Helsinki University of Technology
Development and Management in Industry

Doctoral dissertation series 2006/1
Espoo 2006

FINANCING CLEAN ENERGY MARKET CREATION -- CLEAN ENERGY VENTURES, VENTURE CAPITALISTS AND OTHER INVESTORS

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Dissertation for the degree of Doctor of Science in Technology to be presented with due permission of the Department of Industrial Engineering and Management for public examination and debate in Auditorium TU1 at Helsinki University of Technology (Espoo, Finland) on the 16th of June, 2006, at 12 noon.

Helsinki University of Technology
Department of Industrial Engineering and Management
Development and Management in Industry

Teknillinen korkeakoulu
Tuotantotalouden osasto
Teollisuuden kehittäminen ja johtaminen

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ISBN 951-22-8226-7 (print)

ISBN 951-228227-5 (online)

ISSN 1796-458X (print)

ISSN 1796-4598 (online)

Photo: Tarja Teppo, March 2005. ’*Flowers in the Point Reyes National Seashore*’

Yliopistopaino

Helsinki 2006

Abstract

Many factors have emerged for change towards cleaner and more efficient technologies and services: climate change, increasing oil demands, and rising living standards in many parts of the world are putting an ever-increasing strain on the environment. Recently, these drivers have fueled the formation of a clean energy venture capital market where both independent venture capitalists (VCs) and corporate venture capitalists (CVCs) have invested in clean energy start-ups. Financing of clean energy market creation is the focus of this dissertation. The dissertation contributes to several bodies of literature in the area of entrepreneurship, new industry creation, corporate venturing, and venture capital research. The dissertation uses a grounded theory approach. The study is guided by three data collection approaches with an emphasis on the first two. First, interviews with European and North American VC and CVC firms that have invested in the clean energy sector were carried out. Second, a clean energy venture financing survey that consisted of qualitative, essay-format questions and some quantitative questions was carried out. Third, interviews with clean energy stakeholders were carried out in order to gain a better understanding of the emerging sector.

The research results consist of three main findings. First, the research results suggest that clean energy ventures face the following three main entrepreneurial challenges: financing, market education, and growth management. A further study of three clean energy industry categories revealed additional challenges that varied according to the industry development stage. Second, the results demonstrate that, from a venture capitalist perspective, clean energy venture risk characteristics can be divided into two groups: generally recognized risk characteristics and cognitive risk characteristics. The identified generally recognized risk characteristics were market demand and adaptation, incompatibility with the VC model, technology, regulatory control, and exits. The four cognitive risk factors were investment outcome history, VC risk preferences, investment domain familiarity, and venture framing. Third, the study developed a model showing that parent firm organizational culture affects the performance of a CVC fund. The effect of the organizational culture is moderated by risk-taking practices in the parent firm's decision-making process and the parent firm's skills in managing, measuring, and compensating fund success.

The main contribution of this dissertation is in identifying theoretical models that explain the clean energy venture entrepreneurial challenges, how VCs view clean energy ventures from a risk perspective, and how the organizational culture of a firm affects its CVC activity. The findings of the study suggest several managerial implications to policy makers, corporations planning to launch CVC fund activities, venture capitalists, and clean energy ventures. The findings and limitations of the study suggest several avenues for future research. First of all, the developed models and propositions should be quantitatively tested and further refined. Furthermore, the effect of the parent firm's organizational culture on the CVC fund performance warrants further investigation, preferably in some other than clean energy context. In addition, future research could explore the two other clean energy venture entrepreneurial challenges, growth management and market education, in more detail. The role of institutions and energy policy in the formation of clean energy markets, especially from the perspective of clean energy ventures and investors, would also be worth exploring in future research.

Tiivistelmä

Markkina-ajurit puhtaan teknologian kysynnälle ovat voimistumassa. Ilmastonmuutos, öljyn kysynnän kasvu sekä elinolojen koheneminen siirtymätalouksissa kuormittavat ympäristöämme yhä kiihtyvään tahtiin. Nämä markkina-ajurit on huomattu myös pääomasijoittajien keskuudessa. Sekä itsenäiset riskisijoitusyhtiöt että teollisuusyritysten riskisijoitusrahastot ovat viime vuosien aikana alkaneet sijoittaa puhtaan energiateknologian parissa työskenteleviin pienyrityksiin. Tämä väitöskirjatutkimus keskittyy puhtaan energiateknologian pienyritysten rahoitukseen erityisesti pääomasijoitusten näkökulmasta. Väitöskirjan luo uutta tietoa usealla alueella mukaanlukien yrittäjyys, uusien toimialojen synty, uuden liiketoiminnan luominen suuryrityksissä sekä pääomasijoittaminen.

Väitöskirjatyö käyttää nk. grounded theory –tutkimusmenetelmää. Tutkimuksessa kerättiin tietoa käyttäen seuraavaa kolmea lähestymistapaa: Eurooppalaisten ja Pohjois-Amerikkalaisten puhtaaseen energiateknologiaan sijoittaneiden pääomasijoittajien tutkimushaastattelut, globaali kyselytutkimus kohdistuen puhtaan energiateknologian yrityksiin sekä haastattelut puhtaan energiateknologian sidosryhmien parissa.

Tutkimuksen tulokset koostuvat kolmesta päätuloksesta. Ensiksi, tutkimustulokset osoittavat, että alkuvaiheessa olevien puhtaan energiateknologian yritysten haasteet koostuvat pääasiassa seuraavasta kolmesta aihealueesta: yrityksen toiminnan rahoitus, kohdemarkkinan kouluttaminen sekä yrityksen kasvun hallinta. Lähempi tarkastelu osoitti, että yritysten haasteet eroavat kyseessä olevan energiateknologian kehitysvaiheesta riippuen. Toiseksi, tutkimusten tulosten perusteella voidaan osoittaa, että pääomasijoittajien riskikartta puhtaan energiateknologian yritysten suhteen voidaan jakaa kahteen osaan: yleisesti tiedossa oleviin ja tunnustettaviin riskitekijöihin sekä kognitiivisiin riskitekijöihin. Yleisesti tunnustettavia riskitekijöitä olivat markkinan synty ja sopeutuminen, yrityksen yhteensopimattomuus risksijoitusmallin kanssa, teknologia, lainsäädäntö sekä sijoituksista irtautuminen. Kognitiivisia riskitekijöitä olivat aiemmin tehtyjen sijoitusten menestys, riskisijoittajan riskihakuisuus, sijoituskohteen toimialan tuntemus sekä yrityksen liikeidean esitystapa. Kolmanneksi, tutkimusten tulosten perusteella kehitettiin malli joka kuvaa emoyrityksen organisaatiokulttuurin vaikutusta yrityksen hallinnoiman pääomasijoitusrahaston toimintakykyyn. Mallin mukaan organisaatiokulttuurin vaikutusta voi vähentää emoyrityksen käyttämä päätöksentekomalli sekä emoyrityksen kyky johtaa, mitata ja palkita pääomasijoitusrahaston menestystä.

Väitöskirjatutkimus loi uutta teoreettisesta tietoa puhtaan energiateknologian yritysten haasteista, pääomasijoittajien riskikartasta kyseisten yritysten suhteen sekä organisaatiokulttuurin vaikutuksesta yrityksen pääomasijoitusrahaston menestykseen. Väitöskirjan tuloksia voidaan soveltaa sekä yhteiskunnallisessa päätöksenteossa ympäristöhallinnon alalla sekä elinkeinoelämässä pääomasijoittajien ja puhtaan teknologian yritysen keskuudessa. Jatkotutkimusaiheiksi ehdotetetaan kehitettyjen teoreettisten mallien kvantitatiivista testausta sekä kehitetyn organisaatiokulttuurimallin testausta muilla toimialoilla. Tämän lisäksi kohdemarkkinan kouluttamisen ja yrityksen kasvun hallinnan haasteita aloittelevissa puhtaan energiateknologian yrityksissä tulisi tutkia.

Acknowledgements

One of the great sides of working on a PhD is that one meets a lot of interesting and talented people. My PhD journey has brought me new colleagues and friends in Finland, other Nordic countries, Switzerland and the United States. This manuscript would not exist if not for the support of many people. I want to thank them all for sharing their time and expertise with me.

First of all I express my warmest thanks to my supervisor Professor Tuula Pohjola. She made sure that I had enough time from other research duties to work on my PhD thesis, was very flexible with my several month long research visits abroad, approved all the PhD coursework I carried out in other Nordic universities and provided invaluable assistance in finishing up the PhD project. I also want to thank my instructor Professor Raimo Lovio from Helsinki School of Economics for providing many intelligent perspectives and recommendations to consider. I am also thankful to Professor Lassi Linnanen who encouraged me to pursue post-graduate studies and who helped me to get started with my topic. Finally, my thanks go to Dr. Rolf Wuestenhagen from University of St.Gallen in Switzerland with whom I have collaborated throughout the research process. I have learned a great deal from Rolf by co-authoring papers and conducting research interviews together. I want to thank Rolf also for the many discussions we have had over a cup of coffee or email during the past three years, and for sharing his contacts to VCs and energy entrepreneurs. Rolf has managed to create the IWÖ into a hub that brings together researchers and students that share an interest in sustainable entrepreneurship and venture capital. I also want to express a special thanks to one of the hub members, Bill Moore, for his insightful comments and for being a great research colleague. I also want to thank the whole IWÖ for hosting me and making me feel right at home during my research visit to IWÖ in the spring of 2004.

I wish to thank Professor Staffan Jacobsson from Chalmers University in Sweden for acting as my opponent. I also got many valuable comments and recommendations from my pre-examiners, Professor Michel Bernasconi from CERAM Sophia Antipolis and Docent, Dr. Minna Halme from Helsinki School of Economics. Their comments had a crucial impact on many issues and helped me in clarifying the main message of the thesis. I appreciate them for sharing their time and expertise in this field with me.

The Environmental and Quality Management unit, or better known as the “EMU-team”, has provided me with a fun and supportive working environment. Against all odds, the EMU-team has managed to stay alive and thrived through several re-organizations and focus changes, and has attracted exceptionally warm-hearted and talented researchers into the team. My warmest thanks go for all the former and current members of the EMU-team. I especially want to thank Hanne, Timo and Adeline for the research work we carried out together in various projects during the past years. I also want to thank Professor Janne Hukkinen and his PhD students for all the valuable feedback I received in Janne’s PhD seminars over the past four years. I am also grateful for all the colleagues, PhD students and department personnel at the Industrial Engineering and Management Department for all the help I have received over the years and the interesting discussions we have had. I especially want to thank Satu Teerikangas for all the PhD related discussions we had.

I also give special acknowledgements to all the survey respondents and the interviewees I have worked with. A lot of very busy people found time from their calendars to meet up with me for an interview. The interview part was the most enriching and interesting phase of the research process that I greatly enjoyed. Without them I would not have had the interesting empirical data which formed the core of my research. This manuscript also owes to the

questions raised in conferences, seminars and doctoral consortiums when earlier versions of the research findings have been presented.

The research for this dissertation has been funded by Technology Development Agency of Finland (Tekes), Fortum foundation, Foundation for Economic Education (Liikesivistysrahasto), the Finnish Cultural Foundation (Suomen Kulttuurirahasto) and the Finland-Iceland Culture Foundation, which is gratefully acknowledged. The funding has enabled me to focus full-time on research and has made international interview, research visit and PhD course work related travel possible. I especially want to thank Raija Pikku-Pyhältö and Pekka Pesonen from Tekes and Mervi Salminen from Ministry of Trade and Industry (KTM) for their support of the YmpReg project. Big thanks go also for Torsti Loikkanen and Jukka Hyvönen from VTT without whom YmpReg project would not have succeeded. Big thanks go out also for people at Sitra for showing interest and support in my research.

In the spring of 2005 I had the pleasure of carrying out research in the United States. I especially want to thank Professor Dan Kammen from the University of California at Berkeley who hosted my visit to Renewable and Appropriate Energy Lab (RAEL). I cannot think of a more inspiring environment than UC Berkeley and RAEL lab to pay a research visit to, and I am truly grateful to Dan for hosting me for three months. I also want to thank Greg Nemet for the discussions we had and all the help he provided, and Annette Loveless for helping out with all the practicalities in the lab and making everyday life fun! Big thanks go out also for all the RAELies that I met during the lunch seminars and the ERG PhD seminars. I hope we will meet again.

I want to also express my sincere gratitude to my parents, who have always emphasized the value of education and have invested so much time and effort in their children. Through the time spent at the Loppi farm they have taught me an appreciative attitude towards work and have also supported me in all of my endeavors. Big thanks go also for all my siblings and their families that have been supportive during my PhD studies although it has puzzled them why someone would like to spend so much time doing academic research. I also want to thank all my friends who have shared the ups and downs and contributed significantly by their support, understanding and encouragement. Special thanks to my business partner Timo who has been very understanding in the finishing stage of the thesis, which took away precious time that could have been used to work on Cleantech Invest. Finally, my deepest gratitude and love goes to Tim and little Olav. Tim has made sure I have done also other things than just research and has been a very understanding companion in our common journey. Olav has already shown great patience and understanding in his mother's overly optimistic time management habits. Olav arrived 9 days over the expected date and thus let his mother to submit the thesis for external review before he was born.

Helsinki, May 18th 2006

Tarja Teppo

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1. Introduction

We are investing in environmentally cleaner technology because we believe it will increase our revenue, our value and our profits… Not because it is trendy or moral, but because it will accelerate our growth and make us more competitive.

-- Jeff Immelt, CEO of General Electric

For far-sighted companies, the environment may turn out to be the biggest opportunity for enterprise and invention the industrial world has ever seen.

-- The Economist

1.1. Background

Many factors are emerging for change towards cleaner and more efficient technologies and services: climate change, increasing oil demands, and rising living standards in many parts of the world that are putting an ever-increasing strain on the environment. Russo (2003) argues that there are strong social and institutional elements to the push towards greening. These elements create opportunities for innovative entrepreneurial firms and require existing firms to adapt to a changing business environment. Recently, these factors have led to the formation of a clean technology ("cleantech") venture capital market where both independent venture capitalists (VCs) and corporate venture capitalists (CVCs) have invested in cleantech start-ups. The most prominent area of investment has been the energy sector, as approximately 40% of all cleantech VC investments have gone to clean energy technologies (Parker 2005). Financing of clean energy market creation is the focus of this dissertation.

New venture creation, entrepreneurship, venture capital, and external corporate venturing in the form of corporate venture capital have received significant attention from academic researchers during the past decade. This dissertation is motivated by three reasons. First, most of the studies have concentrated on industries that have experienced a "venture capital glut," such as Internet and communications technologies. Venturing in the area of clean energy has received scant attention from academic researchers, although other press, such as business periodicals, has noted the emerging cleantech and clean energy market on several occasions (Henig 2003, De Callejon 2005, Parker 2005, Prudencio 2005, Cauchi 2004, Liebreich 2005, Sheahan 2004, Copeland 2005, Higginbotham 2005, LaRuffa 2004, Weeks 2004, Wilson

2003, Gunderson et al. 2003, Abrams 2004, Landry 2002, Frankel 2000, Stone 2003, Harvey 2005, and Rivlin 2005). Second, technological change and industry creation literature has largely ignored new business creation or adaptation to environmental and social sustainability-induced changes in the business environment. Recently, it has been noted that, for example, climate change poses strategic dilemmas for companies across a range of industries, affecting those that produce fossil fuels, depend on fossil fuels directly or indirectly, and those interested in developing new opportunities (Kolk et al. 2004).

Third, most existing literature regarding market creation for environmental technologies, referred to in this study as the cleantech sector, has focused on the policy perspective and effectiveness of governmental regulation. However, Kolk et al. (2005) argue that dramatic change has taken place in the policy and strategy debate on climate change. Instead of focusing solely on political and non-market strategies, a range of market responses is emerging to address global warming and reduction of emissions through product and process innovations. Only a small body of literature exists that analyzes business creation in the emerging market of clean energy. One can argue that our knowledge of clean energy venture entrepreneurial challenges, the role of private equity fueling the clean energy industry formation, and the entrepreneurial activities of industry incumbents is very limited. This dissertation aims to expand the knowledge base of clean energy venture entrepreneurial challenges and financing. The dissertation is a theory-building study, which utilizes previous research and empirical data to build models and propositions that can be used in further research of the clean energy market and the cleantech market in general.

1.2. Research Questions and Contributions

We have limited knowledge on clean energy industry emergence and how investors view the market. Also, we have little coherent theory that would explain clean energy entrepreneurial challenges, especially in the area of venture financing. This dissertation addresses the gap in our understanding by developing a venture financing perspective of clean energy industry emergence. Venture financing is the key element for clean energy entrepreneurial ventures, as in all industrial areas where acquiring funding may either “make or break” the venture. By studying the relationship between investors and clean energy entrepreneurial firms, the dissertation illuminates the entrepreneurial challenges that clean energy firms and the emerging clean energy market are facing. The dissertation addresses the following research question:

> In the clean energy market, what entrepreneurial challenges do clean energy ventures face, and what role do venture capitalists and large firms play in the development of the clean energy market?

To contribute to answering the wider research question presented above, three more precise sub-questions are developed that are directly addressed in this dissertation. The first question aims at describing the entrepreneurial challenges clean energy ventures face in order to provide a comprehensive description. The first question to be addressed is:

> 1. What entrepreneurial challenges do clean energy ventures face and how do these challenges vary between the development stages of different clean energy industry categories?

To answer this first question, this dissertation develops a framework of clean energy venture entrepreneurial challenges. The framework is extended by analyzing entrepreneurial challenges specific to clean energy ventures operating in three different clean energy industry categories, where each category is in a different development stage.

The second question concerns the role of VCs in creation of the clean energy market. Venture capitalists have been shown to be indicative for innovation and emergence of a new sector for two reasons. First, in the past decades, several of the new emerging technological sectors, such as biotechnology and Internet and telecommunications sector, have been financed, in large part, by venture capital investment in the early stages of the sector development. Second, venture capital has been shown to have a strong positive impact on innovation (Gompers et al. 2001, and Kortum et al. 2000). For example, Gompers et al. estimate that, on average, a dollar of venture capital appears to have three to four times more potential in stimulating patenting, and thus spurring innovative new activity, than a dollar of corporate R&D. The dissertation is guided by the second question:

> 2. How do the decision-making behavior and possible cognitive biases of a VC contribute to a clean energy venture's chances of raising capital?

The third sub-question studies the role of large firms in creation of the clean energy market, concentrating on a special vehicle of external corporate venturing, namely corporate venture capital. This dissertation argues that analyzing the parent firm's organizational culture brings new perspectives to understanding the performance of a corporate venture capital fund. Corporate venture capital literature has shown corporate venture capital funds to be volatile

(Gompers et al. 2001) and varying in success (Sykes 1986, Siegel et al. 1988, Gompers et al. 1998, and Chesbrough 2000). Learning capability (Keil 2000) has been referred to as one of the factors determining CVC fund performance differences. However, the role of the parent firm's organizational culture on CVC fund performance has remained unexplored. The third question addressed is:

> 3. How does the parent firm's organizational culture affect the performance of a corporate venture capital fund and what are the implications to clean energy market creation?

By answering to these three research questions, the dissertation contributes to several bodies of literature. First, this dissertation contributes to our understanding of clean energy entrepreneurship and the entrepreneurial challenges clean energy ventures face. Second, providing a model of clean energy venture risk characteristics by taking into account the venture capitalist cognitive biases contributes to the venture capital literature by linking behavioral economics literature with the venture capitalist decision-making process. Finally, the dissertation advances our understanding of the role of large corporations in creating the clean energy market and highlights how the parent firm's organizational culture affects CVC fund performance.

1.3. Scope and Limitations

This dissertation focuses on entrepreneurial challenges of clean energy ventures and the role investors and large firms play in the development of the clean energy market. The scope of the dissertation is limited along both theoretical and empirical dimensions.

The theoretical scope is limited to clean energy market development. From the investor's side, the scope is venture capital firms making equity or equity-linked investments in privately held clean energy ventures. The venture capital firms may be independently managed, government-backed, or backed by a corporation. The investment scope excludes buyouts, consolidations, mezzanines, or other forms of private equity.

The empirical data of venture capital firms is limited to Europe and North America. On clean energy ventures, the data are dominated by European and North American ventures, although some Asian and South American ventures are included in the empirical data set.

1.4. Methodology

The dissertation uses a grounded theory approach (Strauss et al. 1998, Corbin et al. 1990, Creswell 1998 and 2003, and Ryan et al. 2000). The study is guided by three data collection approaches with an emphasis on the first two. First, interviews with European and North American VC and CVC firms that have invested in the clean energy sector were carried out. Second, a clean energy venture financing survey that consisted of qualitative, essay-format questions and some quantitative questions was carried out. The survey collected data from clean energy ventures less than 10 years of age. Third, interviews with clean energy stakeholders, media search, and attendance of conferences in the clean energy and cleantech area were carried out in order to gain a better understanding of the emerging sector.

The use of multiple data collection approaches seems justified, as the goal of the study is theory building rather than testing or expanding existing theory. Grounded theory approach was chosen for the following reasons. First, cleantech and clean energy market emergence and the financing of clean energy ventures has received scant attention in the literature. Second, little coherent theory exists that would explain the biggest entrepreneurial challenges clean energy ventures face and the risk characteristics of clean energy ventures from the VC perspective, and especially the characteristics due to possible cognitive biases. Third, the cognitive side of VC decision-making has received insufficient attention in the literature and little theory building exists on this matter. Departing from the tradition of the early-grounded theory methods (Glaser et al. 1967), this dissertation also utilizes links to existing theory. First, an extensive literature review of theories that have guided the thinking and argumentation of the researcher is provided. In the theory building chapters, literature is consulted to refine findings from the empirical data.

1.5. Structure of the Dissertation

The structure of the dissertation is shown in Figure 1. Chapter 2 provides the central definitions. Chapter 3 presents a literature review of previous research relevant to the research questions the dissertation addresses: industry emergence, entrepreneurial challenges, incumbents and technological change, financing of industry creation, and decision-making behavior in risky situations. The theory review highlights the findings of previous research and points out issues that have previously been ignored and that are addressed in the empirical part of the dissertation. Chapter 4 introduces the research methodology and process. Chapter 5

provides an introduction to the research context of the dissertation, the clean energy market, including discussion of the industry drivers and overview of venture capital investment activity in the sector.

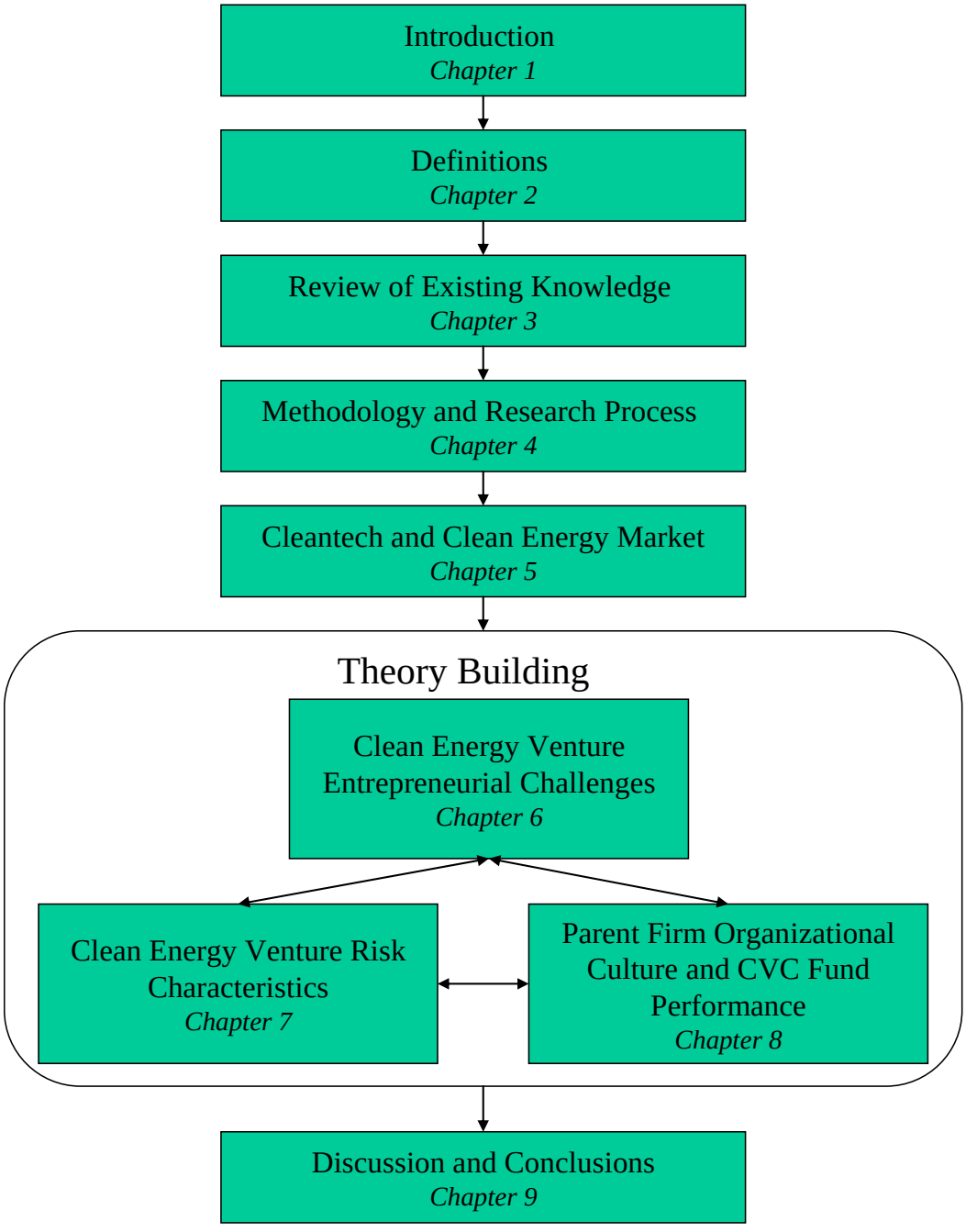

Figure 1 Structure of the dissertation

Theory building of the dissertation takes place in three steps. First, chapter 6 develops a framework of clean energy venture entrepreneurial challenges based on the empirical data

gathered from the clean energy venture financing survey. Chapter 7 introduces a model of clean energy venture risk characteristics by taking into account the venture capitalist cognitive biases on clean energy entrepreneurial ventures. Chapter 8 develops a model that aims to explain the effect of the parent firm's organizational culture on the performance of a corporate venture capital fund. The empirical data presented in chapters 7 and 8 are based on VC and CVC interviews and data from the clean energy venture financing survey.

In chapter 9, conclusions from the dissertation are presented. The theoretical contributions and managerial implications are outlined. Finally, limitations of the study and avenues of further research are presented.

2. Definitions

Several terms used in this dissertation require a clear definition to ensure that the theory building is not only grounded in empirical data but can be used to extend existing knowledge. Eight definitions will be introduced in this chapter: cleantech, clean energy, entrepreneurial challenge, venture capital, corporate venture capital fund performance, organizational culture, venture risk characteristic, and industry development stage.

2.1. Cleantech

In this dissertation, cleantech is used to refer to technologies that optimize the use of natural resources while reducing ecological impacts and increasing economic value. Cleantech, as a term, is not specific to any particular industry, but it is a broader concept that can be applied to various industries (Parker 2005). According to Cleantech Venture Network (CVN), these industries can include agriculture, building materials, energy, household appliances, pharmaceuticals, semiconductors, transportation, and water treatment (Parker). Burtis et al. (2004) have defined eleven cleantech industry categories, as shown in List 1.

List 1 Cleantech Industry Categories

Advanced materials and nanotechnology
Agriculture and nutrition
Air quality
Consumer products
Enabling technologies and services
Energy generation, storage, and infrastructure
Environmental information technology
Manufacturing / Industrial technologies
Materials recovery and recycling
Transportation and logistics
Waste and water purification and management

According to Russo (2003), the common characteristic of firms operating in a sustainable industry, such as cleantech industry, is that they represent a transformational form of entrepreneurial activity that has a trajectory towards sustainability.

2.2. Clean Energy

In this dissertation, clean energy ventures are defined as providing energy technologies and services that reduce environmental impacts, are socially acceptable, and can be economically competitive (Moore 2004). Clean energy technologies and services can be divided into four main clusters: renewable energy, distributed energy systems, natural gas, and demand-side energy efficiency (Pfeuti 2002). Clean energy ventures contain environmental, social, and economic factors. Economic factors consist of cost savings by limiting consumer costs of energy and by providing energy services for economic growth. Environmental factors in clean energy ventures are related to the energy supply source used that may contribute to air pollution, greenhouse gases, or other impacts on ecosystems. Social factors in clean energy ventures consist of the security of supply aspects.

2.3. Entrepreneurial Challenge

Entrepreneurship studies focus on start-up and growth activities, recognizing the importance of such resources as money, people, and information that must be acquired to launch a venture (Brush et al. 2001). In this dissertation, the term entrepreneurial challenge refers to a particular management task that emerges during the venture development. Entrepreneurial challenges are confronted in identifying, attracting, combining, and transforming technological, financial, informational, human, and other resources during the venture development process. Brush et al. have suggested some example prescriptions for meeting entrepreneurial challenges: seeking advice from a network of contacts, assessing decision characteristics of equity providers, delegating responsibilities, developing controls, and setting policies.

2.4. Venture Capital

Venture capital refers, in this study, to as professional equity co-invested with the entrepreneur to fund an early-stage (seed and start-up) or expansion venture (EVCA 2005). A venture capitalist is the manager of a private equity fund who has responsibility for the management of the fund's investment in a particular portfolio company. The venture capitalist brings in capital, domain knowledge, business contacts, brand equity, and strategic advice (EVCA). Private equity provides equity capital to enterprises not quoted on a stock market and can be used to develop new products and technologies, to expand working capital, to make acquisitions, or to strengthen a company's balance sheet (EVCA). Venture capital is a

subset of private equity and refers to equity investments made for the launch, early development, or expansion of a business.

2.5. Corporate Venture Capital Fund Performance

In this dissertation, corporate venture capital (CVC) is defined as investment of corporate funds directly in external start-up companies (Chesbrough 2002). The definition excludes investments made through an external fund managed by a third party, even if the investment vehicle is funded by and specifically designed to meet the objectives of a single investing company. It also excludes investments that fall under the more general rubric of corporate venturing: the funding of new internal ventures that remain legally part of the company (Chesbrough).

In this study, the performance of CVC funds is defined as the degree to which the strategic and financial goals the firm, as set for its corporate venture capital fund, are met, measured by the level of activity and the survival of the fund.

2.6. Organizational Culture

Several definitions for organizational culture exist. Schein (1985) has defined three levels of phenomena in organizational culture: (1) artifacts and creations, (2) values, and (3) basic assumptions. Gordon (1991) describes organizational culture as having been founded on similar "assumptions about customers, competitors and society." According to Davis (1984), organizational culture is defined as being "based upon internally oriented beliefs regarding how to manage, and externally oriented beliefs regarding how to compete." Deal et al (1982) define organizational culture as "the way things get done around here." Deal et al. measure organizations in regard to feedback and risk. Using these two parameters, Deal et al. suggest four classifications of organizational culture: tough-guy macho culture, work hard/play hard culture, bet your company culture, and the process culture**.** Handy (1985) provide definitions for four different organizational culture types that are closely connected with organizational structure of the firm: power culture, role culture, task culture, and person culture. Detert et al. (2000) reviewed previous research on organizational culture and identified eight dimensions of organizational culture that underlie the majority of existing organizational culture concepts. These eight dimensions were: the basis of truth and rationality in the organization; the nature of time and time horizon; motivation; stability versus change / innovation / personal growth; orientation to work, task, and coworkers; isolation versus collaboration / cooperation; control,

coordination, and responsibility; and orientation and focus. In this dissertation, the Davis (1984) definition of organization culture is used.

2.7. Venture Risk Characteristics

Venture capital investing is concerned with balancing risk and return of the investment portfolios (Wuestenhagen et al. 2006, and Ruhnka et al. 1991). Venture capital portfolio managers tend to refer to their venture investments as "winners," "living dead," and "losers" (Ruhnka et al. 1992). Ruhnka et al. note that venture capital risk is "a function of the probability of losing and the amount, which, when taken together, are referred to as the prospect of loss." In addition to prospect of loss, Ruhnka et al. address the exit or liquidity risk. They refer to the exit risk as the so-called "living dead" phenomenon, where firms that were once expected to equal or exceed portfolio target levels of return have stalled in their sales growth or profitability. In this dissertation, venture risk characteristics are the product of investor perception of risk related to a particular venture (Ruhnka et al. 1991).

2.8. Industry Development Stage

In this dissertation, the term industry development stage is used to indicate one of the following stages: early stage, rapid growth, and slow growth stage. The terms have commonly been used in previous literature referring to the so-called S-curve of technology adaptation, innovation diffusion, or industry development. S-curve has been described as a process where the innovation is "communicated through certain channels over time among the members of a social system" (Rogers 1983). The definitions of each of the three developmental stages used in this study are described briefly. In the early stage, the industry development is in its infancy and large-scale commercialization plans are far in the distance. In the rapid growth stage, there are several technology generations and many the firms are struggling to ramp up their production and acquire financing for growth. For firms in the slow growth stage, the rapid growth phase has been delayed.

3. Review of Existing Knowledge

The goal of this chapter is to review existing knowledge that is closely related to industry emergence and the role of investors, entrepreneurs, and large firms in new market creation. The theory building of the dissertation takes place in chapters 6 through 8. As was argued in the introduction chapter, little previous research or existing theory on clean energy market evolution exists. However, literature that discusses aspects related to industry emergence and the role of entrepreneurs, industry incumbents, and financiers in industry creation is available. The chapter consists of four separate sections. The first section provides an overview of the industry emergence and evolution literature and emergence of new firms. A brief overview of previous clean energy and cleantech industry emergence literature is also presented. Review of previous entrepreneurship and industry creation literature is presented in the second section. The third section reviews industry incumbents and market creation. In particular, corporate venture capital literature is reviewed. The fourth section provides an overview of venture financing literature. Literature on venture capital and venture capitalist decision-making are discussed.

3.1. Industry Emergence and Evolution

Industry emergence and evolution has interested researchers for decades. As far back as 1978, Abernathy and Utterback presented their models of product and process innovation (Abernathy et al. 1978, and Utterback 1994). The models hypothesized that the rate of major innovation for both products and processes follows a general pattern over time. The pattern they discovered was that, in the early years of an industry, experimentation with product design and high rate of innovation takes place, with less emphasis on the processes by which products are made. In the transitional phase, innovation slows down and process innovations increase, introducing dominant designs. Finally, the industry enters what Abernathy et al. called specific space, where the firms in the industry focus on cost and volume, and product and process innovation are scarce.

The transition from emerging technologies to new industries is a complex process where new firms enter and either grow and survive or exit from the new industry (Audretsch 1995). The development of a new industry may happen rapidly or it may take several decades. Klepper et al. (1990) finds that the time it takes for an industry to stabilize might vary from 2 to 50 years. Evolution of a new industrial sector is often demonstrated in the form of an S-curve, which

consists of three stages: emergence, growth, and eventual plateau. However, the S-curve may not hold for all industries (Low et al. 1997). Low et al. note that the S-curve is not inviolate, as some industries never take off and others experience sudden rises and falls. For example, in the clean energy sector, the solar energy industry experienced its first boom-and-bust cycle in the early 1980s, only to return to the clean energy cycle almost 20 years later as an interesting investment area. Industry evolution has also been studied from a network perspective. Human et al. (2000) divide the industry evolution into five stages: "pre-network organizational field," "network formation," "early growth," "emerging legitimacy," and "sustainment or demise."

It has been argued that technological development, industry emergence, and entrepreneurship have similarities with social movements (Van de Ven et al. 2004, and Dacin et al. 2002). Rosenberg (1983) notes "what is really involved is a process of cumulative accretion of useful knowledge, to which many people make essential contributions, even though the prizes and recognition are usually accorded to the one actor who happens to have been on the stage at a critical moment." A model that attempts to explain the emergence of a new industry has been developed by Van de Ven et al. (1989 and 1993). Van de Ven et al. model what is called "an augmented view of an industry" thas been applied in various studies to explain the emergence of new industries in various sectors from film industry to health-care (Garud et al. 1994 and 2002, Aldrich et al. 1994, Mezias et al. 2000, and Murtha et al. 2001). The Van de Ven et al. model is used to reflect the findings of this study in chapter 6.5.

According to Bettis et al. (1995), the 21st century faces new aspects of competition and strategy due to the broad nature of technological changes that are taking place: the increasing rate of technological change and diffusion, the information age, increasing knowledge intensity, and the emergence of positive feedback industry. To respond to the change in competitive landscape, Bettis et al. suggest four themes as important. First, the increasing rate of technological change and diffusion will decrease forecastability and thus an increase in risk and uncertainty is expected. Second, the concept of industry will become more ambiguous, causing the traditional boundaries to blur as substitute products are developed in other industries. It thus becomes more difficult to identify the competitors, including their strategies, resources, and future actions. Third, managers must develop a mindset that allows cooperation with competitors. Firms cannot remain static even in mature industries, forcing managers to adopt an entrepreneurial mindset, "emphasizing innovation in most industry settings." Fourth, there will be three new imperatives that drive organizational design:

decreased transaction costs, increased penalties for mistakes and hesitancy, and competition based on knowledge accumulation and deployment. The impact of these imperatives implies a redefinition of organizations and increases the emphasis on learning and strategic response capability.

