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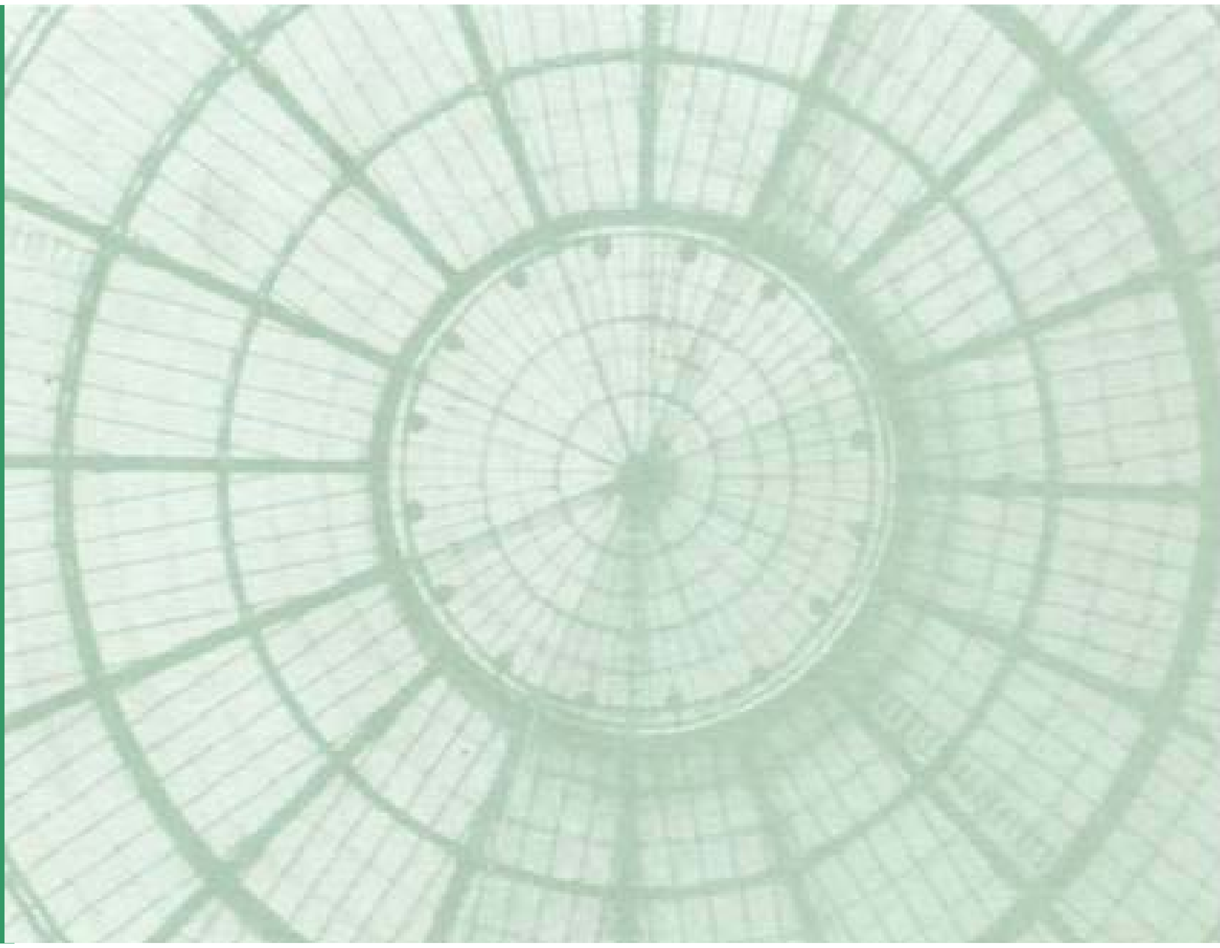

What makes a good industry for venture capitalists?

Risk, return and time as factors determining the emergence of the European energy VC market

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Abstract

Prior research has shown that Venture Capital (VC) plays an important role for the commercialization of innovation in sectors such as information and communication technologies, and biotech. While these sectors account for about two thirds of all VC investments, little attention has been paid to understanding how the venture capital market extends to new industries. Some lessons can be learned from research comparing VC-investment in different countries, which has for example demonstrated the importance of prior IPO activity. Also, scholars have pointed out that a vital VC market does not develop quickly due to path dependencies. Taking the European energy technology sector as an example, we address the question which factors determine the emergence of a new market sector for VC investments. While there are arguably sizeable investment opportunities, VC investments in energy currently account for only 2-5 % of all venture capital. We find that three factors can help explain differences between energy and other more popular VC sectors: (a) the perceived risk (market adoption risk, exit risk, technology risk, people risk, and regulatory risk) of investments in energy technologies; (b) returns in energy VC investments; and (c) in an evolutionary perspective, the maturity of energy as a VC investment sector. The empirical part of our analysis is based on a survey of European energy VCs.

