qualitative research methods, it is more important to present a discussion on the nature of the research for this study, which will provide the reader with an understanding of the type of research conducted and the motivations of the author. Thereafter, an overview of the data collection and analysis process will be presented, alongside a brief overview of the limitations of the study. Finally, a short section on ethical concerns will highlight potential pitfalls of dealing with this type of research, and how this thesis has adhered to the common practice.

3.1 Case Construction

Case studies are a popular method of qualitative knowledge transfer (Eisenhardt and Graebner 2007) used widely among academics as a way of presenting empirical data with context, and thus meaning. It is in the familiarity of the literary writing style, that leads compelling cases to reach national and international audiences. Yin (2003) distinguishes between five different types of case: Critical, Unique, Revelatory, Representative or typical, and Longitudinal. Bryman & Bell (2011) however, critique this notion and suggest that cases can be a combination of any of the above classifications. Indeed, the case of The Company aims to be revelatory in that it opens up the study of alternative energy commercialisation, but it is also longitudinal in that it follows the company over a period of time rather than any specific event. For sociologists such as Burawoy (1998, p.5), the extended case study method *"applies reflexive science to ethnography in order to extract the general from the unique, to move from the micro to the macro, and to connect the present to the past in anticipation of the future, all by building on pre-existing theory".* For

this thesis, the single case study method has been chosen for use with similar intent; to inform the reader of the complex unique circumstances that The Company has undertaken throughout its existence, in order to stimulate discussion of themes which can then be generalised. Alternative methods, such as the multiple case study, were deemed not suitable for the timescales that this thesis is constrained to, however they may make useful comparison for further research going forward.

Usually, cases are set according to boundaries such as single events, organisations, people or locations (Bryman & Bell, 2011), however, it is the author's desire to purposefully mix these boundaries in order to capture a complete story of The Company. In doing so, the reader has an opportunity to learn more about the context of the decision making within the company, so that they are able to follow the subsequent analysis in an informed manner. Additionally, the commercialisation of alternative energy is a rather broad ranging topic, and it is expected that describing a single situation would not be enough to sufficiently explore how alternative energy technology is commercialised in practice. Flyvbjerg (2006) writes that the narrative method is most suitable for providing a forward glance, helping to anticipate situations before they occur, and thereby allowing readers to envision alternative futures. As a weakness perhaps, they cannot start from explicit theoretical assumptions, however, when the subject is not yet well understood, it is often better to approach the description or interpretation of phenomenon from the perspectives of participants, researchers, and others. Thus, the narrative method becomes the most suitable for capturing the context and complexity of reality. Consequently, the case is written instrumentally (Stake, 1995) as a chronological narrative, starting from the very beginning of the company, through several strategic dilemmas, to its most recent business deal. As a narrative, it aims to capture and communicate the story of how The Company has endured over the last 10 years following the main strategic contributors, firstly while navigating the turbulent early days as a start-up seeking financing, and then through expansion and international growth. Unfortunately, The Company decided that they would prefer to remain anonymous, thus all names of important or identifiable stakeholders, companies, markets and products have been changed to protect their identity.

3.2 Research Design

As mentioned previously, this research follows a qualitative case study design, on a single organisation. As a case study, the empirical data collection focuses on performing a detailed and intensive analysis of the organisation's interaction with the innovation system at large, through qualitative means (Bryman & Bell, 2011), using frameworks gathered from the literature review. Thus, an idiographic approach is taken to give greater insight in the strategic workings of the company, thereby elucidating the unique features of the case compared with academic literature. Case studies usually take on an inductive approach to generate theory (Eisenhardt and Graebner, 2007), however in this instance, the theory surrounding innovation and commercialisation of technology at least, is reasonably well developed. Thus, an approach which takes a normative perspective is used to interpret the data gathered, in order to point out practical advice and solutions. Hence this research can also be said to be a hybrid of both inductive and deductive reasoning, in that the literature review is used to identify key success factors for commercialisation, which is then compared to empirical material themes and applied to the alternative energy field. One such problem with normative approaches is that conclusions rely on the experiences of the researcher, and their attempts to dehumanise complex experiences in order to generalise conclusions for academic purposes (Cohen et al, 2005). The case itself is a product of this positivist paradigm, and designed to identify key strategic decisions which have led The Company to their current market position, noting failures as well

as successes in order to tease out the underlying causal themes. Conclusions are then drawn as to the applicability of theory, and whether the empirical material is able to contribute alternative insights to expand the literature.

3.3 Data collection

To collect interview data useful for research purposes, it is necessary for the researcher to develop as much expertise in relevant topic areas as possible, so that they can ask informed questions (Qu and Dumay, 2011). The company, The Company AB, was therefore selected for two main reasons. Firstly, access to key stakeholders with strategic experience was required in order to gather the appropriate material for a detailed case. Fortunately, the chairman of the board is a friend to one of the author's professors, thus establishing the rapport required to perform such an intimate analysis of the inner strategic workings of the company was not an issue. Secondly, the author has a great interest in the topics covered by this research; renewable energy technology, entrepreneurship, and innovation have all contributed heavily to the decision to explore alternative energy commercialisation for this thesis. The Company as a technology company has a unique and rich history within these areas which also served to inspire the author to investigate.

The data for this research is split into two parts; primary data consisting of empirical material gathered by the author, and secondary data in the form of a literature review from academic sources. The main body of empirical data is gathered through semi-structured interviews (Elliot et al, 2016), the participants of which are involved with strategic decision making. The sample consists of one face to face interview, conducted with the Chairman of the Board, 5 subsequent skype interviews conducted via audio only with the CEO, and one site visit to the manufacturing facility in City A . During these interviews, some questions were directed in order to gather information relating to the formation and expansion of the company, and others were focused on understanding strategic decision making. All questions were open ended in order to allow the interviewees the opportunity to recount what they felt were the most important aspects, and to avoid biasing the answers (Bryman & Bell, 2011). If answers were too short, or not quite detailed enough, some prompting was provided by the interviewer. Full transcripts of interviews 1-5 can be seen in Appendix A, however the recording for interview 6 had extremely poor audio, thus only a summary has been provided. From these interviews, areas of interest were collated for further investigation (codified), and a chronological narrative was generated (the case) which follows the company through the first ten years of its existence, through start-up phase to the successful commercialisation of its latest product. The site visit aimed to gain first-hand experience of the latest NRG CUBE product, have the opportunity to clarify any outstanding details missing from the case, and was conducted as part of an investor briefing day. Consequently, there are also some minor ethnographic contributions to the case. In parallel, a comprehensive literature review was generated from a wide body of literature in many related fields, in order to contextualise the process of innovation and identify links to successful commercialisation of alternative energy technologies. Once the data had been collected and surmised, codified themes of interest were compared to the findings of the literature review, following a logical step structure (Merriam, 2009).