3.1.1. Emergence of New Firms

According to Chesbrough (1999), a technical change in an industry may result in a rich variety of organizational phenomena. Chesbrough argues that, in some industries, firms struggle to adapt to new possibilities and threats in their environment and, in others, incumbents are able to adapt to or pre-empt competitive challenges from new entrants. Klepper et al. (1990) identify important differences across industries in the factors that condition the evolutionary process of industries. According to Klepper et al., exogenous factors that differ across industries affect the pace and severity of evolutionary process. Aldrich et al. (1994) argue that established industries may attempt to slow down the development of a new industry and the entrance of new players. According to Aldrich et al., the established industries may change the terms on which resources are available to emerging industries by questioning their efficacy or their conformity to the established order. Other industries may withhold recognition or acceptance of the new industry, even after it has developed into a recognized entity.

Small firms have traditionally been associated with the commercialization of disruptive technologies (Bower et al. 1995) or radical innovations. Radical innovations are ones that "transfer the relationship between customers and suppliers, restructure marketplace economies, displace current products and create entirely new product categories" (Leifer et al. 2001). According to Henderson (1993), neoclassical theory suggests that entrants will replace incumbent firms during periods of radical technological change because they have greater strategic incentives to invest in radical innovation, while organizational theory suggest that established firms often fail in the face of radical innovation because their research efforts are significantly less productive than those of entrants. Henderson synthesizes these contradictory findings and shows that, without examining both under-investment and incompetence as responses to radical innovation, the failure of many established firms to deal with radical innovation cannot be understood. Henderson notes that "the results highlight the danger of assuming that there is any simple relationship between market power, size and experience,

and innovative success, and they open up a number of important issues concerning the role of organizational capabilities in strategic competition."

According to Sine et al. (2003), the biggest impact in terms of entrepreneurship, or as Sine et al. refer to "mobilization of search processes," is on industries that are dominated by a single institutionalized structural and technological logic and are thus closed to alternative ideas. However, the process of commercializing emerging technologies is quite risky and costly (Hung et al. 2004), with a high potential for failure. Kassicieh et al. (2002) show that also the nature of technology is a significant factor in determining whether a large or smaller firm is successful in commercializing the technology. Sanders et al. (2004) demonstrate that, during the emergence of new industries, investors and analysts lack a codified body of knowledge and industry-specific experience. This may lead to difficulties for firms with yet unproven business models to raise financing for their activity, increasing the risk of failure. However, Day et al. (2000) argue that emerging technologies signal their arrival long before they bloom into full-fledged commercial success. Furthermore, according to Day et al., correctly identifying the early signs requires knowledge and a "prepared mind" that is able to see beyond "the disappointing results, limited functionality, and modest initial applications."

Chesbrough (1999) has approached the battle between new entrants and incumbent firms from an innovation constraint perspective. According to Chesbrough, innovating firms face two constraints: incentive constraint and appropriability constraint. Incumbent firms may face an incentive constraint when they try to promote risk-taking in the firm. According to Chesbrough, entrant firms are able to better align incentives within their organizations and elicit greater entrepreneurial efforts from their staff relative to incumbent firms. On the other hand, entrant firms may suffer from appropriability constraint where, due to lack of complimentary assets, the innovation's full value cannot be realized. According to Chesbrough, these two organizational constraints can offset one another, as incentive constraints favor entrant firms and appropriability constraints favor incumbent players. In addition to the relative strength and weakness of entrants and incumbents, the technical advance of industries and technological paths has been studied from a national perspective. These national perspective studies consist mainly of two research streams, namely studies of national innovation systems (Mowery 1992, Nelson 1993 and 1994) and studies of technological regimes (Kemp et al. 1998, Berkhout 2002, and Malerba et al. 1997).

Chesbrough (1999) criticized the innovation literature from the lack of industry-specific studies that span multiple countries. According to Chesbrough, the majority of innovation studies consider many industries within multiple countries. This approach mainly emphasis the differences between countries, but not between individual industries. On the other hand, Chesbrough notes that individual industry studies take little or no account of the external environment. The next chapter takes a look at the previous research findings of cleantech and clean energy industry emergence.

3.1.2. Cleantech and Clean Energy Industry Emergence

The drivers for clean energy industry growth are strong: rise in energy prices due to the finite reserves of oil and gas, lower costs for clean energy technology due to innovation and learning effect, climate change and other environmental concerns, changes in energy industry structure due to electricity deregulation, and security of supply concerns. Russo (2003) argues that there are strong social and institutional elements to the push towards greening. Rothenberg et al. (1999) state that corporations are critical players in the worldwide effort to address greenhouse gases and other emissions. According to Rothenburg et al., “although there has been some growing recognition of the role of private actors in international environmental regimes, little attention has been paid to the role of private sector at the science-policy interface.” Shrivastava (1995) notes that, regardless of whether environmental regulations hurt or help industry, they influence competitive behavior of firms and the competitive dynamics of industries by imposing new costs, investment demands, and opportunities for improving production and energy efficiency.

According to Diefendorf (2000), regulatory action is key in creating a capital market for sustainable industry creation, as has been the case in other sectors where tax incentives and government support mechanisms have helped the development of the VC industry (Manigart et al. 2000). O’Rourke (2004) suggests that regulatory reform could remove subsidies for unsustainable ventures and provide tax incentives for sustainable venture investments. Shrivastava et al. (1995) has emphasized the adaptation skills of industry incumbents. Shrivastava et al. argue that, for the global economy to become ecologically sustainable, it will be necessary to organize business and industry along ecologically sound principles. The change will transform the corporations, their products, production systems, and management practices.

Sine et al. (2003) studied the oil crisis of the 1970s and early 1980s. According to Sine et al., the energy crisis did not force the abandonment of the then-current industrial structure, but it degraded the prominence of the accompanying power generation strategies, changing their status as the only or natural way of power generation to one of many available methods. The shift created fertile ground for entrepreneurship and a new set of organizational forms and practices. When studying the institutional change in the power generation sector in the U.S., Sine et al. found that most electric utilities did not pursue alternative technologies, since the organizational strategies were strongly influenced by the institutional industrial structure that existed for more than 40 years. However, during the oil crisis, many myths about the electric power industry were dispelled and "it was no longer taken for granted that the generating industry was promoting the best interest of the public" (Sine et al. 2003). In addition to delegitimizing the existing institutional logics, the oil crisis increased awareness of pre-existing technological solutions, such as alternative energy and cogeneration. According to Sine et al., the policy makers missed the earlier opportunities for industrial reform and change, since they were not recognized due to information-gathering processes influenced by taken-for-granted assumptions. The oil crisis disrupted the information gathering processes and mobilized advocates of alternative structures and technologies. Sine et al. conclude that technological advances do not always result in immediate entrepreneurial activity but are instead mediated by institutional logistics (i.e., whether or not the institutional conditions are ripe for change).

3.1.3. Barriers, Opportunities, and Characteristics

According to Russo (2003), the common characteristic of firms operating in a sustainable industry, such as the clean energy industry, is that they represent a transformational form of entrepreneurial activity that has a trajectory towards sustainability. Russo argues that "organizations within sustainable industries are mission-driven." Hart et al. (2002) suggest that the four billion people at the "bottom of the economic pyramid" could be the first adopters of profitable, sustainable innovative products. Hart (1997 and 2005) identifies opportunities in sustainable industry creation and markets for sustainable products that both create growth and solve social problems. Hawken (1993) and Hawken et al. (1999) argue that profitable opportunities exist for firms in the area of sustainable resource use. According to Shrivastava (1995), ecological issues regarding energy, natural resources, pollution, and waste

offer competitive opportunities and constraints and are changing the competitive landscape in many industries.

Tsoutsos et al. (2005) introduce a framework of eight barriers to technological regime shift towards renewable energy technologies. The framework is an extension of research work carried out by Kemp et al. (1998) for transportation technologies. The eight barriers identified by Tsoutsos et al. (2005) are presented in Table 1 in more detail, since the Tsoutsos et al. model is used in chapter 6 to reflect the findings of this dissertation on clean energy venture entrepreneurial challenges.

Table 1 Eight Barriers to Technological Regime Shift

Factor	Description
Technological factors	Technological immaturity: need for optimization with respect to user needs and large-scale deployment: ❖ Complexity: often, renewables need to be embedded within another system (e.g., a building) or to interact with other elements (e.g., a battery system or the grid) ❖ The variety of installation sites raises the need for robust modular designs: interfaces between various subsystems have to be established ❖ Skills: the management of the new technology requires the "unlearning" of established wisdom on what is right and the establishment of a new rationale
Government policy or regulatory framework	Unclear messages about the need for the new technologies and their role in the energy system result in uncertainty about the future of market development: ❖ Regulatory barriers to the deployment of new technologies (e.g., there is no provision for small domestic wind-power installations in many EU countries) ❖ Risk aversion: governments do not risk change in the face of the political cost of vested interests
Cultural and psychological factors	Social acceptance is low, as they have not been established as a reliable alternative: ❖ Our electricity- and oil-based civilization is identified with a comfort and ease that people may be afraid to abolish with renewables ❖ Unfamiliarity with the new technologies and possible failures or

Factor	Description
	bad examples (e.g., broken or run-down wind turbines, poorly designed bioclimatic building, etc.) lead to skepticism ❖ Uncertainty that arises from the temporally variable nature of some renewable sources (e.g., sun, wind) put people off when comparing these alternatives with the perceived safety of electricity or oil
Demand factors	Risk aversion: consumers and users cannot form specific expectations of the use and value of renewables: ❖ User preferences: in many cases, users are required to adjust their demands and preferences to patterns that fit the new technologies ❖ Willingness to pay: the share of users willing to trade comfort, perceived security, and low cost for reduced environmental impact is limited, especially as the benefits are not evident
Production factors	Investment in new technology would signal the sharp devaluation of existing facilities: from centralized mass production in oil- and large hydro-based facilities, production should transfer to decentralized, distributed renewable sources: ❖ Competencies in existing technologies would become obsolete, engineers and specialized workers would invest in adopting the new technologies
Infrastructure and maintenance	Network incompatibility: the distribution infrastructure does not fit the topology of renewable energy, (e.g., wind, solar or small hydro-based): ❖ Maintenance needs change in conjunction with the geography of the new system and the new technologies involved ❖ New agents, such as suppliers of maintenance services, may need to enter the system for a variety of new technologies that may be deployed across various regions ❖ Sunk costs may be high with regard to the existing infrastructure and related competencies
Undesirable societal and environmental effects	Conflicts may arise out of aesthetic or environmental concerns over the deployment of new installations (e.g., wind turbines, geothermal installations) or the production facilities of components (e.g., toxic waste from solar cells)
Economic factors	The economic rationale shifts from the growth of consumption to the minimization of environmental impact: ❖ “Sailing ship” effect: short-term improvements in incumbent technologies put off investments in new technology ❖ High initial investment puts off potential adopters, in the absence

Factor	Description
	of corresponding financing mechanisms, such as third-party financing, leasing, etc. ❖ Slow take-off of new technologies reduces the impact of economies of scale and accelerated learning on the unit cost; as a result, high prices, even of relatively simple technologies, slows down diffusion

3.2. Entrepreneurs and Industry Creation

Entrepreneurs in the form of new start-ups have been argued to be essential for new industry growth. Chesbrough (1999) suggests that the absence of aggressive new start-up entrants indicates that prospective new technologies may not be commercialized as rapidly as they might be when start-up entrants are present. The reason why entrepreneurial firms are important for industry growth is that entrepreneurial firms can serve as incubators and carriers of the innovation and attract other followers to further develop the infrastructure for widespread diffusion of the innovation (Hung et al. 2004). Hung et al. suggest three mechanisms as being critical to stimulating new technology-based industries, namely encouraging partnerships in the commercialization process, fostering entrepreneurship and venture initiatives in the innovation system, and sustaining the commercialization and the creation of new firms.

According to Venkataram (1997), entrepreneurship research seeks to understand how opportunities to bring new goods and services are "discovered, created, and exploited, by whom, and with what consequences." Amit et al. (1990) argue that an entrepreneurial firm centers on its ability, consisting of talent, skill, experience, ingenuity, and leadership, to combine tangible and intangible assets in new ways and to deploy them to meet customers' needs in a manner that can not easily be imitated. In the context of emerging industry, a more specific definition of an entrepreneur, namely the institutional entrepreneur, has been adopted. An institutional entrepreneur is an entrepreneurial firm that, with its business activity, manages to affect cultural norms and public perception and gain legitimacy to the emerging industry (DiMaggio 1988 and Suchman 1995). Jones-Evans (1997) extends the inventor-entrepreneur typology introduced by Smith (1967) and Miner et al. (1992) by classifying four categories of technical entrepreneurs: research, producer, user, and opportunist technical entrepreneur. Garud et al. (2003) define technology entrepreneurship as a distributed process that creates opportunities through a process of creative synthesis. Van de Ven (2005) emphasizes the importance of the cooperative, distributed process in entrepreneurship.

According to Van de Ven, an individual firm seldom commands "the resources, power, or legitimacy to go it alone." Van de Ven argued that entrepreneurial firms must simultaneously cooperate and compete (i.e., "run in packs with other firms"). According to Van de Ven, entrepreneurs that operate in an emerging industry form an interconnected group that is linked by similar challenges, some of which are unique to the industry and others that are universal to all entrepreneurial firms.

A research stream within entrepreneurship studies the characteristics and risk-taking of entrepreneurs. Simon et al. (2000) find that individuals start ventures because they do not perceive the risks involved and not because they knowingly accept high levels of risk. Simon et al. also argue that individuals starting ventures might not acknowledge that certain tasks important to the venture's success are beyond their control, leading to decreased risk perception. According to Busenitz et al. (1997), entrepreneurs display greater overconfidence than managers in large organizations do in considering whether to start a venture. Busenitz et al. (1997) argue that "the window of opportunity would often be gone by the time all the necessary information became available for more rational decision-making." Mullins et al. (2005) study new venture decision-making and find that most entrepreneurs would rather risk "missing than sinking the boat." Mullins et al. also find that the source of new venture funding (i.e., the entrepreneur's own money versus that of investors) influences the choices between ventures whose chances for loss or gain differed. Palich et al. (1995) argue that entrepreneurs may not necessarily prefer to engage in more risky behavior but their behavior may be the result of framing a given situation more positively than negatively, thereby focusing on the high probability for favorable outcomes and responding according to these perceptions. Palich et al. further note that non-entrepreneurs may not share this "rose garden" view, leading them to react more cautiously. Decreased risk perception is related to over-optimism, which, according to Cooper et al. (1988), is a known feature of entrepreneurs. Krueger et al. (1994) argue that entrepreneurs have a tendency to overlook very real obstacles. Cooper et al. find that entrepreneurs can be overly optimistic in their assessment of business opportunities. Cooper et al. surveyed almost 3,000 entrepreneurs and found that 81% believed their chances of success to be at least 70% and 33% believed their success to be certain. However, half of all new ventures fail within five years, and 34% to 50% of new businesses discontinue within two years (Cooper et al.). As Timmons (1990) notes, "building a better mousetrap" does not mean that customers want to buy the new mousetrap.

3.2.1. Entrepreneurs and Legitimacy

One of the common themes in research on entrepreneurial challenges is legitimacy of the new firm and its area of business. Organizational ecology theories have been applied to study the "liability of newness" and growth of organizational populations (Baum et al. 1995 and Hannan et al. 1995). In the area of strategic management, legitimacy issues have a long research history (Powell et al. 1991 and Suchman 1995). However, according to Zimmerman et al. (2002), research on new venture legitimacy "is in its infancy."

Independent of the industrial sector, entrepreneurial firms face common challenges such as raising capital from skeptical sources and recruiting untrained employees (Aldrich et al. 1994). Aldrich et al. find that, in the process of industry formation, the constraints that entrepreneurs face emerge from two sources: lack of cognitive legitimacy and lack of sociopolitical legitimacy. By cognitive legitimation, Aldrich et al. mean the spread of knowledge about a new venture. For example, this can be measured as the level of public knowledge of an activity. Sociopolitical legitimization is a process by which key stakeholders and the general public accept a venture as appropriate and right, given existing norms and laws. Aldrich et al. suggest that legitimization processes take place at four levels: organizational, intraindustry, interindustry, and institutional. Industry level legitimacy (Hannan et al. 1989 and Scott 1995) is a measure of the degree to which the solutions offered by organizations in a given industry are accepted as appropriate and right. The lack of external validation (Stone et al. 1996), which can be regarded as part of sociopolitical legitimization, has also been discovered to be a challenge of new ventures.

Suchman (1995) divides legitimacy into three main components: pragmatic, moral, and cognitive. Pragmatic and moral legitimacy concern mostly the firm's stakeholders; cognitive legitimacy is more general and refers to society at large. Schoonhoven et al. (2001) emphasize the importance of legitimacy in entrepreneurship. Schoonhoven et al. argue that "entrepreneurial activity arises from the collective activity of entrepreneurs and others, such as venture capitalists, lawyers, and industry professionals, who together actively create and sustain legitimate market space for new products, services, and technologies." In other words, legitimacy-building is a cooperative process. According to Meznar et al. (1993), gaining legitimacy among the firm's stakeholders is of a great importance. Meznar et al. argue that the ultimate survival of the firm may hinge on adequately managing the relationship between the organization and its social and political stakeholders. Human et al. (2000) carried out a study

on two multilateral networks of small- and medium- sized firms in the U.S. wood products manufacturing industry and found that three forms of network structure had to be legitimized in order to succeed: network as a form, network as entity, and network as interaction. According to Human et al., building the legitimacy of the basic network form must happen early in the evolutionary process of the firm.

3.2.2. Entrepreneurial Strategies

Even though entrepreneurship and new venture creation have been studied widely, factors that consistently lead to entrepreneurial success have not been identified (Low et al. 1997). Low et al. note that the surrounding environmental context has usually been a strong determinant of success or failure. To address this problem, Low et al. identified factors related to industry evolution and showed that emerging, growing, and mature industries present a different set of entrepreneurial challenges.

In order to overcome legitimacy challenges, Aldrich et al. (1994) suggest that the firm founders must build a reputation of the new industry as a reality, "as something that naturally should be taken for granted by others." One approach to reputation-building is framing (Aldrich et al., Nelson et al. 1999, and Elsbach et al. 2000) or impression management (Elsbach et al. 1992). However, firms must be careful in their legitimization-building. Otherwise, their efforts will backfire and "produce the opposite effect of that desired" (Ashforth et al. 1990). Singh et al. (1986) has proposed third-party endorsement as a strategy to avoid legitimization-building looking like self-promotion. Development of entrepreneurial strategies is especially challenging when the number of firms in an industry is small and no role models exist, leading to a lower chance of survival (Aldrich et al.).

To gain sociopolitical legitimacy, Aldrich et al. (1994) suggest that entrepreneurs create stories that explain events. Lounsbury et al. (2001) suggest that stories play a critical role in the process that enables new businesses to emerge. According to Lounsbury et al., stories may enable resource flows to the new enterprise, as the stories that are told by or about entrepreneurs define a new venture in ways that can lead to favorable interpretations of the venture's wealth-creating possibilities. Entrepreneurial stories may also help potential entrepreneurs, venture capitalists, and other institutional actors who need to direct their attention to only the highest potential opportunities in complex environments to make future venture decisions (Lounsbury et al. 2001). According to Lounsbury et al., since many

entrepreneurial ventures are unknown to external audiences, the creation of an appealing and coherent story may be one of the most crucial assets for a nascent enterprise, as the key aspect of stories is their ability to reduce uncertainty. In addition to stories, Lounsbury et al. recommend seeking of formal credentials awarded by recognized accreditation bodies or other third parties.

According to Suchman (1995), legitimacy-building strategies fall into three clusters: efforts to conform, efforts to select, and efforts to manipulate. Conforming means positioning the firm within a preexisting institutional regime and selecting an environment that will grant the organization legitimacy "as is" without demanding many changes in return. Manipulation strategy is intended for firms and innovators who depart substantially from prior practice. According to Lounsbury et al. (2001), positive media coverage of an industry provides generalized institutional capital that individual entrepreneurs can draw on to facilitate their efforts to create new organizations. Lounsbury et al. point to Internet entrepreneurs as an example and note that they "do not expend energy on creating stories to legitimize the Internet itself, since society and financial gatekeepers have already bought in." However, firms should be careful to not "overdo" their story. Lounsbury et al. point out that "it is important to balance the need for legitimacy by abiding by societal norms about what it appropriate with efforts to create unique identities that may differentiate and lend competitive advantage."

As mentioned earlier, Aldrich et al. (1994) suggest there are four levels where legitimation processes take place: organizational, intraindustry, interindustry, and institutional. For each level, Aldrich et al. suggest entrepreneurial strategies that promote new industry development. Table 2 demonstrates these suggested different strategies.

Table 2 Entrepreneurial Strategies to Promote New Industry Development

Level of Analysis	Cognitive Legitimacy	Sociopolitical Legitimacy
Organizational	Develop knowledge base via symbolic language and behaviors	Develop trust by maintaining internally consistent stories
Intraindustry	Develop knowledge base by encouraging convergence around a dominant design	Develop perceptions of reliability by mobilizing to take effective action
Interindustry	Develop knowledge base by	Develop reputation of new activity as

	promoting activity through third-party actors	reality by negotiating and compromising with other industries
Institutional	Develop knowledge base by creating linkages with established educational curricula	Develop legitimacy by organizing collective marketing and lobbying efforts

Several other studies have been carried out at the intraindustry level. Van de Ven et al. (1989) study the intraindustry legitimacy challenges and conclude that dominant design is important for technology-based industries, since a multiplicity of standards and designs may create confusion in the market and undermine legitimacy. However, endorsing a dominant design may not always be beneficial. Garud et al. (2002) find, in the study of Sun Microsystems and its sponsorship of Java technology, examples of the challenges that arise when a firm attempts to function as an institutional entrepreneur and tries to push a common industry standard, effectively a dominant design. According the Garud et al., "standards in the making generate seeds of self-destruction."

Although cooperation between the industry players may be beneficial in order to overcome legitimacy challenges, it also contains risks for small firms. Alvarez et al. (2001) find that, although large firms are usually able to gain access to an entrepreneurial firm's new technology through an alliance, the long-term success of entrepreneurial firms can actually suffer from their alliances with large firms since it is often very difficult for the entrepreneurial firm to learn about and imitate the large firm's organizational resources and capabilities.

As mentioned earlier, Human et al. (2000) argue that three forms of network structure need to be legitimized in order for the firm to succeed. According to Human et al., successful evolution of an industry "depends on legitimizing the network as form, both to members and to external groups, such as funders." The second form of network structure that needs to legitimized is "network as entity," meaning that the network has to develop a recognizable identity that would allow both members and outsiders to perceive the network as a legitimate entity. According to Human et al., a lead organization may take a critical role in developing an identity for the network. In the networks they studied, the lead organization was the network administrative organization. The third and final dimensions, network as interaction and the interaction process, need to be legitimized so that network members would be willing

to work together to build and maintain the levels of involvement and norms of cooperation (Human et al.).

Gans et al. (2003) introduce commercialization strategy environments for technology entrepreneurs. They divide the strategy environments into four areas: the attacker's advantage, greenfields competition, reputation-based ideas training, and idea factories. Table 3 demonstrates the strategies available to start-ups in each of the four strategy environments and briefly describes each of the four strategy environments.

Table 3 Impact of Commercialization Environment on Start-Up Strategies

Commercialization Environment Type	Description of the Environment	Available Start-Up Strategy
Attacker's advantage	❖ Non-excludable technology ❖ Overturns incumbent asset value	❖ Few opportunities for effective contracting ❖ Opportunity to exploit technical leadership to capture market leadership ❖ Performance depends on "stealth" product market entry
Reputation-based ideas trading	❖ Non-excludable technology ❖ Reinforces incumbent complementary assets	❖ May be few opportunities for contracting ❖ Product market entry risk due to high costs and imitation risk ❖ Performance depends on existence of incumbent commitment to ideas trading
Greenfields competition	❖ Excludable technology ❖ Overturns incumbent asset value	❖ Ideal opportunity to choose between contracting and product market entry ❖ Opportunity to use temporary monopoly power to build future positioning ❖ Performance depends on strength of technological competition
Idea factories	❖ Excludable technology ❖ Reinforces	❖ Contracting with established firms ❖ Product market entry is very costly and perhaps impossible

Commercialization Environment Type	Description of the Environment	Available Start-Up Strategy
	incumbent complementary assets	❖ Performance depends on securing bargaining power

3.3. Industry Incumbents and New Market Creation

According to Day et al. (2000), there are four common pitfalls for incumbents in dealing with emerging technology: delayed participation, sticking with the familiar, reluctance to fully commit, and lack of persistence. Delayed participation is due to mental models that cause managers to see only what they are prepared to see, framing the emerging technologies as suitable only for narrow applications not demanded by existing customers and the tendency of managers to compare the first imperfect and costly versions of the emerging technology against the refined versions of the established technology. The second pitfall, sticking with the familiar, is caused by past success that reinforces certain ways of problem-solving, lack of in-house capability to fully appraise the emerging technology, and a proprietary mind-set that gets in the way. According to Day et al. (2000), the first and second pitfalls are rooted in two decision-making biases, namely aversion to ambiguity and risk, and a deep-seated preference for the status quo. The third pitfall, reluctance to commit fully, consists of five causes: the fear of cannibalizing existing profitable products; managerial tendency towards bold forecasts on the one hand and timid choices on the other; usage of customary decision processes that tend to be biased against risky and long-term investments; managerial focus on the current customers; and the tendency of successful organizations to have closely aligned strategy, capability, structure and culture, which makes it difficult to respond to a discontinuous change. The fourth pitfall, lack of persistence, is especially common for firms that are very committed to their core business. What matters more than the financial commitment is the emotional and strategic commitment on behalf of the senior management.

Levinthal (1997) studied the ability of existing organizations to respond to changing environments. According to Levinthal, incumbents in general may have difficulty in adapting to changing environments because the changes negate the value of some of the organization's existing assets. Levinthal argues that tightly coupled organizations are worst off, since efforts at search and experimentation tend to negate the advantages and wisdom associated with established policies and thereby place the organization at risk of failure. According to

Henderson et al. (1990), incumbent firms often fail to recognize destruction brought about by "architectural innovations" that change the architecture of the product without changing its components. Henderson et al. describe that "the essence of an architectural innovation is the reconfiguration of an established system to link together existing components in a new way." Sharma (1999) notes that it is not that incumbents' lack creativity and ability to invent new things, but it is "the inertia of past actions, the stifling effects of bureaucracy, and the inflexibility of collective mind-sets that inhabit large firms." According to Miller et al. (1975), people are more likely to attribute their success to ability and failures to luck than their successes to luck and failures to ability. This leads to a situation where persistent failure leads to a tendency to overestimate the risks and persistent success leads to a tendency to underestimate those risks (Levinthal et al. 1993 and Kahneman et al. 1993).

3.3.1. Organizational Culture and Incumbent Firms

The industry in which the incumbent firm operates is of importance when considering the right strategy to respond to a changing environment. According to Gordon (1991), industries cause cultures to develop within defined parameters. Thus, certain cultural characteristics will be widespread among organizations in the same industry, and these are most likely different from characteristics found in other industries. Because of this relationship, the potential for changing a company's culture is limited to actions that are neutral to, or directionally consistent with, industry demands. Gordon identifies three dimensions: the competitive environment, customer requirements and societal expectations, as elements around which industry-driven assumptions are developed.

Companies are said to carry industry mindsets (Pablo 1999) and follow industry recipes (Spender 1989) or mental models that are "deeply held internal images of how the world works, images that limit us to familiar ways of thinking and acting" (Senge 1990). Chatman et al. (1994) studied similarities in the culture of firms in the same industry. They found that stable organizational culture dimensions existed and varied more across industries than within groups of firms in a particular industry. According to Chatman et al., innovation, stability, an orientation toward people, an orientation towards outcomes or results, and emphasis on being easygoing, attention to detail, and a collaborative or team orientation are pervasive organizational culture themes. Similar findings have been reported by Johnson et al. (1987) in their study on the brewing industry: "The findings of the study [...] highlight the need for the

study of strategies and performance to be carried out in the context of the industry to which the strategies are relevant."

3.3.2. Innovation and Incumbent Firms

Liabilities of bureaucracy, inertia that accompanies organizational size, and aging have contributed to a common perception that new company start-ups are more innovative than established large firms (Chandy et al. 2000). In addition, radical changes in the business environment can render the skills of the incumbent firms obsolete (Tushman et al. 1986). Ahuja et al. (2001) identify three traps that inhibit breakthrough inventions in established firms: favoring the familiar (familiarity trap), favoring the mature (maturity trap), and favoring the search for solutions near to existing solutions (propinquity trap). According to Ahuja et al., organizations can overcome these traps and create breakthrough inventions by experimenting with novel, emerging, and pioneering technologies.

Christensen et al. (1996) studied the disk drive industry and show that established firms "led the industry in developing technologies of every sort whenever the technologies addressed existing customers' needs." However, the same firms were unable to develop simpler technologies that were initially useful in emerging markets. According to Christensen et al. (1996), "projects targeted at technologies for which no customers yet exist languish for lack of impetus and resources." Christensen (1997) introduced a model of disruptive innovation that attempts to explain why current industry leaders do well with sustaining innovations but why disruptive innovations are usually launched by entrant firms. Christensen defines sustaining innovation as one which offers existing customers products that have better performance than what was previously available. Disruptive innovations do not bring better products to the market but redefine the development trajectory by introducing less advanced products that have other merits, such as simplicity or lower costs, targeting new or less demanding customers. The disruptive innovation gains a foothold in the marketplace and starts a cycle of innovation improvement. Once the disruptive innovation improves to the level of more demanding customers, the downfall of incumbent firms begins. Day et al. (2000) emphasize the use of "early indicators" in order to spot emerging technologies. Day et al. encourage firms to look past disappointing results and limited functionality and argue "many signals are available to those who look."

Chesbrough (2001) reviewed 16 empirical studies of the impact of technological change upon incumbent firms and proposed a framework consisting of three dimensions that synthesize the findings of the literature: challenge of managing technical complexity, importance of external linkages, and the institutional environment. According to Chesbrough, the technical complexity dimension suggests that problems of internal coordination may be partly to blame. External linkages are important in managing linkages between firms in the value chain, and to access and absorb knowledge from the external environment. According to Chesbrough, institutional differences between countries may partly explain the differences in the frequency and impact of start-up firms that arise from technological change.

3.3.3. Corporate Venture Capital (CVC)

> *Big companies want to control the technologies that affect their businesses, but they're disenchanted with the idea of sinking huge amounts into research and development that may never see the light of day. It's far better, they seem to be saying, to turn the R&D effort into a profit center.*
>
> *-- Business Week (1999)*

Chesbrough (2003) has introduced a concept of open innovation which states that "in a world of widely distributed knowledge, a company must access external technologies for use in its business and allow its technologies to be accessed by other firms' businesses" (Chesbrough et al. 1996). Stopford et al. (1994) argue that "troubled firms in hostile environments can shed past behaviors, adopt policies fostering entrepreneurship, and accumulate innovative resource bundles that provide a platform on which industry leadership can be built." Corporate entrepreneurship offers the firm a possibility to learn about new technologies and markets and acquire new operational skills (Ahuja et al. 2001 and Dess et al. 2003). One available strategy to access external technologies and foster entrepreneurial activities is the operation of a corporate venture capital (CVC) fund. Corporate venture capital can be described as equity investment into entrepreneurial ventures by established corporations. The investment into start-up companies by incumbents "serve[s] as a bridge that connects incumbents to start-ups that are exploring diverse and oftentimes competing new technologies that could evolve into technological discontinuities" (Maula et al. 2003). According to Schildt et al. (2005), companies are likely to select a less integrated governance mode, such as corporate venture capital, when they conduct risky explorative ventures. Schildt et al. argue that corporate

venture capital and alliances are the least expensive way for a company to conduct external corporate venturing activities, and may also allow the company to limit its risks.

Most firms create CVC funds with a dual mission in mind, as their goal is to reach financial objectives (Block et al. 1993, Chesbrough 2002, and Siegel et al. 1988) and create strategic benefits for the parent firm (Rind 1981, Siegel et al. 1988, Sykes 1990, Block et al. 1993, Maula 2001, and Chesbrough 2000 and 2002). The financial objective is to reach rates of return similar to independent VC funds. However, for many firms, gaining strategic benefits is more important than reaching the financial goals (Block et al. 1993, Rind 1981, and Sykes 1986). Some examples of strategic benefits are identifying future products or technologies, understanding management strengths or weaknesses in acquisitions, designing products faster and at lower cost, gaining a window on technology, and offering a way of studying new markets (Rind 1981).

Most corporations set up a dedicated organization to operate as an intermediary between the venture and the corporation, or alternatively manage the investments through a traditional venture capital firm (Keil 2000, Miles et al. 2002). According to Maula et al. (2003), CVC investments allow incumbents to develop deep relationships with multiple start-ups, making it possible for them to observe their technological skills and understand their goals, resources, and business models. Gompers (2002) shows that CVC investments have been at least as successful as independent VC investments in financial terms and the probability of success is substantially higher for funds operating in industries related to the parent company business. Maula et al. argue that corporate venture capital activity supports the ability of a firm to early recognize technological discontinuities that may threaten the firm. The recognition of threats and learning takes place as incumbents gain access to social networks of venture capitalists by participating in syndication networks. According to Maula et al., the technology recognition effects of CVC investments are best understood by analyzing the structure of incumbents' investment portfolios and how they position incumbents in emerging social networks. Maula et al. argue that incumbents' CVC investments should be use to complement their internal R&D spending that enhances organizational learning and keeps incumbents' knowledge current.

3.3.4. CVC Challenges and Success Factors

> *A corporate venture capital program that has lasted more than 10 years is hard to find.*
>
> *-- Business Week (1999)*

The financial outcome of CVC funds has been found to vary greatly (Sykes 1986, Siegel et al. 1988, Gompers et al. 1998, and Chesbrough 2000). This naturally depends both on the original goals of the fund, (i.e., whether strategic benefits were allowed to override financial objectives) and the way the fund was managed. According to Siegel et al. (1988), CVC funds that enjoyed greater autonomy in investment decision-making and longer-term financial commitment to the venturing activity reached higher financial return on investment and at least as good strategic benefits as the funds with less autonomy and corporate commitment. Gompers et al. (1999) report similar findings on the importance of a high degree of autonomy. They conclude that greater autonomy, combined with long-term commitment, prevents the current corporate management from viewing the CVC fund as the pet project of its predecessors. However, CVC funds have also their benefits. For example, Maula (2001) found that ventures backed by CVCs fared better in initial public offerings than those backed by independent VCs. Gompers et al. (1998) have reported that ventures backed by corporate VCs were as successful as those backed by independent VCs when the lines of business of the venture and the investing corporation were similar. This indicates that some firms have been able to use their complementary capabilities to advance the ventures in the CVC fund portfolio (Gompers et al. 1998) and thus gain a competitive edge over independent VCs.

The high failure rate of CVC funds reveals that such an activity has its operational challenges. Challenges faced by the funds may be one reason for the cyclical nature of CVC funds. In general, CVC funds have been found to be more volatile than independent VC funds (Gompers et al. 1998). According to Chesbrough (2000), “the general pattern is a cycle that starts with enthusiasm, continues into implementation, then encounters significant difficulties, and ends with eventual termination of the initiative.” Sykes et al. (1995) argue that the root of the CVC management problem in corporations is a preconceived mental model about how new ventures should be managed and how performance should be measured. Examples of challenges are problems with venture manager incentives (Block et al. 1987 and Chesbrough 2000), internal politics (Sykes 1986), or inadequate financial commitment (Siegel et al. 1988). One of the most often cited obstacles is a low level of fund autonomy (Siegel et al. 1988) that

often accompanies the execution of strategic goals. Insufficient autonomy of the fund was a direct cause of the following four obstacles in CVC fund management: lack of clear mission, lack of patience, lack of flexibility, and inability to relinquish control to the CVC fund (Siegel et al. 1988). Furthermore, those CVCs that enjoyed organizational independence were generally more effective, as they could respond more aggressively to investment opportunities. Greater autonomy in investment decision-making may also enable the fund to pursue alternative business models in the invested ventures, which is one of the advantages of independent VCs over CVCs (Chesbrough 2000).

Forlani et al. (2000) suggest that new venture investments should be entrusted to individuals whose risk propensities and other individual characteristics best match the needs of the market opportunity and a prospective investor's objectives. According to Winters et al. (1988), the most important factors for the strategic success of an external corporate venturing program are the creation of a high-quality deal stream and the use of outstanding people to interface between the corporation and the venture capital world. Winters et al. also note that there needs to be a long-term commitment, active involvement, and a carefully devised internal communications strategy to promote and protect the program. According to Chesbrough et al. (2003), most of the corporate investment programs that endured through the downturn in venture capital in the early 2000s are ones that were managed by outside professional investors.