Keywords: Venture Capital, Innovation, Renewable Energy, Technological Change.

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The myth is that venture capitalists invest in good people and good ideas. The reality is that they invest in good industries.
Bob Zider (1998): How VC works, Harvard Business Review.

Energy is essential to economic and social development and improved quality of life. Much of the world's energy, however, is currently produced and consumed in ways that could not be sustained if technology were to remain constant and if overall quantities were to increase substantially.
United Nations (1992): Chapter 9.9 of the Agenda 21

1 Introduction[1]

Venture Capital (VC) has been an important driver in the financing of innovative start-ups in several industries, most notably information and communication technologies and biotechnology. Recently, increasing amounts of venture capital are being invested in new energy technologies by newly emerging, dedicated industry VC funds. By taking a closer look at this phenomenon, we realize that there is a lack in prior venture capital research when it comes to understanding how new sectors of the VC market develop. This paper aims at making a contribution to closing this gap. From a practical point of view, commercialization of new energy technologies is important in order to achieve a development of the economy that is environmentally and socially sustainable. The interest in successful development of the energy VC market is therefore not limited to investors and entrepreneurs, but extends to a broader set of stakeholders of the public good.

1.1 Venture Capital

Venture Capital (VC) can be defined as investment by professional investors of long-term, risk equity finance in new firms where the primary reward is eventual capital gain (Wright and Robbie 1998). VC has become particularly popular thanks to some high-profile success stories. Among others, companies like Microsoft, Intel, Sun Microsystems, Federal Express and Genentech were backed by VCs prior to going public. Venture Capitalists do not only provide financial capital, but also take an active role in firm decision making, typically by having a board seat. This is due to the specific situation of new ventures, which are characterized 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/or on a specific stage of development of a company. As Wright and Robbie (1998) note, "venture capital is particularly appropriate in a specific subset of firms which have non-redeployable or highly specialized assets." Early-stage high technology companies in the information and communication technology (ICT) or biotechnology sectors are typical examples, accounting for roughly two thirds of all VC investments (BVK 2003).

VC research (e.g. Barry 1994, Gompers and Lerner 1999, Hellmann and Puri 2002) has shown that VC-backed firms play an important role in commercializing breakthrough technologies, and has investigated the drivers for value creation in the VC-entrepreneur relationship. Historically, empirical research on venture capital has focussed on ICT and biotech, since these two sectors have the best data availability. Very little work has been done

[1] Wüstenhagen acknowledges valuable feedback from participants of the oikos PhD Summer Academy 2004 "Creating & Transforming Markets for Sustainability". Teppo acknowledges financial support from TEKES. A previous version of this paper entitled "Venture capital investment in sustainable energy: Factors determining the emergence of a new market" has been presented at the the GRONEN Workshop 2004, Granada (Spain, April 22-23, 2004), and the International Conference "Innovation, Sustainability and Policy" of the riw Network, May 23-25, 2004, Kloster Seeon, Germany.

to understand how new sectors for VC investment emerge, which is necessary to understand the development of the sustainable energy VC market.

VC research also provides insights into the venture capital cycle (Gompers and Lerner 1999). VC is provided to different stages of company development. While seed funding is typically provided by business angels, venture capitalists provide early- and expansion stage financing. Venture capitalists will typically look at exiting their investment 2-8 years after investing, typically through initial public offerings (IPO) or trade sales. Between expansion stage and IPO, there may be additional financing rounds by Private Equity funds.[2] 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.