Although this may seem a rather sparse dataset to be able to make any generalisations, Flyvbjerg (2006) writes in his analysis of the common misconceptions regarding case studies, that Galileo only had to use a single case to disprove Aristotle's widely believed but flawed theory of gravity. In the same manner, the

conclusions from this case study may also provide some valid additions to the academic debate on alternative energy commercialisation, from the perspective of the entrepreneur. Moreover, Flyvbjerg also asserts that without a large number of thoroughly executed case studies, the theoretical disciplines cannot be demonstrated as effective. Thus, each individual case can strengthen social science theory through good execution.

3.4 Limitations

This thesis focuses on the strategic aspects of commercialisation success which means that any other low level contributory factors, such as individual employee impact, are not considered within its scope. Consequently, the method mostly uses a single approach (semi-structured interviews) from the executive perspective, which may reduce objectivity and the generalisability of the conclusions. Indeed, Alvesson (2011) writes that participants may not be fully explicit or rational when responding to interview questions, and instead may be motivated to answer in relation to self or political interests. Thus, trying to make sense of the entire 10-year history of The Company and its strategic decision making through a few hours of interviews could elicit a one-sided story which would make valid generalisations difficult to justify.

On the topic of performing qualitative research. Mason-Bish (2018) writes about the elite delusion, and the topics of reflexivity, identity and positionality in qualitative research. Given that this research uses interviews with two executive level entrepreneurs, care must be taken when interpreting the data collected, and one cannot automatically assume that information gathered is equivalent to actual fact. For example, as a novice researcher, the author of this thesis may also be subject to any number of positionality biases, which could affect the outcome of the messages or themes gathered through interviews. Consequently, one might expect that a narrative approach to writing a case may also be limited, in that it only captures and highlights the issues of interest to the author when in fact there may be other relevant information or lines of inquiry which are missed. This is known as a verification bias, in that the author only ‘sees’ what they want to see from the data, and confirms the researcher’s preconceived notions. However, Flyvbjerg (2006) demonstrates that in many cases, preconceived notions tend to be discovered by the researchers as incorrect, and that using a case to empirically test these preconceptions is part of what makes the case study method so scientifically rigorous. Thus, subjectivity bias is no greater than with other methods of research, and should be treated as such.

Unfortunately, after writing, the case study itself was deemed to contain information that was too commercially sensitive, and it was requested that it be withheld until sufficiently anonymised or enough time passes that it is no longer a commercial risk. Obviously, this has had knock-on effects on the rest of this thesis, though it remains to be seen as to whether the new found knowledge that this thesis has generated is any less relevant as a result. As mentioned, the true markets, names of stakeholders, companies and products have been changed to protect the identity of the company that this thesis is based on. Consequently, this may add a layer of confusion to certain aspects of the case, and analysis, where real world information is combined with fictional elements deliberately.

3.5 Ethical considerations

In any qualitative study, ethical issues relating to the protection of the participants can be of concern (Merriam, 2009). In order to make the participant feel comfortable, it was asked at the beginning of each interview whether they would mind being recorded. Additionally, it was highlighted that the participants were not obliged to answer any question if they did not want to. Once accepted, it was made clear that transcripts would be provided to the participant in order to maintain transparency and check the information for accuracy. Although not requested, the data collected leading to case of The Company was then uploaded to a private cloud storage system, and treated as confidential information. This was to avoid any unnecessary leaks of potentially sensitive competitive information, and is considered necessary professional courtesy. Both the interview transcripts and the case were deemed too detailed for publication, however this thesis has been cleared by the CEO and the chairman, to provide peace of mind to all parties.

Furthermore however, there are always ethical considerations that lie outside the methodological, in terms of the implications of knowledge generated. This significance has not escaped the author, and a minor discussion will cover the implications of any findings in a self-reflection chapter towards the end of this thesis.

4 Analysis

This section focuses on analysing the case study and interview transcripts, in order to identify commonalities which can enhance or deduct from the theoretical view.

One guiding question of interest was to discover what entrepreneurial or organisational attributes lead to successful commercialisation, and how does this occur? Thus, as is with the narrative method, a chronological approach has been taken to begin with, looking first at the early formation of The Company and its key strategic decisions, all the way through to the different hybrid products. From this, themes for success are discussed in relation to their corresponding theories from the literature review, to highlight how these factors have influenced The Company throughout its history. Subsequently, the major markets The Company targeted are analysed using the innovation systems view, to explore why certain markets were inhibitive to alternative energy technology adoption, and to investigate the second and third guiding questions. In particular, a case study from the entrepreneurial perspective on alternative energy innovation systems is something missing from current literature and is especially considered of academic value. Finally, an analysis of The Company's latest opportunity will combine the two prior analyses to ascertain how strategic decision making is tied to the interplay between operational assets, and the innovation system at large. This aims to generalise the findings of this study, so that other alternative energy entrepreneurs may learn from The Company's experience and apply the conclusions to their own endeavours.

4.1 Themes for Success from Empirical Data

This section identifies empirical themes which have led to The Company's success and compares them to the theoretical criteria for improved commercialisation success uncovered during the literature review. From the case study there are four clear themes which can be linked to The Company's performance, and relevant literature. Table 3 shows an overview of these commonalities at the end of this discussion, in order to clarify the empirical position.

4.1.1 Sufficient protection of intellectual assets

The early configuration of a start-up is one of the most important considerations for any new business. With limited resources, naturally one does not want to overcommit, thus the early strategy and business plan are imperative. From the study, it is clear that The Founder was able to secure an eternal patent for commercial development of the core technology, with 10 years exclusivity. This is enormously valuable as it means the company would have a ten-year head start on product development with no competition over the technology and will never have to worry about the licence expiring. Consequently, the company begins on a much more stable platform, and is therefore more attractive to potential financiers. Thus, the first theme for commercialisation success, is sufficient protection of intellectual assets.

This is corroborated in theory by Song et al (2008), who found that new technology ventures are more successful when their intellectual property is protected, and Foxon et al (2005) who find that IP protection is essential for young companies in securing private equity finance. This makes sense as private investors are usually much more concerned with the financial returns on their investments, thus want to make sure

their interests are protected before they commit capital, to reduce risk. As pointed out in the literature review, Kirchberger & Pohl (2016) also find that property rights are important for technology commercialisation success, in particular, with CEO ownership. As an owner, The Founder is better positioned to respond to the needs of the business, and being intimately familiar with the technology enables him to put resource into protecting the right parts. For example, his decision to work only with close partners for implementation of the NRG CUBE, are part of his strategy to ensure that The Company's intellectual assets are not reverse engineered, and this ends up being cheaper than taking out multiple patents covering every aspect of every product which would be costly to enforce should infringement occur.