3.4. Financing Industry Creation

According to Cassar (2004), how business start-ups are financed is one of the most fundamental questions of enterprise research. Cassar argues that capital decisions and use of debt and equity at start-up have been shown to have important implications for the operations of business, risk of failure, firm performance, and the potential of the business to expand. The main financing sources available for entrepreneurial ventures are venture capital, so-called angel money, corporations, banks, government grant programs, and self-financing by family and friends. Business angels or angel investors are often referred to as providers of informal venture capital (Mason et al. 1999), consisting of wealthy individuals with an interest in investing in young companies. According to Mason et al. (1999), informal venture capital is the main source of risk finance for early growth, start-up, and seed stage firms. Venture capitalists provide early-stage and expansion-stage financing and will typically look at exiting their investment two to eight years after investing, typically through initial public offerings

(IPOs) or trade sales. Between expansion stage and IPO, there may be additional financing rounds by private equity funds. For a healthy venture capital market, it is essential that there is sufficient capital and know-how on all stages of the VC cycle, as well as exit opportunities. Corporations invest in entrepreneurial ventures either directly or through an intermediary organization, such as a corporate venture capital fund, as described earlier. Banks provide loans or engage in a venture capital investment through a bank subsidiary, but they tend to be generally more conservative investors (Hellman et al. 2000). Hellman et al. provide a short review of entrepreneurial financing options and conclude, "It seems reasonable to conjecture that venture capitalists are a somewhat distinct type of investor who specialize in the financing of entrepreneurial companies." According to Cassar (2004), the larger the start-up is, the greater is the proportion of debt, long-term debt, outside financing, and bank financing the start-up holds. Cassar also finds that firms with a relative lack of tangible assets appear to be financed through less formal means, where non-bank financing, such as loans from individuals unrelated to the business, plays a more important role in the capital structure of the start-ups.

3.4.1. Venture Capital (VC)

Venture capital (VC) can be defined as investment of long-term, risk equity finance by professional investors in new firms where the primary reward is eventual capital gain (Wright et al. 1998). The typical venture capital firm is organized as a limited partnership, with the VCs serving as general partners and the investors as limited partners (Gifford 1997). General partner venture capitalists act as agents for the limited partners investing in their funds. Venture capitalists do not only provide financial capital, but also take an active role in firm decision-making. This is due to the specific situation of new ventures, which are characterised by high levels of uncertainty and information asymmetries between insiders and outsiders. Therefore, VCs are typically highly specialized in identifying, investing in, and monitoring new firms in a specific sector and at a specific stage of development of a company. As Wright et al. (1998) note, "venture capital is particularly appropriate in a specific subset of firms which have non-redeployable or highly specialized assets." Amit et al. (1998) show that VC funding concentrates on industries where the importance of monitoring and due diligence is particularly great due to informational asymmetry.

Mason et al. (1999) refer to an industry folklore of the 2:6:2 rule on venture capital investing, when it comes to VC investment risk: an average portfolio contains two losses (the lemons),

six moderately performing investments (the living dead), and two very successful investments (the plums). Fiet (1995) divides venture capital investment-related risk into two parts: agency risk and market risk. Market risk is associated with unforeseen competitive conditions affecting the size, growth, and accessability of the market, and factors affecting the market demand, which may be influenced by changes in a venture's industry environment. Divergent interests of principals (VCs) and agents (entrepreneurs) are the cause of agency risk. According to Fiet (1995), venture capitalists enjoy a much more efficient flow of information when compared to business angels, and trust mainly other venture capital firms in information gathering. According to Fiet, "presenting a request for funding to one of [venture capital firms] will quickly result in sharing of it among their informant associates." Tyebjee et al. (1984) argue that VCs use five characteristics when they assess a deal. The characteristics are highlighted in Table 4.

Table 4 Characteristics Used by VCs in Deal Assessment

Characteristic	Description
Market attractiveness	❖ Size of market ❖ Market need ❖ Market growth potential ❖ Access to market
Product differentiation	❖ Uniqueness of product ❖ Technical skills ❖ Profit margins ❖ Patentability of product
Managerial capabilities	❖ Management skills ❖ Marketing skills ❖ Financial skills ❖ References of entrepreneurs
Resistance to environmental threats	❖ Protection from competitive entry ❖ Protection from obsolescence ❖ Protection against downside risk ❖ Resistance to economic cycles
Cash-out potential	❖ Future opportunities to realize capital gains

3.4.2. VC and Entrepreneurs

According to Chesbrough (1999), venture capital allows new firms to enter the industry by creating high risk / high reward positions for talented managers and engineers. Incumbent firms are the main available pool of experienced engineering and management talent on which the VC community depends (Chesbrough 1999). On the other hand, Gompers et al. (2005) suggest that the ultimate success of VC-backed firms is bounded because employees of the firm are likely to leave to start their own ventures when the firm growth slows. Chesbrough observes that, when there is relatively little external capital available for new venture formation, incumbent firms do not confront the prospect of losing people or customers to new start-up competitors. Gompers et al. shows that existing public companies are an important source of entrepreneurs for venture-capital backed start-ups, especially those corporations with patents in areas that venture capitalists are interested in.

Hellmann et al. (2000) study the factors that determine whether entrepreneurs are able to raise venture capital. Their study of high-tech start-ups in Silicon Valley shows that innovator firms are more likely to obtain venture capital than imitator firms. In addition, Hellman et al. shows that venture capital shortens the time to market for new innovative products. Also, the presence of a venture capitalist is associated with a significant reduction in the time required to bring a product to market. According to Hellmann et al. (2000), firms also list obtaining venture capital as a significant milestone in the lifecycle of the company as compared to other financing events. According to Amit et al. (1990), failure rates among venture capital-backed firms is higher than in the population of new firms because the most promising entrepreneurial firms will not seek venture capital financing. Carpenter et al. (2003) find that, although venture capitalists are risk specialists, technology-based IPO firms are less likely to have extensive global sales when they are backed by a VC. Carpenter et al. also find that VCs are risk-seeking when VC backing is complemented by the international experience of their board appointees, top management team members, or both. To understand what venture capitalists are looking for in an entrepreneurial firm, a profile of “the ideal entrepreneur” (Zider 1998) is presented in List 2.

List 2 Profile of Ideal Entrepreneur from VC Perspective

Ideal Entrepreneur, from a Venture Capitalist's Perspective
❖ Qualified in a "hot" area of interest
❖ Delivers sales or technical advances, such as FDA approval, with reasonable probability
❖ Tells a compelling story and is presentable to outside investors
❖ Recognizes the need for speed to IPO for liquidity
❖ Has a good reputation and can provide references that show competencies and skills
❖ Understands the need for a team with a variety of skills and therefore sees why equity has to be allocated to other people
❖ Works diligently toward a goal but maintains flexibility
❖ Gets along with the investor group
❖ Understands the cost of capital and typical deal structures and is not offended by them
❖ Is sought after by many VCs
❖ Has realistic expectations about process and outcome

3.4.3. VC and Cleantech Ventures

Lack of capital is cited by many entrepreneurs as a barrier to growth, or sometimes even for the failure of the start-up (Amit et al. 2000). According to O'Rourke (2004), ventures that are environmentally oriented face the same financing barrier as other ventures, but also have an additional hurdle to overcome: investors who do not recognize or understand the environmental sector. Other than O'Rourke (2004), there are only a few other studies that have explored VC and investing in green technology, cleantech, or environmental technology (Diefendorf 2000, Wuestenhagen et al. 2006, and Randjelovic et al. 2003). Randjelovic et al. noted that defining a venture capital category for "green venture capital," "ecological," or "environmental" venture capital is difficult. During the past few years, the terms "clean energy" and "cleantech" have become more commonly used in the investment circles.

O'Rourke (2004) introduced four strategic levels of sustainable VC: (1) VC investments that target enterprises and technologies that deliver socially, financially, and environmentally sustainable returns and avoid investing in clearly unsustainable practices; (2) VC practices that guide companies in adding value but prevent the potential negative environmental and social impacts of new ventures; (3) VC work that aims to develop market and stakeholder support for sustainable products and services; and (4) VC activity that generates financially,

socially, and environmentally sustainable rates of return on investment. According to O'Rourke, the apparent blindness of VCs to the sustainability or environmental sector often results in under-investment in such ventures and makes it even harder for new environmentally oriented business ventures to be launched. O'Rourke accuses VCs of "waiting for some spectacular success stories to emerge" and argues that treating sustainable or green VCs as a niche market actively marginalizes the concept of sustainable development within the finance sector and reduces the many different ways that VCs could develop more sustainable ventures across their whole portfolios. Regarding clean energy sector, Sonntag-O'Brien (2003) argued that there is a general lack of understanding of the clean energy industry among mainstream financial institutions. Information, experience, and tools are needed to anticipate and quantify product and project risks in the clean energy sector and develop strategies to mitigate and hedge them. According to Sonntag-O'Brien, experience from the wind energy sector has shown that, when investors are able to understand and judge the risks, the money starts to flow.

3.4.4. VC Investment Decision-Making

It is not so much that people hate uncertainty – but rather they hate losing.

-- Amos Tversky (1990)

Behavioral finance aims to explain what drives investment decision-making behavior and tries to find explanations for it from psychology. A short review of the theories and psychological phenomena that behavioral finance uses to explain investor behavior is demonstrated in Table 5.

Table 5 Review of Behavioral Finance

Phenomenon	Description
Anchoring	Anchoring effect takes place when decision is made adjusting from an existing position (Tversky et al. 1974, Northcraft et al. 1987, and Shiller et al. 1996).
Information constraints	Information constraints include problems of attention, memory, comprehension, and communication (March 1994).
Problem framing	Problem framing occurs when decision makers adopt paradigms to tell themselves what perspective to take on a problem, what questions should be asked, and what technologies should be used to ask questions (Thaler et al. 1990, and March 1994).

Phenomenon	Description
Prospect theory	Prospect theory states that people are risk-averse when facing gains but become risk-seeking when facing losses (Kahneman et al. 1979, Feigenbaum et al. 1988, and Feigenbaum 1990).
Loss aversion	Loss aversion refers to the tendency of people to strongly prefer avoiding losses to acquiring gains ((Tversky et al. 1991, and Kahneman et al. 1991).
Overconfidence; hindsight and success-induced bias	Examples of overconfidence (Odean 1998) are hindsight bias and success-induced bias. Hindsight bias occurs when events that happen are thought of as having been predictable prior to the event, in comparison to events that do not happen that are thought of as having been unlikely prior to the event (Goitein 1984 and Bukszar et al. 1988). Because of success-induced bias, people are more likely to attribute success to ability and failure to luck (March 1994).
Ignorance of probability distributions	Ignorance of probability distributions leads people to consider those events more probable which they find easier to imagine (Tversky et al. 1974 and Camerer et al. 1992).
Mental accounting	Mental accounting refers to a process of coding, categorizing, and evaluating outcomes (Thaler 1985 and Thaler et al. 1990), which in turn affects decision-making.
Status quo bias	Status quo bias states that people have a marked preference to keep things the way they are (Kahneman et al. 1991).

Sitkin et al. (1992) review previous research on decision-making behaviour in risky organizational situations and find several contradictory results. Sitkin et al. argue that the conflicting results are due to two main factors: (1) issue-oriented focus that leads to oversimplified models of individual risk behavior and (2) studies that identify characteristics that are claimed to influence risk behavior directly, instead of mediating, indirect effect. Sitkin et al. further argue that once the findings of previous studies are reformulated, contradictory findings are reconcilable. They propose a new model on risky decision-making behavior that is based on the results of previous studies but reconciles the contradictions present in the results.

The Sitkin et al. (1992) model is briefly discussed in more detail, as the model is used in chapter 7 to reflect and refine the findings of this dissertation. The Sitkin et al. model was chosen since the model has been successfully applied to previous research on

entrepreneurship and venture capital (Mullins et al. 2002, Carpenter et al. 2003, Manigart et al. 2002, and Simon et al. 2000). The Sitkin et al. model of the determinants of risk behavior is based on two mediating mechanisms: risk propensity and risk perception. Risk propensity acts to shift decision-makers' attention regarding risk-related information, influencing what information is used and what is discarded. In the Sitkin et al. model, decision-maker risk propensity has three determinants: risk preferences, inertia, and history of risk-related success and failure. Risk perception is an individual's assessment of risk in a particular situation. In the Sitkin et al. model, decision-maker risk perception has six determinants: risk propensity, problem framing, top management team homogeneity, social influence, problem domain familiarity, and organizational control systems. Sitkin et al. (1995) tested the model further using only one determinant of risk propensity (i.e., outcome history) and two determinants of risk perception (i.e., problem framing and risk propensity). The results of Sitkin et al (1995) support the inclusion of risk perception and risk propensity as mediators of effects on risky decision-making behavior. They also lend support for direct effect of problem-framing on risky decision-making behavior.

The goal of venture capitalist decision-making is to assess the possibility for success and the risk of failure by evaluating the information surrounding a particular venture and the industry in which it operates. Venture capitalists have developed several financial risk management tools, some of them exhibited in Table 6, to minimize their downside exposure in case the venture does not perform. In making the decision to participate in the new venture, the venture capitalist has few hard facts to rely on, making the venture capitalist rely heavily on his assessment of the entrepreneur's ability to develop the new venture (Amit et al. 1990). Uncertainties regarding business models, lack of codified operating and industry data, and investor inexperience with similar firms all present market participants with the potential of investing in "virtual lemons" (Sanders et al. 2004).

Table 6 Venture Capital Industry Strategies to Manage Risk

Way to Manage Financial Risk	Result
Staging of investments	Reduced financial risk, as not all of the money is invested up front. This gives a possibility for the venture capitalist to either back out from investing more or "re-value" the company at each stage.

Way to Manage Financial Risk	Result
Syndicating deals with other investors	The total investment burden is shared with two or three other venture capitalists, diminishing the exposure to risk. This also creates a possibility to participate in several deals and offers a possibility to diversify the investment portfolio.
Use of preferred shares by venture capitalists	Guarantees a senior position in the case of liquidation of the venture.
Anti-dilution provisions	Right to purchase securities in subsequent rounds of financing on the same terms offered to outside investors.
Use of debt instead of equity	Portion of the risk may be placed in the form of subordinated debt, which may even accrue interest.

According to Gifford (1997), venture capital contracts have three main characteristics: (1) staging the commitment of capital and preserving the option to abandon, (2) using compensation systems directly linked to value creation, and (3) preserving ways to force management to distribute investment proceeds. Chesbrough (2003b) argues that the staging of venture capital investments, combined with the strong incentive alignment between the venture managers and their investors, creates an ability to adjust the direction of the venture rapidly as market and technical uncertainties are resolved. Chesbrough contrasts the venture capital practice to internal capital market of a firm and notes that the process that allocates capital through an annual capital budgeting process is "much less suitable for early-stage ventures experimenting in areas of high uncertainty that lie far from the primary business of the firm."

Previous research on decision-making in venture capital includes descriptions of decision-making stages, followed by expressions of doubt on the logical behavior of venture capitalists, and recently some studies on the cognitive elements in venture capitalist decision-making. In addition, some research has been carried out on perceived risks and differences in risk-taking propensity among entrepreneurs' new venture decisions (Forlani et al. 2000 and Simon et al. 2000). Tyebjee et al. (1984) presents the venture capitalist decision-making as a process consisting of five steps. The steps are: (1) deal origination, (2) deal screening (3) deal structuring (4) deal evaluation, and (5) post-investment activities. Fried et al. (1994) present a similar task-oriented and rational description of the venture capital decision-making process

consisting of six stages. Other studies on the venture capitalist decision-making process include Silver (1985) and Hall et al. (1993). MacMillan et al. (1985) studies the decision-making process from evaluation criteria perspective.

Various researchers have expressed their doubt on the accuracy of describing the venture capitalist decision-making process as a flow of logical steps. Roberts (1991) states, "venture capitalists are as different from each other as are individuals" and noted that finding consistent and learnable criteria for venture capital investment decisions is difficult. Sandberg et al. (1988), who studied venture capital decision processes, states, "Human decision-making cannot be understood by simply studying final decisions." Shepherd (1999) warns venture capital researchers of potential biases and errors with venture capitalist self-reported data. Shepherd notes further that "venture capitalists have a tendency to overstate the least important criteria and understate the most important criteria."

Studies that research the cognitive side of venture capitalist decision-making process are quite recent. Shepherd (1999) studies "espoused" and "in-use" decision-making policies of venture capitalists. In Shepherd's study, the term "espoused" is used to mean decision-making policies venture capitalists report and "in use" to mean those that they actually use. The study shows that several decision-making factors, such as industry-related competence, lead-time, and scope differed in importance when "in use" decision-making policies were compared to "espoused" decision-making policies. Shepherd notes that the results also show that venture capitalists have only limited introspection into their decision-making when assessing the likely profitability of a new venture proposal. A later study Shepherd carried out together with Zacharakis (Zacharakis et al. 2001) shows that venture capitalists are overconfident and have cognitive bias in their decision-making. Zacharakis et al. (1998) suggests that venture capitalists are not good at introspecting their own decision-making process. Zacharakis et al. (1998) argues that VCs may suffer from a systematic bias, caused by a lack of understanding of their intuitive decision-making process because of information overflow, that impedes the performance of their investment portfolio. Zacharakis et al. (1998) also finds that VCs are very consistent in their decision-making process, even though they do not necessarily understand how they make their decisions.

Although the elements of risk, risk propensities, and risk perceptions of venture capitalists have not explicitly been studied, Forlani et al. (2000) examine how risk propensities and risk perceptions affect entrepreneurs' new venture decisions. Forlani et al. state, "our results

suggest that investors should entrust their new venture investments to entrepreneurs whose risk propensities best match the needs of both the opportunity at hand and the investor's objectives." Simon et al. (2000) study new venture formation and conclude, "Our findings suggest that risk perceptions may differ because certain types of cognitive biases lead individuals to perceive less risk." Their study examines three types of biases: overconfidence, illusion of control, and belief in the law of small numbers, which occurs when the sample of information is too small to draw firm conclusions.

4. Methodology and Research Process

Chapters 1 through 3 present the study research questions and findings of previous research on industry emergence and evolution and the role of entrepreneurs and financiers in industry creation. Chapters 4 through 8 discuss the empirical study that was carried out and is used in theory building of this dissertation. This chapter presents methodology, research setting, and the research process. First, the methodological choices are discussed and justified. Second, the research setting is introduced, including the selection criteria for the interviewed investors and selection criteria for entrepreneurs that were included in the clean energy venture financing survey. A description of the wider research context, concentrating on clean energy market drivers and the clean energy and cleantech VC market development, will follow in chapter 5. Third, the research process is discussed, including a description of the data collection and analysis.

4.1. Methodological Choices

The empirical part of this study was collected from the clean energy technology sector. This sector was chosen because of its prominence among cleantech investment categories. Clean energy technologies have attracted the largest share, over 40%, of all cleantech VC investments (Parker 2005). The study consisted of three subsequent data collection phases, with emphasis on the first two:

VC and CVC funds: twenty-nine semi-structured, in-depth interviews were carried out with venture capitalists and corporate venture capitalists who have invested in the cleantech sector, and specifically to clean energy ventures. Face-to-face interviews were conducted in Europe and North America.

Clean energy ventures: A clean energy venture financing survey that consisted both of qualitative, essay-format questions and some quantitative questions was carried out. The survey results contain data from 164 clean energy ventures less than 10 years of age.

Other clean energy sector stakeholders: Data collection was conducted in the form of stakeholder interviews, media search, and attendance of conferences in the clean energy and cleantech area in order to gain a better understanding of the emerging clean energy and cleantech sector. Interviews with trade organizations, research park technology transfer officials, entrepreneurs, and other related actors were carried out. In addition, newspaper and

magazine articles and press releases concerning clean energy as an investment area were collected and analyzed. Clean energy conferences and other related events were attended.

The choice of qualitative approach and the usage of a variety of data collection methods are justified by the following arguments. This dissertation is concerned with the clean energy venture entrepreneurial challenges and the role VCs and large companies play in the development of the clean energy market. In order to capture the richness of the clean energy market emergence phenomenon, emphasis on the qualitative approach was found suitable, since the goal of qualitative studies is to gain an understanding of a complex problem area (Creswell 2003). Denzin et al. (2000) describe the qualitative researcher as a *bricoleur* who learns to borrow from many different disciplines. Denzin et al. describes the qualitative research approach as follows:

Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretative, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret phenomena in terms of the meanings people bring to them.

The following arguments exist for the use of the grounded theory approach, the use of empirical materials among them, interviews, and survey data. First, clean energy market emergence and the financing of clean energy ventures have received very limited attention in literature. Second, little coherent theory exists that would explain the biggest entrepreneurial challenges clean energy ventures face and the risk characteristics of clean energy ventures from VC perspective, especially the cognitive risk characteristics. Third, the cognitive side of VC decision-making has received insufficient attention in literature and little theory building exists on this matter. Also, no previous theory building exists regarding the link between clean energy market development and the role of VCs or corporate VCs. Therefore further explorative, theory-generating research is needed in order to establish such a body of theory.

Qualitative research is multi-method in focus (Flick 1998). Flick argues that combining multiple methodological practices, such as empirical materials, perspectives, and observers in a single study is a strategy to add rigor, breadth, complexity, richness, and depth to the research inquiry. According to Denzin et al. (2000), the use of multiple methods, also referred to as triangulation, reflects the attempt to secure an in-depth understanding of the

phenomenon in question. In grounded theory, one develops a theory, which is an abstract analytical schema of a phenomenon related to a particular situation (Creswell 1998). This situation is one in which individuals interact, take actions, or engage in a process in response to a phenomenon. To present the results, the researcher writes theoretical propositions or hypotheses or presents a visual picture of the theory (Creswell). According to Creswell, the grounded theory data collection methods involve primarily interviewing, but other methods can also be used. Grounded theory researchers use systemic procedures for analyzing and developing theory, with the overall tone of rigor and scientific credibility (Creswell).

Theory is a plausible relationship among concepts and sets of concepts (Strauss et al. 1998). According to Creswell (1998), in grounded theory study, the researcher typically conducts 20 to 30 interviews based on several visits "to the field" to collect data to saturate the categories of information. While the researcher collects the data, she or he begins analysis (Creswell). Creswell calls the analysis process a "zigzag," where the researcher ventures "out to the field to gather information, analyze the data, back to the field to gather more information, analyze the data, and so forth." Corbin et al (1990) propose the following three procedures for grounded theory analysis: open, axial, and selective coding. Open coding develops categories of information, axial coding interconnects the categories, and selective coding "builds the story." The process ends with the development of theoretical propositions (Strauss et al.).

In addition to empirical data, this dissertation uses existing literature in theory building. The proponents of traditional grounded theory methods advise that the researcher should allow the theory to emerge from the data only and ignore the findings of previous literature (Glaser et al 1967). However, later grounded theory proponents have taken a more permissive approach to the use of previous literature findings in theory building (Strauss et al. 1998). The purist's approach to grounded theory proposed by Glaser et al. (1967) received criticism as early as the 1960s. A review by Loubser (1968), published in the American Journal of Sociology, stated "Sociologists are urged to shed all the pre-conceived notions, received theories, and propensities to logical deduction, and to expose themselves to the data. Hence the problem of the relation between induction and deduction in scientific activity is solved by taking either-or position, declaring that induction is the best, if not the only, method." This dissertation uses previous literature to focus research issues, set criteria for the study, and refine the research findings.

4.2. Research Setting

The empirical focus of the dissertation is clean energy venture entrepreneurial challenges, VC and clean energy venture interaction, and performance of CVC funds that invest in clean energy ventures. In the area of clean energy, both VC and CVC funds have, during the last five years, showed rapidly increasing investment activity. The wider research context, clean energy market, will be discussed in more detail in chapter 5. The names of the 29 interviewed VC and CVC firms are disclosed, as is the time of the fund interview. However, for reasons of confidentiality, the names of the informants are not disclosed, neither are the quotes used in chapters 6 through 8 attributable to the interviewed firm name. The names of the 164 clean energy ventures whose survey responses are used in the study are not disclosed for reasons of confidentiality. A brief discussion of the three data collection phases and the logic behind the selection of the studied VCs, CVCs, ventures, and other clean energy sector stakeholders follows.

4.2.1. VC and CVC Funds

All together, 29 interviews were carried out among independent, corporate, and government-backed VCs, both in Europe and in North America during 2003-2005. The researcher personally carried out all except for three interviews. However, these three interviews followed the same format as the interviews conducted by the researcher herself. A written transcript was received from the three interviews. Table 7 shows the interviewed VC, CVC, and government-backed funds. Due to practical limitations, most of the interviews were carried out among European VCs and CVCs. The funds were identified through energy sector VC conferences, such as Cleantech Venture Forum[1] and European Energy Venture Fair[2], and

[1] www.cleantechventure.com

[2] www.europeanenergyfair.com

by crosschecking with the already interviewed funds. Almost all of the European VC and CVC funds that were actively investing in clean energy ventures in 2003-2004 were interviewed. In Spring 2005, additional interviews were carried out among North American VCs investing in clean energy ventures in order to lessen possible geographical bias.

All of the interviewed VC funds had made at least one investment into clean energy technologies. Most of the interviewed funds publicly promoted the clean energy sector as one of the fund's focus areas. It was essential to concentrate in one cleantech category only in order to acquire solid understanding of the research context, the clean energy sector. The clean energy sector was chosen as the source of cleantech empirical data for three reasons. First, the energy industry, which is one of the largest sectors of the economy, is currently under pressure to change. Second, the energy sector is attracting a growing amount of attention from VCs (Parker 2005). Third, since European CVC funds have been active investors in the clean energy market, it was expected that interesting and rich research data would be available if clean energy focus was chosen.

Table 7 Interviewed VC and CVC Funds

Fund Name	Fund Type	Parent Company Type	Fund Location	Interview Date	Interview Type
Norsk Hydro Technology Ventures	Corporate VC	Oil & gas	Norway	6.11 2003	Face-to-face (taped)
RWE Dynamics	Corporate VC	Utility	Germany	17.2 2004	Face-to-face (taped)
MVV/Accera	Corporate VC	Utility	Germany	18.2 2004	Face-to-face (taped)
Eon Venture Partners	Corporate VC	Utility	Germany	19.2 2004	Face-to-face (taped)
Vattenfall Europe venture	Corporate VC	Utility	Germany	5.2 2004	Face-to-face (taped)
Suez NovInvest	Corporate VC	Utility	France	24.3 2004	Face-to-face (taped)
Edf Business Innovation	Corporate VC	Utility	France	25.3 2004	Face-to-face (taped)
EdF Capital investissement	Corporate VC	Utility	France	24.3 2004	Face-to-face (taped)

Fund Name	Fund Type	Parent Company Type	Fund Location	Interview Date	Interview Type
Schneider Electric Ventures	Corporate VC	Technology Manufacturer	France	23.3 2004	Face-to-face (taped)
BASF Venture Capital GmbH	Corporate VC	Technology Manufacturer	Germany	18.2 2004	Face-to-face (taped)
Easenergy	Corporate VC	Utility	USA	17.2 2005	Face-to-face (notes)
Nth Power	Independent VC	None	USA	9.10 2003	Face-to-face (taped)
SAM Group	Independent VC	None	Switzerland	20.8 2003	Face-to-face (taped)
MSBI Capital	Independent VC	None	Canada	20.10 2003	Face-to-face (taped)
Innofinance	Independent VC	None	Finland	21.11 2003	Face-to-face (taped)
Glastad Invest	Independent VC	None	Norway	5.11 2003	Face-to-face (taped)
PEM-fund	Independent VC	None	Finland	7.11 2003	Face-to-face (taped)
Proventia Group	Independent VC	None	Finland	20.10 2003	Face-to-face (taped)
Capman	Independent VC	None	Denmark	14.11 2003	Face-to-face (taped)
Apax	Independent VC	None	Germany	11.3 2004	Face-to-face (taped)
Nordstjernan Ventures	Independent VC	None	Sweden	29.10 2003	Face-to-face (taped)
Draper Fisher Jurvetson	Independent VC	None	USA	1.2 2005	Face-to-face (taped)
Rustic Canyon Partners	Independent VC	None	USA	26.1 2005	Face-to-face (taped)
Good Energies Inc	Independent VC	None	USA	26.1 2005	Face-to-face (taped)

Fund Name	Fund Type	Parent Company Type	Fund Location	Interview Date	Interview Type
Pacific Corporate Group	Independent VC	None	USA	29.3 2005	Face-to-face (taped)
California Clean Energy Fund	Independent VC	None	USA	21.3 2005	Face-to-face (taped)
Chrysalix	Independent VC	None	Canada	24.1 2005	Phone interview (notes)
Finnish Industrial Investment	Government VC	None	Finland	7.11 2003	Face-to-face (taped)
Start-Fondet	Government VC	None	Norway	4.11 2003	Face-to-face (taped)

4.2.2. Clean Energy Ventures

Collecting data on clean energy ventures, and specifically the challenges the firms face when trying to raise venture capital for their firms, is difficult. No readily available databases or previous studies exist or, if they do exist, they could not be identified. Therefore, a decision was made to carry out a survey among clean energy ventures. A Web-based survey method was chosen for practical implementation of the survey. The first step was to assemble a contact database of clean energy ventures worldwide. The goal was to identify clean energy ventures less than 10 years of age that have tried to raise venture capital funding for the firm. The database was built using publicly available data on energy venture fair participants, national registries of renewable energy firms, portfolios of venture capitalists, and other databases such as GreenTie[3]. Publicly available lists of Energy venture fair[4], European energy

[3] www.greentie.org

[4] www.energyventurefair.com

venture fair[5] and National Renewable Energy Lab (NREL) Industry growth Forum[6] participants provided a starting point for building the contact database. Using the firm Web sites and the above-mentioned sources, contact information for each firm was added to the database. The clean energy venture contact information included the email addresses of either the CEO, CFO, or investor relations representative of the firm. The contact database was gradually built between June 2004 and February 2005 and consisted of 916 clean energy ventures worldwide. The survey was sent out in February 2005. Prior to sending the request to participate in the survey, the survey questionnaire was tested by two North American clean energy ventures. The survey questionnaire is shown in Appendix 1.

4.2.3. Other Clean Energy Market Stakeholders

In order to acquire background information on the clean energy market, clean energy market drivers, and to design the survey format, additional stakeholder interviews were carried out. These interviews have guided the research direction and provided additional viewpoints into the research area. For reasons of confidentiality, the informant names are not disclosed. Only the informants' organizations are shown in Table 8.

Table 8 Interviewed Clean Energy Market Stakeholders

Organization Name	Organization Type	Location	Interview Type	Interview Date
Lawrence Berkeley Labs, Technology transfer unit	Energy research and technology development	USA	Face-to-face (taped)	2.3 2005
Lawrence Berkeley Labs, Energy efficiency research	Energy research and technology development	USA	Face-to-face (taped)	2.3 2005

[5] www.europeanenergyfair.com

[6] www.cleanenergyforum.com

Organization Name	Organization Type	Location	Interview Type	Interview Date
WestStart/CalStart	Non-profit organization working with transportation issues	USA	Face-to-face (taped)	26.1 2005
Hydrogen Ventures LLC	Firm providing research, financial and technological advisory services on alternative energy technologies	USA	Face-to-face (taped)	25.1 2005
Quantum Insight	Emerging technology and assessment service firm	USA	Face-to-face (notes)	10.2 2005
UC Berkeley, Open Innovation Center	University research organization	USA	Face-to-face (videotaped)	22.3 2005
Ecosa Capital	Environmental debt fund	USA	Face-to-face (notes)	Feb-March 2005
CleanEdge	Cleantech advisory firm	USA	Telephone (notes)	22.2 2005
Enginion	Clean energy venture	Germany	Face-to-face (taped)	6.2 2004
Sulfurcell	Clean energy venture	Germany	Face-to-face (taped)	6.2 2004

In addition, a large number of conferences, workshops, and trade fairs in the area of cleantech and clean energy were attended in order to gain further understanding of clean energy as an emerging investment area. Newspaper and magazine articles and press releases concerning clean energy as an investment area were collected and analyzed.

4.3. Research Process

Empirical data were collected over a period of two years. The majority of the VC and CVC interviews were carried out in 2003 and 2004 (Table 7), concentrating on the European investors. Additional interviews were carried out in the spring of 2005 in North America (Table 7). Although Table 7 shows the funds' physical locations, many of the interviewed VC and CVC funds have made investments in ventures that operate in other countries or

continents. For example, Germany-based BASF Venture Capital and Norway-based Norsk Hydro Technology Ventures have made several investments in North American ventures. The same is true for European independent VC funds, such as SAM Group. These cross-border VC investments are argued to lessen the possible Europe-centric bias of the VC and CVC interviews. Stakeholders other than VC and CVC interviews (Table 8) were carried out in 2004 and 2005. The survey contact database was built during the latter half of 2004 and the survey was carried out in February 2005. Conferences, workshops, venture fairs, and trade fairs in the area of cleantech and clean energy were regularly attended during the period from 2002 through 2005. Newspaper and magazine articles and press releases concerning clean energy as an investment area were collected and analyzed during this same time period.

4.3.1. Data Sources and Data Collection

The research process varied for all of the three data collection phases (chapter 4.1). Data sources, collection, and analysis are next discussed for each of the three approaches.

(1) VC and CVC Funds

The average duration of the informant interviews was 1.5 hours. For each of the interviewed funds, at least one of the fund partners was interviewed. In some cases, all of the fund personnel attended the interview session. All interviews except for one were face-to-face interviews that were carried out in the fund premises (Table 7). All interviews except for two were taped and later transcribed. Those interviews that were not taped were transcribed during the interview.

The goal of the interview was to cover clean energy activities of the fund. Every interview was guided by open-ended questions that were, in most cases, sent to the informants prior to the interview. In the interview, a brief description of the study was first presented and the confidentiality of all responses was assured. Second, the informant was asked about his or her responsibilities in the fund, the informant background, and personal experience on clean energy ventures. The interviewee was also asked to describe the fund history, objectives, and reasons for investing in the clean energy sector. The informant was then asked about the clean energy sector investments his or her fund had made and the involvement of the interviewee in these investments. The informant was also asked about his or her views on clean energy market drivers and the challenges he or she had experienced with clean energy technology investments. Informants in independent VC funds were also asked about their views on CVC

funds active in the sector. CVC fund informants were asked about the involvement of the CVC fund's parent firm in the fund's daily operation, and the financial and strategic goals of the fund that had been set by the parent firm. At the end of the interview, the interviewee was asked to name additional clean energy funds and contact people for the use of the researcher. These contact leads were used to cross-check that the leading clean energy VC funds were covered during the data collection process. In addition to the fund interview data, documents and other secondary sources were consulted whenever available. This included World Wide Web documents, press releases, and fund annual reports. These documents were used to triangulate the findings from the interviews. In the case of corporate venture capital funds, secondary data from news services and trade journals were important in understanding the CVC fund parent firm's technology and market situation. Understanding the industry and market context surrounding the CVC fund parent firm was needed in analyzing the CVC interview data.

(2) Clean Energy Ventures

A Web-based survey, using the contact database described earlier, was carried out in February 2005. A brief description of the survey respondents is presented in Table 9. The survey invitation was sent via email to 916 clean energy ventures. Of these invitations, 161 emails did not reach their destination. It was discovered that, during the eight months it had taken to collect the contact information database, some of the clean energy ventures had ceased to exist, some had merged with other firms, and thus some had changed their contact information. In several cases, the contact person that had been added to the database no longer worked for the firm and the email account had become inactive. When these losses were taken into account, 755 emails reached their destination. The survey questionnaire is shown in Appendix 1. The survey started with questions on the venture background, in order to make sure that the firm was part of the target group. The eligibility criteria were that the firm was less than 10 years of age and it operated in the area of clean energy technology. The survey received 164 eligible responses.

Of the respondents, 68% were in leadership or senior management positions and 64% of the respondents were one of the firm founders. Of those respondents that were one of the firm founders, 69% had previous start-up experience. Roughly half, 54%, of the ventures had participated in an energy venture fair or other similar event in order to make contact with investors.

The goal of the survey was to study the experience of clean energy ventures with venture capitalists and the challenges the ventures were facing. Of the survey data, the open-ended questions provided the researcher with the most useful data. Since the contact database was constructed using participant information of various clean energy and other cleantech sector venture fairs (chapter 4.2.2), the database and the survey respondents exhibit a certain bias. For example, the ventures included in the contact database were actively looking for additional financing for their firms or had already secured VC funding. The success rate in raising VC financing (Table 9) was also exceptionally high among the respondent firms. Although no quantitative measures on the ease or difficulty in raising funding for a clean energy venture can be given based on this study, the open-ended essays regarding venture challenges and experience with venture capitalists provided the researcher with rich data on the interaction between the stakeholders. The clean energy venture financing survey data provided a view to the "other side of the financing table" and complement the data acquired through VC and CVC interviews.

Table 9 Clean Energy Venture Financing Survey Overview

Topic	**Details**
Peak year of venture founding	2001; 16% of the respondent firms were founded in 2001
Company size	41% of the respondent firms employed five people or less, 32% employed 6-25 people. In other words, companies in the area of clean energy that participated in the survey were fairly small, as 73% employed fewer that 25 people.
Location	57% of the respondent firms were located in the US, of which roughly one-third were located in California. 27% of the respondent firms were located in Europe and 9% in Canada. The US bias is partly due to the better visibility of energy start-ups. The survey contact database was built using venture fair participant lists and other forums where clean energy ventures promote their businesses.
Energy technology area	The survey respondents were asked to identify their main business area. The largest groups were fuel cells and other hydrogen–related technologies (23%), solar PV technology (16%), wind (8%), energy efficiency (15%), and energy management solutions (10%).