1.2 The Investment Opportunity in Sustainable Energy Technologies

The energy sector is one of the largest sectors of the economy, accounting for annual sales of about $2'000 billion worldwide (SAM 2002). In the US alone, the electricity sector represents approximately 7% of GDP (Stuebi 2001). The total investment requirement for energy-supply infrastructure worldwide over the period 2001-2030 is estimated at $16 trillion by the International Energy Agency, which is a substantial increase, in real terms, compared to the prior 30-year period (IEA 2003). A set of environmental and security concerns, in conjunction with technological innovation, is currently leading to fundamental changes in the energy industry. For example, more than 80 % of the electricity worldwide is generated based on either fossil fuels, which are one of the main reasons for global warming, or nuclear energy, which involves security concerns and hazardous waste issues.[3] Looking at all energy (including fuels for transportation and heating), the lack of sustainability becomes even more evident, with the combined share of oil, coal and gas achieving 86 % of global energy consumption and nuclear adding another 6.5 % in 2001 (Source: DOE EIA[4]). With increasing concentration of oil reserves in a few countries of the Middle East, as well as new strong demand coming from emerging countries like China, security of supply concerns add to the environmental drivers for change. Also, more than two thirds of the primary energy gets lost due to inefficiencies in the energy sector and on the demand side (UNDP/WEC/UNDESA 2000). With very few notable exceptions, governments around the world have realized the upcoming sustainability challenges and started to design policy mechanisms intended to support market introduction of sustainable energy technologies. At the same time, a number of both private and corporate energy users seem to be willing to do their bit and demand renewable forms of energy (Bird et al. 2002).

These drivers lead to investment opportunities in three particular segments of what we collectively refer to as the sustainable energy sector:[5]

- **renewable energy** sources (such as wind, solar, geothermal, biomass or ocean wave energy)
- **distributed energy** systems that involve local use of the waste heat inherent in most forms of traditional power generation (also referred to as small-scale combined heat and power generation, or CHP)

[2] The term Private Equity is also sometimes used as a generic term including all stages of private financing from early-stage venture capital to late-stage pre-IPO investments. In this paper, however, we only look at venture capital and use the term Private Equity to describe late stage and buyout investments.
[3] http://www.eia.doe.gov/pub/international/iea2002/table63.xls
[4] http://www.eia.doe.gov/pub/international/iea2001/table18.xls
[5] See for example Wüstenhagen 2000 and SAM 2002 for similar categories.

- increased **energy efficiency** on the demand side (by means of better energy management, improved processes, intelligent software etc.)

One particularity of technologies and services in the sustainable energy sector is that they create both private and societal added value. In terms of the private added value, they compete directly with conventional energy sources – a wind turbine provides technically more or less the same quality of electricity as a coal-fired power plant. The societal added value – avoiding emissions, increasing national security – is what makes them attractive for governments. Venture Capitalists, unlike governments, look for investments that create private rather than societal value. Looking strictly at private value, the equation might often look unfavourable for sustainable energy technologies, since they are early on the learning curve and hence they often have higher cost. Side-benefits, such as modular scale, lower maintenance, hedging against fuel price fluctuations, can partly offset this disadvantage.

So while investment needs are huge in this sector, it is not trivial whether there will be the right incentives to mobilize enough private capital (IEA 2003). This may be an issue for the venture capital segment of the financial market, too, even though new energy technologies have recently made it to the headlines of the venture capital community.[6]

1.3 Status of Venture Capital Investment in Sustainable Energy

Compiling information about VC investments in sustainable energy is not a straightforward task, since (a) data on venture capital investment is generally not publicly available, and (b) as energy is an emerging VC category, energy deals are often not properly identified in the statistics[7]. The following sources of information provide some partial evidence:

- The MoneyTree Survey is a quarterly study of venture capital investment activity in the United States, done in collaboration between PricewaterhouseCoopers, Thomson Venture Economics and the National Venture Capital Association (NVCA) in the US (http://www.pwcmoneytree.com/). The problem is that there is no specific category for energy, but energy is a subcategory of industrial/energy. According to MoneyTree, overall US VC investment in 2003 was $18.2bn, of which $848m (4.7 %) in industrial/energy.
- For Europe, the European Venture Capital Association (EVCA), in cooperation with PriceWaterhouseCoopers, publishes data on overall VC investments. Total VC investments decreased from 19.6 billion Euro in 2000 to 6.5 billion Euro in 2003, with the share of VC among all Private Equity investments (including buyouts) decreasing from 56 % to 28 % over the same period. The breakdown of European VC data by industry sector is not publicly available.
- In Germany specifically, according to the German Venture Capital Association (BVK 2003) energy and environmental technologies each accounted for about 9 million Euro or 1.3 % of early-stage VC investments in 2002, while biotechnology, software and communications technologies added up to 63.6 % of all VC investments (see Figure 1).

[6] See for example a recent cover story of the US Venture Capital Journal (Henig 2003).
[7] See Sagar/Holdren (2002) for a similar argument about the difficulties in counting energy-relevant R&D expenditures.