4.1.2 Able to leverage a strong and relevant personal network

Secondly, in order to negotiate the licence for the technology, The Founder turned to his strong personal network, and hired individuals who possessed important intangible assets to his first board of directors. Two came from Core Tech X themselves, which provided much needed expertise in terms of the technology, and industry contacts. Another was a senior manager for Manufacturer Y, which ultimately led to an extremely valuable deal whereby The Company was able to licence their old manufacturing facility for very low margin. The final hire was a personal friend; an ex-CEO who obviously had lots of experience in running a company and was well connected in the industrial sphere. From these network connections, The Founder was able to pull together all the required goodwill in order to strike a deal for the core technology licence, and achieve very generous terms. Furthermore, when searching for financing, The Founder met with Contact A, who again was introduced by a member of his personal network. Later in the case, Contact A's family connection became the link that introduced The Chairman to The Founder, to help with sales and commercialisation, and who ended up owning the largest stake in the company. Another network connection in their home market introduced The Company to the industry contacts in Market C, which led to the opportunity in the mining industry. Finally, one of the later additions to the board of directors was also a senior executive, who then facilitated the deal to integrate The Company's technology and manufacture the NRG CUBE product at his facility, which is based nearby to the factory in City A. Thus, the second theme for commercialisation success is being able to leverage a strong and relevant personal network.

This theme of a strong and relevant personal network is also supported by several pieces of literature. For example, Foxon et al (2005) find that a diverse team with suitable knowledge and experience is generally associated with high performance, thus gathering an executive team to this specification becomes highly important for success. Additionally, Teece (2009) and Bryant (2009) both contribute in a slightly more abstract manner, in that dynamic capabilities and entrepreneurial ambidexterity refer generally to the operations of the organisation itself. However, in this particular case, the ability to leverage his personal network is the attribute that provided The Founder with dynamic capabilities and entrepreneurial ambidexterity. Without his relevant and experienced executive team, many of the specific business deals would not have been completed so quickly, or at worst, even been possible. Kirchberger & Pohl (2016) conclude furthermore, that industry closeness, networking activities, and resource availability are important factors for technology commercialisation success; three further attributes demonstrated throughout the case, which can be linked to The Company's interactions with its executive's personal networks.

4.1.3 Logical and objective, agile decision making

Thirdly, The Chairman and The Founder both mention several times that their trust in one another is a factor which they feel has contributed to their success. This, combined with the fact that they operate essentially as a two-man executive team, allows them to make relatively quick strategic decisions. Things are perhaps not as straightforward as they might seem however, as there are several variables at play here. For example, the fact that The Founder and The Chairman trust one another enough to make relatively difficult decisions in such a quick timeframe says a lot about their characteristics as entrepreneurs, and their appetite for risk. There is also the fact that operationally speaking, The Company has been and continues to be, an agile organisation that can flexibly scale it's engineering capability depending on the customer or market demand. This shows a shrewdness for logical operations management, and is demonstrated further by the fact that they twice completely changed their core business idea, quoting their lack of idea prestige as a major strength of the company. This decision-making prowess which allows The Company to quickly pivot between opportunities was not always present, and has been gained through many experiences however, including some unsuccessful attempts to commercialise their technology. The first time they met Contact B , for example, he tried to convince them to remove a core feature of their product, which they did not want to do just yet. This caused them to miss the mining industry opportunity and it took a further two years before the decided to re-look at it. Consequently, the third theme for this discussion is logical and objective, yet agile decision making.

This third theme refers more to the entrepreneurs themselves, and has a wide body of literature to support each facet. For example, Zhao et al (2010), find that entrepreneurs are more likely to be successful if they have specific personality traits that match the requirements of entrepreneurial tasks; and Hindle & Yencken (2004), find that successful entrepreneurs are able to apply a different mix of tacit and codified knowledge inputs for each phase of opportunity development. Thus from the entrepreneurs perspective, higher rates of success are linked to having the personality traits that allow you to logically weigh up the many variables in a given dilemma, remain calm and objective, and execute the decision quickly. Additionally, to be able to actively manage the difference between gently probing a new market, or going all in and spending lots of resource on a completely new product, is a highly beneficial attribute, and something that The Company has achieved through the interactions of its executive team. For example, when looking to expand into global markets, The Company quickly identified that they were not suited to do business in the Middle East and they quickly exited. Hemert et al (2011) and Katila et al (2012) support this assessment, and both discuss the virtues of being able to readily switch operations between exploring or exploiting a new opportunity. Part of the skill set required to be able to logically make these decisions is related to the entrepreneur's self-awareness, or as Namvisan & Baron (2013) put it, entrepreneurs self-regulatory processes. Venture success is improved, they argue, if entrepreneurs have self-control, grit, and metacognition, all of which have been demonstrated in abundance by The Founder and The Chairman throughout the interviews and The Company's current progress.

4.1.4 Capable and driven leadership

Finally, whilst it may seem a bit of an oxymoron considering the last paragraph's focus on objective decision making, without The Founder's consistent drive and belief in the core technology's capability or his passion for technology and entrepreneurial curiosity, there would be no The Company. Without The

Chairman's ambition to do something meaningful with his skills, his belief that he could make a difference, the company would not have survived long enough to reach its current level of sustainability. For example, when the company was facing bankruptcy, The Chairman put up around 2 million Euros of his own capital in order to gain a controlling share of The Company and continue development. Thus, the combination of perseverance, and a strong leadership has enabled The Company to survive several fundamental iterations to its core value proposition. Consequently, the final theme from The Company's success can be attributed to capable and driven leadership, and this is also reflected in the literature review.

Starting with Hambrick (2007), he argues that the prior experiences, values and personalities of executives, greatly influence their interpretations of the situations they face, thus affecting their choices. Applying this theory to The Founder and The Chairman highlights their individual capabilities for dealing with their role requirements in the company. However, it also highlights the potential reasons for failure in places like Market B, where there was no capability within The Company for dealing with that kind of business environment. Beckman et al's (2012) goal theory is useful to superimpose the motivations of The Founder and The Chairman into a driving force behind their determination to succeed, but also explains perhaps one reason for example, it took so long for The Company to move away from a pure renewable energy product to a waste energy harvesting product. Similarly, Binder & Belz argue that entrepreneurs can be driven by different but not mutually exclusive goals, however commercialisation focus is required in order to be able to scale a business. Thus venture success, can at least in part be attributed to an unrelenting drive for commercialisation or sustainable and scaled production goal. Coincidently this focus is something that The Chairman brought to The Company when he first joined.

Table 3 - Organisational assets for successful commercialisation of alternative energy technologies from the empirics gathered, compared with relevant literature source themes.