Venture capital funding	72% of all respondent firms had sought venture capital funding either from independent, corporate, or government-backed VC funds. 44% of the firms that had sought VC funding had managed to raise it. The high rate of success in raising venture capital is due to the bias in firm selection, since VC portfolios and energy venture fair participant lists were used when building the contact database.

(3) Other Clean Energy Stakeholders

The data collection procedure for clean energy stakeholders was the same as described earlier for VC and CVC funds. The informants in each of the interviewed organizations were in a leading position within the organization. The open-ended questions included questions on clean energy market drivers and challenges for the clean energy market growth, as observed by the informant. The stakeholder interview data, newspaper and magazine articles and press releases concerning clean energy as an investment area were used in gaining general understanding of the research area, but they were not used in the theory building of the study. References to the collected and analyzed stakeholder interview data and newspaper and magazine articles are made in the theory building chapters when it is judged necessary in order to help the reader to understand the energy industry context and the emerging clean energy market in more detail.

4.3.2. Data Analysis

According to Ryan et al (2000), grounded theory is an iterative process by which the analyst becomes more and more "grounded" in the data and develops increasingly richer concepts and models of how the phenomenon being studied really works. The data on clean energy venture challenges and the role of financiers and large firms in the clean energy market development was collected in three different data collection phases, as described earlier. Data from phases 1 and 2 were used in the data analysis. Data from phase 3 served as background material for the researcher. Data collection of this study was a challenging task, carried out over two years' time. The long data collection period resulted in having copious amounts of data to be analyzed, mostly in text format. Grounded theory data analysis principles (Creswell 2003 and Strauss et al. 1998) were followed in the manner described in this chapter. An iterative

process between data, emerging theory, and literature was used to make sure that reliability and validity concerns were addressed during the data analysis.

The typical way of carrying out grounded theory research is collecting verbatim transcripts of interviews and reading through a small sample of text, usually line by line (Ryan et al. 2000). The data analysis of this study followed the typical way described by Ryan et al. The coding part of the data analysis process that led to the theoretical models presented in the theory chapters (chapters 6 through 8) consisted of three stages. These stages are discussed next in more detail, including a description of theoretical memos that were kept during the data analysis.

(1) Open coding

The VC and CVC interviews were taped and transcribed as described in chapter 4.3.1. The interview data was coded using open coding (Strauss et al. 1998). In practice, the coding meant re-reading the transcribed interviews with questions such as "What is the fund manager discussing here?", "What caused the described situation?", "How did the VC fund manager react to the situation?", "How does the fund manager's previous professional experience influence his view of the situation?" and "What was the outcome of the situation?" in mind. With the help of questions data categories and properties (Creswell 2003) were identified. Since the interviewed VCs and CVCs tended to use very similar terminology in the interviews such as "exit strategy", "capital intensity" and "due diligence", in-vivo labels i.e. terms used by the informants themselves were used for category names in most cases.

The VC and CVC interview transcript coding started while additional interviews were carried out. More categories were added when new data came along. To keep track of the data categories, and to note down the emerging relations between the categories and their properties, the researcher started to write working paper versions in an early stage of the VC and CVC interview process. Literature was consulted to refine these early empirical findings. These working paper versions served also as code books (Creswell 2003) for the researcher. The early working paper versions gradually developed into theoretical memos and helped in axial coding of the data. Both axial coding and theoretical memos are discussed in more detail later in the chapter.

Ryan et al. (2000) noted, "as grounded theorists develop their concepts and categories, they often decide they need more data from informants." After the initial coding of European VC and CVC interviews (Table 7), it became apparent that "other side of the financing coin," the

clean energy entrepreneurs trying to raise funding for their venture, needed to be studied. The categories and properties that had been identified from the European VC and CVC interview data were used to construct the survey questionnaire (Appendix 1). Since many of the survey respondent ventures were located in North America and had thus interacted with North American VCs instead of European VCs, additional interview data from North American clean energy VCs were collected in the Spring 2005 to compensate for the possible geographical bias of the VC and CVC interviews carried out earlier. After the survey had been carried out in February 2005, the open-question essay responses from the survey data were coded in a similar manner as the European VC and CVC interviews. The same was done for the North American VC and CVC interview transcripts. Initial codes that emerged from the European VC and CVC interview transcript data were supplemented by codes that emerged from the survey data and North American VC and CVC data open coding process.

(2) Axial coding

The goal of axial coding is to relate the separate codes (categories and their properties) to each other and to fit the data into a frame of generic relationships. The process proceeds in an inductive manner mainly concentrating on causal relationships. The axial coding and open coding process proceeded in a parallel manner during the data analysis, mainly due to the usage of early working paper versions mentioned earlier. During axial coding categories and their properties were divided into separate elements. These elements were phenomena, causal conditions, context, intervening conditions, action strategies and consequences. Table 10 demonstrates axial coding by giving an example of some of the codes used in the development of the theoretical model presented in chapter 8.

Table 10 Elements Used in Axial Coding and Examples

Element	Code	Description
Phenomenon	Manager support	Difficulties in gaining support for CVC fund activities among the parent company operational unit managers
Causal conditions	Innovation	View on the importance of innovation within a parent firm of a CVC fund
Context	Industry values	Traditions and value systems of energy industry, “way things are done”.
Intervening conditions	Success compensation	Venture success often goes unnoticed in the parent company

Action strategies	Investment decision-making	Involvement of parent company managers in the investment decision-making
Consequences	Fund performance	Problems in CVC fund performance

(3) Selective coding and theoretical memos

Selective coding means that one category is chosen as the core category to which all the other categories relate to. Another way of selective coding is an attempt to find a single "storyline" around which everything else is connected to. After the open and axial coding had been carried out, three storylines, one for each of the theory-building chapters (chapters 6 through 8), started to take shape. With the help of working paper versions (theoretical memos) that were refined throughout the data analysis process, the three storylines evolved into three theoretical models. The data analysis process thus started when the first interviews were carried out (fall 2003) and continued until the last interviews had been carried out (spring 2005). During this time several working paper versions of all the three theoretical models were developed and iterated towards a final model. For chapter 6, only survey data were used to construct the theoretical model. For theory-building of chapters 7 and 8, both survey data and VC and CVC interview data were utilized. Literature was consulted to refine the findings as had been the practice starting from the early versions of the working papers. Data display techniques, such as matrices and graphs, were used in constructing the theoretical models. Initial propositions were defined and evaluated to identify problems and make appropriate revisions.

The end results of grounded theory are often displayed through presentation of text segments, such as quotes from informants, as exemplars of concepts and theories (Ryan et al. 2000). In this study, the results are presented in the form of frameworks, theoretical models, and propositions. Quotes from the informants, both from the interview and survey data, are used as prototypical examples of the study findings.

5. Cleantech and Clean Energy Market

The empirical data of the study come from one cleantech sub-sector, clean energy. As was argued in the introduction and chapter 4.1, the most prominent investment activity in the cleantech market has taken place among clean energy technology-related ventures.

The data analysis of this dissertation is organized around the following three issues: clean energy venture entrepreneurial challenges, venture capitalist and clean energy venture interaction, and clean energy corporate VC funds. This chapter provides the reader with an overview of both the cleantech and the clean energy market development. Drivers behind changes in the energy sector are also discussed. The goal of the overview is to acquaint the reader with the research context to a degree that allows the reader to challenge the interpretations put forth in this study.

5.1. Cleantech VC Market

> *Clean technology is a hot funding sector that is just coming into its own after being on VC's back burner for so long.*
>
> *-- Sheahan (2004)*

The annual global revenues of cleantech markets are upwards $150 billion, with segments such as solar or wind growing at annual rate as high as 35% (Parker 2005). According to CleanEdge (2001), the following six factors can be identified as the source of today's cleantech revolution: energy uncertainty, technological advances, pressing environmental issues, changing political winds, sustainable development, and new business opportunities. Among other factors, the strong growth figures have attracted venture capitalists and other investors to the cleantech space. De Callejon et al (2005) state five principal factors behind the emergence of cleantech as an investment category. First, many clean technologies serve large and fast-growing markets. Second, market trends and economic forces are behind the adoption of clean technologies. Examples of the trends and forces include rising commodity prices, technology innovation that has driven down the cost of resource-efficient technologies, and technology spillover effects from other industries. Third, experienced and professional management teams often run today's cleantech companies; the emergence of serial entrepreneurs having the experience of taking their cleantech companies public is an important factor. Fourth, the cleantech sector is seeing a strong and growing flow of attractive deals. Finally, the strong venture returns in cleantech investments have confirmed that VCs

can find attractive returns in cleantech. LoGerfo et al. (2005) estimates, using a sample of 56 publicly traded U.S. cleantech companies, that the median returns realized by investors in privately held cleantech companies were 433%, or about 5.3 times the invested capital. LoGerfo et al. also argue that cleantech companies are able to provide long-term shareholder value. The argument was supported by creating a cleantech index consisting of 11 segments and comparing the index to the NASDAQ and Russell 2000 indexes' performance over a ten-year period. Based on the cleantech index, LoGerfo et al. argued that the cleantech index had strongly outpaced the performance of the NASDAQ and Russell 2000 indexes it was benchmarked against.

According to the Cleantech Venture Network (Parker 2005) over the past three years, nearly 700 investors have invested more than $3.6 billion in over 500 VC deals in the cleantech sector, making cleantech at least the sixth largest venture investment category. Based on data from investments starting in 2002, North American VCs have allocated the cleantech VC money mainly to the three following sectors: clean energy –related technology (40%); materials recovery, clean manufacturing and enabling technologies (22%); and advanced materials and nanotechnology (17%) (Parker).

Four main VC groups can be identified in the cleantech market. The first group consists of the traditional venture capital firms that have expanded their investment horizon to cleantech. The first group also includes top-tier VC firms (Rivlin 2005). The second group consists of firms that have specialized in the cleantech sector. An example of a VC firm from the second group is the Swiss Sustainable Asset Management Group[7]. The third group consists of VC firms that invest in a cleantech sub-group such as water technologies or hydrogen-related ventures. Examples of these tightly focused VC firms investing in a particular cleantech sub-sector are the Canadian Chrysalix[8] and the Swiss Good Energies Inc[9]. The last and fourth group is CVC

[7] www.sam-group.com

[8] www.chrysalix.com

funds that invest in the cleantech sector. CVC funds investing in clean energy technologies are discussed in more detail in chapter 5.2.

5.2. Clean Energy VC Market

> *The reason we see growing investment in energy technologies is obvious. As the industry and its customers find themselves going from crisis to crisis, there is a growing realization that patchwork solutions are not going to solve the challenges facing energy producers and users. The emergence of new technologies and their adoption are capable of fulfilling the promise for solving systemic problems involving how we generate, use, track, and manage electric power.*
>
> -- *Venture capital firm Nth Power (2004)*

Venture capital has been flowing into the energy sector since the late 1990s, when the first dedicated clean energy funds were established. According to CleanEdge (2005), sky-rocketing oil-prices, conflicts in the Middle East, power outage concerns, and support from state governments are pushing clean-energy investments into the mainstream. Although the clean energy venture capital market has experienced a downturn from the figures of late 1990s, as shown in Figure 2, this is a result of the overall lower venture capital investment levels. The relative share of energy VC of total venture investments has remained relatively stable, around 2.2-2.8% (CleanEdge), since 2001.

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[9] www.goodenergies.com

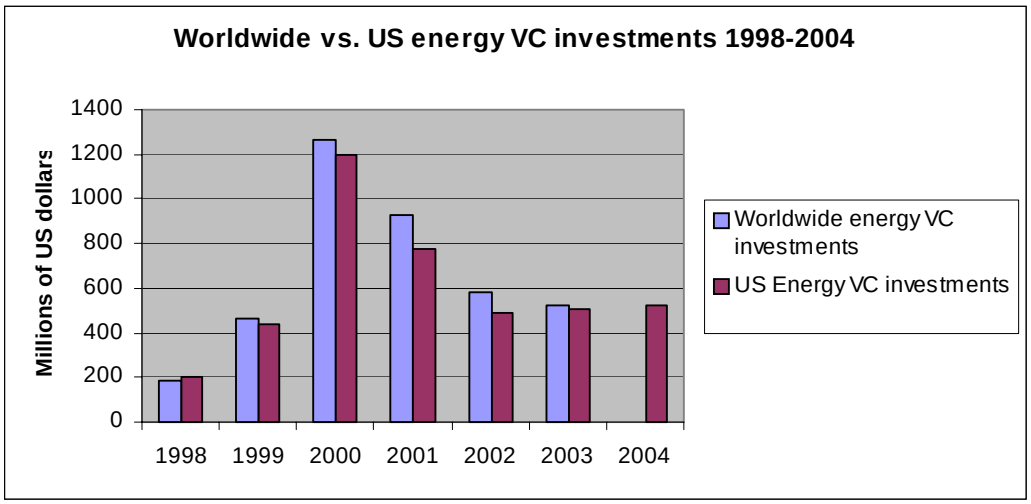


Figure 2 Source: Nth Power, CleanEdge, PricewaterhouseCoopers / Venture Economics / NVCA money tree survey

U.S.-based VCs have made most of the energy VC investments (Figure 2). To put the energy VC investment figure into perspective, the sum invested by the VCs is roughly equal to the yearly private sector energy R&D investment (Kammen et al. 2005).

According to Prudencio (2005) the development of energy venture capital market consists of five periods. During the first period, from the early 1990s through 1995, venture capital investments into energy technology were practically non-existent, barely totaling about $90 million over five years. In the second period, which started in 1995 and continued to 1997, Europe and Japan started to take steps to make power and energy markets more competitive, followed by New Zealand and the United States. Entrepreneurs and venture capitalists activated and in 1996, $122 million poured into companies developing new energy technologies and services. From 1997 to 2001, which constitutes the third period, more than 266 investment rounds were closed, resulting in investments totaling more than $3.3 billion. The last period was 2002 to 2004, which started with the market cooling as investments in energy technology companies dropped by 45% in 2002. However, the relative share of energy investments to all investments grew to 2.7% by 2003, as compared to 1996, when the share was 1%. The overall size of deals shrank from the highs in 2000 and was just over $8 million in 2004 (CleanEdge 2005). It should be noted, however, that the average size of European energy VC deals tend to be smaller than their North American counterparts.

5.2.1. CVC Funds and Other Investors

Energy sector CVC funds have followed an unusual market entry order when compared with CVC funds in other sectors, such as ICT or biotechnology. Many corporate VC funds entered the energy VC market before independent VCs started their own funds. The energy sector CVC funds have been established by three main groups of companies: oil and gas companies, electric utilities, and energy technology manufacturers. Most of the CVC funds investing in new energy technologies were established during the boom years of the late 1990s or during 2000. Compared to capital investments going into infrastructure maintenance and power capacity additions, the sizes of the CVC funds set up by the largest European companies in the energy sector are still modest. According to International Energy agency estimates, based on current demand trends, the world will need to invest $16 trillion over the next three decades to maintain and expand the energy supply. This number is equivalent to 1% of annual global GDP over the period (IEA 2003).

In addition to CVC funds, other strategic investors both from inside and outside of current energy sector major players are getting involved in clean energy technologies, either through venturing programs, mergers and acquisitions, or investments into basic research programs. Examples of recent acquisitions are two purchases carried out by General Electric, where Enron Wind was acquired in 2002 and AstroPower was acquired in 2004. Examples of successful clean energy products that have spun off from corporate internal R&D activities into major business units are Toyota's Prius hybrid car and Sharp Electronics' solar photovoltaic equipment business, worth $1 billion in 2004. An example of investments into clean energy services is Carlyle-Riverstone's purchase of a majority interest in California's solar-power-generating systems (RedHerring 2005). Several of the independent VCs that have focused on the clean energy market have large corporations as investors. One example is the Canadian hydrogen technology-focused VC fund, Chrysalix, whose investors include Ballard, Shell, Mitsubishi, and Boeing Corporation. Large corporations have also recently funded basic clean energy research related programs in research institutes and universities. One example of a corporate-funded research program is the Global Climate and Energy Project carried out by Stanford University, sponsored by Exxon, Toyota, Schlumberger, and General Electric.

5.3. Clean Energy Market Drivers

Several drivers for emergence of the clean energy market can be identified. According to CleanEdge (2002), the following factors have placed clean energy technologies and companies in the spotlight: security issues, energy uncertainty, the need for increased power reliability and quality, technological advances, pressing environmental issues, the rise of the developing world, strategic investors, government commitments, and venture capital. An overview of some of these factors, including a short review of energy policy as a market driver, follows.

5.3.1. Climate Change and Governmental Commitment

Extraction, transportation, and conversion of fossil fuel, and generation and transmission of electricity have always had many local and regional environmental impacts. Carbon dioxide from the combustion of fossil fuels poses a different challenge: it remains the most important of anthropogenic greenhouse gases, and its rising emissions will be the main cause of higher tropospheric temperatures (Smil 2003). Smil argues that, in addition to climate change concerns, loss of biodiversity, human interference in the biogeochemical nitrogen cycle, and the health of the world ocean are other leading environmental concerns associated with the rising use of energy.

Adverse impacts from greenhouse gases include severe heat-waves (Meehl et al. 2004), major storms (Knutson et al. 2004), frequent and serious droughts (Dai et al. 2004), great floods (Milly et al. 2002), and changes in species (Parmesan et al. 2003). The most recent discovery is the effect climate change is claimed to have on the Gulf Stream (Bryden et al. 2005). The speed of climate change has a regional aspect, as well. According to the eight-nation Arctic Climate Impact Assessment (ACIA 2004), the reported arctic average temperature has risen at almost twice the rate as the rest of the world in the past few decades.

Increasing concentrations of greenhouse gases (GHGs) is the dominant driver of current global climate change. Among the greenhouse gases, carbon dioxide (CO_2) is the most important source. Emission of CO_2 from fossil-fuel combustion arises as the result of a process that currently supplies nearly 80% of our global energy demand. According to an IPCC scenario (IS92a) CO_2 will account for 75% of GHGs in 2100. The dominant source of anthropogenic CO_2 is fossil-fuel combustion. Concerns of climate change have pressured countries, firms, and individuals to start considering more environmentally friendly ways for

producing energy. A multi-national effort that is the most visible sign of this gradual movement is the formation of Intergovernmental Panel of Climate Change (IPCC)[10].

According to Holdren (2005), there is leverage in four areas to reduce CO_2: population, GDP per person, energy intensity of GDP, and carbon intensity of energy supply. According to Holdren, energy intensity of GDP, in other words, getting more GDP out of less energy, is the cheapest, largest, and fastest leverage on carbon emissions. Reducing the carbon intensity of energy supply entails changing the mix of fossil and non-fossil fuel energy sources, such as introducing more renewable and/or nuclear energy, and the characteristics of fossil-fuel technologies, such as introduction of carbon capture and sequestration (Holdren).

Various countries have introduced policy instruments to mitigate climate change. These instruments include fiscal measures, regulatory instruments, voluntary agreements, policy process and outreach, research and development programs, and tradable permits (IEA 2004). Some countries, such as France and the United Kingdom, have also published long-term GHG reduction targets. In 2003, the European Union published the European Union GHG emission trading scheme, often referred to as EU-ETS.

For most International Energy Agency (IEA) member countries, energy efficiency is one of the key policy tools to achieve GHG emissions reduction targets, as well as energy security (IEA 2004). These policies include adjusting energy prices, establishing financial instruments to encourage the use of efficient products and practices, mandating minimum efficiency levels, and voluntary measures. New instruments, such as energy efficiency certificates, also referred to as white certificates, have also emerged.

[10] www.ipcc.ch

5.3.2. Energy Uncertainty and Security

Between 1900 and 2000, global consumption of fossil fuels rose almost fifteen-fold (Smil 2003). This large expansion meant that, in spite of the near quadrupling of global population, average annual per capita supply of commercial energy more than quadrupled. When gains in useful energy per unit of primary supply are taken into account, the energy services have experienced eight-fold to twelve-fold increases in per capital supply of energy services, as well as improvements in comfort, safety, and reliability during the past century (Smil).

Energy systems may also be used as targets and weapons for terrorists. In addition, they have potential for conflict over access to remaining supplies of inexpensive gas and oil. There are also links among nuclear energy technologies, nuclear weapon capabilities, political tensions, and upheavals resulting from energy strategy inadequacies that create economic or environmental impoverishment (Holdren 2004).

Energy markets have experienced significantly higher energy prices since 2003 (IEA 2004). For example, in 2003, the average spot price for natural gas at Henry Hub was 63% higher than in 2002 (IEA 2004). The price of oil has often been connected with the health of the world economy. IEA estimates that in the Organization for Economic Cooperation and Development (OECD) countries, every $10US increase averages to a loss of 0.4% GDP in OECD countries, 0.8% in Asia, and 1.6% in poor, heavily indebted countries.

Most OECD countries have national policies that support renewable energy production. For example, in 2001, the EU agreed that the share of electricity from renewable energy sources in the EU consumption should reach 21% by 2010 (EU 2006). In 2003, it agreed that at least 5.75% of all petrol and diesel should be bio-fuels by 2010. EU is currently preparing an EU action plan of energy efficiency that is planned to be put in place at the end of 2006 (EU 2006). However, renewable energy research and development programs have experienced serious decline since the 1970s (Kammen et al. 2005 and 1999, and IEA 2004). Since the 1970s, governments set up research and development programs for renewable energy, technology deployment schemes, investment incentives, tax measures, and incentive tariffs. Since the late 1990s, quota obligations with tradable certificates have become popular (IEA).

However, according to the World Energy Outlook 2004 (IEA 2004b), the current set of national and international energy policies are not enough. If governments adhere to the policies in force as of mid-2004, the world's energy needs will be almost 60% higher in 2030

than they are now. CO_2 emissions are estimated to be 60% higher in 2030 than they are now (IEA). Fossil fuels will continue to dominate the energy mix, the share of renewable energy sources will remain limited, and short-term risks to energy security will continue to grow (IEA).

5.3.3. Technological Advances and Solutions to Climate Problem

Pacala et al. (2004) have suggested that humanity already possesses the fundamental scientific, technical, and industrial know-how to solve the carbon and climate problem for the next half-century. They suggest a portfolio of "potential wedges" as strategies available to reduce the carbon emission rate in 2054 by 1 GtC/year. The overview of potential wedges is presented in Table 11. A more detailed analysis of the effort needed is available from Pacala et al. (2004) article.

Table 11 Strategies Available to Reduce Carbon Emissions

Option	Comments and Concerns
Efficient vehicles	Car size, power
Reduced use of vehicles	Urban design, mass transit, telecommuting
Efficient buildings	Weak incentives
Efficient baseload coal plants	Advanced high-temperature materials
Gas baseload power for coal baseload power	Competing demands for natural gas
Capture CO_2 at baseload power plant	Technology already in use for H_2 production
Capture CO_2 at H_2 plant	H_2 safety, infrastructure
Capture CO_2 at coal-to-synfuels plant	Increased CO_2 emissions, if synfuels are produced without CO_2 capture and storage
Nuclear power to coal power	Nuclear proliferation, terrorism, waste
Wind power for coal power	Multiple uses of land because windmills are widely spaced
Photovoltaic power for coal power	PV production cost
Wind H_2 in fuel-cell car for gasoline in hydrid car	H_2 safety, infrastructure
Biomass fuel for fossil fuel	Biodiversity, competing land use
Reduced deforestation, plus reforestation, afforestation, and new plantations	Land demands of agriculture, benefits to biodiversity from reduced deforestation

Option	Comments and Concerns
Conservation tillage	Reversibility, verification

Hoffert et al. (2004) have suggested, as future primary energy sources, terrestrial solar and wind energy, solar power satellites, biomass, nuclear fission, nuclear fusion, fission-fusion hybrids, and fossil fuels from which carbon has been sequestered. Non-primary power technologies that could contribute to climate stabilization include energy efficiency improvements, hydrogen production, storage and transport, super-conducting global electric grids, and geoengineering (Hoffert et al.).

The aim of this chapter was to acquaint the reader with the cleantech and clean energy research context. The following three chapters will present the theory building of the dissertation. Chapter 6 develops a framework of clean energy venture entrepreneurial challenges, based on the empirical data gathered from the clean energy venture financing survey. Chapter 7 introduces a model of clean energy venture risk characteristics by taking into account the venture capitalist cognitive biases on clean energy entrepreneurial ventures. Chapter 8 develops a model that aims to explain the effect of a parent firm's organizational culture on the performance of a corporate venture capital fund. The empirical data presented in chapters 7 and 8 is based on VC and CVC interviews and data from the clean energy venture financing survey.

6. Clean Energy Venture Entrepreneurial Challenges

Chapters 6, 7, and 8 form the core of this dissertation. The previous two chapters review the methodology, research process, and the research setting of the study. The following three chapters contain the theory-building of this dissertation. In this chapter, clean energy venture entrepreneurial challenges are analyzed. The chapter forms a basis for the theory-building of the following two chapters, as one of the identified clean energy venture entrepreneurial challenges, financing, is explored further in chapters 7 and 8.

6.1. Introduction

Previous studies on sustainable, or cleantech, industry emergence have concentrated on system level and policy perspective (Kemp et al. 1998, Tsoutsos et al. 2005, Jacobsson et al. 2000, and Russo 2003). Many of the previous studies use the energy industry, and especially the emergence of renewable energy and new transportation technologies, as the source of empirical data. Tsoutsos et al. studies the diffusion of renewable energy technologies and argues, "a successful policy for the speedy deployment of renewables should focus on the systemic innovation processes." Kemp et al. develop a framework of barriers that impede regime shifts to sustainability. Berkhout (2002) studies the technological change in the energy sector and finds that institutional entrapment in large technological systems is the cause of barriers of technological change and entry of firms.

These and other studies have widened the understanding of both system-level policy drivers and technological regime-induced barriers to clean technologies during the last ten years. However, cleantech industry firm-level studies have remained absent, even though entrepreneurial firms form the core elements of emerging industries. The need for further research among sustainable, or cleantech, technology entrepreneurial firms has been identified also in the previous studies. Jacobsson et al. (2000) noted that one of the key issues in technological transformation of energy systems is that more information is needed on how the "prime movers" in the creation of new technologies emerge. By "prime movers," Jacobsson et al. refer to strong actors or group of actors within the energy system. Russo (2003) notes, "We cannot answer essential questions, such as where and when sustainable industries emerge." The goal of this chapter is to study the clean energy venture entrepreneurial challenges, building on empirical data. In this dissertation, the term entrepreneurial challenge refers to a particular management task that emerges during the venture development (see chapter 2.3 for

a more detailed definition). Based on the study results, six propositions and a framework are developed.

6.2. Methodological Notes

Instead of studying the entrepreneurial challenges of an individual firm, in this study, the experiences of several clean energy entrepreneurs "running in packs" (Van de Ven 2005) are pooled and developed into a framework. The source of empirical data used in theory building is the clean energy venture financing survey that includes firms less than 10 years of age. The survey data collection and analysis was described in chapter 4.3.

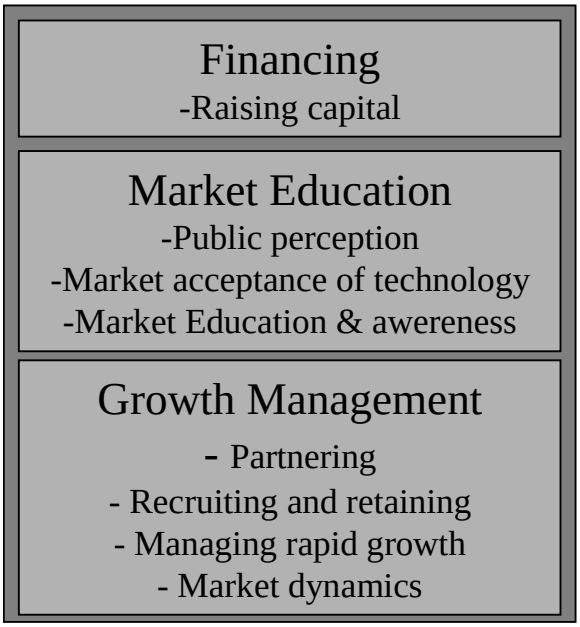
The analysis of clean energy venture entrepreneurial challenges proceeded in two stages. First, entrepreneurial challenges were identified on the clean energy industry level. Next, entrepreneurial challenges were studied separately in three clean energy industry categories that all were in a different industry development stage. The following three industry development stages were studied: early, rapid growth, and slow growth stage. Three clean energy industry categories selected to represent each of the three industry development stages were: fuel cell and other hydrogen-related industry (early stage), solar PV industry (rapid growth stage) and energy efficiency industry (slow growth stage). The analysis of different industry categories reveals additional entrepreneurial challenges, and also shows that some of the overall clean energy industry entrepreneurial challenges are less relevant on the individual industry category level. In other words, solar photovoltaic venture entrepreneurial challenges differ from the ones identified for energy efficiency ventures.

One entrepreneurial challenge that remains the same for the clean energy industry and for the individual clean energy industry category level is venture financing. The clean energy venture financing survey, which was the source of empirical data of the study, contained several specific questions on financing background of clean energy entrepreneurial ventures and experience with independent and corporate venture capitalists. Therefore, the discussion on the financing challenge is presented in more detail, than is the case for the other two entrepreneurial challenges, growth management and market education, identified in the study.

6.3. Entrepreneurial Challenges

The survey data suggest that the three main clean energy entrepreneurial challenges are **financing**, **market education**, and **growth management**. These three entrepreneurial challenges and the factors within each challenge are demonstrated in List 3.

List 3 Framework of Clean Energy Entrepreneurial Challenges



The first entrepreneurial challenge, financing, is common to new ventures independent of industrial sector. For clean energy firms, the financing challenge consists of one main factor, raising capital for the venture. Gaining investor acceptance for a venture operating in the clean energy area was found to be particularly challenging. Market education constitutes the second entrepreneurial challenge. It includes factors related to public perception, market acceptance of the technology, the venture promoting it, and the need for market education among potential customers. The third entrepreneurial challenge is referred to as growth management, which includes a multitude of factors ranging from personnel recruitment to ability to react to dynamic market conditions.

6.3.1. Financing

Venture capital is the most common form of equity financing for early-stage ventures. Of the survey respondents, 72% had sought venture capital funding for their firm. The success rate in raising capital among the survey respondents was surprisingly high, 44%, exhibiting a bias based on the survey database, as discussed in chapter 4.3.1. The survey respondents were asked about the sources of funding for the venture. The three most important sources of financing, using a measure of raising at least half of the venture total financing needed from that particular source, were founder's personal funds (37% of all respondents), venture capital (33% of all respondents), and angel investors (24% of all respondents). In other words, for the

survey respondent firms, venture capital funding had been the second most important source of capital after the founder's personal funds. Based on the survey data analysis, the financing challenge consists of one main factor, raising capital. Survey response examples are exhibited in Table 12.

Raising capital (Table 12, factor 1) in order to finance a new venture is a central part of entrepreneurial process as entrepreneurs are often wealth-constrained and need external financing (Shane et al. 2002). It is common for small businesses to frequently fail due to insufficient funding and heavy debt loads (Deeds et al. 2004). Raising funding from VCs is challenging, since "new technology ventures are typically resource-poor, possess few tangible assets, and can provide very little concrete data with which external constituents can predict performance" (Deeds et al. 2004). As one clean energy entrepreneur points out:

> *[Our top three challenges are] 1) Raising money, 2) Raising money and 3) Raising money. And no, I'm not trying to be funny. Sufficient capital is becoming critical to the smaller companies in this sector.*

Venture capital, often referred to as "risk capital," is a financial instrument often utilized by new ventures. The element of risk is always present for early-stage investors, since they cannot shift all the risk to entrepreneurs (Shane et al. 2002). All entrepreneurs seeking funding have psychological and financial incentives to convince investors that their opportunities are important and that they are entrepreneurial visionaries (Shane et al. 2002). An entrepreneur's frustration with financiers who do not understand the value of the venture's offering is evident in the following survey response:

> *[Among our three biggest challenges is] overcoming the financial world's attitude that they don't want to be the first one to try something, but would wait to see what somebody else does first. [Another big challenge is] coming to terms with a public that is screaming for our product, but not having the financing to build the product because the financiers are too timid to take a chance. [The third big challenge our venture is facing is] seeing that the market is ripe with potential, but not being able to act on it.*

Gaining investor acceptance is challenging for new ventures. According to Aldrich et al. (1994), the lack of legitimacy hinders the new ventures from raising capital, as they have to convince investors of the formation of a new industry. Deeds et al. (2004) showed that legitimacy at both the industry and firm level increases the flow of financial resources into a venture. Cognitive legitimacy on the firm level has been shown to have a stronger influence

on the resource inflows than sociopolitical legitimacy (Aldrich et al. 1994). However, on the industry level, especially when it comes to IPO valuations, sociopolitical legitimacy has been found to be more important (Deeds et al. 2004). A clean energy entrepreneur may also experience the lack of industry-level legitimacy in trying to raise capital for the venture, as the following survey response demonstrates:

> *[Among our top challenges is] raising risk capital in a non-risk, non-environmentally oriented society.*

Table 12 demonstrates some examples of the financing challenge.

Table 12 Survey Data Examples Regarding Financing Challenge

Identified Factor	**Evidence: Answer to the Question, "Among our Top Three Challenges is...."**
Raising capital	*Raising money, raising money, raising money.* *Funding for full-scale demonstration and pre-commercial projects.* *Raising start-up capital.* *Raising pre-product capital.* *Issues with raising adequate capital.* *Financing the first deal.* *Finding the required additional funding.* *Raising capital.* *Raising sufficient equity capital to complete our business plan.* *Completing financing of same facility on a non-recourse project finance basis.* *Raising financing.* *Not give up too much ownership to hungry investors.* *Raising capital.* *Fundraising.* *Financing the company.* *Raising enough capital to start production.*

Identified Factor	Evidence: Answer to the Question, "Among our Top Three Challenges is...."
	Fundraising, fundraising, fundraising. *Funding seems to be the largest problem.* *Availability of capital.* *Securing funding (particularly grant-related).* *Securing future financing.* *Obtaining equity financing that has a 5-7 year return window instead of 3-5.*

Proposition 6-1: One of the top three entrepreneurial challenges facing clean energy entrepreneurs is venture financing, consisting of challenges in raising capital for a venture operating in the clean energy area.

6.3.2. Market Education

> *As these technologies get better, we're seeing things being developed like solar panels integrated into roofing tiles. That way, they don't look like a science project hanging on your roof.*
>
> *Walter V. Nasdeo, as quoted in Gray (2005)*

The second of the three main entrepreneurial challenges to emerge from the clean energy entrepreneur survey is named market education; it is shown in List 3. The market education challenge contains issues that were also identified in previous research. Examples from the previous research are cultural and psychological issues (Tsoutsos et al. 2005) and problems encountered through the experienced lack of cognitive and sociopolitical legitimacy (Aldrich et al. 1994). Market education is used in this study as an umbrella term for three factors that surfaced from the survey data shown in Table 13: public perception, market education and awareness, and market acceptance of technology.

In order to have an impact on **public perception** (Table 13, factor 1) of the clean energy sector, several organizations and entrepreneurial firms have been involved in creation of the social movement (Van de Ven et al. 2004 and Dacin et al. 2002) for clean energy technologies

for years. Interviews among clean energy stakeholders (chapter 4.2.3) confirm these clean energy market "social movement creation" efforts. However, the change in the public perception, at least judging by the responses of frustrated entrepreneurs, is slow. As one of the survey respondents notes:

> *[Among our top three challenges is] changing the public perception of biofuels.*

Aldrich et al. (1994) emphasizes the importance of cognitive legitimization, which stands for the spread of knowledge about a new venture. For example, this can be measured as the level of public knowledge of an activity. In some cases, achievements or missteps of the clean energy entrepreneurs in the past can also have a negative impact on the cognitive legitimization of current clean energy entrepreneurs. As one clean energy entrepreneurs points out:

> *The history of photovoltaics in United States [is among our top three challenges].*

Educational campaigns that raise the **market education and awareness** (Table 13, factor 2) of both the clean energy entrepreneurial firm and the available clean energy solutions are essential. As one entrepreneur notes:

> *[Among our top three challenges is to] explain why our technology works (it is revolutionary, and sometimes against old theories).*

In Tsoutsos et al. (2005), the cultural and psychological factors that form a barrier to a technological regime shift to renewable energy technologies, consist of four main elements: lack of social acceptance, fear of consumers that their life will become less comfortable with renewable energy, unfamiliarity or negative previous experiences with new energy technologies, and uncertainty that arises from the temporally variable nature of some renewable sources. Overcoming these fears and prejudices is also evident from the entrepreneur survey data, as is demonstrated in Table 13.

Lack of sociopolitical legitimacy (Aldrich et al. 1994) was also evident in the form of **market acceptance of the technology** (Table 13, factor 3). In a conservative industry such as the energy industry, the technological solutions have traditionally changed very slowly. Therefore, gaining sociopolitical legitimacy may be especially challenging. As one entrepreneur points out:

> *[Among our top three challenges] is gaining acceptance as a viable technology in a very conservative arena.*

Previous research suggests strategies to overcome the entrepreneurial challenges of insufficient legitimacy, public perception, and market education. To build trust in the new venture and in order to gain cognitive legitimacy, Aldrich et al. (1994) suggest that entrepreneurs should follow a strategy that "concentrates on framing the unknown in such a way [that] it becomes believable." The goal of the entrepreneurs is to "behave as if the activity were a reality" in order to convince others (Aldrich et al.). To gain sociopolitical legitimacy, Aldrich et al. (1994) suggest that entrepreneurs create stories that explain events. One solar thermal entrepreneur describes the entrepreneurial challenge of creating a simple and convincing story as follows:

> *[Among our top three challenges is] marketing solar thermal to the masses demonstrating that it is easy to understand, it's safe and easy to use and saves the most on utility bills.*

Table 13 demonstrates some example responses to the three identified factors under the clean energy entrepreneurial challenge of market education: public perception, market education and awareness, and market acceptance of technology.