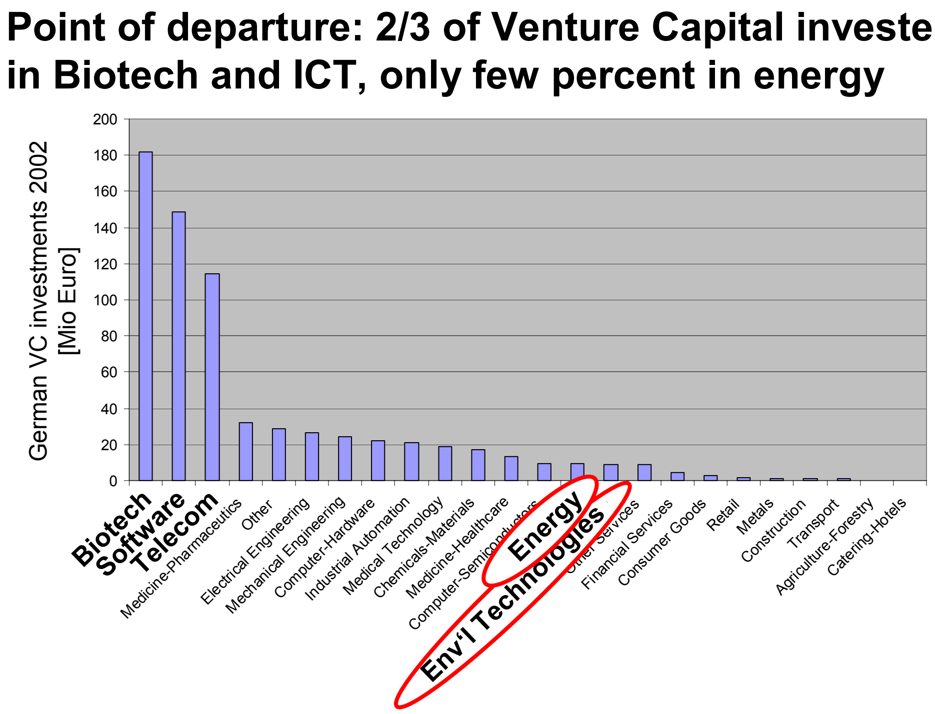

Figure 1: Sectoral distribution of early-stage VC investments in Germany 2002, data: BVK 2003

- The Cleantech Venture Network, a private organisation aimed at promoting investment in "clean technology" ventures through the provision of market facilitation services, issues the quarterly Cleantech Venture Monitor. This includes energy, water and other sustainability-related sectors and has a strong North American focus. For Q1-3 2003, Cleantech estimates that $954m were invested in 144 deals, of which $380m in energy. Energy was 53 % of total cleantech investments in 3Q03: $165 million. ($91m in Q2, $123.6m in Q1).
- Nth Power, a leading energy VC fund based in San Francisco, are compiling their own figures (cf. Figure 2). According to them, global sustainable energy VC deals accounted for $526m in 2003.

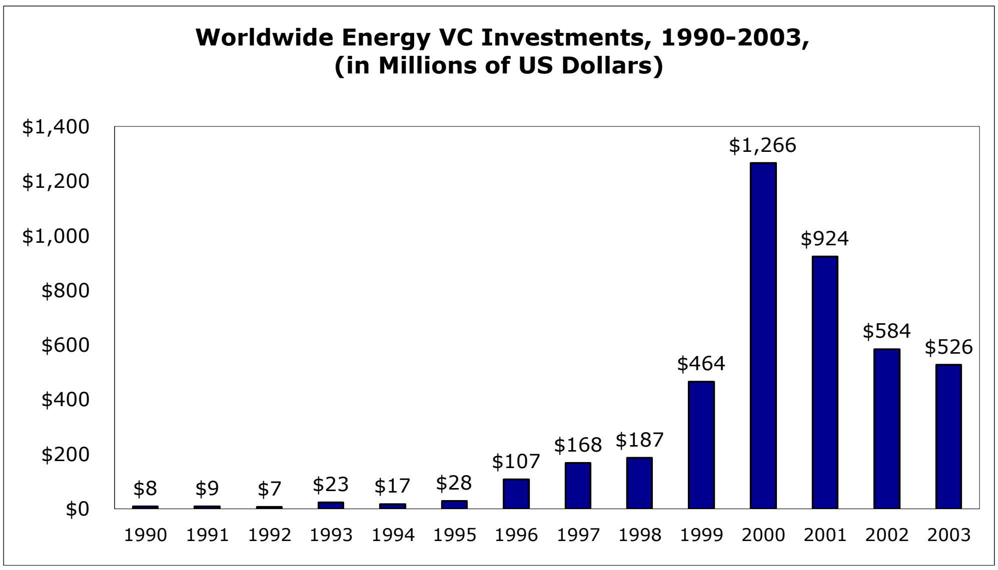

Figure 2: Worldwide Energy VC Investments, 1990-2003 (in million USD) Source: Nth Power