Themes from Empirics	Relevant Literature Themes	Source(s)
Sufficient protection of intellectual assets	Patent protection Intellectual property rights	Song et al (2008) Foxon et al (2005), Kirchberger & Pohl (2016)
Able to leverage a strong and relevant personal network	Founders Industry Experience Team diversity Entrepreneurial ambidexterity Dynamic capabilities Industry Closeness, Networking Activities, Resource Availability	Song et al (2008) Foxon et al (2005) Bryant (2009) Teece (2009) Kirchberger & Pohl (2016)
Logical and objective agile decision making	Entrepreneur personality traits Exploitation vs exploration Organisational ambidexterity Entrepreneurs self-regulatory processes	Zhao et al (2010), Hindle & Yencken (2004) Hemert et al (2011) Katila et al (2012) Namvisan & Baron (2013)
Capable and driven leadership	Upper echelons theory Goal theory Sustainable Entrepreneurship	Hambrick (2007) Beckman et al (2012) Binder & Belz (2015)

From table 3, it is clear to see the association between empirical evidence and academic literature, and how The Company has gained the organisational assets it needed to successfully commercialise its technology. Whilst it was not entirely clear from the literature review whether it was purely entrepreneurial behaviours, or traits that were the key attributes for successful commercialisation, the term 'Operational Assets' has been borrowed to summarise the combination of these qualities that can be attributed to the generation of The Company's success. That is not to suggest that these themes are the only indicators for improved success that exist, merely that these particular aspects of the case have demonstrated how they are empirically linked to successful commercialisation in the real world. In all cases, these themes are identified as they are corroborated in the academic literature, thus further research should aim to replicate these findings empirically in other young start-ups or industries, in order to provide some level of confidence that they are relevant and valid generalisations. Whilst some of the literature also contained other themes, these were not applicable to The Company and have therefore been removed.

The question remains however, what led The Company to struggle in its earlier attempts to commercialise their products? For this to be answered, one must analyse The Company's performance in relation to external factors, best summarised under that of the target innovation system.

4.2 External Innovation System

This section looks at the empirical experience of The Company, as captured by the case study, and analyses the organisational performance with respect to three of its main target markets, Market A, Market B, and Market C. Using the innovation systems approach, earlier literature identified a suitable framework for external systems analysis, and it is applied here to explore the intersection between individual entrepreneur and the target innovation system. At the end of this section, a discussion will link the empirical analysis back to the literature.

To analyse barriers to innovation diffusal within an innovation system, examples of systemic variables leading to a new technology being repelled were highlighted based on the information gathered from Jacobsson & Johnson (2000), and Negro et al (2012) (see table 2 in the literature review). Table 4 takes these systemic variables, and compares them to the three main markets which The Company has explored. For variables that are present in a given market, a check (✔) has been placed in the table, and a cross is marked (✗) for those that are not. Where insufficient information exists to determine whether or not the variable is a factor in the given market, a 'not equal' sign (≠) has been used instead. Consequently, and perhaps counter intuitively, markets with many checks are indicative of high likelihood of technology repulsion, whereas those with more crosses appear more attractive for technology adoption and diffusal.

Table 4 - Systemic variables leading to repulsion of technology, compared with The Company markets. A perfect market has no barriers to technology adoption.

Systemic variable		Market A	Market B	Market C	Perfect Market
Actors and Markets	Poorly articulated/lack of demand	✔	✗	✗	✗
	Established technology characterised by increasing returns	✔	✗	✗	✗
	Local search processes	✔	✗	✔	✗
	Market control by incumbents	✔	✔	✔	✗
	Lack of capabilities/capacities	✗	✔	✗	✗
	Lack of skilled staff	✗	✔	✗	✗
Networks	Poor connectivity	✗	✔	✗	✗
	Wrong guidance with respect to future markets	✗	✗	✔	✗
	Too weak and too strong interaction problems	≠	✔	≠	✗
Institutions (Hard & Soft)	Legislative failures	✔	✔	✔	✗
	Failures in the educational system	✗	✔	✔	✗
	Skewed capital market	✗	✔	✔	✗
	Underdeveloped organisational and political power of new entrants	✗	✔	✔	✗
	Poor knowledge infrastructure	✗	✔	✗	✗
	Lack of supporting physical infrastructure	✗	✗	✗	✗

4.2.1 Market A

Market A's energy market has a high level of sophistication, (according to the definition of Walsh, 2011), and this means that Market A in general is familiar with renewable energy technologies and the different options that are available to suit their energy needs. They also have a large portion of electricity supplied cost effectively through renewable means such as hydropower, and consequently the demand for additional alternative energy technologies is relatively low. This is the main reason for The Company's 'market failure' in Market A, especially with regards to the early product, as it was simply not competitive with the incumbent supplies nor was it any more eco-friendly than other options on the market. As a country, Market A has a highly skilled workforce capable of building and developing these technologies, which means this is not a potential factor for market failure, and is therefore marked accordingly.

In terms of networks, The Company was very well connected and had plenty of opportunity to meet with various stakeholders, thus this variable posed no specific or identifiable problems. More generally, Market A has lots of networks for new entrepreneurs and business investment opportunities, as well has a thriving and open economy which means that the business environment is generally favourable.

Institutions within Market A are well established and generally are not considered a variable for repelling technology diffusion. For example, as an advanced society the rule of law means intellectual property rights are enforced, as is market-based regulation. In terms of legislative failures there has been a slight bias towards certain energy technologies such as nuclear and hydropower, which are already mature (Jacobsson & Johnson, 2000), hence this variable could have contributed to The Company's difficulty in making progress with public financing early on. The university system provides a highly educated workforce however, and the capital markets are relatively free flowing with plenty of investment opportunities, hence disruption is quite possible within the innovation system. Likewise, there is sufficient physical infrastructure to support electricity generation and a local manufacturing capability, hence this variable is generally favourable for technology diffusion.

4.2.2 Market B

Compared to Market A, the systemic environment in Market B is much more complicated. Using the recent experiences of The Company combined with a report from the World Bank (2009), it is plausible to analyse the variables which contributed to The Company's ultimate failure in commercialising their hybrid product in Market B. With regard to actors and markets, one can argue that the nation is aware of the importance of renewable energy in its future security. In the world bank report, urban pollution is considered a future challenge, and climate change is considered a threat to the natural resources-based economy. Consequently, Market B is a signatory to many international environmental frameworks, although government spending on environmental protections is not particularly high. In order to combat incumbent technology and increase the value proposition, The Company generously offered to pay the upfront capital costs to install the hybrid product and produce a technology demonstrator that would be used to prove the concept to local stakeholders. The business plan was that by charging only for electricity supplied, and using only local labour in order to build a skilled workforce capable of installing and maintaining their products in future, they would have an attractive value proposition for technology adoption and no economic reason for technology rejection. At this stage, The Company correctly identified that the national electricity supplier held a monopoly over the market, and through a recommendation letter were able to partner with them to open negotiations. Thus overall, the actors and markets seemed positive and The Company were able to substitute the perceived market deficiencies in local skills and capabilities with their own expertise in order to lessen the chance of their new technology being repelled.