Table 13 Survey Data Examples Regarding Market Education Challenge

Identified Factors	Evidence: Answers to the question: "Among our top three challenges is..."
Public perception	*Public perception of wind.* *Overcoming skepticism.* *Overcoming old technology "truths" about the Stirling [engine].* *Adoption of new concepts in energy usage.* *Difficulty in communicating the value of R&D for renewable energy, especially cellulosic ethanol.*
Market education and awareness	*Educating the market, as this is a unique and revolutionary product.* *Lack of education among energy buyers.* *Marketplace awareness.* *Industry education, given that we are defining a new market and providing a new technology and service type.*

Identified Factors	Evidence: Answers to the question: "Among our top three challenges is..."
	Showing the differences between solar electric (PV) [and] solar thermal: thermal is 2-5 times more efficient, less costly, and more practical for domestic uses.
Market acceptance of technology	*Gaining acceptance for technology.* *Acceptance of [our] technology.* *Market acceptance of new [clean energy] products.*

Proposition 6-2: Second of the three main entrepreneurial challenges facing clean energy entrepreneurs is a lack of market education that is apparent in public perception, market acceptance of technology, and market education and awareness.

6.3.3. Growth Management

The third entrepreneurial challenge that is identified from the clean energy entrepreneur survey data is growth management, as shown in List 3. This entrepreneurial challenge, as the survey responses of clean energy entrepreneurs in Table 14 show, consists of four factors: partnering, recruitment and retaining of human resources, growth management, and market dynamics.

A resource needed by all entrepreneurial firms, independent of the industrial sector, is external partners. **Partnering** (Table 14, factor 1) challenges have often, in previous research, been referred to as management of external networks. These networks involve relationships with customers, suppliers, and competitors, among others, and often extended across industry, geographic, political, and cultural boundaries (Hitt et al. 2001). Networks are important in creating legitimacy and credibility for new ventures (Cooper 2002) and are becoming ever more important for all types of firms, as the marketplace competition has increased (Gulati et al. 2000). As one of the survey respondents points out:

> *[Among our top three challenges is] developing effective industry partnerships for financing, product development, etc.*

Human resource issues concentrate around **recruiting and retaining** (Table 14, factor 2) the right people, and managing to retain the key employees. Previous studies raise the recruiting

challenge of new ventures as the most frequent and important activity to manage, in addition to financing (Kaulio 2003). For clean energy entrepreneurs that participated in the survey, the human resource challenges were well known, as the following quote demonstrates:

> *[Among our top three challenges is] hiring and retaining skilled and experienced employees.*

As the venture expands, changes are needed to the original management and the founding team. The change may become a source of additional human resource challenges. As one of the survey respondents describes:

> *Dealing with founder issues and change of control [is among our top three challenges].*

Managing rapid growth (Table 14, factor 3) is crucial in order to anticipate and understand the change the venture is undergoing, without discarding the values and techniques that allowed the growth in the first place (Hambrick et al. 1985). According to Hambrick et al., many rapid-growth firms fail because of growth mismanagement. The main challenges of rapid growth are the increase in size (per se), a sense of infallibility, internal turmoil, and extraordinary resource needs. In clean energy sectors facing rapid growth, management of resource needs in the area of human resources, sales channels, production, and other areas may become a major challenge. As one entrepreneur points out:

> *[Among our top three challenges is] growth management as our expansion rates are 100% per annum.*

Understanding of **market dynamics** (Table 14, factor 4) and adaptation to the ever-changing environment is another key issue for successful entrepreneurship. Although there exists a folklore about the responsiveness of entrepreneurs across all kinds of situations and in the force of all sorts of adversity, this belief is misplaced and inaccurate (Mullins 1996). Growth decisions can prove to be risky because new ventures often lack the competencies and resources that larger firms have to pursue growth (Churchill 1983). Entrepreneurs may also become victims of over-optimism, which has been shown to be a known feature of entrepreneurs (Cooper et al. 1988 and Shane et al. 2002). In an emerging market, the market demand may experience sudden changes, as is demonstrated by the following entrepreneur response:

> *[Among our top three challenges is that] while we develop products, the market shifts.*

Thus one of the major entrepreneurial challenges is, as one entrepreneur notes:

> *[Among our top three challenges is] keeping abreast of rapid changes in the landscape of the industry.*

Hambrick et al. (1985) suggests that successful strategies to manage rapid growth in new ventures include a chief executive who is able to envision and anticipate the firm as a larger entity, the early hiring and development of the team needed in the future, constant reinforcement of the original core vision of the firm, gradual introduction of "big company" processes to supplement existing approaches, minimization of hierarchy, and giving employees a financial stake in the firm. Previous research has shown that a continuous competency development with regard to key operational, technical, market, and other issues is a central step in providing a firm with a basis for sustainable competitive advantage (Day 1994).

Table 14 demonstrates some example responses related to the four identified factors under the clean energy entrepreneurial challenge growth management: partnering, recruiting and retaining, managing rapid growth, and market dynamics.

Table 14 Survey Data Examples Regarding Growth Management Challenge

Identified factor	Evidence: Answers to the question: "Among our top three challenges is..."
Partnering challenges	*Expand sales channels.* *To find good and qualified resellers.* *Penetrating large OEM accounts.* *Marketing the technology to OEMs.* *Successful partnership with commercialization partners.* *Lining up sufficient distribution network.* *Getting noticed with the right commercial partners.* *Find the right partners.*
Recruiting and retaining	*Hiring top-notch people.* *Recruitment of suitably qualified staff.* *Organizational development.* *Finding good people.*

Identified factor	Evidence: Answers to the question: "Among our top three challenges is..."
	Ability to retain human talent and nurture their growth. *Acquisition of quality personnel.* *Retaining key staff.* *Hiring new employees.* *Maintaining staffing requirements.* *Finding the right personnel.* *Attracting good employees when financing is in doubt.* *Hiring enough people at the right time to fulfil all of our objectives.* *Retaining and rewarding good people.*
Managing rapid growth	*Managing growth.* *Size and emergence of market, magnitude of development needed.* *Balance growth with capital outlay.* *Manage growth once we start selling.* *Keeping the financial requirements in pace with the company's growth.* *Scaling up in a timely and cost-effective manner to meet customer demand.* *Growth, given limited financial resources.*
Market dynamics	*Volatile carbon products market.* *The establishment of a hydrogen infrastructure.* *Delays in the commercialization of fuel cell and hydrogen technology.* *Lack of established market for bioenergy.*

Proposition 6-3: One of the three main entrepreneurial challenges facing clean energy entrepreneurs is growth management consisting of four factors: partnering, recruiting and retaining of human resources, rapid growth and market dynamics factors.

6.4. Entrepreneurial Challenges in Development Stages

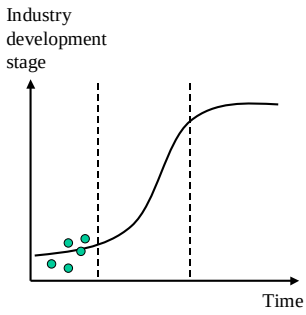
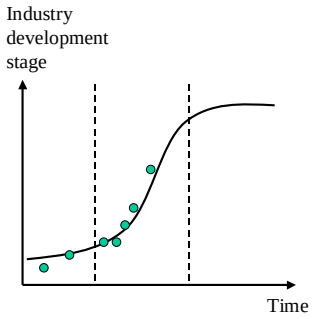
The second step in the data analysis process on clean energy venture entrepreneurial challenges was studying entrepreneurial challenges in different industry development stages. Analysis of how clean energy venture entrepreneurial challenges vary based on the industry development stage was carried out as follows. First, based on the S-curve terminology (Rogers 1983), three industry development stages were analyzed: early-stage, rapid growth and slow growth stage. The definitions of each of the three development stages used in this study are described in chapter 2.8. From the clean energy venture financing survey, empirical data on "fuel cells and other hydrogen technology related"-technology ventures were selected as an example of early-stage clean energy ventures. Solar photovoltaic technology ventures were selected as an example of rapid-growth clean energy ventures and energy efficiency technology ventures as an example of slow-growth clean energy ventures. Clean energy stakeholder interviews (chapter 4.2.3) were utilized in choosing the clean energy technology categories that represent each of the clean energy industry development stages.

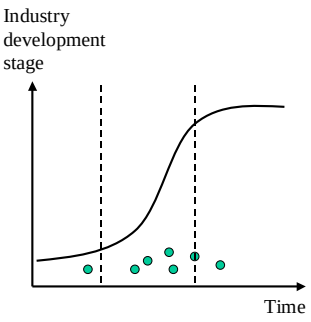
The "fuel cell and other hydrogen related"-technology industry development is in its infancy and large-scale commercialization plans are far in the future (Table 15). Governments all over the world have sunk billions of dollars in the hydrogen initiatives aimed at speeding up the technology development and propelling it to the market (Service 2004). Based on the clean energy stakeholder interview data (chapter 4.2.3), examples of this are George W. Bush administration's 5-year hydrogen initiative, EU's 10-year public-private partnership program around fuel cells, substantial investments into hydrogen-related R&D by the Japanese government, and smaller efforts by other countries, such as Canada and China.

For solar photovoltaic (PV) firms, several technology generations exist. Many of the solar PV firms are struggling to ramp up their production and acquire financing for growth. As the information in Table 15 indicates, there are several firms in different stages of the growth curve and financing stage, employing both more mature and next-generation solar PV technologies. World solar photovoltaic market installations grew 62% over 2003 installations (Solarbuzz 2005). Germany led the pack with a startling 152% growth (Solarbuzz). The U.S. market showed 27% growth, Japan an increase of 27%. The world market for solar PVs has been growing, on the average, at 30% annually for the past five years (Ciorba et al. 2004). During the history of solar PV development, the U.S. and Japan have been the leaders. During the past five years, Europe has gained in position (Ciorba et al.).

According to Perrels et al. (2006), energy efficiency appears to be harder to sell than other options that focus on the supply side. Perrels et al. noted, “It is remarkable that, in this new era, the demand side still does not receive the same level of attention as the supply side.” The market rarely delivers energy efficiency improvements spontaneously, as there is no market push (Boardman 2004). According to Boardman, consumers are either ignorant or indifferent to the range on the market or the energy implications of their purchases. According to Boardman, policy has to be the driver for energy efficiency. Many energy efficiency ventures have remained in the slow-growth, R&D, and government grant funding stages, and have experienced great difficulties in raising growth capital (stakeholder interviews, chapter 4.2.3). In addition, energy efficiency technologies have remained very dependent on governmental push rather than market pull (Banerjee et al. 2003).

Table 15 Industry Development Stages and Clean Energy Industry Categories Used in Study

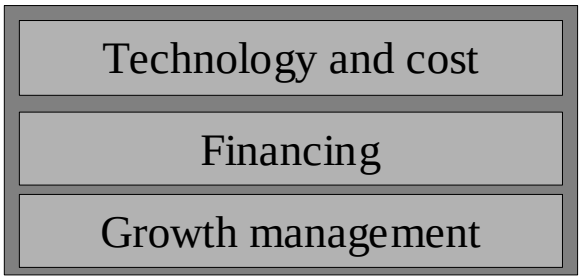
Sub-industry	Example Sub-industry	Justification
Early-stage 	Fuel cells and other hydrogen related technologies	❖ Main emphasis currently on both governmental and private-sector funded development programs ❖ Mainstream consumer products still several years away
Rapid growth 	Solar PV technologies	❖ Several technology generations already in the market ❖ Solar PV market has been experiencing double-digit growth for several years
Slow growth	Energy efficiency technologies	❖ Demand for energy efficiency solutions is seen as policy-driven rather than market-driven ❖ Solutions have existed in the

		market for years, but growth has been slow

6.4.1. Early-Stage Ventures: Technology and Cost Challenge

For fuel cells and other hydrogen-related technology ventures that are used as an example of an early-stage clean energy industry category, three entrepreneurial challenges were identified from the survey data. Two of these entrepreneurial challenges, growth management and financing, were the same as were detected at the clean energy industry level. An additional new entrepreneurial challenge, combined technology and cost challenge, was identified from the data. The three identified early-stage entrepreneurial challenges for early-stage clean energy ventures are demonstrated in List 4. The market education challenge that was identified to be among the three most important clean energy venture challenges in the clean energy industry level was not relevant for early-stage clean energy ventures. For "fuel cell and other hydrogen-related" technology ventures, this is most likely due to the fact that, for most ventures, large-scale market deployment is still a far-away target.

List 4 Early-Stage Clean Energy Venture Entrepreneurial Challenges



For early-stage clean energy ventures, most of the entrepreneurial firms are in the seed and VC funding stage or, alternatively, they still reside in the R&D stage. The firms are developing their technology with the help of government grants and other investors. Next, the entrepreneur sample is described, followed by a description of technology and cost challenge.

Thirty-seven of the survey respondents (i.e., 23% of the total) were firms operating in the fuel cells and hydrogen-related technology area. For these firms, 2001 was a banner year; 31% of the hydrogen-related firms were founded that year. Most of the firms were relatively small, as 68% of the firms employed fewer than 25 people. Thirty-eight percent of the hydrogen-related firms that participated in the survey were headquartered in Europe. Respondents from the U.S. followed with the share of 32% and the share of Canadian firms was 19%. Sixty-four percent of the survey respondent firms had sought venture capital funding. Of those firms, 57% managed to raise venture capital funding for the firm.

Early-stage clean energy ventures struggle with technological problems and try to reduce the cost of the product through technological development. **Technology and cost** (Table 16, factor 1) issues were among the three most important entrepreneurial challenges that the fuel cell and other hydrogen-related ventures faced, as Table 16 demonstrates. The two other entrepreneurial challenges, financing and growth management, were the same as were identified earlier in the industry-level clean energy venture analysis.

Fuel cell and other hydrogen-related technologies have aimed to provide both stationary and mobile application solutions. However, most of the emphasis has been on mobile applications, such as fuel-cell cars (Solomon et al. 2005, Farrell et al. 2003, Arnason et al. 2000, and Mourato et al. 2004). Spencer Abraham, the U.S. secretary of energy, has stated that the transformation into hydrogen economy has "the potential to change our country on a scale of the development of electricity and the internal combustion engine" (Service 2004). The hydrogen economy vision has its skeptics. A large part of the criticism has been aimed at the long timeframes that are needed in order to bring the change about (Service 2004) and the uncertainty related to these timeframes. As one of the survey respondents points out:

> *[Among our top three challenges is] delays in the commercialization of fuel cell and hydrogen technology.*

In addition, the high cost of fuel cells and hydrogen production, making fuel cells rugged enough, safety issues, and challenges in building the hydrogen infrastructure have been mentioned as the biggest economic and political difficulties the hydrogen-related technologies industry currently faces (stakeholder interviews, chapter 4.2.3). In the words of one fuel cell entrepreneur:

> *The major challenges of the fuel cell industry in order are: cost, cost, cost.*

For example, converting a carbon economy into a hydrogen economy would require 150 million tons of hydrogen each year to change the U.S. economy (Service 2004). Despite these entrepreneurial challenges, hydrogen ventures have experienced hype from investors and the press. Table 16 demonstrates the clean energy entrepreneurial challenge of technology and cost.

Table 16 Survey Data Examples Regarding Technology and Cost Challenge of Early-Stage Clean Energy Ventures

Identified factor	**Evidence** Answers to the question: "Among our top three challenges is..."
Technology and cost	*Magnitude of development needed.* *Maintaining focus of R&D and product development. Activities.* *Getting product into field trials.* *Technology development.* *Final proof of concept, time for prototype development.* *Getting the technology right fast enough.* *Ensuring that the technical program delivers.* *Achieving product performance and cost goals.* *Increasing the reliability of fuel cell.* *Manufacturing cost-competitive fuel cells.* *Cost reduction.*

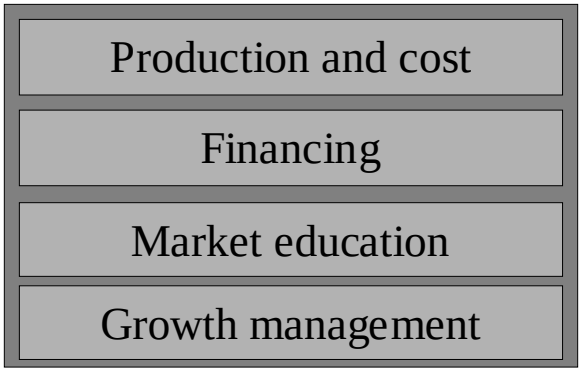
Proposition 6-4: Early-stage clean energy ventures face their biggest entrepreneurial challenges in the area of financing, growth management, and technology development with cost reduction.

6.4.2. Rapid Growth Ventures: Production and Cost Challenge

According to Solarbuzz (2005), the worldwide annual photovoltaic (PV) installation rate will reach 3.2 Gigawatts by 2010, a three-fold increase over 2004 market installations. World PV industry annual turnover will grow from $6.5 billion in 2004 to reach $18.5 billion by 2010 (Solarbuzz). For rapid-growth clean energy ventures, using empirical data for solar PV firms

that participated in the clean energy venture financing survey, altogether four main entrepreneurial challenges were identified from the survey data. Three of the entrepreneurial challenges: financing, market education and growth management, were the same as for clean energy industry level in general. An additional fourth entrepreneurial challenge was named production and cost. The four entrepreneurial challenges are demonstrated in List 5.

List 5 Rapid Growth Clean Energy Venture Entrepreneurial Challenges



Next the entrepreneur sample is described, followed by a description of production and cost challenge.

Twenty-six of the survey respondents (i.e., 16% of the total) were firms operating in the solar PV area. For these firms, years 1999 and 2002 were banner years, as 38% of the solar PV firms were founded during those two years. Most of the firms were relatively small, as 62% of the firms employed fewer than 25 people. Forty-six percent of the solar PV firms that participated in the survey were headquartered in the U.S. Respondents from Europe followed with the share of 42%. Sixty-one percent of the survey respondent firms had sought venture capital funding. Of those firms, 57% managed to raise venture capital funding for the firm.

The solar PV technology can be divided into two generations: (1) crystalline silicon technology and (2) thin-film solar cells (Green 2000). The crystalline technology generation borrows heavily from the microelectronics industry and is based on the use of silicon wafers (Green). The thin-film technology is non-wafer based and five different thin-film technologies can be commercially identified (Green).

Larger markets will lead to increased production scales and gains in cost reduction (Oliver et al. 1999). **Production and cost factors** (Table 17, factor 1) were identified as one of the major entrepreneurial challenges for solar PV ventures that participated in the survey. The

ability to respond to rapidly growing demand is demonstrated by the following response from a solar PV entrepreneur:

> *[Among our top three challenges is] being able to match product production levels with the increased demand.*

Crystalline technologies have profited from economies of scale in the microelectronics industry, especially since solar PV cells can be manufactured from material of lower quality than that in microelectronics, gaining access to off-specification silicon wafers from the microelectronics industry (Green 2000). Current production of PV generation is mostly based on the crystalline silicon technology, using either single- or multi-crystalline approach (Ciorba et al. 2004). The following response demonstrates how solar PV production has benefited from the symbiosis with microelectronics industry:

> *[Among our top three challenges is] starting in a region of the U.S. that lacks a high-tech semiconductor manufacturing infrastructure.*

Thin-film technology has the most potential for ongoing cost reduction and has been called the photovoltaic technology of the future (Green 2000). The key advantage in cost reduction is the reduced use of material. Another production-related advantage is the possibility to grow the unit of production by using large sheets of glass. Crystalline-based technology is tied to the size of the wafer.

According to Solarbuzz (2005), during 2005-2006, there will be insufficient silicon feedstock to meet the planned cell manufacturing capacity expansion announcements and, as a result, overall PV market growth will be restricted. In the words of one solar PV manufacturer:

> *[Among our top three challenges is] to secure enough feedstock.*

Table 17 demonstrates some examples regarding the clean energy entrepreneurial challenge production and cost.

Table 17 Survey Data Examples Regarding Production and Cost Challenge of Rapid-Growth Clean Energy Ventures

Identified Factor	Evidence: Answers to the question: "Among our top three challenges is..."
Production and cost	*New thin-film technology based on a simplified cell structure and a robust production process. High cost reduction potential. First pilot production (max. capacity 5 MW).*

Identified Factor	Evidence: Answers to the question: "Among our top three challenges is..."
	To build up production capacity fast enough. *Being able to match product production levels with the increased demand.* *Ramping up production to 50 MW.* *Production scale-up.* *Ability to source raw materials and build higher capacity utilization.* *Maturity of production technology.* *To be able to reduce unit costs.* *Developing a module level product.* *Getting the volume to reduce costs.*

Proposition 6-5: The major entrepreneurial challenges of rapid growth clean energy ventures are financing, growth management, market education, and ramping up production while reducing unit costs.

6.4.3. Slow Growth Ventures: Marketing Challenge

For slow-growth clean energy ventures, using the energy efficiency industry as an example, two main entrepreneurial challenges, namely financing and marketing, were identified from the survey data. The marketing challenge is similar to the market education challenge identified in the clean energy industry level. However, the marketing challenge was specifically emphasized in the slow-growth clean energy venture data. The two identified entrepreneurial challenges of slow growth clean energy ventures are demonstrated in List 6.

List 6 Slow-Growth Clean Energy Venture Entrepreneurial Challenges

Twenty-four of the survey respondents (i.e., 15% of the total) were firms operating in the energy efficiency area. For these firms, 2001 was a banner year, as 17% of the energy efficiency firms were founded that year. Most of the firms were relatively small, as 83% of the firms employed fewer than 25 people, 63% had fewer than 5 people. Most of the energy efficiency firms (58% of total) that participated in the survey were headquartered in the U.S. Respondents from Europe followed with the share of 33%. Forty-eight percent of the survey respondent firms had sought venture capital funding. Of those firms, 30% managed to raise venture capital funding for the firm.

Providing a precise definition of energy efficiency solutions is not easy, as energy efficiency products exist in every industrial sector (stakeholder interviews, chapter 4.2.3). Perrels et al. (2004) have divided energy efficiency solutions in terms of client groups. Examples of the client groups are markets for delivery of energy carriers, industrial energy-intensive users, building sector, agriculture, transportation, households, and public sector. Use of eco-labels, such as Green Seal, Scientific Certification Systems, Energy Guide, Energy Star and Green-e, has been one approach to promote and market energy efficiency solutions (Banerjee et al. 2003). The governmental role has been important in eco-labeling, since public programs, such as Energy Star, have been far more successful than private initiatives (Banerjee et al.).

The complexity of managing products in different industrial sectors and markets is demonstrated by the response of one energy efficiency entrepreneur who participated in the survey:

> *[Among our biggest challenges is] complexity management in different geographies, product segments, and technology streams.*

Birner et al. (2005) offer examples of supply-side interventions for promoting energy-efficiency products, as shown in Table 18. Most of the interventions suggested by Birner et al. have to do with consumer education and general marketing efforts. The survey data analysis for slow-growth clean energy ventures, using data for energy efficiency firms that participated in the survey, shows similar results.

Table 18 Demand-Side Interventions

Demand-side interventions to promote energy-efficiency products
Educate consumers about the characteristics, costs, and benefits of energy-efficient technology
Conduct media campaigns to increase consumer awareness of energy-efficient technology, and to increase its mass appeal
Educate professionals about the characteristics, costs, and benefits of energy-efficient technology
Reduce retail prices of technology through rebates or subsidies
Conduct bulk purchases and procurements
Provide consumer financing
Offer payback / recycling programs
Facilitate voluntary agreements by industrial consumers to improve efficiency

Inability to sufficiently market the energy-efficient products was clearly demonstrated by those ventures that participated in the survey. Previous research on market creation for energy-efficient solutions indicates that, although consumers are concerned about climate change and generally understand the causal role of fossil fuels, they believe that they have done everything they can or that one person cannot make a difference (Boardman 2004). As one of the entrepreneurs who participated in the survey points out:

> *[Among our top three challenges are] MARKETING, MARKETING, MARKETING.*

Table 19 demonstrates some examples responses regarding the clean energy entrepreneurial challenge of marketing.

Table 19 Survey Data Examples Regarding Marketing Challenge of Slow-Growth Clean Energy Ventures

Identified Factor	Evidence: Answers to the question: "Among our top three challenges is..."
Marketing	*Explain why our technology works.* *Money for marketing.* *Now we are struggling with marketing.* *Access to market, marketing efforts.*

Proposition 6-6: Slow-growth clean energy ventures face their biggest entrepreneurial challenges in the area of financing and marketing their solutions.

6.5. Discussion

The Van de Ven et al. (1989 and 1993) model for industry development is presented in chapter 3.1. The Van de Ven et al. model includes four subsystems: institutional arrangements, resource endowments, market consumption, and propriety activities. As explained in the literature review (chapter 3.1), the model has been applied to various industries. The Van den Ven et al. model is shown in more detail in Figure 3.

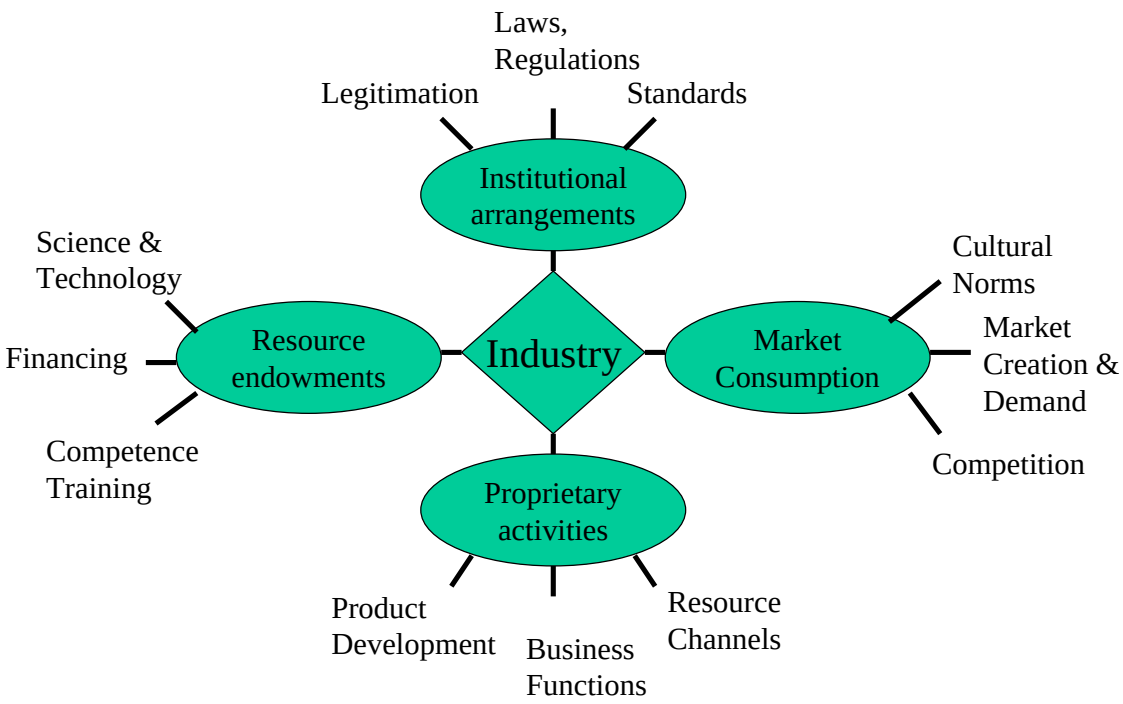


Figure 3 Van de Ven et al. (1989 and 1993) model for industry development

The institutional arrangement subsystem includes the governmental agencies, professional trade associations, and scientific/technical communities that legitimize, regulate, and standardize a technology. The resource endowments subsystem includes advancements in basic scientific and technological knowledge, financing and insurance arrangements, and training of competent professionals. The market consumption subsystem includes informed, competent, and responsible consumers. The proprietary activities transform the available supply of public resources, such as scientific knowledge and work force competence, into proprietary products and services to meet the customer demand.

The clean energy industry-level entrepreneurial challenges that were identified in the study are made apparent by applying the Van De Ven et al. model. A representation of the three main entrepreneurial challenges identified by clean energy entrepreneurial ventures is shown in Figure 4. Factors under each of the three identified entrepreneurial challenges shown in List 3 have been placed under appropriate component in the Van de Ven et al. model.

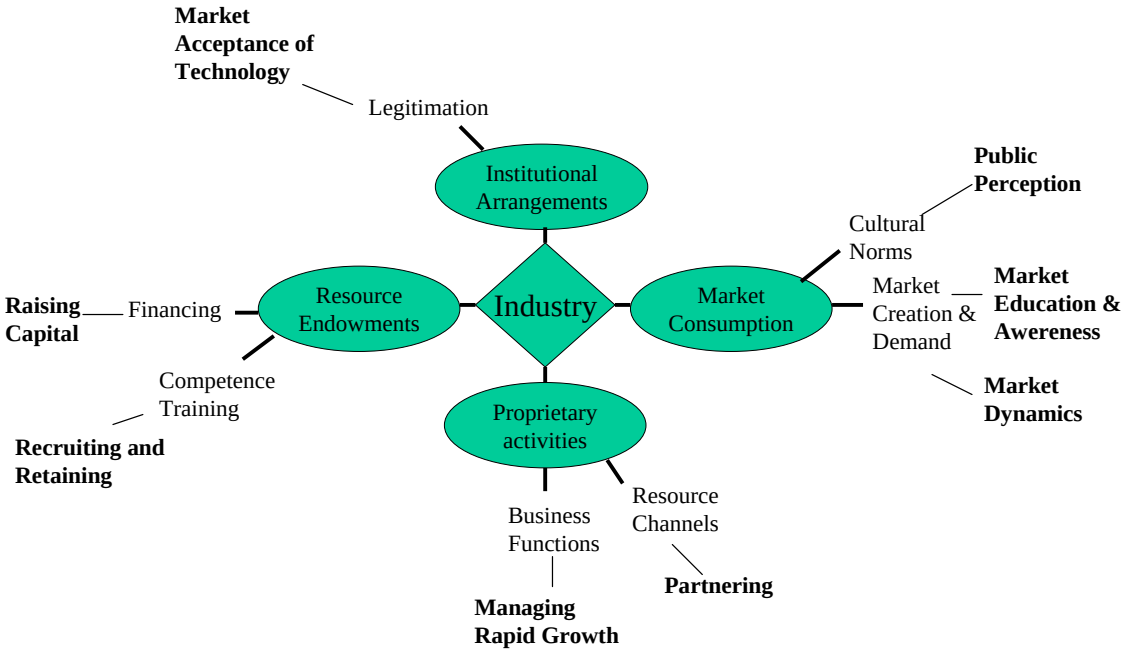


Figure 4 Van de Ven et al. (1989 and 1993) model for clean energy ventures

As the Figure 4 demonstrates, the clean energy venture entrepreneurial challenges are found in each of the four components of the Van de Ven et al. (1989 and 1993) model. However, at the industry level, clean energy ventures do not seem to be hamstrung by laws, regulations, and standards, or even science, technology, or product development issues. The main entrepreneurial challenges the clean energy venture faces are found in the area of resource endowments, such as capital and human resources, and market consumption, such as market education and public perception. The area of proprietary activities, including management of rapid growth and partnering with external players, is another major entrepreneurial challenge facing clean energy ventures.

In the introduction of this chapter (chapter 6.1), it was noted that previous research on sustainable industry emergence has concentrated on the system level and policy perspective.

Sustainable or cleantech industry firm level studies have remained absent. This study on clean energy venture entrepreneurial challenges shows that clean energy ventures struggle with issues other than institutional arrangements, which has been the main focus of previous studies. Further studies that concentrate on resource endowments (e.g., raising capital, recruiting and retaining personnel), proprietary activities (managing rapid growth, partnering), and market consumption (public perception, market education and awareness, market dynamics) are needed. This may help to increase our understanding of the market solutions that are needed to facilitate the further growth of the clean energy industry or cleantech industry in general.

The identified clean energy venture main entrepreneurial challenges are similar to the challenges one may expect to find in other innovative industries. However, as previous research has found, entrepreneurial challenges may vary based on the industry development stage (Low et al. 1997 and Aldrich et al. 1994), nature of technology (Kassicieh et al. 2002), industry context (Chesbrough 1999), or the difference in time the industry takes to evolve (Klepper et al. 1990 and Low et al.). In this study, the entrepreneurial challenges of clean energy ventures in different industry development stages were also analyzed. The industry development stage analysis brought to light differences when compared with the clean energy venture main entrepreneurial challenges identified earlier. This result indicates that a further study that would analyze clean energy entrepreneurial challenges from the perspective of the nature of the technology or the time the particular clean energy industry category has taken to develop would be likely to bring even more variance to clean energy venture entrepreneurial challenges. Low et al. noted that it has not been possible to identify factors that have consistently led to entrepreneurial success. Based on the results of this study and the findings of previous research, it is argued that no generic strategies that could be applied over different industries, technologies, and development stages even exist. In order to provide clean energy ventures or any other innovative industry ventures with efficient strategies to tackle the entrepreneurial challenges the ventures face, an in-depth understanding of the industry context, technology, industry development stage, institutions, and industry history is needed.

Chapter 9 contains a more detailed discussion on the findings, limitations, and contributions of the findings of this chapter.

7. Clean Energy Venture Risk Characteristics

The previous chapter showed that venture financing is a common entrepreneurial challenge for clean energy ventures independent of the firm's development stage. This chapter takes a closer look at clean energy ventures' search for one particular type of venture financing: venture capital. The chapter develops a model of clean energy venture risk characteristics from the VC perspective.

7.1. Introduction

Previous studies suggest that the decision-making behavior of venture capitalists is affected by biases similar to those affecting all the other humans, despite the "homo economicus" rational decision-makers that they are supposed to be (Zacharakis et al. 2001 and 1998). The essential argument of this chapter is that, in addition to risk characteristics that are generally recognized by both the VCs and the clean energy ventures, venture capitalists' cognitive biases in decision-making create additional risk characteristics. These additional cognitive risk characteristics are demonstrated to be especially severe for ventures that operate in a complex environment involving not just economical, but also social and environmental aspects. Gompers et al. (2001) point out that understanding VC risk and return is one area of empirical academic research on venture capital that still remains relatively unexplored. The goal of this chapter is to build understanding on clean energy venture risk characteristics from the VC perspective.

Studying venture capitalist decision-making is not novel. However, at the same time that certain aspects, such as the VC decision-making process, have been widely studied (Tyebjee et al. 1984, Fried et al. 1994, and Roberts 1991), cognitive factors in VC decision-making that try to explain "how decision actually happen rather than how they ought to happen" (March 1994) remain understudied. During the past decade, some steps have been taken on the cognitive side of the venture capital decision-making process (Shepherd 1999 and Zacharakis et al. 2001 and 1998). Based on the study results, clean energy venture risk characteristics can be divided into two groups. The first group, consisting of five risk characteristics, is named generally recognized risk characteristics. The second group, consisting of four risk characteristics, is named cognitive risk characteristics. Based on the study, nine propositions that can be tested in future research were developed. The developed model on clean energy venture risk characteristics suggests that cognitive risk characteristics of venture capitalists

are key to understanding why clean energy ventures have received only a small amount of venture capital investment.

7.2. Methodological Notes

Both the VC and CVC interviews and the clean energy venture financing survey were utilized as the source of empirical data in the theory-building of this chapter. Both the interviews and the survey are described in detail in the methodology chapter (chapter 4). The main flow of the data analysis proceeded as described in chapter 4.3.2. The Sitkin et al. (1992) model on risky decision-making behavior was utilized in refining the results of this study. The Sitkin et al. model is described in more detail in chapter 3.4. The Sitkin et al. model was chosen since the model has been previously successfully applied to entrepreneurship and venture capital research (Mullins et al. 2002, Carpenter et al. 2003, Manigart et al. 2002, and Simon et al. 2000). When quotes from the empirical data are used as prototypical examples of the study results in the chapter, labels [VC] and [Venture] are used to indicate whether the quote came from the clean energy venture financing survey or the VC and CVC interviews.

7.3. Clean Energy Venture Risk Characteristics

Results of the previous chapter show that seeking funding from venture capitalists is a strenuous exercise for most clean energy ventures. As Zider (1998) notes, “Many excellent entrepreneurs are frustrated by what they see as an unfair deal process and equity position.” Venture capital investing is all about balancing risk and return; this applies to both the clean energy or cleantech ventures (Wuestenhagen et al. 2006 and Ruhnka et al. 1991). According to Zider, venture capitalists focus on the middle part of the classic industry S-curve, avoiding both the early stages, when technologies are uncertain and market needs are unknown, and the later stages, when competitive shakeouts and consolidations are inevitable and growth rates slow dramatically.