By any measure, energy VC accounts for a small share of overall VC investments today. For example, taking Nth Power and PWC Moneytree data for the US and EVCA data for Europe, the relation of energy VC to all Venture Capital investments is about 2 % ($526m compared to about $27bn) in 2003. However, this share has been continuously rising since 2000. Also, due to the way that deals are categorized in these databases, these numbers are likely to underestimate the true share of energy technology investments. For example, two classical German energy VC deals in the fuel cell/CHP area, were categorized as "Other electronics/power supplies" and summarized in the IT category rather than energy. Other energy deals are included in categories such as "fiberoptics/photonics" or "software" and also counted as IT investments.

Looking at the striking differences in investment between energy technology and other VC sectors leads us to the following two **research questions**:

- Which factors determine the attractiveness of sustainable energy as a target for venture capital investments relative to other sectors (like ICT and biotech)?
- Which drivers and barriers do venture capitalists perceive as influencing future growth of the sustainable energy VC market?

2 Data and Methods

There has been very little industry-specific academic research on venture capital investments in the energy sector to date. Also, the number of funds active in this area and VC-backed energy ventures is still fairly small and their operating history limited to only a few years in most European cases. Therefore, we have chosen a mainly qualitative approach for our research.

The core of our data is taken from 23 semi-structured, qualitative, face-to-face interviews with Venture Capitalists that were performed between August 2003 and March 2004. Interviews were taped and selectively transcribed, usually lasted about 1.5 hours, and were led at the VC fund's premises. Our interviewees were either Partners/Principals of the VC fund or Senior Investment Managers. We interviewed VCs in nine countries, mainly in Europe, but with 2 interviews in North America. 11 of these 23 interviews were with independent VCs, 11 with corporate VCs, and one with a government VC. All but one of the VCs in our sample had active investment experience in the energy sector, so we probably had a certain "believer bias", but people knew what they were talking about.

To validate our interview data, we also performed a written survey among attendants of the 2nd European Energy Venture Fair in Rüschlikon/Zurich (Switzerland) in October 2003, which is the key industry event for energy venture capitalists in Europe. The questionnaire covered the topics that came up in our interviews, such as barriers to expansion of energy VC, fostering factors for energy VC, exit routes, as well as section about personal/fund data. The 3-page questionnaire was handed out to all 114 participants of the event, of which 64 were Venture Capitalists, representing 41 different VC firms. We received 26 responses, of which 23 were from Venture Capitalists (a 36 % response rate for this group), representing 17 different VC firms (41 % coverage) from 11 different countries, of which 9 European. While the sample is small in total numbers, we believe that we have achieved a very good coverage among the pioneers of energy VC investing in Europe. The quality of the sample is underlined by the experience of the responding VCs. VC professionals in our sample had an average energy industry experience of 8.4 years (ranging from 0 to 42 years), and an average VC industry experience of 4.6 years (between 0 and 15 years). On average, the VC funds that they represented had made 9.8 investments, of which 4.4 in energy. 56 % of the VCs in our sample represented an independent venture capital fund, 35 % came from corporate venture capital funds, the rest being other investors or consultants. Not unusual for both the energy sector and the VC industry, 88 % of respondents were male, and just 12 % female.

Finally, at some points of our paper, the previous working experience of the two authors may shine through, since the lead author used to work for a European energy VC fund between 2000 and 2003, while the co-author is currently on study leave from the corporate venturing group of a major Finnish communications technology company.