In terms of networks, the government is committed to supporting broader-based industrialisation and there are initiatives to diversify the industrial base through sponsorship of favourable business policies. However, this has not been well subscribed, hence the networks between organisations are relatively poor. The majority of Market B's economy is split between agriculture, mining, and services, hence the knowledge economy for new technology development is not yet established. The figures from 2008 show only a small percentage of the population is educated to university level, which may also account for the lack of industry expertise in renewable energy. Most of its electricity is imported, though there is a small biomass and fossil fuel capability. Combined with The Company's experience of multiple delays to negotiations and difficulty in finding the right contacts with authority to move forward, the networks variable is considered generally prohibitive to technology diffusion, despite the government's publicised aspirations.

Since its independence in 1990, Market B has enjoyed political and economic stability, and is actively working to improve democratic institutions. According to the world view report, it respects the rule of law and has relatively low corruption compared to other similarly located nations, ranking in 2009, inside the top third of 181 countries for ease of doing business. Whilst on paper, this sounds promising, The Company had an alternative experience, finding the process of doing business particularly challenging. This is most likely due to legislative failures in the energy markets, which meant there was not enough central drive to procure renewable energy generation capacity, and thus their business was not prioritised by the energy generation authorities. Indeed, The Company spent one week a month in Market B for at least a year attempting to negotiate a power purchasing agreement which would have enabled them to move forward installing a hybrid power station. However, this was not forthcoming, and once The Company ran out of money to fund negotiations, the interest in their product evaporated.

As highlighted previously, the world bank report quotes failures in the education system as a serious obstacle for businesses, though The Company aimed to alleviate this deficiency by providing on the job training. Another potential pitfall that The Company may have been a victim of, is Market B's overly complicated legal environment. The report highlights various policy deficiencies which make for a weak investment opportunity, and states that Market B is particularly difficult to set up a new business, taking approximately 66 days for the paperwork to process. Consequently, one can argue the country has underdeveloped organisational and political power for new entrants into the market. Additionally, research conducted later between 2009 and 2013 by the Electricity control board, exposed knowledge gaps and the need for further research into the impacts of new renewable energy regulations (REEEP, 2018). Compared with many other similarly located countries however, it has fairly developed infrastructure that does not present a major constraint to business, once set up.

In conclusion, despite the apparent positive market appearance, in retrospect it is clearer to see that the Market B networks and institutions were not reliably set up in order to make the most of The Company's hybrid technology, hence it was ultimately repelled.

4.2.3 Market C

Please note, Market C is a fictional country name. It has been used to anonymise the real market and protect the interests of 'The Company'.

Similarly to the prior section, using the OECD 2017 economic survey report combined with The Company's recent experiences, it is possible to analyse the systemic variables in Market C and give some conclusions on the likelihood of alternative energy technology repulsion. In terms of demand, firstly, roughly three quarters of Market C's primary electricity supply is produced through coal fired plants. Not only does this create a lot of air pollution, but also significant political will to instigate change, hence demand can be said to be high even if it not articulated in line with The Company's core technology. There are also renewable technologies already established in Market C that are economically competitive with fossil fuel based sources, however, these supplies do not appear to be increasing in market share from around 15%, thus with the right value proposition, The Company should have been able to find an applicable market for their hybrid technology. Indeed, there is a public-private partnership in Market C which aims to increase installed capacity of renewable energy.

Even still, orders were not quite as forthcoming as expected. In order to widen the potential for innovation translation to other applications, The Company also engaged in market exploration, and almost by chance came across a completely new opportunity in one of Market C's larger niche markets, the mining industry. At the first instance, The Company could not justify the risk of developing a new technology at the expense of their current hybrid product, thus it can be argued that their local search processes did not match the opportunities available. One factor which made Market C particularly attractive, was that all electricity generation capacity is controlled by incumbents (state owned monopoly and highly regulated), and The Company was able to establish that security of affordable energy supply was high on many private industrial organisation's agendas. Additionally, as a highly industrialised nation, Market C contained sufficient competencies and labour skills, to develop an on the ground prototype facility. Eventually, some two years later, they gained enough experience to fully understand the larger potential of the mining opportunity, and committed their entire production capability to developing the NRG CUBE. The fact that it took so long to realise however, was one of The Founder and The Chairman's biggest regrets.

In terms of networks, Market C has a western style private sector which is open and actively growing. Networking events such as trade fairs are commonplace, thus connectivity is considered high. Unfortunately, it also has some semblance of corruption with cartels regularly being disbanded by the competitions authority. This is detrimental to conducting business, but does not affect the private sector as much as the public sector, which is much more accountable to the rule of law. The most interesting part of the networks variable is how one actor within the Market Cn mining network was able to open up such a large opportunity for The Company. Whilst this partially overlaps the prior section, incumbent mining producers were unaware of The Company's technology, or at least had not considered reclaiming the waste energy that was lost through burning of the flare gas at that time. It took the foresight and network connections of Contact B, a well-connected consultant, in order to make The Company aware of the application and link them to potential customers who had not yet articulated their need. Even so, The Company did not connect the potential to the opportunity on the first instance, thus it can be concluded that with respect to future markets, their initial interpretations of the market were wrong.

The public institutions in Market C are mostly state owned, and therefore industries such as energy generation are heavily regulated. Consequently, the political power of new entrants is capped. Private industry however, is generally well supported with government incentives for micro and small businesses an increasing priority. Renewable energy generation, although a reasonable portion of the generation capacity, is not growing due to a lack of political will; even with the REIPPPP, signing deals is a very bureaucratic process and is mostly completed through private equity financing. Thus it can be said there are inhibitory institutional legislative failures. Additionally, according to the OECD there are failures in the educational system with high levels of school dropout rates, and a skewed capital market towards existing technologies. Despite having low economic growth and a high unemployment rate, the knowledge infrastructure in Market C is reasonably well established, thus is not considered detrimental to innovation. Physical infrastructure is also well developed with modern cities well connected to communication services, transportation links, and utilities.

In conclusion, Market C appears to benefit from a budding private sector, but is handicapped by an overly bureaucratic public sector. This may explain why The Company has had more success with the NRG CUBE product than its hybrid product, since the NRG CUBE does not require any interaction with public institutions. It is installed on private land, for the sole benefit of the private customer.