Based on an iterative process between empirical data and previous literature, a model emerges. The model that emerges from the study is shown in Figure 5. The model consists of two types of risk characteristics: **generally recognized risk characteristics** and **cognitive risk characteristics**. Altogether, nine risk characteristics are identified. Next, both risk characteristic types will be discussed in more detail.

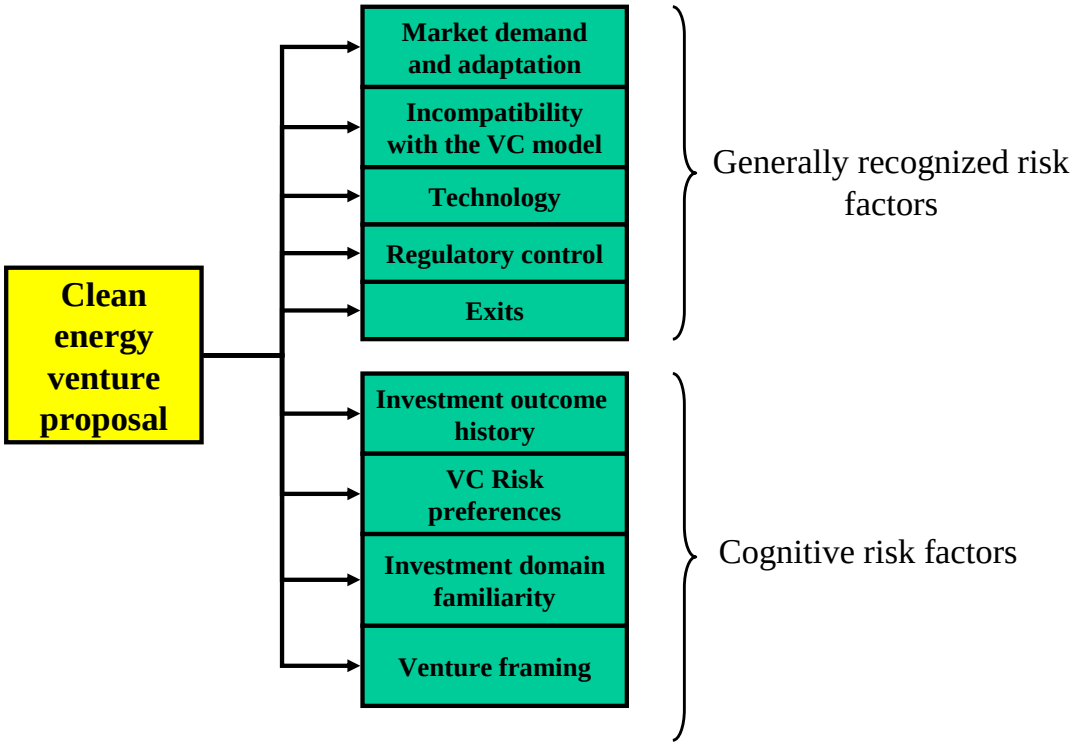


Figure 5 Clean energy venture risk characteristics

7.4. Clean Energy Venture Generally Recognized Risk Characteristics

Based on the clean energy venture financing survey and VC interviews, five generally recognized risk characteristics are identified. These five characteristics are: (1) **market demand and adaptation**, (2) **incompatibility with the VC model**, (3) t**echnology**, (4) **regulatory control,** and (5) **exits**. These five characteristics are similar to the ones identified in previous research (Wuestenhagen et al. 2006, Tyebjee et al. 1984, and Zider 1998). Next, all five risk characteristics are discussed in more detail.

7.4.1. Market Demand and Adaptation

Under the risk characteristic of market demand and adaptation, several themes could be identified. These are scale of change, dominance of market incumbents, and speed of market adoption, as shown in List 7. These themes will be discussed in more detail.

List 7 Risk characteristic: Market Demand and Adaptation

Market Demand and Adaptation
-Scale of change
-Dominant position of market incumbents
-Speed of market adoption

The first identified theme associated with the market demand and adaptation risk characteristic is the **scale of change** needed to alter the current industry infrastructure, in this case, the energy infrastructure. The interviewed VCs expressed this concern as the "need to change the world" before a large-scale market adaptation could take place. In the words of one interviewed VC:

> *[VC]: And you have to change the way the infrastructure is and so many other big things that, when you look at it, you think, "This technology is fantastic and it can really solve some problems, but it will take ages for it to have real breakthrough."*

Another point of concern is whether the energy market has intrinsically different qualities that would inhibit successful market introduction of new products. As expressed by one VC:

> *[VC]: And I think the thing that is still the big question mark is [whether] the electricity and power market just has a different kind of technology adoption practice or curve or time line, [which] really affects how successful venture capital can be in this area. So it's how we tend to think about it here and observe it. There is obviously nothing we can do, very little we can do other than focus on making our investments that can actually shift the balance of power here. It's really watching how the big electricity and power customers or power providers, you know, companies like Shell and BP, [are] doing as they identify new market areas. And then [you] look at the companies they need to work with or invest in to take advantage of those new market areas. So, [there is] a lot to do.*

Second theme that emerges is the **dominant position of market incumbents**. In the current study context, this indicates the dominant position electric utilities and oil firms have of the energy market. This concern is expressed both by VCs and clean energy ventures. In the words of an interviewed VC:

> *[VC]: The energy market is not really a competitive market when you have five players really controlling the market. They are doing what they can to*

> *protect their business. I'd say it is more cartel- looking business. It sometimes takes months to change supplier[s], or changing the network supplier is almost impossible. That's their way of keeping the market.*

Another interviewed VC describes the control the market incumbents have as follows:

> *[VC]: All of the energy sectors are within the control of the environment. Extremely controlled with very large players. So there is very little innovators can do to change the roles. In information technology, you just invent the Internet. You invent a new protocol to communicate over the Internet and you can compete with Goliath.*

Clean energy ventures experience the reluctance of VCs to invest in the energy sector dominated by large corporations that have strong business models. In the words of one survey respondent:

> *[Venture]: Engine industry is dominated by big corporations. VCs don't want to deal with large, lethargic corporations controlling markets and prices that makes the work of small start-ups all the more difficult.*

The size of the industry incumbents may not necessarily scare VCs away. One example is the pharmaceuticals sector, where the industry incumbents are large players. However, the pharmaceuticals market is not as concentrated as the energy sector, and this makes VCs more at ease when compared with investing venture capital into the energy sector. As one of the interviewed VCs comments:

> *[VC]: The pharmaceutical sector is very competitive. The largest pharma company right now is GlaxoSmithKline, [which] has 8% of the market. If I give you another example in the field of transmission equipment, which I know well in detail, if you look at power equipment for transmission lines or transformers or all of that. Three players control over 70% of the market. ABB, Siemens, GE. […] It's way more concentrated than pharma.*

The third identified theme is the **speed of market adoption**. For a VC to invest, the opportunity, mainly concerning the growth rate in the area, needs to be perceived as big enough (McDougall et al. 1994). By investing in areas with high growth rates, VCs primarily consign their risks to the ability of the company's management to execute (Zider 1998). Zider continues: "Picking the wrong industry or betting on a technology risk in an unproven market segment is something VCs avoid." Clean energy technologies, such as solar PV and wind,

have experienced rapid growth curves during the past ten years. Despite of the impressive growth rates, market adoption rates are still a concern for VCs:

> *[VC]: I think the two things that are constraining, so that's one thing certainly that constrains electricity, is that your adoption of a technology still is in [the] hand[s], largely, of utilities.*

One aspect of market adoption speed is how fast the habits of consumers are changing. The majority of the interviewed VCs express concern over the knowledge level and motivation of consumers to change. An interviewed VC comments:

> *[VC]: People use energy without being aware of that. When they enter a room, [they] turn on the air conditioning, [thus] they buy something from the electric utility. So they don't see the value. They just see the downside; they see when the lights go off. They see the bill. It's just negative. They're not aware where the energy comes from.*

Most of the concerns related to consumer habits expressed by the VCs are associated with insufficient knowledge of end-users on the available alternative solutions. In the words of an interviewed VC:

> *[VC]: Energy is not visible. People have an opinion about it. They don't have knowledge about it. Ok? […] When it comes to energy, […] in the traditional energy supply system, it's always being top-down. It's always being top-down whether it's electricity or oil or gas. You have some big companies owning some sources, you have some transmission systems, which are still owned by some big companies. And then the companies tend to get a little bit smaller when it comes to distribution, but it's still kind of anonymous. It's just there, whether it's oil or gas or electricity or fuel for your car, you know. It's just there and you don't think about it. As a consumer, as an energy consumer, when do you, how many people decide upon fuel consumption?*

The venture survey respondents experience difficulties in convincing the VCs on the market adoption speed, as is demonstrated by the example survey responses shown in List 8.

List 8 Example Venture Responses Regarding Speed of Market Adoption

[Entrepreneur]: [The problem we experienced with the VCs was] industry growth and potential market.
[Entrepreneur]: [The problem we experienced with the VCs was] acceptance of the slower

growth of the business in the energy sector compared with IT.
[Entrepreneur]: [The problem we experienced with the VCs was] size and emergence of markets.

Proposition 7-1: One of the five most important generally recognized risk characteristics of clean energy ventures is market demand and adaptation risk, consisting of the large scale of change needed, dominant position of market incumbents, and insufficient market adoption speed.

7.4.2. Incompatibility with VC Model

The optimal VC investment target is generally described as having a short lead time, preferably leading to an IPO (Zider 1998). Typically, the VCs look at exiting their investments within two to eight years after the investment. Naturally, some variations to optimal VC investment targets exist. For example, Baum et al. (2004) studied the biotechnology industry and identified three types of capital that determine the VC's decision to invest in a start-up: alliance capital, intellectual capital, and human capital. Biotechnology start-ups financed by VCs typically have high intellectual capital, in the form of patents. Although the lead time to an IPO for many biotechnology firms may be long, this is compensated by the high intellectual capital of the start-up, which enables the VC to make an early exit in the form of a trade sale or a secondary sale (Cumming et al. 2003).

Capital intensity of a deal also increases the downside risk, forcing the VCs to build large investment consortiums in order to make sure their portfolios remain diversified. Both of these two themes, long lead times and capital intensity, emerge from the VC and CVC interviews and the clean energy venture survey data, as a generally recognized risk characteristic. This risk characteristic is named incompatibility with the VC investment model, as shown in List 9.

List 9 Risk characteristic: Incompatibility with the VC Model

Incompatibility with the VC Model
-Long lead times
-Capital intensity

The first theme, **capital intensity** of the energy sector investments, is a cause of concern for VCs:

> *[VC]: Another thing is the capital intensity. There are so many big projects. Either you have a windmill park of hundreds of stations costing billions or you have some wave energy project costing large amounts.*

Clean energy venture survey responses resonate with the VC interview findings, as is demonstrated by the following comment:

> *[Venture]: Entering into the mass market of consumer electronics is difficult for a small company. In consequence, the capital need is rather high and might not be raised by one VC but rather a VC consortium.*

The second theme that emerges has to do with **long lead times**. Most venture capital funds have a limited lifetime of seven to ten years, making multi-year investments impossible. As Zider (1998) notes: "The idea is to invest in a company's balance sheet and infrastructure until it reaches a sufficient size and credibility so that it can be sold to a corporation or so that the institutional public-equity markets can step in to provide more liquidity." Not being able to create a credible short-term story to support a VC investment decision may thus become a barrier for a VC investment. In the words of an interviewed VC:

> *[VC]: In the energy field, the investment times are often too long for a VC. Even though a VC would say five to eight years, what they really mean is three to four years and then they want to exit. The venture has gone badly if they wait until the end of the discussed period (eight years). Since they don't want to sound opportunistic, they make it sound like they are a good partner instead of saying that [their] investment times are one to three years. You start planning the exit right away: this is what the professional investors do. Since you want high profits, you wait until the firm is worth enough (i.e., you wait a few years).*

Long lead times have created difficulties for most of the ventures that participated in the survey. Several ventures that were asked what challenges they had faced in selling their business ideas to the VCs reflected time-scale concerns as a common hurdle. Some examples from the survey are collected in List 10.

List 10 Example Venture Responses Regarding Long Investment Lead Times

[Venture]: [VCs] think that the timescales are too long for VC investment. They need an exit and positive cash flow in three years from a start - this is unrealistic, but what they require.
[Venture]: The future business is still far away, so the risk seems big for a VC; therefore they ask a big share of the company for relative little sum of money.
[Venture]: The time to market for our product, the micro fuel cell, is rather long.
[Venture]: [Our challenge with the VCs is] lack of a defined market in the short term because the hydrogen economy has been delayed.
[Venture]: [Our challenge with the VCs is that] we cannot show a big pop in three years.
[Venture]: [Our challenge with the VCs is the] time horizon to commercialize and deploy technology necessary to meet fund/return objectives

The investments in clean energy technologies remain relatively modest, and experience from clean energy venture investment exits is scarce among the VC community. Therefore, many VCs rely on the image, not actual personal experience, they have of the energy sector lead times. An interviewed VC comments on the long lead time perception among VCs as follows:

> *[VC]: At least the perception among venture capitalists is that [the] energy field has long investments times, whether or not this is true. There have been so few investments and exits that this has not been verified yet. Everything in the energy field works on a longer time horizon, so investors feel that the same is true for their capital.*

Proposition 7-2: One of the five most important generally recognized risk characteristics of clean energy ventures is incompatibility with the VC model consisting of long lead times and capital intensity.

7.4.3. Technology

The third generally recognized risk characteristic that is identified from the interview and survey data is technology risk. The concerns concentrate around lack of intellectual property rights (IPR) protection and technological uncertainties, as shown in List 11.

List 11 Risk characteristic: Technology

Technology
-Lack of IPR protection
-Technological uncertainties

The interviewed VCs point to a **lack of IPR protection** as a potential weak point in the clean energy ventures and cleantech ventures in general. The interviewed VCs tend to contrast the clean energy ventures with biotech ventures, for which patenting practice is more widely in use. A survey respondent venture comments on the patent protection issue as follows:

> *[Venture]: Biotech and IT investors require levels of IPR protection that are difficult for us to provide. We are basically an engineering company, where to steal the IPR would be easier in the longer term than a formula for biotech or [a] piece of nanotechnology or minute component in IT.*

However, non-patentability is not necessarily a show-stopper in raising venture capital, as the nature of the business opportunity may differ fundamentally from a biotech venture. An interviewed VC comments the lack of patentable technology among clean energy ventures as follows:

> *[VC]: What I want to emphasize is that these new companies are not technology companies that have extensive patent portfolios. Of course this would be nice, but the companies coming to the field are either distribution channel[s] or concept innovations. I think these are the most interesting innovations. Examples of this are services that do off-site reading of electricity meters and send it to reporting software. This is not rocket science technology and often not even patentable. But the [genius] is in the concept itself and it may be based on conventional technologies.*

Technological uncertainties are common for all new ventures. At the time of raising growth capital for the venture, only an early version of the final product or a preliminary prototype of the technology may exist. Demonstration, testing, future development of the technology, and the impact the new technology will have on the market all contain uncertainties that raise the VC investment risk. The risk of whether the technology actually works and can be successfully demonstrated to potential customers is expressed by the majority of the interviewed VCs and the ventures that responded the survey. Some example responses are collected in List 12.

List 12 VC and Venture Responses Regarding Technological Uncertainty of Clean Energy Ventures

[Venture]: Our technology is new to the iron-making industry and to achieve market acceptance, full-scale testing of our product will be required, even though it meets all necessary quality requirements. Producing enough products for full-scale testing requires a sizeable investment into building a demonstration facility. The risk associated with the demonstration facility and possible market rejection of an unproven product is viewed by potential investors as high.
[VC]: Because I don't think [fuel cells] are financeable right now, [the] same goes for high energy stuff. They probably would be financeable in 15 years or so, but not right now with venture money.
[VC]: One of the things that we have been seeing in the fuel cell scene is that, for instance, your technology development time continues to be long.
[Venture]: The toughest problem [we have encountered] has been the time to develop our revolutionary technology, which can make investors nervous.

Proposition 7-3: One of the five most important generally recognized risk characteristics of clean energy ventures is technology risk consisting of lack of patent protection and technological uncertainties.

7.4.4. Regulatory Control

The fourth generally recognized risk characteristic that is identified from the interview and survey data is regulatory risk. Although many industrial sectors are regulated, the interviewed VCs tend to view the energy sector as particularly strongly affected by regulation. The central problem with regulation, according to survey respondent ventures, is that the control of market direction is in the hands of the regulators, and not VCs or the ventures themselves (List 13).

List 13 Risk characteristic: Regulatory Control

Regulatory Control
- Regulators have control of the market direction

The interviewed VCs recognize that the governmental intervention may also create new profit potential, but with the price of **handing the control over to governmental regulators**.

> *[VC]: I think that in the late [19]80s and early [19]90s, there was a big interest, particularly in California, [in] what they called environmental technology. [..] But the problem was that most of it, or all of it, was an added cost and that it was regulated. And as long as it remained, so that the law was in place but it wasn't enforced, a lot of companies and their good technology ended up on a shelf and the companies went bankrupt. [..] I think a lot of people who remember that [California experience] that when it is regulated, it is not true market force, there are too many unknowns and you will shy away from investing.*

Whether or not the interviewed VC see opportunities or threats with regulatory intervention, the majority of the interviewed VCs view regulatory power as a definitive risk for clean technology market formation. Some example responses from both the interviews and the survey are collected in List 14.

List 14 VC and Venture Responses Regarding Regulatory Risk of Clean Energy Ventures

[Venture]: [VCs] are nervous of the [energy] market, as it depends on government intervention.
[VC]: A lot of business plans rely on other extensive factors that you cannot control and VC is getting very nervous when you see big investment in capital-intensive and regulated market[s] relying on a fundamental change in the environment.
[VC]: So it might be that some of these political aspects might favor you. Because you are investing and suddenly there is a new law and you capitalize on that by selling. And two years later that law is changed. So you have to make a distinction between your holding period and your success as a VC and the success of the technology in the long run. […] If you are well informed, [regulation] brings an extra opportunity.
[VC]: I have to say, the regulation in the energy sector is not easy. I mean, it's easy to blame all the governments. California crisis […] was caused by deregulation but I'm pretty careful to [not] blame anybody because I don't have any better suggestion.
[VC]: If there is no clear need for the government, make them stay out of the way.
[VC]: VCs often see a red flag with government money. The nice way of doing it is to put the government money into a professional fund or institutions to support the industry.
[VC]: Tthe problem with governments is they always have to make sure everybody gets treated equally. And that's very difficult because certain things aren't equal. So they have to establish certain rules and publish them […] The rules say white shirts, and it was too easy to get to the money, and investments were made too fast before we really knew what we

needed, because the money was there, you know. So, I doubt that [governmental intervention] is good.
[VC]: In energy, you have two compounding uncertainties. You have one uncertainty, which is the technology and will it work, does it work. This is the same as in biotech, ok? But you're compounding another uncertainty, which is the regulatory uncertainty. And that, in most cases, you don't have that in biotech.

Proposition 7-4: One of the five most important generally recognized risk characteristics of clean energy ventures is regulatory risk, as the VCs feel that the regulators have too much control over the market direction.

7.4.5. Exits

The fifth generally recognized risk characteristic that is identified from the interview and survey data is insufficient amount of exit opportunities for clean energy ventures. Exits are an essential part of the VC business model and are considered carefully at the time of investment. Two routes, initial public offerings (IPOs) and trade sales, are the most common forms of VC exits. Other exit routes include a secondary sale, where the VC sells its share to a strategic investor or another VC, management buyout, where the VC sells its share to the entrepreneurial firm or its management, and a write-off in case the venture fails (Wuestenhagen et al. 2006, Cumming et al. 2003, and Gladstone 1989).

Many of the interviewed VCs express concern with the fact that they feel there are **not enough exit opportunities** in the clean energy market, whether in the form of IPOs or trade sales (List 15).

List 15 Risk characteristic: Exits

Exits
- Scarce exit opportunities

An important part of the scarcity problem is the concentration of market power in the hands of relatively few players, as discussed earlier (chapter 7.4.1).

[VC]: I think what the industry is lacking is [exit opportunities]. […] You remember the joke that is always made on the water deals where every single business plan has a section about a potential exit and they say, "We could be bought one day by Vivendi." And Vivendi doesn't know how many companies they're supposed to buy.

Some example responses regarding the exit opportunity scarcity are collected in List 16.

List 16 VC and Venture Responses Regarding Scarcity of Exit Opportunities

[VC]: Currently there is not enough exit potential in the market. The market is still too immature. I think the exit market is immature and you have to see some success stories in the exit market for this sector to take[off].
[VC]: Well, it could be, just again my perspective of looking out for the interests of the investor, but I almost think that it starts with not enough sustainable exit opportunities. Following that logic, [...] if you put the emphasis on the exit, not enough exits means that VCs need to spend their time looking at different kinds of deals in different industries or whatever. And therefore they pay less attention to the broad base of business plans/ They might only pick amongst the very very best in the energy sector.
[Venture]: VCs believe that utilities are a "bad" or difficult market to sell to and are thus hesitant to invest in this space.
[VC]: My belief is that not so [many] traditional utilities are [exit targets] yet. Maybe we'll see the same trend as in telecom, that they first try to solve the problem themselves and then they realize that it is cheaper and easier to buy an existing company that has looked into this field for several years, to buy incompetents in a way.

Proposition 7-5: One of the five most important generally recognized risk characteristics of clean energy ventures is exit risk, as the VCs perceive that the exit opportunities in the clean energy market are too scarce.

7.5. Clean Energy Venture Cognitive Risk Characteristics

7.5.1. Investment Outcome History

The first cognitive risk characteristic that is identified is the outcome history of venture investments. According to Sitkin et al. (1992 and 1995), the decision–makers' propensity to take risks is contingent upon the degree of outcome success associated with their propensity

to take risks. In other words, if previous risk-taking was successful, decision-makers will seek new opportunities in similar situations.

For clean energy ventures, this implies that those venture capitalists that have not yet made investments into clean energy ventures have to base their investment decision on the experiences of other investors. Survey respondent clean energy ventures are more inclined than the VCs to argue that VC risk aversion is a product of the recent technology bubble collapse in the late 1990s and early 2000s. Some of the early experiences in clean energy investing may have been very negative, as the following quotes demonstrates:

> *[VC]: Based on our experiences, I could say bitter experiences with the energy sector, I can say this. We have had two investments into [clean energy] and both of them have gone bust.*

Among the interviewed VCs, **lack of clean energy success stories or absence of clean energy investment category track record** is the most often quoted risk related to investment outcome history, inhibiting new investors from entering the market (List 17).

List 17 Risk characteristic: Investment Outcome History

Investment Outcome History -Lack of clean energy success stories or absence of a track record

Some example responses regarding the lack of clean energy success stories or absence of a track record are collected in List 18.

List 18 VC and Venture Responses Regarding Clean Energy Venture Outcome History

[VC]: With information technology, this bubble happened and you could earn a lot of money and I know many investors who have this wet dream of doing it again because it happened once, so why cannot it happen twice. But in the energy field, this has not happened yet. So you don't know yet whether you're going to see these huge valuations.
[VC]: We don't have enough track record in the sector, where we could say, look at this.
[Venture]: The situation is improving, but the problem of few success stories remains and [there is] only modest participation by mainstream VCs.
[Venture]: Energy-focused funds do not have a poster child success story to point to. These funds tend to be smaller. The size and ability to participate in follow-on financing is a concern for large, traditional VCs. When we started to look for funds in early 2003, the VC

industry was still licking their wounds from the dot-com bust. VCs were reluctant to invest and few of the traditional funds had any understanding of the PV market. Draper-Fisher-Jurvetson's investment in Konarka got many funds interested in looking at the PV sector, but many of these funds were primarily trying to get educated on the investment opportunities, as opposed to being committed to making an alternative energy investment.

Proposition 7-6: One of the four most important cognitive risk characteristics of clean energy ventures is the lack of clean energy success stories and absence of a clean energy investment category track record.

7.5.2. Venture Capitalist Risk Preferences

The second cognitive risk characteristic that is identified from the research and survey data is venture capitalist risk preferences. According to Sitkin et al. (1992), the risk propensity of decision-makers is consistent with their preferences concerning risk. For a venture capitalist, venture decisions are about weighing the risks and the potential returns of an investment (Tyebjee et al. 1984). In order for a venture capitalist to take on more risk, the expected return on an investment needs to be higher as well.

Clean energy venture investing attracts both generalist and specialist venture capital funds. For early-stage ventures, going with a specialist fund may be a better strategy in regards to venture capitalist risk preferences, as specialized venture capital funds are associated with lower required returns for early-stage ventures (Manigart et al. 2002). Among venture capital funds that have invested in clean energy, specialized funds, such as Nth Power[11] and Sustainable Asset Management[12], have been more active in their investments in energy sector than generalist funds.

[11] www.nthpower.com

[12] www.sam-group.com

Three main themes emerge from the study: strong risk aversion among investors, reluctance to invest in early-stage deals, and unwillingness to be seen as the "first mover investor" in the market (List 19).

List 19 Risk characteristic: VC Risk Preferences

VC Risk Preferences
-VC risk aversion
-Avoidance of early stage deals
-Reluctance to be seen as the first mover

The interviewed VCs exhibit high levels of **risk aversion** in regard to clean energy investments. Some example responses regarding the VC risk aversion are collected in List 20).

List 20 VC and Venture Responses Regarding VC Risk Aversion

[VC]: Venture capitalists are risk-averse, even if they are venture capitalists. They basically look for opportunities that other people didn't understand, not opportunities [where] they feel they'll be taking a very large risk. They feel and they know they're taking a very low risk, but that the other people didn't understand [the opportunity]. If that technology has to change habits and ways that people work, think, buy, sell, then that risk is extremely high, so they won't touch that billion-dollar opportunity if it means that everybody has to change their way of working or thinking, which is the case of energy.
[Venture]: VCs prefer to invest many millions in one risk-free company [than] to invest small sums in many start-ups. VCs have forgotten what "V" means venture.
[CVC]: We are actively looking for fuel cell investments. But I think they will still require quite a lot of money and you will not be punished not to invest right now […] To get fixed on one technology right now is very dangerous and you will not be rewarded by taking this risk right now. […]If you see [how many] funds are going for fuel cells, it is like [the 3rd generation mobile networks in the telecom sector], you can never get this money back.
[VC]: And what happened was that, in the boom time, [the] late 1990s, so much money came into VC that VCs shifted over here in order to chase deals and returns, crowded out the angels, who stayed here, because that's all they could afford to do. And the risk profile of the public companies came over here. [A clean energy venture called] Proton Energy raised, what was it, $240 million on the public market with a trickle of revenue, right. You can't do that in today's market. But it was a sort of a sign of the market times. Well, now today the problem is that everyone [is] risk-averse. VC now wants to be over here. The

public market wants to be over here. And angels are still over here. So, two effects, there are two effects: one is there's a financing gap for start-ups, the second is these people are not as wealthy, so the overall size of this pie, […] has got smaller.
[Venture]: [VCs exhibit] risk aversion due to [the] tech bubble collapse.
[Venture]: Venture firms have strong ideas of what kind of company they want to fund: Low risk, existing revenue stream.
[Venture]: Risk-adverse nature of investment in energy sector, particularly for electricity industry, is next single biggest obstacle - most investors are in a wait-and-see mode - wanting to invest in plays that actually are profitable.
[Venture]: VCs do not want to invest in innovative start-ups, but prefer no-risk, mid-size companies with some years of profitable business.
[Venture]: VCs do not take real risks. They are only looking for companies they can expand with little or no risk.
[Venture]: VCs as a rule -- energy sector/other, corporate/independent, whatever -- are much more conservative than they like to appear.

Most of the interviewed VCs are very **reluctant to enter early-stage deals** in the clean energy sector. Some example responses are collected in List 21.

List 21 VC and Venture Responses Regarding Reluctance to Enter Early-Stage Deals in Clean Energy Sector

[Venture]: There is a total reluctance, by both corporate and independent VCs, to invest in early stage development. The interest is solely in commercializing proven technology.
[VC]: About the companies presenting [in the European energy venture fair], an analogy can be drawn to companies in the [clean energy] field in general: so many of them are in such an early phase. This is why there are so few investments. Many of them are in the seed phase. They have [...] very capital-intensive products. This is [a] very unfortunate position.
[VC]: And it takes longer or it's harder for start-ups to even get their first round of money, because the VC team wants to play [with] more mature companies and angels are harder to find to support the companies. And even the angels, if you can find them [...] the company has to raise enough or to make progress enough that VCs will pay attention to them. Eventually this will normalize, this should normalize back to the point where VC is moving back to early-stage risk. The public market becomes a place where public or IPOs or mergers and

acquisition markets become a place where VC-backed start-ups have a place to go. But that adjustment will take some time and I don't think we will see a return to the time when the overall VC market is, you know, investing in a hundred billion dollars of start-ups in a given year. You know, in the year 2000, a hundred billion dollars of investment went into venture capital start-ups.

The third theme that is identified is that the VCs are very **reluctant to be seen as the first movers** in the clean energy VC market. Survey respondent clean energy entrepreneurs view the reluctance to commit until others commit as VC herd-like behavior. Some example responses are collected in List 22.

List 22 VC and Venture Responses Regarding Reluctance to be First Movers

[Venture]: Herd effect - going where others have gone.
[Venture]: Expectation for others to commit first.
[Venture]: We had no lobbying power. It seems these guys just give to the kind that one of them already invested. Nobody wants to be the first to invest.
[Venture]: They are pack animals.

> **Proposition 7-7**: One of the four most important cognitive risk characteristics of clean energy ventures is the VC risk preferences consisting of VC risk aversion, avoidance of early-stage deals, and reluctance to be seen as the first mover in the market.

7.5.3. Clean Energy Venture Investment Domain Familiarity

The third cognitive risk characteristic that is identified is clean energy venture investment domain familiarity. According to Sitkin et al. (1992), decision-makers with moderate levels of domain familiarity will have more accurate estimates of risk than will decision-makers with high or low levels of domain familiarity. In the venture capitalist decision-making process, investment domain familiarity is just one measure of venture capitalist experience. Zacharakis et al. (2001) found a curvilinear relationship between experience with the venture capital task and the accuracy or efficiency of their decision processes. In other words, as the venture capitalists become more familiar with the investment domain and other factors related to the

venture capitalist decision-making process, their reliability first increases but then decreases. The finding of Zacharakis et al. resonates well with Sitkin et al., who note, "As experience increases, decision makers are more likely to focus on their own abilities and past successes rather than current situational constraints."

Clean energy venture investing is still an emerging area and thus the curve depicting the relationship between venture capitalist experience and accuracy of their decision-making is argued to be still increasing for most venture capitalists.

Many clean energy ventures who participated in the survey feel that their business ideas are not appreciated and understood by venture capitalists used to investing in IT or biotech sectors. According to Zider (1998), the lack of understanding goes both ways: "Most VCs have never worked in the funded industry, or have never been in a down cycle. And, unfortunately, many entrepreneurs are self-absorbed and believe that their own skills and ideas are the key to success." Zider continues that the growth in fund size and the amount of investments one partner needs to manage leads to a situation where "the partners are usually far less knowledgeable about the industry and the technology than the entrepreneurs." Finding a suitable VC firm to fund the venture was a painstaking activity for most of the survey respondent ventures. The following quote demonstrates well the challenges of the fundraising process:

> *[Venture]: Also, there is huge variability in knowledge, experience, technical savviness, ethics, etc. across all categories of VCs. And contrary to the popular expression, a dollar is not a dollar. It takes a great deal of effort to find a good match with an investor who brings not only the right amount of money on acceptable terms, but also good practical value.*

Lack of clean energy venture business domain familiarity is the most often quoted challenge clean energy ventures face with the VCs. The VC interviews confirm the ventures' view of insufficient clean energy category knowledge. Two main themes can be identified, as is shown in List 23. First, due to a low level of sector knowledge, VCs have difficulties identifying clean energy business opportunities they would be willing to fund. Second, VCs are hesitant to invest in a sector where they feel they have not enough knowledge.

List 23 Risk characteristic: Investment Domain Familiarity

Investment Domain Familiarity
- Difficulties in identifying business opportunities
Hesitance to invest in an unfamiliar area

The difficulty of identifying clean energy business opportunities due to insufficient sector knowledge is described as follows by an interviewed VC:

> *[VC]: Are VCs competent enough to see, to think in a contrarian fashion and see the opportunities today that aren't obvious in the market today? Because that's ultimately where VCs, where the really good venture capitals, make their money: investing their time where nobody sees it coming. And that may be just an issue [that there] aren't enough practitioners in the energy area. How many […] really creative revolutionary thinkers are out there investing in energy and really see where this industry is transforming and changing? There aren't that many and there aren't that many that have funds behind [them].*

Naturally, the survey respondent ventures are more eager than the interviewed VCs themselves to point out that the VCs are not competent to understand the presented business opportunities due to their low level of knowledge of clean energy market drivers. Example responses regarding the clean energy opportunity recognition difficulty are collected in List 24.

List 24 VC and Venture Responses Regarding VC Ability to Identify Clean Energy Business Opportunities

[VC]: Software has no limitations; it is just people. Electricity, power has limitations. It is certain. Newton's laws you have to follow. So now [the] whole IT sector is spinning into services and entertainment and there is no limit, you can use it everywhere. You can also say that energy is everywhere, but it is almost always in the same form. There is always this sine wave. I mean, "How's your sine wave today?" We are not that interested.
[Venture]: Investors tends to look at the payback time as the one criteria; unless the buyer makes profit within a few years, they expect nobody is interested to buy a renewable energy system.
[Venture]: VCs are just not interested.
[Venture]: We have a PV technology based on crystalline silicon, and it was often judged as

"not radical" when compared to nanotechnology or thin-film companies.
[Venture]: Because our initial focus is renewable energy, VCs feel that our potential market is too small. They don't want to consider that the technology, once developed for renewable energy, can transfer easily to other energy and monitoring applications.
[Venture]: The biggest problem with the VCs is the Silicon Valley high-tech mentality of the VCs.
[Venture]: They do not like the marine risk - they cannot assess it, and believe that it requires too much capital.
[Venture]: VCs are investing in low-risk, ongoing expansionary vehicles and do not have technical basis to understand exotic, new energy (mechanical) technology concepts.
[Venture]: [VCs]' lack of knowledge of sector and opportunities in the sector are the biggest obstacle [we have faced with the VCs].
[Venture]: VCs are morons, or at least the ones that operate the local circuit. They are pack hounds, scared shitless to do anything the big dogs are not already doing. They talk up prospects that are already obvious prospects. They also are full of buzzwords and, this is just my opinion, achieved their personal success because of their verbal prowess, as opposed to any innate knowledge or true skill […]. Then there are a few who do have experience and are true good guys, but they don't understand climate, and grasp why others would be pushing renewables, while coal is so much cheaper. Alas.
[Venture]: My experience with non-energy specialized VCs is they are arrogant in their assessments and not very capable either. [For them,] energy is special, long-term, small number of players, etc. Those who aren't in it should get out, and those who are in it should continue to invest.
[VC]: The media publicity that IT and telecom got during their years of boom [was great]. If the energy sector could have more media attention, it probably would boost the investments as well.
[VC]: I think this is one of the problems: there are not enough people that made their money from [the energy] sector. No Bill Gates.

Following the money trail of previous investments allows VCs to accumulate the knowledge of certain sectors, such as biotech and ITC. The second identified theme is that the VCs are **hesitant to invest in an unfamiliar area**. The following quote from an interviewed VC

demonstrates the power of previous sector exposure in driving the investment interest into a familiar direction:

> *[VC]: Venture capital was nothing like an industry in the 1970s. It was really small-scale stuff and, in the [19]80s and [19]90s, it really grew. And it grew, I think, in the area of communications, biotech, software systems, and information technology. So the returns come and the investments go into areas that the managers know.*

Some example responses regarding the hesitancy to enter an investment area where the VC has no previous experience or knowledge are demonstrated in List 25.

List 25 VC and Venture Example Responses Regarding VC Hesitancy to Enter Unfamiliar Investment Areas

[Venture]: The VC community, at least in California, does not understand energy technology and has no sound basis for making logical early-stage funding decisions. One VC told me, "There are at least 500 companies like yours. I don't understand any of them. You can sort yourselves out and I will invest in the survivors for the next stage."
[VC]: It's kind of hard to get [venture capitalists] to invest in new type[s] of technologies, new type[s] of green or environmentally safe technologies. It's a question of identifying of what he understands best. Most of the venture capitalists, when they have operational backgrounds, the operational backgrounds are actually in research or managing IT, telecom or bio companies.
[VC]: People tend to invest in technologies that they know, where they know people they can talk to, where they can check the technology is good.
[VC]: When [VCs] hit an energy deal, they don't want to do it […] because you have so much work to do when you have a deal and it's difficult to find [...] and they just put it away and never answer to it. And it just dies because people don't get it and that's probably certainly one key reason for the lack of people in funds.
[Venture]: If VCs don't understand the market, they don't want to look at the deal.
[Venture]: No one has enough background in our particular technology to be comfortable leading an investment round. Same lack of background or knowledge means they can not share our vision and passion.
[Venture]: Most VCs who operate in the technology sector do not understand energy, and those that operate in the energy sector are interested in asset-based companies and not energy technology.

Proposition 7-8: One of the four most important cognitive risk characteristics of clean energy ventures is VCs' low level of clean energy venture investment domain knowledge, consisting of difficulties in identifying business opportunities and hesitance to invest in an unfamiliar area.