3 A "Good Industry" for Venture Capitalists – A Matter of Risk and Return

Since there is a deficit in previous research with regard to explaining why Venture Capitalists invest in one sector rather than another and hence we have not yet identified an appropriate theory, we took a pragmatic approach based on the fundamentals of any investment: Risk and return. We suggest that VCs, as any investors, will avoid investments where risk is perceived as being too high or returns are expected to be too low to compensate for the risks encountered. This is not only in line with common sense but also with much of the previous work on VC decision making.[8] Tyebjee and Bruno (1984) analyzed the factors that VCs use in assessing a deal. Starting out from 23 characteristics, they reduced those to five underlying dimensions (Market Attractiveness, Product Differentiation, Managerial Capabilities, Environmental Threat Resistance, Cash-Out Potential), which they in turn summarized as describing expected return and perceived risk. Moreover, as Ruhnka and Young (1991) hypothesize, VCs with special skills and expertise are able to alter both sides of the return-to-risk ratio for the ventures that they invest in. They can manage risk by possessing particular knowledge about a specific industry, which gives them a competitive advantage over other investors. And they can manage return by leveraging their industry-specific network to increase the probability of a successful exit. Both a VC's expertise and network are typically sector-specific, which explains the existence of VC funds that specialize in certain industries.

We therefore explore the risk characteristics of energy technology VC investments (3.1), and subsequently discuss factors that influence their returns (3.2).

3.1 Risk

There are many different approaches to defining risk. In the finance literature, risk is usually defined as deviation from an expected result, both upwards and downwards. On the other hand, a popular conception of risk is rather associated with negative deviations, i.e. losses (March and Shapira 1987). Another distinction is between financial risk and operational (non-financial) risk. Operational risk has been defined by Hoffmann (2002) in five categories, namely people risk, relationship risk, technology risk, physical risk and risk that results from external factors (including regulatory risk).

[8] See for example Zacharakis and Meyer (1998, p. 61) for an overview.

For venture capital investing specifically, Ruhnka and Young (1991) have compiled a list of 37 different risks that occur on different stages of VC investing. Categorizing these risks as either internal or external to the venture, they argue that internal risks dominate for early-stage ventures, while external risks, i.e. those that can be managed by the entrepreneur or the VC only to a limited extent, increase in relative importance over time as the company matures. Baum and Silverman (2004) choose a different term, when they talk about three types of capital that determine the VCs decision to finance start-up firms in the biotechnology and their impact on future startup performance: Alliance capital, intellectual capital (i.e. patents) and human capital. This can be easily translated into risks, where for example uncertainty about the quality of human capital can be referred to as people risk.

For reasons of practicability, we summarize the risks identified by Ruhnka/Young and others in five categories:[9] market adoption risk, technology risk, people risk, regulatory risk, and exit risk. For each of these risks, we will try to answer the following questions:

- Where does this risk come from?
- Why is this risk relevant in a VC investment context?
- How does this risk affect VC investments in energy technology differently than in other sectors?
- How can this risk be managed?

In answering the first two questions, we will mostly draw on VC literature, while the third and fourth question will mainly be addressed based on data from our interviews.

3.1.1 Market Adoption Risk

Market adoption risk refers to the fact that demand for a new product is usually unknown in advance. The adoption of a new product, service or technology ultimately depends on the customers, and can be influenced by the venture only to some limited extent. An additional source of market adoption risk appears in B2B markets with high levels of market concentration, where a small number of potential buyers decide about the adoption of a new technology and act as gatekeepers for the venture to reach the final customer.

Zider (1998) points out that, in contrast to a common perception, VCs are not particular risk-seekers, but are rather focusing on “the middle part of the classic industry S-curve”, that is the segment in the process of diffusion of innovation where growth rates have already taken off but not yet reached saturation. This is confirmed by one of our interviewees:

“VCs are risk avert, even if they are VCs. They basically look for opportunities that other people didn‘t understand. Not opportunities that they feel they‘ll be taking a very large risk. [...] So they won’t touch that billion dollar opportunity if it means that everybody has to change their way of working or thinking.”

Therefore, one way of managing market adoption risk is to avoid early-stage investments, where by definition there is the highest uncertainty about market needs. This can be transferred from individual investments to sectors: In sectors with a certain history of VC investing, such as IT or biotech today, there is less uncertainty about market needs for new technologies than for example in distributed energy systems, where it is still unclear who will be promising customer segments and what is the best way of addressing them. Successful market penetration of these technologies, such as fuel cells and other technologies for small-

[9] See for example http://www.brentsjam.com/Notes/notesventurec.htm for a similar categorization.

scale combined heat and power generation (micro-CHP), depends on things like that customers must be allowed to connect them to the grid, that interconnection standards exist and that customers are able to sell excess electricity to the grid operator at attractive prices.

"A lot of business plans [in the fuel cell sector] rely on other external factors that you cannot control, and a VC is getting very nervous when you see big investment in a capital intensive and regulated market relying on a fundamental change in the environment."

On top of these uncertainties with regard to the end user of distributed energy technologies, electric utilities play an important role in market adoption risk since they act as gatekeepers.