4.2.4 Discussion on Markets

This section discusses the empirical analysis above in relation to academic literature, in order to explore how the individual entrepreneur is linked to the wider innovation system.

Using the framework (table 4) above, one can perform a reasonable assessment of a target market, and gather some relevant predictions as to where commercialisation issues may arise. The second guiding question brought from the literature review, was whether or not alternative energy technologies can actually be successfully commercialised without sufficient political will, and if so, how? The answer appears to be yes in the case of The Company, as early on it was apparent that the entities controlling government subsidies in Market A were too risk averse to finance small start-ups, and The Founder was forced to find private equity financing instead. All of its subsequent customers have been private partnerships whereby private energy companies raise financing to procure The Company's technology, to generate and sell electricity. Thus, a good go to market strategy was to look for markets that had insecure supplies of fossil fuel based electricity alongside government policy which is supportive of alternative energy technologies, as it made it more likely that there was a market demand for reliable renewable energy. Future research should measure which, if any, systemic variables are stronger factors for technology repulsion, as this would be highly useful to inform commercialisation and product strategy. Negro et al (2012) highlight this aspect in their review, concluding that renewable energy technologies will find it difficult to break through into markets where incumbent fossil fuel technologies reap the benefits of economies of scale, and socio-institutional embedding. One of the ways in which The Company is able to get around this with the NRG CUBE is that it does not rely on institutional support, thus it does not compete with large-scale centralised generation.

Comparing the two prior markets, they look quite similar in performance. Why then did one version of The Company's technology get repelled in Market B, and another accepted in Market C? Negro et al (2012, p 3842) advocate that support and opposition for new energy technologies is not *"stereotypically bounded to specific actor groups in the innovation system"*, and that *"unique combinations of advocates and opponents arise under different circumstances"*. Thus, it is important to look at what systemic differences exist within these two markets, as they may look similar but are unique. The key is in the product details; in Market B, it appears their technology was rejected mostly due to institutional and network failures. However, in Market C, network success avoided institutional failures and provided a new route to technology adoption through creation of a new product. The difference between the hybrid and NRG CUBE products is not simply the customer use case however, from a marketing perspective it is the difference between technology push, and technology pull. Using Walsh's (2011) expanded environmental landscapes (see figure 3), one can position each market and product to analyse this effect and compare with the suggested commercialisation strategies.

Figure 6 - Systemic variables for technology repulsion leading to different innovation system environments (based on a combination of Jacobsson & Johnson, 2000, Negro et al, 2012, and Walsh (2011).

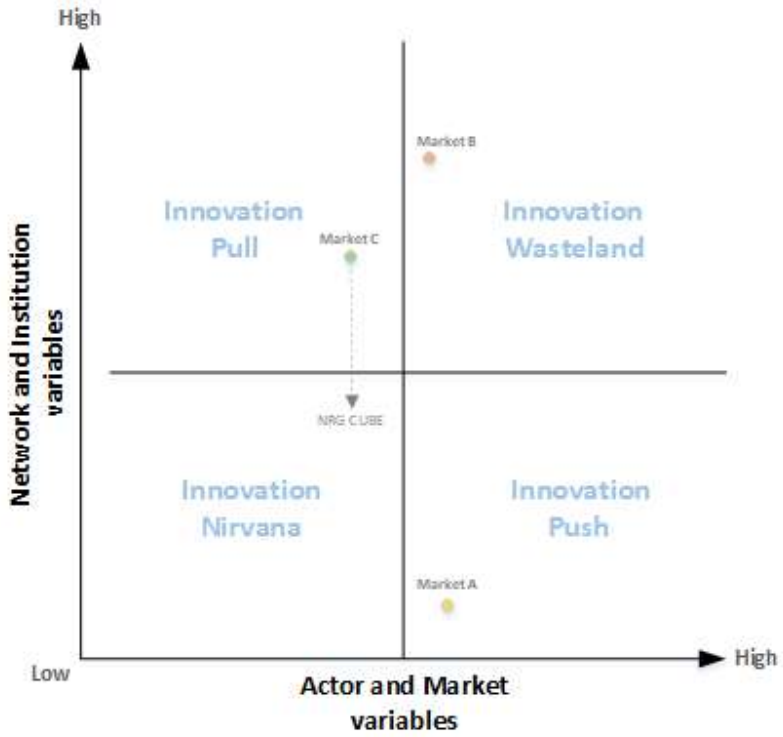

Figure 6 shows The Company's markets in relation to the innovation system landscape. However, as demand and eco-sophistication are essentially an alternative measure of the complex interactions between actors and markets, network connections, and institutions, the diagram has been modified into its constituent parts using the systemic variables for technology repulsion.

To provide context to what is displayed on the chart; when all systemic variables are highly repulsive to new technology, then an innovation wasteland environment occurs, and it becomes very difficult to commercialise a technology. When network and institutional variables are highly repulsive, but the actors and market variables are less repulsive, then an innovation pull environment occurs because potential customers have a need for the technology, but may not be able to find it. With an innovation push environment however, customers are aware of a technology but do not feel that they need it, usually due to an unattractive cost-benefit value proposition. Consequently, institutions usually legislate some kind of incentive in order to improve the attractiveness to adopt a technology, hence this environment is categorised by high repulsion from actors and market variables, but low repulsion from networks and institutions. Finally, in a perfect market there are no systemic variables that repel a technology. There is clear customer demand as well as institutional support, hence the name innovation nirvana, and this makes commercialisation more dependent on the actions of the entrepreneur.

Plotting The Company's ventures into various markets onto the chart, one can see the innovation system effects. In Market A and other earlier opportunities, the actors and markets were aware of The Company's

hybrid technology. They could see and measure the benefits; however, The Company were competing against existing renewable energy products with lower capital costs, in areas that were not particularly supportive of new alternative energy technologies on an institutional level. Thus, growth was limited to private equity projects where their value proposition had greater utility than incumbent electricity supplies. Consequently, their product was not in particularly high demand, and they struggled to achieve the volume of sales required to scale up production and lower the costs of their core technology. In this environment, The Company was pushing an invention that was not yet cost competitive to incumbent technology, and thus had limited demand. In this environment, Walsh (2011) suggests that (see table 1) commercialisation strategy should focus on discontinuous innovation; i.e. outsourcing or licencing of the technology, or forming a joint venture or strategic alliance. Instead of building their own product, The Company should have licensed their design to a wide variety of companies that would use their technology in their own products. This way, The Company could focus on achieving the volumes required to reduce cost and successfully commercialise their core technology through economies of scale.