7.5.4. Venture Framing

The fourth cognitive risk characteristic that is identified is clean energy venture framing. According to Sitkin et al. (1992), positively framed situations will be perceived as involving higher risk than negatively framed situations. Zacharakis et al. (2001) studies framing of information in venture capitalist decision-making and shows that venture capitalists are more confident with decisions based on information framed in a familiar way than information framed in an unfamiliar way. This result shows that venture capitalists are intuitive decision-makers (Zacharakis et al.) who formulate the venture information into a mental model, which is then used to make a decision.

Clean energy venture proposals emphasize economical, social, and environmental factors. This may lead to a situation where the **venture is framed as a way of solving problems outside of the traditional scope of economical factors**, affecting the venture capitalist risk perception (List 26).

List 26 Risk characteristic: Venture Framing

Venture Framing - Framing the venture outside of the traditional economic factors

Some example responses regarding the venture framing issue are demonstrated in List 27.

List 27 Entrepreneurs' Tendency to Solve Problems Beyond Traditional Economic Scope

[VC]: [Clean energy entrepreneurs]' drive for doing [the venture] is to solve the energy problem of the world. So they have this ideological way of trying to solve the global energy problem.
[VC]: Enough people in the renewables space, their primary motivation is to save the world, create jobs, equal opportunities, and interestingly enough, many times making a lot of

money is almost unethical, you know. And obviously, VCs, they shy away from that.
[VC]: Environmentally oriented people, they see the end of the world coming.

Proposition 7-9: One of the four most important cognitive risk characteristics of clean energy ventures is the tendency of ventures to frame the venture proposal so that it argues to solve problems outside of the traditional economic scope, raising the VC's perceived risk.

7.6. Discussion

The study presented in this chapter argues that, in addition to risk characteristics that are generally recognized by both the VCs and the clean energy ventures, venture capitalists' cognitive biases in decision-making create additional risk characteristics that make it more difficult for clean energy ventures to raise venture capital funding. Results of this study demonstrate that clean energy venture risk characteristics can be divided into two groups. The first group, consisting of five risk characteristics, is generally recognized risk characteristics. The second group, consisting of four risk characteristics, is cognitive risk characteristics. Based on the study, nine propositions that can be tested in future research were developed. Chapter 9 contains a more detailed discussion of the findings, limitations, and contributions of the findings in this chapter.

8. Parent Firm's Organizational Culture and CVC Fund Performance

The previous two chapters argue that venture financing is one of the main challenges of clean energy ventures and that complex clean energy venture risk characteristics may diminish the willingness of VCs to invest in the clean energy sector. This chapter complements and expands the clean energy venture financing challenge argument by empirically developing an organizational culture-based model that aims to explain how the organizational culture of the corporate venture capital (CVC) fund's parent firm affects the performance of the fund.

8.1. Introduction

A review of previous literature (chapter 3.3) shows that large corporations play an important role in new industry development. For example, they provide exit opportunities for VCs, supply competent personnel for start-ups to recruit, and offer partnering opportunities for new ventures. Corporations have also become important funders of new venture activity through corporate venturing programs. One form of corporate venturing is a corporate venture capital (CVC) fund, as discussed earlier in the literature review (chapter 3.3.3). A fair amount of academic research has been carried out regarding CVC activities during the past decade. However, one of the central and enduring research questions in corporate venture capital (CVC) research is: Why is the outcome of CVC funds often disappointing, leading to poor performance or even a failure of a fund?

The strategic and financial outcomes of CVC funds of large corporations, in the form of equity investments in entrepreneurial ventures, are found to vary substantially (Sykes 1986, Siegel et al. 1988, Gompers et al. 1998, and Chesbrough 2000). Part of the variance is due to differences in goal-setting, as some parent firms emphasize strategic benefits over financial returns. Also, the life span of a CVC fund is found to be shorter and, in general, more volatile than that for an independent VC fund (Gompers et al.). In short, CVC investing is a painstaking activity for many parent firms, in some cases leading to failures reported by several studies (Baird et al. 2002, Rind 1981, Sykes 1990, and Gompers 2002).

This chapter develops an organizational culture-based model that aims to explain how the parent firm organizational culture affects the performance of a CVC fund. The chapter utilizes empirical data gathered from CVC and VC interviews and the clean energy venture financing

survey. Prior to introducing the model, the motivational factors for a corporation engaging itself with corporate venture capital activity in the clean energy sector are presented, followed by a brief review of difficulties the survey respondent clean energy ventures face with CVC funds. The developed model on the effect of the parent firm's organizational culture on CVC fund performance is introduced in chapter 8.5. The model consists of the following components, each of which will be discussed in detail: (1) **industry context**, (2) **parent firm organizational culture**, (3) **organizational decision-making practices**, (4) **managing, measuring and compensating success,** and (5) **CVC fund performance**. Propositions are developed that can be tested in future research.

8.2. Methodological Notes

Both the VC and CVC interviews and the clean energy venture financing survey are utilized as the source of empirical data in the theory-building of the chapter. The interviews and the survey are described in more detail in the methodology chapter (chapter 4). The data analysis proceeded as described in chapter 4.

As shown in Table 7 most of the parent firms of the interviewed CVC funds are electric utilities. The organizational culture of electric utilities can be regarded as having been founded on similar "assumptions about customers, competitors and society" (Gordon 1991). The energy industry context is briefly reviewed in chapter 5. The organizational culture part of the developed model, shown in Figure 6, is based on interviews with CVC funds whose parent firm is an electric utility. Interview data from other than electric utility-backed CVC funds are used in understanding the energy industry context. When quotes from the empirical data are used as prototypical examples of the study results in the chapter, labels [VC], [CVC], and [Venture] are used to indicate whether the quote came from the clean energy venture financing survey respondent or the CVC or VC interviews.

8.3. CVC Fund Motivation for Investing in Clean Energy

CVC funds backed by large corporations have become significant players in the VC market. By 2000, CVC funds were managing approximately 15% of all VC investment that year (Dushnitsky 2004).

All of the interviewed CVC funds had made investments into clean energy ventures. Among the interviewed CVC funds, strategic reasons dominate the investment motivation. The most important strategic benefit for the interviewed CVC funds is to engage the organization in a

learning process, providing inside information of the market trends and technological development that could not be gained from the corporation's everyday business activities.

> *[CVC]: You don't see the same things when you invest in a company and when you monitor from outside. If you check from the Internet, you don't get the same information. That is information that is available for everybody. If you invest, you feel what the ecosystem of a sector is: all the relationships with the players and so on.*

Many of the interviewed CVC funds note that, prior to establishing a CVC fund that invests in external ventures, internal venture activity had been tried out. In some cases internal venture activities are run side by side with external CVC activities.

> *[CVC]: We had this internal incubator... In fact, to have this incubator, we saw that there were much more interesting projects outside of [our company] than inside.*

Another interviewed CVC fund manager comments on the reasons behind setting up a CVC fund as follows:

> *[CVC]: So we had projects that were not in the hands of anybody and there was a [connection missing] [...] between R&D and the market. So the board of [our company] asked us to create this [CVC fund].*

However, the vision of the fund direction and purpose are not always clear for the CVC fund manager running the fund. The original goals or the market situation from the time of fund initiation are modified or changes in the parent company leadership alter the parent company priorities. Many of the interviewed CVC fund managers find themselves defending the existence and continuation of the fund.

> *[CVC]: [Our company] is very core-areas focused and lots of companies are these days. That means it is not obvious why you need a CVC unit. You still need it to spot migration opportunities.*

As CVC funds have grown to be significant players in the VC market, many of the interviewed independent VCs followed closely the activities of the CVC funds investing in the clean energy sector. Several of the interviewed independent VCs remain skeptical about the motives and dedication of the corporate venture capital activity they saw sprouting around them. The interviewed independent VCs comments about the CVC activity as follows:

> *[VC]: You see Norsk Hydro, BP, and others having their own venture fund doing separate venture investments in this field. My analysis of that is that they still want to believe that the oil will be there for so many years yet that they don't have to worry about it during their life cycle. They are not so sure that they can bet on that the new technologies won't happen so they "buy insurance" in case fuel cells are going to hit. They have to be somewhere in that market.*

During the past decade, some large firms have acquired clean energy start-ups or have launched clean energy R&D activities within the corporation. The activity of these strategic investors is reviewed briefly in chapter 5.2.1. Many of the strategic investors active in the energy sector are potential trade-sale partners for VCs that invest in the clean energy sector. Despite this, the interviewed VCs express skepticism about the motivations of large energy firms entering the alternative energy business:

> *[VC]: BP has got a big solar business, and so does Shell. What did they see in this? The efforts in renewables so far are such a small piece of the business […] I think [these businesses] allows them to be present and involved in new power sources. But it's, you know, I think it's still a mystery about whether they're planning that ever to be a huge business.*

The interviewed VCs see the CVC activity as a way for the industry incumbents to control the industry direction and protect their own business interests. However, based on the interviews carried out with the CVC units of European energy companies, there is no large-scale concern among the power producers that their dominant position in the power sector is under a threat unless regulatory conditions in the industry toughen. This would seem to suggest that the current regulatory framework largely insulates at least the European energy firms from some of the environmental uncertainties.

> *[VC]: Most oil companies are very protectionist and, in their heart, they want cars to be driven with petroleum. They don't really like the idea of hybrid cars and that stuff. But they have to be proactive so that, in 20 years, they don't have to look at others taking their business.*

Most of the interviewed European CVC funds were founded during the height of the technology investment boom of the late 1990s. The frenzied investment activity of the so-called dot-com era activated many traditional energy companies to set up their own corporate venture capital funds and other venturing activities in the energy sector:

> *[CVC]: At the time [of founding the fund], it was very hip to speak about e-commerce and Internet and so on, and we were thinking, "Let's do this game in the energy sector, why not."*

Most of the interviewed electric utility-owned CVC fund managers have a long career working for the parent company and an extensive career in the energy sector. Most of them had been working with either business development or corporate finance related activities prior to their appointment with the CVC fund. They are familiar with the problems of pushing through new radical innovations within the operational units, and see the CVC fund as a way to ensure that disruptive innovations were pursued within the firm.

> *[CVC]: Disruptive innovations were not taken up by the operative branches of [our company]… They could handle the incremental R&D, like improvements for the nuclear plant or some other existing business. But if you had a disruptive innovation for new activities and business, they didn't know how to do it. It was not in [our company] culture to create companies and new activities…The only movement that is done is to reduce the personnel and the budget by 3-5%.*

8.4. Clean Energy Venture Experience with CVC Funds

The clean energy venture financing survey respondents express problems with CVC funds in three main areas, when compared with independent VC funds: **incompatibility between the venture offering and the CVC fund strategic goals**, **CVC fund decision-making process,** and **unprofessional management practices** (Table 20).

Corporate venture capital funds have dual goals: to reach both strategic and financial gains (Chesbrough 2000, Siegel et al. 1988). A venture offering needs to be compatible with the CVC fund strategic goals in order to enter an investment. The "strategic fit" criterion is recognized by most of the interviewed CVC funds, but slowness in decision-making or unprofessionality is not brought up by the CVCs themselves as a factor affecting the CVC fund deal flow. Table 20 demonstrates the three problem areas clean energy ventures experience when trying to raise capital from the CVC funds.

Table 20 Venture Responses Regarding Challenges with CVC Funds

Challenge	*Response*
Incompatibility of venture offering with CVC fund strategic goals	*[Venture]: You must demonstrate a strategic benefit for the corporation funding you [in order to get funding].*
	[Venture]: [The CVC fund had a] pre-defined view of the kind of company they needed.
	[Venture]: [The challenge we faced with the CVCs was] finding a close match between our technology and their investment "needs." Many just follow the pack and look for investments like others have made.
CVC fund decision-making process	*[Venture]: [Problem with the CVC funds was the] long decision processes depending on corporate structure, which could be changed overnight.*
	[Venture]: [Our problem with the CVC funds was a] lack of "insider" promoting an investment.
	[Venture]: [CVC funds have] too many layers of decision-making. Corporate lawyers are too eager to show they are still relevant.
	[Venture]: [CVC funds] are slow to make decisions.
Unprofessional management practices	*[Venture]: [In CVC funds] no one in particular seems to be in charge.*
	[Venture]: [In CVC funds there is] a lack of commitment to the whole process.
	[Venture]: [In CVC funds there is] a lack of business knowledge about core business of parent.
	[Venture]: [In CVC funds there is] inexperience at financial due diligence.

The CVC fund managers themselves tend to be optimistic of their chances to attract clean energy ventures, and see their fund as an ideal partner for many of the ventures:

> *[CVC]: When we talk to [entrepreneurial] companies, [our parent company] is reasonably attractive because it has a good reputation that it is a fairly easy corporation to deal with. So they are not afraid that they're going to get screwed. And then they know it is a fairly big company so there is potential help in marketing the products and that there is a potential technology help.*

8.5. Developed Model

In order to gain a better understanding of the factors that determine the performance of a CVC fund, a view concentrating on the organizational culture of the parent firm was chosen. Selecting organizational culture as the viewpoint of the analysis is argued to bring fresh new perspectives on the CVC fund performance challenges for two main reasons. First, many of the obstacles faced by the CVC funds mentioned in previous research, such as venture manager incentives (Block 1987 and Chesbrough 2000), internal politics (Sykes 1986), low level of fund autonomy (Siegel et al. 1988), and lack of clear mission (Siegel et al.), have their source in the interface between the parent firm and the CVC fund. Thus, the findings of previous research on CVC indicate that studying the organizational culture of the parent firm, defined as being "based upon internally oriented beliefs regarding how to manage, and externally oriented beliefs regarding how to compete" (Davis 1984), could be helpful in understanding, and possibly even pre-determining, the performance of a CVC activity.

Second, organizational culture of the firm and the surrounding industry context are closely linked. Gordon (1991) presents a model on industry determinants of organizational culture that is described as follows: "Organizations are founded on industry-based assumptions about customers, competitors, and society, which form the basis of the company culture. From these assumptions, certain values develop concerning "the right thing to do," and consistent with these values, management develops strategies, structures, and processes necessary for a company to develop its business." Most of the previous CVC research relies on empirics from the ICT or telecom sector. The empirical data of this study comes from the energy sector where the industry context differs from the ICT sector in many respects, such as in market concentration, regulation, and patenting activity. Analyzing energy sector CVC fund investments in clean energy ventures is argued to bring out new perspectives that have gone unnoticed in previous research.

The dependent variable of the research is performance of the CVC fund. Previous research on CVC shows that firms engage in CVC activities for both financial and strategic reasons. Since most of the interviewed CVC funds had been in operation for less than five years at the time of the interview, the financial performance of the funds was not yet available. For many of the funds, the strategic goals had been altered along the way and therefore comparison with the original goals could have led to misleading results. The volatile nature of the CVC funds is mentioned earlier (chapter 3.3.4). Closure or low investment activity of the fund can be

regarded as a sign of a decrease in top management commitment to the CVC fund operation. Therefore, in this study, the performance of CVC fund is defined as **the degree to which the strategic and financial goals the firm has set for its external corporate venturing are met, measured by the level of activity, and survival of the fund.**

The explanatory model shown in Figure 6 emerges as a result of the data analysis of CVC and VC interviews, clean energy venture financing survey, and previous research findings on organizational culture, industry context, and decision-making behavior.

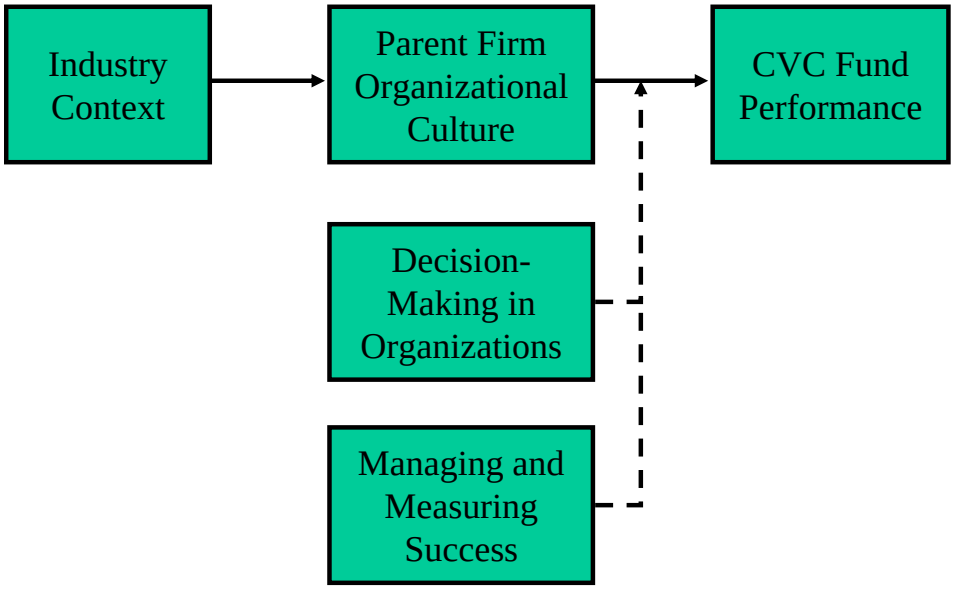


Figure 6 Effect of parent firm's organizational culture on CVC fund performance

The model is based on the argument that the **parent firm organizational culture** affects the CVC fund performance. The effect of the organizational culture is moderated by risk-taking practices in the parent firm's **decision-making process** and the **parent firm's skills in managing, measuring, and compensating fund success**. The **industry context** has an indirect effect on the fund performance through its impact on the parent firm's organizational culture. Therefore, depending on the strength and nature of the two moderating factors and constraints and opportunities set by the industry context, the parent firm's organizational culture may have more or less effect on the CVC fund performance.

Although organizational decision-making practices and parent firm skills in managing, measuring, and compensating fund success are influenced by the parent firm's organizational culture, they are included in the developed model (Figure 6) as separate organizational activities. In other words, it is argued that, by developing additional skills in these two

organizational activities, the parent firm can moderate the effect the its organizational culture has on the performance of the CVC fund. The following chapters discuss the model in more detail.

8.6. Industry Context

Industry context is, in this study, used as an umbrella term for institutional, regulatory, competition, and innovation related factors that form the operating environment for a network of firms that operate in the same industrial sector, such as forestry, chemical, energy, or pharmaceutical industry. According to Gordon (1991), industries cause organizational cultures to develop within defined parameters. Thus, certain cultural characteristics will be widespread among organizations in the same industry, and these are most likely different from characteristics found in other industries. Because of this relationship, the potential for changing a company's culture is limited to actions that are neutral to, or directionally consistent with, industry demands (Gordon). Industry context can also act as a constraint, causing organizations to follow mental models (Senge 1990) that are "deeply held internal images of how the world works, images that limit us to familiar ways of thinking and acting."

The industry context where this study takes place is the energy sector. As discussed in the methodology chapter, most of the parent firms of the interviewed CVC funds are electric utilities (Table 7). The organizational culture of electric utilities can be regarded as having been founded on similar "assumptions about customers, competitors and society" (Gordon 1991). Interview data from other than electric utility-backed CVC funds, independent VC funds, and the clean energy venture financing survey are used in understanding the industry context.

In the energy sector, innovations are traditionally incremental in nature (stakeholder interviews, chapter 4.3.2). Therefore, accepting radical innovations from small ventures challenges the basic assumptions electric utilities hold on innovation and market potential. Discovery and extraordinarily rapid market introduction of nuclear fission (Smil 2003) can be regarded as an exception to the energy sector incremental innovation rule. Traditionally, large players whose competitive advantage is based on market power and price-based competition, not technologically innovative products and services, dominate the energy sector.

Previous research identifies some links between CVC performance and industry context. Gompers (2002) shows that the probability of success is substantially higher for funds

operating in industries related to the parent company's business. Although CVC studies analyzing the effect of industry context are not numerous, strategy scholars recognize the importance of industry context. According to Pablo (1999), it is widely agreed that research findings in strategy differ with industry contexts. Dess et al. (1990) shows that a lack of industry controls in what was referred to as the "40 most important strategy research contributions of the 1980s" led to inconsistent and misleading results. Miller (1987) shows that there are significant links between what he calls environmental characteristics, namely dynamism, heterogeneity, and hostility, and changes of strategy.

8.7. Parent Firm's Organizational Culture

The parent firm's organizational culture, as shown in Figure 6, is defined in this study (chapter 2.6) as being "based upon internally oriented beliefs regarding how to manage, and externally oriented beliefs regarding how to compete" (Davis 1984). CVC funds operate as separate entities within the parent company, some more autonomously than others. CVC managers interact with the parent company in investment decision-making, due diligence, and other services such as legal help. When the empirical data from the CVC and VC interviews are analyzed, large numbers of the CVC fund challenges are shown to link to interaction with the parent company. When these challenges are analyzed further, three main factors related to parent firm organizational culture are identified: **parent firm view on innovation**, **parent firm view of industry development,** and **parent firm entrepreneurial spirit** (List 28). These three factors are discussed in detail below.

List 28 Factors related to Parent Firm's Organizational Culture

Parent Firm Organizational Culture
- View on innovation
- View of industry development
- Parent firm entrepreneurial spirit

8.7.1. Parent Firm's View of Innovation

From the CVC and VC interviews, two issues are identified regarding innovation in the energy sector. First, many electric utilities **did not perceive innovation as a key competitive advantage**, which in turn makes the life of a CVC fund, concentrating on identifying new innovative business approaches promoted by new ventures, difficult. Second, even in cases where the parent firm realizes that scouting for new innovative business approaches is important, the **parent company saw no urgency to act**. The lack of urgency is due to the fact that parent companies are used to reacting to external regulatory pressures, not to business threats imposed by new external ventures. In other words, the CVC activity is not perceived as a crucial activity, but rather a convenient approach to keep track of the latest market developments.

The term innovation has become a buzzword in many industrial sectors, with biotech, pharmaceuticals, and ICT leading the way. The energy sector seems to have headed to the opposite direction in innovation when measured in terms of R&D spending, both in the public and private sector. Kammen et al. (2005) studies the U.S. energy industry and finds that both the federal government and the private industry cut investments in energy R&D "at a time when geopolitics, environmental concerns, and economic competitiveness call instead for a major expansion in U.S. capacity to innovate in this sector." According to Kammen et al., investments in energy R&D by U.S. companies fell by 50% between 1991 and 2003. When the energy sector spending is compared with other sectors, such as biotech, the picture is even bleaker. Total private sector energy R&D is less than the R&D budgets of individual biotech companies, such as Amgen or Genentech (Kammen et al.). An interviewed VC comments on the electric utilities as follows:

> *[VC]: The way that the power industry has changed in the last three years has been one of reverting [...] to the kind of the core business of serving customers, generating electrons, and managing risks and things like that. Not really about innovation and not about innovating service. So, I think most of them have done away with innovation culture.*

However, previous research has shown that in order for the CVC activity to be successful, the parent firm organizational culture must make venturing a mainstream function of the business (Sykes et al. 1989) or create an atmosphere and structure that supports the innovative activity (Quinn 1985). In other words, the parent firm's organizational culture must provide a

supportive structure for innovation, which may consist, for example, of R&D or corporate venturing activities within the parent firm. Creating a structure or atmosphere that nurtures innovation may take a long time to develop. According to March (1988), preferences tend to adapt in response to experience. Therefore, firms that have not developed competencies for innovation and R&D operations, also tend to lack a taste for these activities, which, in turn, shows in the level of organizational support a CVC fund enjoys.

Currently, the large electric utilities have a strong hold on their customers, but not on energy technologies (stakeholder interviews, chapter 4.2.3). They are in the business of generating and supplying the heat and power service, but they are not in charge of bringing new technological innovations to the energy sector. For many electric utilities, competitive advantage through innovation is not a familiar concept. Kammen et al. (1999) argue that cutbacks in energy R&D during the past decades reduced the capacity of the energy sector to innovate. In the words of one interviewed CVC fund manager:

> *[CVC]: The message is that it is really difficult to make a CVC unit exist [in a large electric utility] when you are not convinced that innovation will be the key in competition. [At] the corporate level, they don't think that innovation will be the key in winning the competition. They think it is the price or classical services.*

Regulatory authorities, rather than identify new business innovations and practices, enforce the push for innovation in the energy sector.

> *[CVC]: I think the extent to which the established corporations like [our company] are ready to accept innovation and invest in new business models largely depends on the regulatory framework. Because it is relatively stable, they do not have any urgency to change their business model. Just do nothing and do nothing new, is the best strategy. I'm definitely convinced that this is the best strategy.*

The independent VCs that observe the energy company CVC fund activities are more optimistic about the chances of success of CVC funds backed by energy technology companies than of the funds backed by electric utilities.

> *[VC]: [Energy technology companies] are the ones that ultimately are much more focused on innovation [than electric utilities] because they know how to absorb it and turn it into a value proposition. There's very little that an electricity company can innovate on, because again, ultimately, I think that*

they are just in the core business of selling, you know, electrons. And there are no big changes that have happened [in] over two hundred years, not that long, sorry, but since the beginning of last century, that has really changed the way that the wholesale power has been delivered to customers.

Proposition 8-1: A parent firm whose organizational culture does not view innovation as a key component in gaining competitive advantage negatively affects the performance of a CVC fund.

8.7.2. Parent Firm's View of Industry Development

From the CVC fund interviews, a theme is identified regarding the parent firm's view of industry development. The theme is concerned with the **parent firm's not recognizing that the surrounding business environment is undergoing a change** and acknowledging that some of the new entrants could potentially threaten the firm's market position.

According to Bettis et al. (1995), the 21st century faces new aspects of competition and strategy due to rapid technological change, including the blurring of traditional industry boundaries as substitute products are developed in other industries. This phenomenon is starting to take hold in the energy sector. For example, several of the independent VCs that focus on the clean energy market have large non-energy corporations as investors. One example is the Canadian fuel cell VC fund, Chrysalix, whose investors include Ballard, BASF, BOC, Boeing, Shell, and Mitsubishi (chapter 5.2.1).

An interviewed CVC manager comments on the views of his parent company managers on the change that is taking place in the energy sector:

[CVC]: This industry is moving slowly, the driver is not technology but market power. So we are not really in the battle, even if [the new market entrants] claim that we are in a battle. In the mind of a manager, we are not in a battle. So we are anticipating here and it is not easy to anticipate in big companies.

Many of the interviewed CVC fund managers indicate that the parent company's views on the changes in the surrounding industry context and the introduction of new business models are in conflict with the views of the CVC fund, especially when it comes to acknowledging the speed of change taking place. As one of the interviewed CVC managers comments:

> *[CVC]: I'd say we are not completely mature in Europe today to think that the additional services and businesses will be the key to differentiate between the competitors. So [at the parent company] the battle was the price, and in the minds [of the people] it still is the price. And we [at the CVC fund] think that in two to three years, considering the mass market, this will be on service, competition on services.*

Although the clean energy market and the large-scale introduction of new technologies is still modest, many of the interviewed CVCs and VCs see the momentum for change building as the new technologies continue to flow to the energy sector and synergistic benefits among the new technologies start to be apparent.

> *[CVC]: Right now, the biggest issue in energy is the decentralized production. It starts, definitely, in the technology sector with fuel cells and steam cells and whatever. And the more these technologies are stable and in the market, the more they will generate follow-up business.*

According to Aldrich et al. (1994), established industries may withhold recognition or acceptance of the new industry when they feel threatened. Sometimes they are even able to change the terms on which resources are available to emerging industries. This kind of blocking behavior is not foreign to the CVC managers, who involve the parent firm's managers in the CVC fund investment decision-making:

> *[CVC]: Then we have had deals that have been very convincing. And [corporate headquarters] say, "People are great, as a technology it seems to be very, very interesting." Then came, "If these guys become a success, they will cannibalize our business. We cannot invest in a company that is cannibalizing our own business."*

According to Abernathy et al. (1978) and Utterback (1994), product and process innovation follows a general pattern of three stages. In the first stage, during the early years of an industry, a high rate of innovation takes place and new players enter the market. However, making sense of the new developments may be challenging, since, according to Sanders et al. (2004), during the emergence of new industries, investors and analysts lack a codified body of knowledge and industry-specific experience. Therefore, identifying the winning business models among the various unproven but interesting models explored by competing start-up firms is difficult, even for an energy-company backed CVC fund manager. The CVC fund managers are, at times, in a position, where they see potential threats to the status quo of the parent company, but take no serious counteraction on behalf of the parent company itself:

> *[CVC]: I'd say it is not very easy to compete against [our parent company]. So perhaps we don't see the sign [that we need to act], we see a lot of start-ups working on these special systems to measure the consumption, to evaluate the right services to cut on consumption. But we don't see a big movement of [a] large energy company heading to catch the value of these start-ups.*

Proposition 8-2: A parent firm whose managers have not internalized that their business environment is changing negatively affects the performance of a CVC fund.

8.7.3. Parent Firm's Entrepreneurial Spirit

A theme related to the parent firm's view on entrepreneurial activities within the organization emerges from the CVC and VC interviews. The theme is concerned with a **lack of entrepreneurial thinking and spirit within the parent firm** that is a cause of conflicts in the CVC fund and parent firm's interaction.

Levinthal et al. (1993) argue that organizations find and construct their private comprehensible worlds. The parent firm's view of the world may differ strongly from the one present in the CVC fund. The organizational culture mismatch may lead to a clash of management cultures if the parent firm does not provide adequate autonomy for the venturing activity to establish its own more entrepreneurial management processes. An interviewed CVC fund manager comments about a clash he had experienced with the parent company as follows:

> *[CVC]: [Our company], of course, tried to duplicate their controlling system here at [our CVC fund]. And I said, "Hey, I'm not willing to accept this." Otherwise you are calculating every project to death. You are not able to [apply the corporate] mindset [to a CVC fund]. We have a different mindset and culture.*

One example of the entrepreneurial mindset mismatch may show in belittling the significance of the emerging industry context when compared with the existing business, as the following quote demonstrates:

> *[CVC]: And [the person] from the corporate HQ was saying to me, "Hmm, you are right, obviously it is a great company, but do I really want to have this fight with the operations just because of this small company?"*

According to Bettis et al. (1995), due to the increasing rate of technological change in the 21st century, firms in mature industries cannot remain static but are forced to develop an entrepreneurial mindset in order to survive. Changing the prevailing mindset means adopting a different worldview. Until recently, electric utilities in many countries have been part of a government-owned and -regulated entity (stakeholder interviews, chapter 4.2.3). For these firms, switching to an entrepreneurial mode of operation and thinking can be difficult. An interviewed CVC fund manager's frustration was evident in his comments on the lack of entrepreneurial spirit in his parent company:

> *[CVC]: You always have to ask why people are working with a big conglomerate or a big energy company and not working as an entrepreneur. They have a different spirit. And I asked a board member, very close relationship with the board of [our company]. And he said: "Look at these people. They are not entrepreneurs." So you are trying to do something that is impossible, to move these people to your side.*

Another interviewed CVC fund manager describes his parent company's research center activities as follows:

> *[CVC]: It is always a question of people. And if you have a research center with 100 people or 200 people, they can gather all the information available in the world about technologies and trends and so on. But they are not thinking in terms of business, they are just thinking in terms of a department that delivers information.*

Foster (1986) shows that the reason incumbent firms fail in the face of technical change is not due to the character of the technology but the cognitive errors the managers make in understanding the challenge of the emerging industry context. One interviewed independent VC fund manager, who was following the CVC activities of energy companies, comments on the willingness of electric utilities to engage in business activities with small firms as follows:

> *[VC]: The other characteristic of this industry might be that the utilities have a tendency to really only want to work with more mature companies and not with companies that they are concerned would disappear. Whereas you see in companies, like, you know, Cisco or maybe even in the biotech area partnerships between, you know, small lab companies and these big pharmaceutical companies. And, you know, lab companies don't make the required discovery or something like that. They disappear or go away but this is probably their whole plan to work with this diversified portfolio of*

> *small companies. Utilities don't seem to approach it that way. So you have to pass a certain level of maturity before the utilities really want to do business with you.*

In a similar fashion, Henderson (1996) finds that radical innovation could displace incumbent firms for organizational reasons due to cognitive limits and inertia, in addition to the more rational reasons, such as unwillingness to render existing assets obsolete. One example of cognitive limits is the inability to adapt to a new way of serving the customers. An interviewed VC fund manager comments on the electric utilities and the way they conduct their business as follows:

> *[VC]: So far, they've always looked like, "We are the utility and you are the subscribers," and not like, "You are the customer, how can I serve you and make a business?" [...] And that is an attitude that, you know, "It has worked, so let's not change it."*

Proposition 8-3: Lack of entrepreneurial spirit within the parent firm's personnel negatively affects the CVC fund's performance.

8.8. Risk and Organizational Decision-Making

In the CVC fund manager interviews, two themes emerge regarding organizational decision-making in risky situations, mainly concerned with venture due diligence and investment decisions as show in List 29. The first theme, **gaining an outside view, both in technical and market matters, through the parent company's involvement** in the CVC fund investment decision-making, and thus balancing the overconfidence of the CVC fund managers, has an upside effect on the CVC fund performance. The second theme, **involving the parent firm's managers with no venturing experience in the decision-making**, has a downside effect on the fund performance.

List 29 Factors related to Decision-Making in Organizations

Decision - Making in Organizations
-Involvement of parent firm managers with no venturing experience
-Gaining an outside view through the parent company involvement

The parent firm's risk-taking practices in the organizational decision-making process are argued to moderate the effects the parent firm's organizational culture has on the performance of the CVC fund, as shown in Figure 6. The decision-making process regarding the fund investments often involves managers both from the parent firm and the CVC fund, making the decision-making behavior and the biases each party brings to the table critical in making decisions on venture investments, divestments, and the direction of the fund.

The basic assumptions and values that are part of organizational culture also affect decision-making in organizations. Kahneman et al. (1993) studies cognitive perspectives of decision-making and argues that decision-makers in organizations are prone to two types of biases. First, their forecasts of future performances are often anchored on plans and scenarios of success rather than on past results, and are therefore overly optimistic. Second, their evaluation of single risky prospects neglects the possibilities of pooling risks and is therefore overly timid. Kahneman et al. introduce a concept of an inside view and an outside view. The inside view is generated by focusing on the case at hand, by considering the plan and the obstacles to its completion, by constructing scenarios of future progress, and by extrapolating current trends. The outside view is a conservative approach that relies on statistics of cases similar to the present one.

One example of the outside view's upside effect is the help provided by the parent firm's technical experts in technical due diligence. The interviewed CVC fund managers tend to appreciate the technical knowledge that they receive from the parent company side.

> *[CVC]: If you are investing in start-up companies, [the knowledge needed] is definitely more on the technical side, definitely. The evaluation of the*

> *technology is really the core and very essential for calculating the risk and reward scheme.*

The parent firm's managers can offer the "outside view" to the CVC managers in order to help balance the overly optimistic scenarios and thus avoid hype over a certain technological solution.

> *[CVC]: For our investments, we have invested in very early-stage companies. It was really technical due diligence and we were working closely together with [our parent company]'s engineering. And they do have four or five hundred specialists. Every specialist really has a specific area that he is concentrating in so you really get the best of technical experiences.*

Involvement of parent company personnel may also shield the CVC fund managers from overconfidence. Managers may view risk as a challenge to be overcome and believe that risk can be modified by "managerial wisdom and skill" (Kahneman et al. 1991 and Donaldson et al. 1983). Zacharakis et al. (2001) shows that VCs are overconfident in their decision-making and the same result can be assumed to apply also to CVC fund managers.

> *[CVC]: In the beginning, we were very broad. Everything was energy but we were able to invest in batteries, for example, which was really not core of the energy business. But we were able to do almost everything. And it was really essential to do so. But as soon as we got into discussions with the operating units, and we had to get into contact whenever we make a project or an investment, of course, we have to involve them and to get some technical feedback.*

One example of the outside view downside effect is the involvement in the investment decision-making of the parent firm's managers with no venturing experience. The parent firm's managers' involvement in the venture investment decision-making process may lead to overly timid decisions, demonstrating loss aversion as losses and disadvantages are weighted more than gains and advantages, favoring inaction over action, and the status quo over any alternatives (Kahneman et al. 1993).

> *[CVC]: I had very deep discussion with all the board members, and also the ones that have been on my side. And I discovered one phenomenon. They feel definitely uncomfortable in making the decision if they were not able to understand the business. And you are not doing them a favor by giving them a proposal. The better way is to say, "Give me the money and let other*

> *people [...] decide for this money." So they can always say: "It was somebody else's decision."*

The loss aversion problem becomes especially severe when the CVC fund has to involve the parent firm's managers in the investment decision-making who have insufficient market or technical knowledge to judge the investments accordingly. This involvement may lead to excessive loss aversion and inhibit the CVC fund from necessary risk-taking. Kahneman et al. (1993) proposes that one way to avoid excessive risk aversion is to analyze whether the organizational context in which the decisions are made is more likely to enhance or inhibit risk aversion. As the quotes below demonstrate, involvement of the parent firm's inexperienced managers clearly enhances the risk aversion in investment decision-making.

> *[CVC]: The problem was the corporate headquarters (HQ). The people who were deciding about the investments, they were corporate people from corporate HQ, they didn't have any knowledge of the technical things and the market things. So they were very insecure.*

Fighting against loss aversion may require CVC managers to spend time on internal lobbying work, instead of focusing on the operation of the fund.