"One thing certainly that constrains electricity is that your adoption of a technology still is in the hand largely of utilities"

In the case of sustainable energy technologies, an additional element of market adoption risk is that much of the unique selling proposition (USP) lies in their societal added value, not in the private benefit that they generate for the end user. A mobile phone is likely to be preferred by customers over fixed line telephony because it provides him with completely new (private) benefits. Whether a solar cell will be bought by a residential customer to displace the fixed line electricity in his house is less obvious, since he cannot tell the difference in the final product that comes out of the wall socket. Uncertain advantages from the consumer's point of view have also been identified as one important barrier to sustainable energy investments by European VCs in Kasemir et al. (2000).

Rather than seeing this as a higher risk for sustainable energy technologies, one can also look at it as simply being a different risk profile. The positive externalities associated with these technologies are something that is unique compared to many other sectors that VCs invest in. The challenge lies in getting someone to pay for it, which will be discussed in more detail in the section on regulatory risk below.

3.1.2 Technology Risk

Another form of risk associated with VC investments results from the fact that it is often unknown in advance whether or not a new technology will ultimately work. As Zider (1998) points out, "betting on a technology risk in an unproven market segment is something VCs avoid." He acknowledges, however, that there are exceptions to this rule in the case of "concept stocks", such as genetic engineering, where technology risk is very high, but potential returns are, too.

Technology risk can be managed to some extent by VCs requiring a working prototype before they invest, and by staging investments, so that later financing rounds are tied to the achievement of certain milestones in technology development. Technology risk is particularly important when it comes to technologies that are capital intensive to develop and have long lead times. Not surprisingly, capital intensity of energy technologies (as opposed to, for example, internet companies) is one of the main barriers mentioned by several VCs:

"[If you develop for example a microturbine with] $ 200 mio of capital need to go in there, there are very few and almost no deals unless you are in a bold market like in 1999/2000 where you can raise that much money. [...] So in a bold market it works but as soon as the market becomes more normal or becomes varied like now, it's very difficult to find any investors for capital intensive cases like that [Capstone]."

A VC who is not currently investing in sustainable energy even sees capital intensity as prohibitive for venture capital investment in the energy sector:

"This [the capital intensity of developing new energy technologies] means that there are some sectors that I think cannot be financed by venture capital. They can be financed by other means, maybe they need more public money, or by money that is not as say impatient as VC money"

While the challenge of capital intensity is acknowledged by the "believers" in energy among the VC community, too, they see it as something that needs to be managed rather than an insurmountable barrier. One way of managing capital intensity is to develop adequate business models that allow for maximum impact with limited capital input. Strategies to cope with capital intensity include (a) licensing / manufacturing partnerships, (b) franchising / distribution partnerships, (c) early exit, and (d) pursuing multiple target markets (real options). Implementation of such capital-extensive business models is only beginning to emerge in the energy sector. An example of strategy (a) is Energetech,[10] a VC-backed Australian wave energy technology venture, which initially intended to go into construction of wave energy plants, but realized that putting their equity money into building concrete walls was too expensive. They then changed their business model and now focus on the "intelligent core" of their devices, while contracting the less IP-intensive parts out. Strategy (b) has been adopted by Capstone Turbine,[11] who initially tried to sell their product directly to every individual commercial customer, but soon had to realize that going through established distributors is more efficient. Strategy (c) is common practice in the biotechnology sector, which is equally capital intensive:

"Well, look at biotech, you know, developing, getting a drug from discovery to market is a 7 year process. Although once you get that you have a monopoly in the market, right, for another 7 years or so." (Interview #2)

In biotech, however, there is an established "early" exit route for ventures. Biotech VCs manage capital intensity by taking investments only to a certain stage, such as FDA approval for their product, and then exiting through trade sale or IPO (Zider 1998). We will discuss this in more detail in the chapter on exit risk below.

An example of strategy (d) is Enginion,[12] a German manufacturer of steam cells. Their primary target market is micro-CHP, i.e. developing units for combined heat and power generation in residential or small commercial buildings. This is a large market, but has a number of entry barriers attached to it. Therefore, the company pursues another near-term market opportunity in parallel, which is auxiliary power units (APUs) for cars and trucks. This provides them with two options to capitalize on their heavy R&D investment, rather than just betting on one horse.

Finally, capital intensity can actually also be regarded as an advantage rather than a disadvantage, namely for later-stage investors that are looking for larger financing rounds and are not set up to cope with early-stage deals, where they have to put in relatively high management effort to apply relatively small amounts of capital. Apart from some larger VC firms, this might be the rationale behind the oil companies' investment in solar cell manufacturing, which is one of the most capital-intensive renewable energy technologies.