In Market B, high network and institutional barriers alongside a difficult business environment meant that it was difficult for The Company to gain the authority to commercialise its hybrid product, despite lowering the number of actor and market variables by offering to finance the capital cost up front. In this high commercial risk environment, Walsh (2011) suggests (see table 1) that The Company is dependent on government incentives, external R&D contracts, or Utility funding, and thus should collaborate with local stakeholders to achieve disruptive innovation. Given that Market B did not have these institutional support mechanisms, it is clear to see why progress was slow and eventually failed, even though The Company did partner with the national electricity company in order to lower perceived barriers, and had a letter of recommendation from a well-respected honorary citizen. Furthermore, there is something to be said for the differences between innovation systems. The Chairman mentioned that in his opinion, perhaps The Company should have given someone a bribe in order to move things forward. Whilst this did not happen, and ethically speaking is not consistent with western business standards, perhaps it is a systemic key to opening the network variable in the Market B's innovation system?

Market C on the other hand, was slightly more open in terms of doing business, this moved the market into the innovation pull environment. Whilst private industry was aware of renewable technologies and actively seeking to reduce carbon emissions, bureaucratic government institutions had led to slow progress. In this situation, Walsh (2011) would suggest (see table 1) a discontinuous innovation approach, and that The Company form a joint venture or strategic alliance with another company, capable of exploiting The Company's technology whilst compensating for their market limitations. Instead, at first however, The Company chose to continue pushing their hybrid technology into a market that had institutional deficiencies, which led to a challenging sales environment. Negro et al (2012) concur that disappointments and lack of support from government should lead to cooperative strategies. Consequently, when The Company met Contact B at a networking event and were introduced to a market opportunity that bypassed the high level of institutional systemic variables, the environment quickly became more promising. Interestingly, the NRG CUBE product meets an untapped need of a particular niche section in the market. Actors within this niche had not previously considered the application of The Company's technology, but when they were introduced to the possibility and informed of the impressive savings that could be made, the opportunity quickly escalated.

Empirically, it is this combination of technology push vs market pull (Brem, 2008; Lubik et al, 2012) which sees the NRG CUBE product operate in an innovation nirvana environment (Walsh, 2011), and benefit from a lack of competition. From the discussion above, it appears it is more beneficial to operate in an innovation pull environment, as customers tend to be more active in manoeuvring around inhibitive network or institutional variables. Where an opportunity exists with no competition, as in the case of the NRG CUBE, a niche market is created. This view of niche market creation is also reflected in literature by Katila et al (2012), Hemert et al (2011), and Avdeitchikova & Coenen (2015), thus exploitation of a niche market can also be advised as an additional strategic decision variable which can improve chances of commercialisation success.

In summary, there are forces that are outside the scope of organisational influence, and for this, it is productive to take an innovation systems approach to strategy development. For example, looking at The Company's product strategy, it is clear to see that the hybrid product had a decent value proposition, but in many cases the innovation system at large was working against them. In order to achieve successful commercialisation in the markets they had chosen, it was advised by the literature, for The Company to change strategy from building their own integrated alternative energy products, to focusing on producing their core technology, and outsourcing or licensing the larger product development. At first, The Company were not able to move beyond their original product strategy, and the mining opportunity was missed. Two years later however, the situation was desperate enough for them to risk changing strategy, and this led to the design of the NRG CUBE, and what would be considered successful, sustainable commercialisation. As a result, one can conclude that the approach advised by academic literature is somewhat valid, and has been reflected through empirical experience.

5 Self-Reflections on the Process

This thesis has been written over the course of three months, and utilised the extended knowledge of previous professional experience alongside that gained from the Industrial Master's program to which I, the author, have undertaken. Throughout, I have often reflected on various aspects in order to better understand my own position, and assess the outcomes of the conclusions I make. This section is a summary of those thoughts, and is an offering to the reader so that they too may reflect on this process of doing research, and its results.

5.1 Research methodology

Research is rarely performed in a linear fashion, it requires iteration, reformatting, and continual reflection. That being said, I found the process to be relatively smooth. The interviews themselves, in terms of discussions and content, went well. In terms of organisation however, it was not so straight forward. The Founder, as a CEO, was very busy, and finding time to talk over Skype for a sufficient period of time was difficult. At first, this may have been inconvenient for him, to have to recollect each time what we had previously spoken about. However, I also think it allowed him to focus one step at a time, on the things that I was asking. After all, the Case of The Company is not such a simple story to tell. In splitting up the interview, I was also able to reflect after each interview and consider whether I had all the details I needed to complete the case. Empirically, the case is not simply a digested narrative of the interview transcripts, but more a distillation of the essence of both The Founder and The Chairman's entrepreneurial journeys, and my interpretation of it. Visiting the manufacturing site, for example, in City A , Market A, was exceptionally interesting. First, I was collected at the train station by one of the employees, alongside three other middle-aged men, visiting as part of an investor awareness day. In the car to the facility, I was offered a unique experience; 35 minutes of uninterrupted ethnographic study with real potential Company investors, and an employee! Admittedly, once introductions had been made, the conversation returned to speaking the local language and I was only able to follow the outline of what was being said. However, I was able to gain an understanding of how the company is perceived from the outside, as well as at the employee level. This is turn, helped me to set the tone for various decisions that had been made during the case, and I used this experience to help construct the narrative in a more authentic manner. For example, having never met The Founder in person before travelling to City A , it would have been difficult to accurately reflect his unique personality in the case, which may have detracted from its authenticity. This is important for many reasons, but mostly as I also have an ambition to publish the case separately so that it may be used as a standalone teaching case for students wishing to study technology entrepreneurship or alternative energy commercialisation. To share experiences and insight gathered during such an undertaking is at the heart of doing research, and it is hoped that in writing the case as an accessible narrative, knowledge may be distributed wider than this thesis may have originally been destined. The implications of this are two-fold; obviously I would like very much for alternative energy entrepreneurs to be able to use my findings to help them achieve successful commercialisation of their technology. However, the most utility in sharing the case of The Company is to help the next generation of alternative energy entrepreneurs familiarise themselves with tools that can inspire and expedite their own journey to a sustainable low carbon future.

Using aspects of the case to form the main content for analysis was a little bit harder. There are a few decisions or quotable moments that did not lead to any significant academic contribution. For example, The Chairman mentioned several lessons such as *"a lot of companies have gone wrong to actually start to*

invest in their own factory", which would be useful for entrepreneurs to know but was not reflected in the case narrative, and was not highlighted by the literature review. These aspects therefore, may go unrecognised by readers of the case, and were left out of the core analysis.

In terms of the analysis itself, the frameworks used are representative of the current academic conversation in innovation and commercialisation research, thus comparing them to The Company's experience was relatively straight forward. In some cases however, the literature had many divergent 'success factors' that were deemed irrelevant for this study. For example, Kirchberger & Pohl (2016) discuss 'Technology Transfer Strategy' and 'University Policy and Structure', as some of their other factors for commercialisation success. These particular attributes were not applicable to the case of The Company, so were deliberately not included in the analysis, though they may have been of use to other entrepreneurs.