> *[CVC]: So you have to convince people about the VC idea, who have not ever thought about VC. And maybe you get 50% of them, if you are really convincing. So it was pretty much fighting against the organization.*

Proposition 8-4A: Parent company involvement in technical and market due diligence positively affects the performance of the CVC fund.

Proposition 8-4B: Parent company involvement in investment decision-making negatively affects the performance of the CVC fund.

8.9. Measuring and Managing Success

An important theme that emerged from the CVC interviews, the **parent firm's skills in measuring and managing success** (List 30), is argued to moderate the effects the parent firm's organizational culture has on the performance of the CVC fund, as shown in Figure 6.

List 30 Factors related to Managing and Measuring Success

Managing and Measuring Success
- Parent firm skills

The term managing success is, in this study, used to analyze the way firms reward the fund managers, the extent to which out-of-the-box thinking is encouraged, and the level of trust and patience the parent firm has with the fund managers. The term measuring success is used to describe the methods parent firms use to quantify the strategic and financial benefits for the firm.

Managing success requires understanding what Levinthal et al. (1993) refer to as the political structure of an organization. Managers who have been successful in the past are launched into positions of power in the organization. These individuals tend to carry the recipe for past successes in their mind, which discourages out-of-the-box thinking. As Levinthal et al. argue, "Organizations code outcomes into successes and failures and develop ideas and causes for them." This easily leads to a situation where unconventional thinking within the CVC fund is not supported or rewarded from the parent firm's side. Levinthal et al. also notes that, since return from any particular innovation or technology is partly a function of the organization's experience of the new idea, even successful innovations tend to perform poorly at first until the organization has gathered experience. An interviewed CVC fund manager comments about his parent firms' disinclination to support innovative approaches the fund was trying to promote as follows:

> *[CVC]: The problem [with venturing] is that if you are really innovative, you get in trouble with the traditional organization…And if [the ventures] are gaining market share, the headquarter or the operating unit is losing market share. And losing market share in the traditional sector or an operating unit is valued more than chances in the new growth area.*

All of the interviewed CVC funds are small compared to the annual turnover of the parent company. This may lead to a situation where failures get punished and success goes unnoticed. As an interviewed CVC fund manager comments:

> *[CVC]: So we have only risk and even if you are very, very successful, it'll never be so successful that it will be reported in the quarterly report. So we as a supervising team can only lose. So if the money is [gone], the shareholders are asking, "What happened to our money? Is it really necessary to do these kinds of investments?" And if you're successful, it is "So what."*

Not having a clear view of how strategic benefits are measured and compensated and what is regarded as a successful execution of strategic objectives is also found as a constraining factor in the CVC fund managers' interviews. Especially difficult for many of the interviewed CVC managers is finding a balance between strategic and financial objectives.

> *[CVC]: [By focusing on strategic objectives], I'm definitely limiting potential. Sometimes you cannot do a deal that is financially very attractive because of strategic reasons.*

Since finding the balance between the strategic and financial objectives may be difficult, the fund managers may try to follow the traditional VC model and concentrate solely on the financial return.

> *[CVC]: So, basically, it means we go after profits. If you don't go after the profits, how do you know what you're finding? Is it going to be the market leader in the future? So, by definition, if you can't spot the best deals and get the best returns, you cannot spot what the market is doing.*

Measuring the success of the CVC activity is challenging, since the investment committee, consisting often of both parent firm managers and fund managers, needs to be able to quantify the strategic value of a venture investment in addition to the potential of future financial returns. Emerging industry operating procedures, competitive environment, firm size, and market dominance strategies may differ from the current industry context, making the strategic value quantification difficult for managers tuned to the current industry context. An attempt to fulfil the strategic goals may require easing on the financial targets, as the following CVC fund manager's quote demonstrates:

> *[CVC]: I'm now concentrating on delivering strategic benefits and maybe I'm suffering on the return side, because I cannot invest so many resources to making financially really attractive deals.*

In addition, the self-interest of the parent firm managers may cause bias in quantifying the strategic gains of the CVC activity. The financial returns from small ventures may also appear

modest when benchmarked against the existing business units. A more fair quantification can be reached by benchmarking the CVC fund against a similar fund outside of the firm. Parent company managers may also see an investment in a venture as threatening and attempt to contain a negative strategic value for the parent firm, especially if competing firms are investing in the same venture. As an interviewed CVC fund manager comments:

> *[CVC]: It was odd to have so many other corporate [funds] in there. It is very hard to argue for this investment from a strategic point of view. If you go to your investment committee they say, "Ok, it is an interesting case and you have these risks and benefits." But then they also notice that [competing firm] is inside and then they say, "Hey, what is [this]...competitive advantage? Maybe it is a disadvantage if they invest and we don't." But it is not so convincing. It is always more convincing when you say, "We have this exclusive deal and, if it is a big hit, we have the advantage to acquire [the] rest of the shares and make a huge business out of it." That is really convincing.*

Proposition 8-5: Parent firms who fail to reward out-of-the-box thinking and accomplishments of the CVC fund, and have not been able to develop appropriate mechanisms to measure both strategic and financial success of the fund, negatively affect the performance of the CVC fund.

8.10. CVC Fund Performance

The majority of the CVC fund interviews were carried out between Fall 2003 and Spring 2004, as is demonstrated in Table 21. When the current status of the interviewed funds is analyzed in October 2005, the electric utility-backed funds seem to have fared the worst, supporting the results of the study. Some of the funds are closed down, some still exist but are not actively investing, and some have been spun off to operate as independent VC funds. The first signs of the struggle are already evident during the time of the interviews in many of the electric utility-backed funds. In many cases, the parent firms of interviewed CVC funds seemed to have forgotten why the fund had been set up in the first place.

Table 21 Status of Interviewed CVC Funds, October 2005

Fund	Fund Status on 10/2005	Interview Date
Electric utility CVC fund (RWE dynamics)	Spun off from the electric utility via a management buy-out in 2005.	17.2 2004
Electric utility CVC fund (MVV/Accera)	Spun off from the electric utility via a management buy-out in 2005.	18.2 2004
Electric utility CVC fund (Eon Venture Partners)	Fund essentially closed down.	19.2 2004
Electric utility CVC fund (Vattenfall Europe venture)	Not actively investing.	5.2 2004
Electric utility CVC fund (Suez NovInvest)	Closed	24.3 2004
Electric utility CVC fund (EdF Business Innovation)	Closed	25.3 2004
Electric utility CVC fund (EdF capital Investissement)	Active, although no recent investments.	24.3 2004
Electric utility CVC fund (EasEnergy)	Active	17.2 2005
Non-electric utility CVC fund (Norsk Hydro Technology ventures)	Active, although not many recent investments.	6.11 2003
Non-electric utility CVC fund (Schneider Electric Ventures)	Active	23.3 2004
Non-electric utility CVC fund (BASF Venture Capital GmbH)	Active	18.2 2004

In many of the interviewed CVC funds, changes in the corporation leadership, re-organization of competitor CVC funds, and changes in the competitive environment affect the commitment corporations have in their CVC funds. As one electric utility-backed CVC fund manager frustratingly comments:

> *[CVC]: What I see now is that all the CVCs [in the energy sector] are in a more defensive position. All of them, I cannot tell you one exception, are struggling with their own company. And everybody is looking at his competitor. And they say: "If they are closing their business, why should I*

> *be in this business? There are only risks and if I do nothing, I will be punished. If I don't make the decision other people have already taken, maybe I'm proven wrong and I'm fired in two years". So, it is very, very difficult.*

Some of the electric utility-backed CVC funds are already ramping down their business at the time of the interview, as times had turned difficult and the support of the upper management for the CVC activity had decreased.

> *[CVC]: We are now [at] the low point of the curve for investment in the company, but we still produce a very high cash flow in the company, and so the priorities are now to consolidate and reduce debt, but in two years, the situation will change and we will come back to the investment period. And we want to keep the contacts so that when the investment will start again, we want to be ready.*

CVC funds were the first movers in the energy venture capital market prior to independent VC funds entering the market. The fact that several of them are planning to exit their investments due to changes in strategy, provides independent VCs with opportunities to get involved in clean energy investing at a bargain price:

> *[CVC]: Some independent VCs are entering the market for energy, they are interested in it but they are a little bit hesitant, of course, because they don't know too much about the business. So they really try to link with these [CVC] guys over their funds… That is definitely a trend. Others are, of course, going in a secondary market [.…] They can make great deals right now with the [energy companies].*

The interviewed CVCs generally feel that one of the reasons independent VCs are not entering the sector in larger numbers is the lower level of knowledge, both in terms of energy markets and technologies. The interviewed CVC fund managers generally feel that they and their parent company, are accrueing some strategic benefits by learning through venturing.

> *[CVC]: We have gone through a learning curve ourselves. We'll now avoid capital intensive deals. The other lesson is the market adoption time: [you] just need to look at microturbines. Market adoption takes a lot of time. And people tend to be incredibly over-optimistic about that. And even when you have discussions with large suppliers on how long it takes to take products to the market, they can also be far [more] optimistic than they should be.*

For many of the parent firms and their CVC funds, it also becomes clear that the unique selling points they thought had existed at the time of founding the fund, in most cases during the boom years of the late 1990s, are not supporting them in the investment activity. In other words, the struggle with the parent organization and the inability of the CVC fund to harness the capabilities, such as technical knowledge, of the parent organization to achieve a competitive advantage over other VC funds has not worked out as planned. As an interviewed CVC fund manager comments:

> *[CVC]: Our previous model was that the pearl that we thought we [had] detect[ed], could not be detected by other funds, because they look[ed] at it with the financial eyes and we look[ed] at it with the strategic eyes. So now we just look at the [financial] opportunities, the pearls, and think of them also as strategic.*

8.11. Discussion

The study presented in this chapter develops the notion of the role of the parent firm's organizational culture as a determinant of CVC fund performance. The developed model on the effect of parent firm organizational culture on CVC fund performance consists of the following components: industry context, parent firm's organizational culture, organizational decision-making practices, managing, measuring and compensating success, and CVC fund performance. Propositions are developed that can be tested in future research.

The main argument that derives from the results is that understanding the parent firm's organizational culture limitations may offer the firm tools to avoid the CVC fund activity pitfalls and diminish the chance for fund failure. The status of the interviewed CVC funds (Table 21) also indicates the difficulty of operating a CVC fund in general, and specifically in the area of clean energy. Corporations that are planning on launching external venturing activities should carefully consider the obstacles involved in operating a CVC fund. Significant savings in capital and labor costs could be achieved if a corporation planning a CVC fund would analyze the limitations of its organizational culture and the challenges posed by the surrounding industry context. Instead of a CVC model, maybe another internal or external venturing model would be found more suitable in the pre-launch phase.

Chapter 9 contains a more detailed discussion on the findings, limitations, and contributions of the findings of this chapter.

9. Discussion and Conclusions

The last chapter of this dissertation summarizes the findings and puts them in perspective. In addition, theoretical contributions of the dissertation and implications for practitioners are identified. Finally, limitations of the study and avenues for future research are presented.

9.1. Discussion of Results

The aim of this dissertation was to expand the knowledge base of clean energy venture entrepreneurial challenges, especially in the area of venture financing. Figure 7 shows the integration of the results from theory chapters 6 through 8.

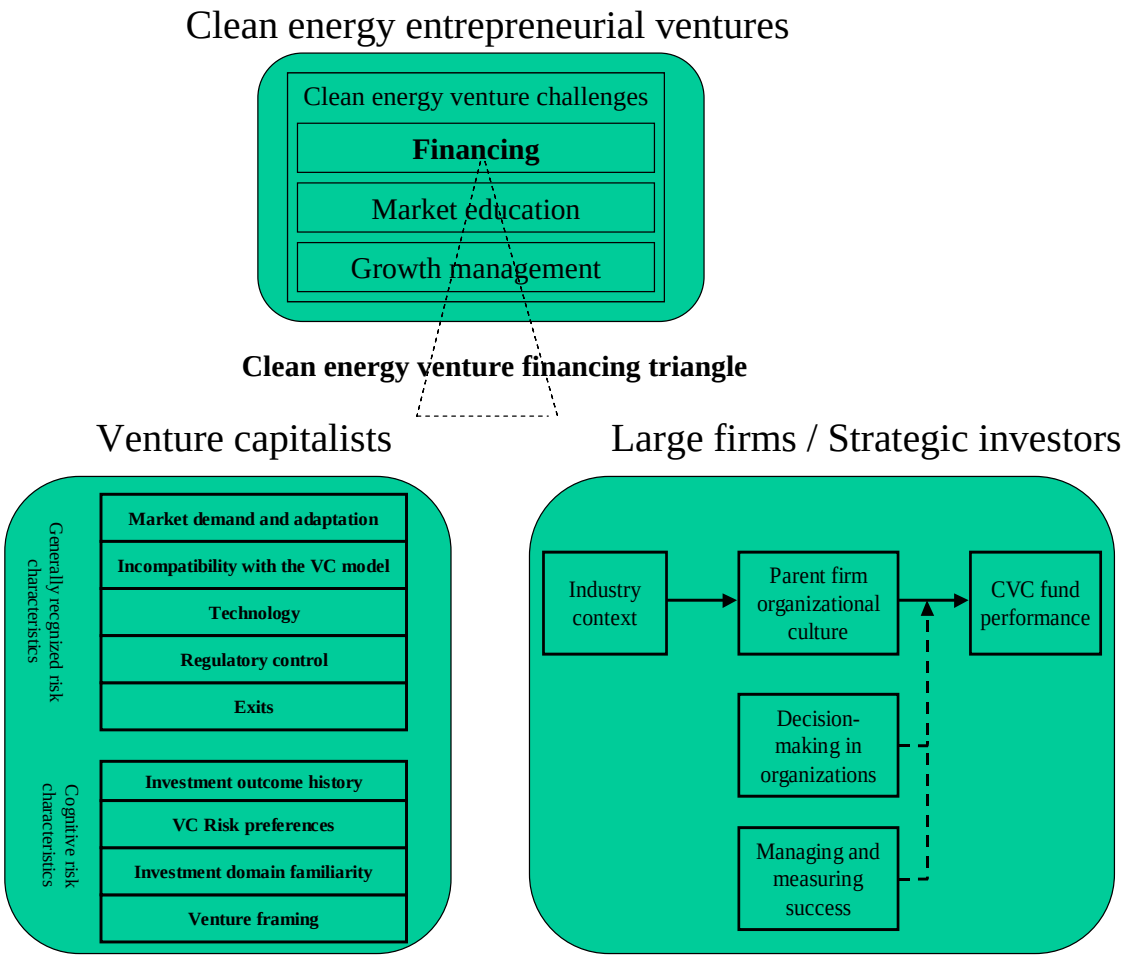


Figure 7 Summary of the study results

The results from chapters 6 through 8 come together in what is referred to as the clean energy venture financing triangle (Figure 7). Within the financing triangle, three stakeholders,

namely the venture capitalists, clean energy entrepreneurial ventures, and large firms in the form of strategic investors, operate and interact in the emerging clean energy market. Chapter 6 identifies three main clean energy venture entrepreneurial challenges: financing, market education, and growth management. One of these challenges, financing, is identified as a common challenge for all clean energy ventures, independent of the clean energy industry category development stage. The financing challenge is studied further, in chapters 7 and 8, from the perspectives of VCs and CVC funds of large firms. The two other identified main entrepreneurial challenges, growth management and market education, were not studied in more detail in the consecutive chapters. Instead of studying the relationships between the VCs and clean energy ventures, or operational partnerships between large firms and clean energy ventures, the focus is on operational challenges within VCs and CVC funds. Chapter 7 aims to bring in new knowledge on cognitive risk factors of VCs. Chapter 8 brings new knowledge on operating a CVC fund from an organizational culture perspective.

Since the goal of this study was theory-building, the dissertation employed a grounded theory approach. Three data collection approaches were utilized during the cource of the study. First, interviews with European and North American VC and CVC firms that have invested in clean energy ventures were carried out. Second, a clean energy venture financing survey that consisted both of qualitative, essay-format questions and some quantitative questions was conducted. In addition, interviews with clean energy stakeholders, media search, and attendance of conferences in the clean energy and cleantech area were carried out in order to a gain better understanding of the emerging sector.

9.1.1. Clean Energy Venture Entrepreneurial Challenges

Chapter 5.3 provides an overview of clean energy market drivers and shows that most OECD countries have national policies in place that provide support both for clean energy technological R&D programs and clean energy production. However, the current set of national and international energy policies are not enough (IEA 2004b). It is estimated that both the world's energy needs and the CO_2 emissions will be almost 60% higher in 2030 than they are now (IEA). An addition to introducing more effective policy instruments that support clean energy market creation, it is important to gain a better understanding of the challenges clean energy ventures are facing in developing new solutions to the energy problem. The goal of chapter 6 is to bring more light to the entrepreneurial challenges of clean energy ventures.

Previous literature related to cleantech industry emergence emphasizes system-level and policy perspective (Kemp et al. 1998, Tsoutsos et al. 2005, Jacobsson et al. 2000, and Russo 2003). These studies widen the understanding of both system-level policy drivers and technological regime-induced barriers to clean technologies. However, cleantech or clean energy industry firm-level studies remain absent, even though entrepreneurial firms form the core elements of emerging industries. The need for further research among sustainable, or cleantech, technology entrepreneurial firms is identified in the previous studies (Jacobsson et al. 2000, Russo 2003). This dissertation employed a micro-level approach and studied the firm-level entrepreneurial challenges in clean energy market creation.

The goal was to study the clean energy venture entrepreneurial challenges building on empirical data. The source of empirical data used in the theory-building was the clean energy venture financing survey that was specifically designed for the study. The survey data include firms less than 10 years of age that operate in the clean energy technology area. The survey received 164 eligible responses. In the course of this study, three main challenges of clean energy entrepreneurial ventures were identified. These three entrepreneurial challenges are financing, market education, and growth management. The financing challenge consists of one main factor, raising capital for the venture. For the survey respondent firms, venture capital funding had been the second most important source of funding (after the founder's personal funds). The second main entrepreneurial challenge, market education, consists of three factors that surface from the survey: public perception, market education and awareness, and market acceptance of technology. The last of the three main entrepreneurial challenges of clean energy ventures, growth management, consists of four factors: partnering, recruitment and retaining of human resources, growth management, and market dynamics.

A study of three clean energy industry categories reveals additional challenges that vary according to the industry development stage. The three industry development stages are early-stage, rapid-growth, and slow-growth stage. Fuel cells and other hydrogen related technology ventures are selected as an example of early-stage clean energy ventures. Early-stage clean energy ventures are found to face their biggest entrepreneurial challenges in the area of financing, growth management, and technology development and cost reduction. Solar photovoltaic technology ventures are selected as an example of rapid-growth clean energy ventures- and energy efficiency ventures as an example of slow-growth clean energy ventures. The major entrepreneurial challenges rapid-growth clean energy ventures face are found to be

financing, growth management, market education, and ramping up production while reducing unit costs. Slow-growth clean energy ventures are found to face their biggest challenges in the area of financing and marketing of their solutions.

The main argument deriving from the study results is that clean energy venture entrepreneurial challenges concentrate on other areas than what the previous clean energy industry related studies have emphasized. In other words, in order to facilitate clean energy industry growth, further research needs to be conducted to understand the venture level obstacles in greater detail.

9.1.2. Clean Energy Venture Risk Characteristics

Previous research has shown VCs to favor innovation and emergence of a new sector for two reasons. First, new emerging sectors, such as biotechnology and ITC, have been financed, in large part, by venture capital investment in the early stage of the sector development. Second, venture capital has been shown to have a strong positive impact on innovation (Gompers et al. 2001). The study was motivated by the fact that cognitive factors in VC decision-making remain understudied. During the past decade, some steps have been taken to understand the cognitive side of venture capital decision-making process (Shepherd 1999 and Zacharakis et al. 2001 and 1998), but cognitive biases, especially related to clean energy ventures, have not been researched.

The goal was to develop a model of clean energy venture risk characteristics from the VC perspective. The source of empirical data used in the theory building was VC and CVC interviews and the clean energy venture financing survey. All together, 29 interviews were carried out among independent, corporate, and government-backed VCs, both in Europe and in North America. The clean energy venture financing survey was specifically designed for the study. The main argument of the study was that, in addition to risk characteristics that are generally recognized by both the VCs and the clean energy ventures, venture capitalists' cognitive biases in decision-making create additional risk characteristics that make it more difficult for clean energy ventures to raise venture capital funding. Results of this study demonstrate that clean energy venture risk characteristics can be divided into two groups. The first group, consisting of five risk characteristics, is generally recognized risk characteristics. These five generally recognized risk characteristics are market demand and adaptation, incompatibility with the VC model, technology, regulatory control, and exits. Each of these

risk characteristics consists of several themes that are discussed in more detail in chapter 7.4. The second group, consisting of four risk characteristics, is cognitive risk characteristics. These four cognitive risk factors are investment outcome history, VC risk preferences, investment domain familiarity, and venture framing. The four cognitive risk characteristics consist of several themes discussed in more detail in chapter 7.5. For example, one of the identified cognitive risk characteristics, investment domain familiarity, is found to contain two themes: difficulties of VCs in identifying business opportunities and hesitancy of VCs to invest in an unfamiliar area.

Based on the study, nine propositions that can be tested in future research were developed. The main argument deriving from the results is that cognitive risk characteristics of venture capitalists are key to understanding why clean energy ventures have received only a small amount of venture capital investment.

9.1.3. Parent Firm's Organizational Culture and CVC Fund Performance

Previous literature finds that the strategic and financial outcomes of CVC funds of large corporations vary substantially (Sykes 1986, Siegel et al. 1988, Gompers et al. 1998, and Chesbrough 2000). The CVC funds are also found to be short-lived and more volatile than independent VC funds (Gompers et al.). The study was motivated by the following research question: Why is the outcome of CVC funds often disappointing, leading to poor performance or even a failure of a fund?

The goal of the study was to complement and expand the clean energy venture financing challenge argument by empirically developing an organizational culture–based model that aims to explain how the organizational culture of the CVC fund's parent firm affects the performance of the fund. The performance of CVC fund was defined as the degree to which the strategic and financial goals the firm has set for its external corporate venturing are met, measured by the level of activity and survival of the fund. In addition to developing the model, the motivation of CVC funds to invest in clean energy ventures was reviewed briefly. The source of empirical data used in the theory building was VC and CVC interviews and the clean energy venture financing survey.

The developed model on the effect of parent firm organizational culture on CVC fund performance consists of the following components: industry context, parent firm's organizational culture, organizational decision-making practices, managing, measuring, and compensating success, and CVC fund performance. The model is based on the argument that the parent firm's organizational culture affects the CVC fund performance. The effect of the organizational culture is moderated by risk-taking practices in the parent firm's decision-making process and the parent firm's skills in managing, measuring, and compensating fund success. The industry context has an indirect effect on the fund's performance through its impact on the parent firm's organizational culture. The model components consist of several factors and themes. For example, three main factors that are related to the parent firm's organizational culture were identified: the parent firm's view on innovation, the parent firm's view on industry development, and the parent firm's entrepreneurial spirit. When the factors were studied further, more specific issues surfaced. For example, two themes were identified regarding the factor of the parent firm's view on innovation. First, many electric utilities did not perceive innovation as a key competitive advantage. Second, the parent company saw no urgency to act, despite the fact that it had realized that scouting for new innovative business approaches was important for its future survival.

Six propositions were developed that can be tested in future research. The main argument deriving from the results is that understanding the parent firm's organizational culture limitations may offer the firm tools to avoid the CVC fund activity pitfalls and diminish the chance for fund failure. The status of the interviewed CVC funds was reviewed in October 2005 (Table 21) and several funds were found to have been closed down, spun-off to operate as independent VC funds, or were in a non-active investment mode. The status review strengthened the study results and also indicated the difficulty of operating a CVC fund in general, specifically in the area of clean energy.

9.2. Theoretical Contributions of the Dissertation

The main contribution of this dissertation is in identifying theoretical models that explain the clean energy venture entrepreneurial challenges, how VCs view clean energy ventures from risk perspective, and how the organizational culture of a firm affects its CVC activity. The dissertation contributes to several bodies of literature in the area of entrepreneurship, new industry creation, corporate venturing, and venture capital research.

The previous literature has ignored firm-level studies related to cleantech and environmental technology industry and has focused on system-level studies only (Kemp et al. 1998, Tsoutsos et al. 2005, Jacobsson et al. 2000, and Russo 2003). The system-level studies have often failed to analyze whether the system-level environmental industry creation challenges correspond to what new firms in the cleantech, or environmental, area are experiencing. In this dissertation, three main clean energy venture entrepreneurial challenges were identified. In addition, this study analyzed how the entrepreneurial challenges varied according to the industry development stage.

Venture capital research related to investment decision-making (Tyebjee et al. 1984, Fried et al. 1994, and Roberts 1991) has been mainly process-oriented. Some recent studies analyze the cognitive aspect of the VC decision-making process (Shepherd 1999 and Zacharakis et al. 2001 and 1998). However, gaps in understanding still exist. This dissertation provides a model of clean energy venture risk characteristics by taking into account the venture capitalist cognitive biases. The study contributes to the venture capital literature by linking behavioral economics literature with the venture capitalist decision-making process. In particular, this dissertation has contributed to our understanding of why clean energy ventures have received only a small part of the invested venture capital to date. In this dissertation, four cognitive risk characteristics were identified, in addition to five generally recognized risk characteristics.

This dissertation has also demonstrated that incumbent firms, especially the electric utilities that were the empirical focus of the CVC study of this dissertation, face big challenges in renewing their business through CVC activities because of the constraints related to their organizational culture. In this dissertation, three factors related to the parent firm's organizational culture were identified that negatively affect the CVC fund performance. In addition, two moderating mechanisms in the area of decision-making practices, and measuring and managing success were identified.

Finally, the dissertation has contributed to the emerging literature on clean energy market creation. The findings of this dissertation emphasize that a complex web of social, environmental, and economical factors are behind the clean energy market drivers.

9.3. Managerial Implications

The dissertation has concentrated on theory-building rather than testing previous theory. Despite this limitation, important implications for clean energy sector stakeholders arise from

the study. The findings of the study suggest several pointers to policy-makers, corporations planning to launch CVC fund activities, venture capitalists, and clean energy ventures.

From a public policy perspective, understanding and internalizing the identified entrepreneurial challenges, growth management, financing, and market education is of paramount importance. First, educating the market is essential for the small clean energy firms. Although the survey sample cannot be used as a generic sample of the clean energy market due to biases in database building, it may still be concluded that the majority of the clean energy firms remain very small. Of the survey respondent companies, 73% employed 25 people or fewer. Therefore, reaching out to the market and providing education to the consumers on clean energy solutions is very difficult for most clean energy companies due to their limited resources. Help from governmental programs that provide consumers information on clean technologies would speed the clean energy market development. For governmental and private sector programs that promote the clean energy market, providing enough help and resources to clean energy ventures on financing and growth management would enable the ventures to cross the "valley of death" safely and grow to a sustainable business. For policy-makers, understanding the clean energy venture risk characteristics helps to explain why clean energy ventures have received only a small amount of venture capital investment. The study findings also emphasize the importance of providing public policy instruments that aim to lower some of these risk characteristics, such as providing better seed funding opportunities, investing "patient government capital" into clean energy VC funds, or providing better R&D funding support for early-stage clean energy ventures.

For venture capital firms, the implications of this study are to analyze the risk perceptions and risk propensities of their partners and investment analysts. The study of clean energy venture risk characteristics shows, for example, that overly homogenous venture capital firms having backgrounds in IT, telecom, and biotech might lead to missed opportunities in clean energy venture area.

For clean energy ventures, an important implication of this study is to understand the clean energy venture risk characteristics from the VC perspective and identify areas for improvement. For example, clean energy firms should analyze how they present their venture proposals to the venture capitalists. Both theoretical arguments and empirical evidence show that the way venture proposals are framed has direct implications on how the venture capitalists view the risks and opportunities of the venture. In addition, the dissertation study

shows that CVC funds, especially the ones backed by electric utilities, may experience problems due to the parent firm's organizational culture. Thus, the clean energy ventures that aim to raise funding from CVC funds should take the higher volatility and even possible failure of the CVC fund into account when choosing between the different investors.

The study results bear implications also for corporations that are planning to launch corporate venturing activities. The status of the interviewed CVC funds in October 2005 (Table 21) also indicates the difficulty of operating a CVC fund in general, and specifically in the area of clean energy. The findings suggest that firms should closely analyze the parent firm's organizational culture and the industry context in which the firm operates. In this way, the firm could identify the potential shortcomings in its organizational culture, such as view of innovation, industry development scenarios, and the entrepreneurial spirit within the organization prior to setting up the fund. A further study on decision-making processes and skills in managing and measuring success could be carried out in the firm to alleviate the negative effects, potentially leading to a better outcome of the corporate venturing activity. Significant savings in capital and labor costs could be achieved with this kind of pre-study. Instead of a CVC model, maybe another internal or external venturing model would be found more suitable in the pre-launch phase.

9.4. Limitations and Directions for Further Research

As this dissertation was concerned with theory-building rather than testing existing theory, a number of limitations to the results exist. The models and propositions were developed grounded in empirical data. In other words, the findings are based on empirical qualitative data and the theory developed in this study has not been tested in a quantitative manner. In addition, the theoretical scope is limited to clean energy market development. The empirical data of this dissertation are from the venture capital firm side limited to Europe and North America. On the clean energy venture side, the data are dominated by European and North American ventures, although some Asian and South American ventures are included in the data set. The applicability to other cleantech environments may be limited due to peculiarity of the energy sector.

The findings and limitations suggest several avenues for future research. First, the developed models and propositions should be quantitatively tested and further refined. It would also be interesting to use empirical data from a cleantech category other than an energy-related technology in the quantitative testing of the results of this study. Furthermore, the effect of the

parent firm's organizational culture on the CVC fund performance warrants further investigation, preferably in some context other than clean energy.

Several additional topics for further research surfaced during the study. In chapter 6, three main entrepreneurial challenges were identified, but only one of the challenges, venture financing, was explored further in the consecutive two chapters. Future research could explore the two other clean energy venture entrepreneurial challenges, growth management and market education, in more detail. When the identified clean energy entrepreneurial challenges were mapped on the Van de Ven et al model (Figure 4), institutional arrangements did not appear significant. However, as discussed in chapter 5.3, energy policy and governmental commitments have made a significant contribution to the clean energy market development. The role of institutions and energy policy in the formation of clean energy markets, especially from the perspective of clean energy ventures and investors, would be worth exploring in future research.

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Appendix 1

Exit this survey >>

TEKNILLINEN KORKEAKOULU
TEKNISKA HÖGSKOLAN
HELSINKI UNIVERSITY OF TECHNOLOGY

Energy venture financing: Entrepreneur perspective

Introduction

Thank you for agreeing to participate in the 2005 energy entrepreneurship and venture financing survey conducted by Helsinki University of Technology in Finland.

This study will take a snapshot of the landscape concerning entrepreneurship and venture financing in the energy sector. We define an "energy venture" as a company, less than 10 years old, that seeks to bring new energy technologies and services to the market.

In exchange for your participation, you'll receive an electronic copy of our final report that provides aggregate findings.

There are 2 main sections to our 10-15 minute survey:

- THE BACKGROUND SECTION (1 page) will ask you for public information about your company.

- THE CONFIDENTIAL SECTION (5 pages) asks for information on:

*Financing background of your energy venture
*Experience with venture capitalists
*Experience with corporate venture capitalists

The survey information will never be released in association with your company's name. It will be reported only in the aggregate across surveyed companies.

REQUIRED QUESTIONS: Throughout the survey, questions denoted by an asterisk (*) are required and must be answered in order for you to proceed.

Exit this survey >>

TEKNILLINEN KORKEAKOULU
TEKNISKA HÖGSKOLAN
HELSINKI UNIVERSITY OF TECHNOLOGY

Energy venture financing: Entrepreneur perspective

Background section: Your company

Your position in the company

- Leadership/Senior Management
- Director/Manager
- Professional (legal, accounting, product engineering)
- Other (please specify)

Please specify the year your company was founded

*** Are you one of the founders of the company?**

- Yes
- No

How many people are employed full-time by your company?

- 0-5
- 6-25
- 26-50
- 51-100
- 101-250
- 251-500
- 501-1,000
- >1,000

Where is your company headquartered?

- USA - California
- USA - Other
- Canada
- Europe
- Asia-Pacific
- Africa

Which of the following legal forms of organization describes your company?

- Sole Proprietorship
- General Partnership
- Limited Partnership
- Corporation, privately-owned
- Corporation, publicly-owned
- Limited Liability Company
- Other (please specify)

Which category best describes your main business?

- Fuel cells / Hydrogen infrastructure

- [ ] Solar PV
- [ ] Solar other
- [ ] Wind
- [ ] Wave
- [ ] Bioenergy
- [ ] Transportation solutions
- [ ] CHP
- [ ] New materials
- [ ] Energy efficiency solutions
- [ ] Energy management solutions
- [ ] Oil or gas technology
- [ ] Other (please specify)

What would you describe as three of your company's biggest challenges?

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TEKNILLINEN KORKEAKOULU
TEKNISKA HÖGSKOLAN
HELSINKI UNIVERSITY OF TECHNOLOGY

Energy venture financing: Entrepreneur perspective

Venture founder

Do you have prior start-up experience?

- [ ] Yes
- [ ] No

If your venture is a spin-off of a federal research institute or an university, please give the name of the institution.

Please provide a brief description of the founding of your venture

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Exit this survey >>

TEKNILLINEN KORKEAKOULU
TEKNISKA HÖGSKOLAN
HELSINKI UNIVERSITY OF TECHNOLOGY

Energy venture financing: Entrepreneur perspective

Energy venture financing background

Has your company participated in an energy venture fair or other event in order to look for capital?

- Yes
- No

If yes, name the energy venture fair that has been most beneficial to your firm

*** Has your company sought venture capital funding?**

- Yes
- No

Since your company was formed, please indicate the SOURCES of financing your company has obtained relative to total capital raised.

	None	Less than 1/2	About 1/2	More than 1/2	Most
Founder's personal funds					
Friends and family					
Bank loans					
Angel investors					
Venture capitalists					
IPO					
Government (grants)					
Corporations					
Other					

Which federal programs or funding efforts have been most successful for your firm?

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Energy venture financing: Entrepreneur perspective

CONFIDENTIAL SECTION: Venture proposal presentation

*** VC funding was sought from**

- Independent VC funds
- Corporate VC funds
- Government backed VC funds

Describe how the initial contact with VCs was made

Please rate how your company emphasized the following benefits in its business plan presented to the VCs

	Strong emphasis	Medium emphasis	Low emphasis
Cost-savings for the consumer			
Revolutionary technology that will change the current energy business environment			
More reliable electricity production			
Providing energy basis for economic growth in developing countries			
Lower indoor and outdoor air pollution			
Less greehouse-gas emissions			
Lower Emissions			
Security of supply			

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Energy venture financing: Entrepreneur perspective

CONFIDENTIAL SECTION: Corporate venture capital

Based on your experience with corporate VCs, do you agree with the following statements:

	Yes	No	Not sure
Corporate VCs are no different from independent VCs			
Corporate VCs can make their investment decisions against the corporate interest			
Energy company corporate VCs cannot be trusted			
Energy sector corporate VC decision-making is slower than for independent VCs			
Energy sector corporate VCs are willing to take on more risk than indepenent VCs			
Energy sector corporate VCs are a significant source for funding for energy ventures			
Operating a corporate VC fund is difficult for an energy company			

Please desribe the biggest obstacles your company faced when seeking corporate VC funding

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Energy venture financing: Entrepreneur perspective

CONFIDENTIAL SECTION: Venture capitalist decision-making

Based on your company's experience with venture capitalists:

	Yes	No
VCs who have not invested in energy ventures are more risk-averse than the ones that have made previous investments		
VCs that have made successful investments into energy sector are willing to take more risks		
VCs that have specialized energy funds are more willing to enter an investment		
VCs with moderate experience with energy sector investing compared with high experience are more thorough in their due diligence		
There are too many VCs with IT, telecom and biotech backgrounds, that don't understand our venture offering		

Please describe the biggest obstacles your company faced when seeking venture capital funding from independent VCs

* Has your company raised venture capital funding?

- Yes
- No

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Energy venture financing: Entrepreneur perspective

CONFIDENTIAL SECTION: Venture capital search background

You are more than half way done!

Funding for your energy venture came from:

- Independent general venture capital fund(s)
- Independent specialized venture capital fund(s)
- Corporate venture capital fund(s)
- Government venture capital fund(s)
- Other (please specify)

How many financing rounds have you gone through?

How much venture capital have you raised for your energy venture (in millions of USD)?

Have your venture capital funding deal(s) been syndicated by a lead VC?

- Yes
- No

What do you think will be the most likely way for VCs that have invested in your company to exit their investment?

- Trade sale
- IPO
- Other (please specify)

Name the leading venture capital firm that invests in the energy sector

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Energy venture financing: Entrepreneur perspective

Thank You

Thank you very much for participating in the survey. Survey results will be tabulated over the spring 2005. We expect to release and distribute our report in May 2005.

If you have any questions, please do not hesitate to contact us.

Tarja Teppo, Research project manager, tarja.teppo@hut.fi

If you want to receive an electronic copy of our final report, please provide your email address

Any final comments, suggestions or feedback not covered by this survey?