5.2 Future implications

As with most research, it is possible to speculate on the future implications of the work completed. Morally, bringing about a sustainable low carbon future is a desirable outcome, and helping new entrepreneurs be more successful therefore is generally considered a beneficial thing, both for the economy and the environment. As societies and markets become more eco-sophisticated, their purchasing habits change, thus leading to a higher market pull for alternative and renewable energy technologies. This research highlights in the first instance, the necessary change required to avoid a breakdown of the global climate that has made life on this planet sustainable, and thereafter demonstrates how this change can be accelerated. Ethically, however, one can take all manner of perspectives. Utilitarianists may for example, argue that new innovations with low utility are not deserving of funding, as is the case with the capitalist neo-classical assessment criteria. Fortunately, the world is not governed by a single perspective, and simply by raising awareness of the socio-political implications of this research, it can have a net positive effect.

In terms of the research itself, a gap was highlighted in the literature between the institutional support provided at governmental level, to low level technology commercialisation efforts. Whilst this thesis proves that it is not always necessary to use government subsidies to commercialise early alternative energy technology, much of the academic debate agrees that institutional support does help, and can support niche market generation. Additionally, the innovation systems analysis demonstrated that high customer demand is more indicative of sustainable commercialisation success, than a good technical solution. Future policy therefore, should aim to reduce the risk to entrepreneurs, by incentivising consumer behaviour to create market pull, instead of directly funding the early technology development. This allows start-ups to achieve the economies of scale that make their innovations sustainable, and reach critical mass for diffusion.

The theoretical concepts of innovation diffusion, technology entrepreneurship, and commercialisation strategy are relatively well studied, though as discovered, not in combination with the alternative energy context. This research therefore highlights a potentially new contribution to certain aspects of the theory simply by its linkages to commonalities. Despite academics often discussing these topics as separate entities with their own rules and ecosystems, there are a surprising number of common concepts between themes. Consequently, it is believed that this research adds to a theory of entrepreneurial

commercialisation practice which can be applied to any industry. Further research should aim to replicate the findings of this thesis empirically in other young start-ups or industries, in order to provide some level of confidence that they are relevant and valid generalisations.

Furthermore, this thesis has looked at the systemic variables that lead to technology repulsion and combined the views of key academics to replicate and modify a framework for market review (see table 4). Avoiding markets where these variables are strongly repulsive to technology diffusion is, rather obviously, a contributor to successful commercialisation. However, there may be ways, as in the case of The Company, to avoid certain unfavourable systemic conditions which can open up new opportunities to achieve commercialisation success; this is where individual entrepreneurial strategy can have the most impact. Additionally, during the analysis it was apparent that each variable could be differently weighted, perhaps being a stronger or weaker indicator for technology repulsion depending on the intricacies of the target innovation system. Thus, further research should also aim to investigate and perhaps dive deeper into the components of this framework in order to uncover a more holistic tool for market analysis, and the significance of each variable.

6 Conclusion

This conclusion draws together the two analytical sections and their respective discussions, in order to demonstrate what has been learned from this study, with respect to the initial research question.

In recognising the reality of climate change, the purpose of this thesis was to investigate the intersection between the individual entrepreneur and the innovation system at large, in order to identify how strategic decisions can affect an entrepreneur's ability to successfully commercialise alternative energy technology. Consequently, the overarching research question looked to explore how the intersection between the innovation ecosystem and the individual entrepreneur affect the chances of successful commercialisation in this field. To do so, it highlighted three guiding questions from an initial literature review, and gathered empirical evidence to explore them from the cleantech start up, Company AB.

Through an extensive literature review, it was apparent that the majority of existing studies focus on the macro scale environment, that is, how can institutions facing the undeniable certainty of global warming, affect change within their national innovation ecosystem. Initially it was thought that alternative energy technology required institutional support in the form of government incentives, in order to reach successful commercialisation. However, using the case of The Company, this thesis has explored how the strategic decision making of a young company can affect success within the constraints of a wider innovation system, and how the tensions within this intersection can be more effectively navigated.

Flyvbjerg (2006) argued that the single case study was indeed capable of producing generalisable conclusions, and these findings concur with that assessment. From the case, it was identified that The Company's success can be linked to four key themes:

- Sufficient protection of intellectual assets,
- An ability to leverage a strong and relevant personal network,
- Logical and objective, yet agile decision making,
- Capable and driven leadership

These operational assets are within the boundaries of executive influence, thus entrepreneurs looking to improve their chances of successful commercialisation should aim to establish and expand these capabilities. However, even though these attributes are widely supported by literature, it is recommended that further research should aim to replicate these findings empirically in other young start-ups or industries, in order to provide some level of confidence that they are relevant and valid generalisations.

Furthermore, alternative energy technology entrepreneurs are advised to take an innovation systems view of a given market, and aim for those which have lower systemic variables for technology repulsion. In particular, this study demonstrates that an innovation pull environment is more attractive than an innovation push environment, as market demand helps to remove institutional barriers to technology diffusion. Obviously however, an innovation nirvana environment is the most ideal, yet finding a niche market with no competition remains the 'holy grail' for commercialisation success, and is difficult to strategise for. This is where the intersection between the individual entrepreneur and the innovation system is most relevant, and start-ups that demonstrate the organisational assets highlighted above, are better placed to identify and take advantage of opportunities that arise in a given innovation system. One

might argue that there may remain a semblance of ‘luck’ involved, or additional unknown variables, thus it is recommended that future research should aim to assess the weighting of each systemic failure variable and perhaps investigate what other variables could exist specifically for the context of alternative energy technology.

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Appendix A – Interview Transcripts

Date	Participant	Interview number
10th Jan 2018	The Chairman	1
16th Jan 2018	The Founder	2
18th Jan 2018	The Founder	3a
18th Jan 2018	The Founder	3b
19th Jan 2018	The Founder	4
4th May 2018	The Founder	5

Appendix B

The Case of 'The Company'

Authors: Matthew Davis, Annika Skoglund

Unfortunately at this time, the case study does not have permission to be published publicly. Consequently, all names of important companies, markets, stakeholders, and products have been changed throughout this thesis to protect commercially sensitive information, at the request of the company executives.

'The Company' is a small cleantech company. The case study will eventually present the story of early development, through to the most recent commercialisation efforts, from the perspective of two executives; The Founder (CEO and Founder), and The Chairman (Chairman of the Board). It is written in the teaching case style, using a chronological narrative in order to make the text more engaging and accessible for the average reader.