"I think it's still a mystery whether [the oil companies] are planning [renewable energy] ever to be a huge business. (...) [Their rationale might be that] they also view it as a good early hedge on being able to have, you know, quickly turn more resources on to something that gives them a carbon hedge or reduce carbon-risk-exposure. [This] may be another motivation."

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[10] www.energetech.com.au
[11] www.capstoneturbine.com
[12] www.enginion.com

When we look at technology risk beyond investing in a specific company, but more broadly on a sector level, a question raises about whether there is a sufficient technology base in the energy sector to lead to good VC deals in the first place. One way of measuring this is to look at government R&D spendings in the energy sector. Margolis and Kammen (1999) argue that there is underinvestment in energy R&D in the US. Calculating R&D intensity, defined as total (public and private) industrial energy R&D as a proportion of the country's total energy expenditures, they show that the energy sector with just 0.5 % of sales going to R&D lags far behind sectors like drugs and medicine or communications equipment, who have a R&D intensity in the order of 10 %. A similar argument can be made with regard to R&D intensities of major European companies (Wüstenhagen and Teppo 2004). Then again, as Sagar and Holdren (2002) argue, measuring R&D spendings is complicated by the interdisciplinary nature of many energy innovations, so what should count as energy-relevant research is often unclear. Furthermore, they point out that just measuring R&D input will not provide the full picture of the energy innovation system, and that it is necessary to look at input-output relationships (how effective are R&D efforts in bringing about technological advances) as well as the utilization of the output (implementation and diffusion of new technologies). If we summarize this discussion for our energy VC context, there seems to be preliminary evidence that energy suffers from a lack of R&D that could be an important input to the energy venture capital sector. To fully assess the relevance of this, however, one would have to include other elements of the energy innovation system into account, such as technology transfer mechanisms, public and private funding for demonstration projects, university spin-offs, etc. This would go well beyond the scope of the present paper.[13]

3.1.3 People Risk

The success of VC investments crucially depends on the ability of entrepreneurs and venture managers to grow the company, or to "execute" to use a term from typical VC jargon. This is once again something that can be judged in advance only to a limited extent. High-growth companies constantly change, and that means constant changes in the challenges that their management faces. Apart from careful selection of the investment target and due diligence on the management team,[14] this risk is typically managed by close monitoring of the investment, coaching the team as the company grows, and sometimes by replacing the existing management.

One of the questions we tried to answer in our interviews was whether VCs perceive that there are creative inventors and courageous entrepreneurs in energy just as in any sector, or whether energy is different. This North American VC seemed not to see a lack of creativity or entrepreneurship in energy:

"I don't think that the entrepreneurial instinct or interest drops off a cliff, you know, when you're looking at other industries and then you get to energy. There are entrepreneurs trying to find opportunities everywhere. [...] They are all driven by greed or wealth creation. But also have these characteristics of being, you know, creative driven and obsessed, good team builders and I don't think that's asymmetric in a sense to the energy sector. You still find these kinds of entrepreneurs in energy."

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[13] See the analysis of Müller et al. (2004) on "Sources of Bioentrepreneruship" for a sample of aspects that such an analysis would have to cover, or Venkataraman's (2004) discussion of the "seven intangibles of regional technological entrepreneurship".

[14] A particularly innovative proposal for managing people risk in the selection phase comes from one of the VCs interviewed by Fried and Hisrich (1994, p. 32) who proposes to visit the entrepreneur at home: "I like to go out and meet the spouse and the kids and try to see if their home is in chaos or if it's pretty orderly." We should add, though, that none of the VCs we interviewed seemed to have adopted this methodology.

On the other hand, respondents of our survey, when asked about the importance of "better engineers for energy ventures" versus "better management teams for energy ventures" as possible fostering factors for energy VC in Europe, ranked the issue of better management as the 4th important of 13 items, while better engineers was the least important factor in their view. One possible explanation is that there is a US-European difference here; with Europe having (more than) enough good engineers but not enough business people capable of managing growth for energy ventures, while North Americans care less about the beauty of technology but have a large population of managers to make money out of it. Anyway, it seems that at least for Europe, the lack of entrepreneurs is indeed an issue in growing the energy VC sector.

Since successful venture managers need not just creativity and entrepreneurial spirit but also some solid industry expertise, it is interesting to think about where such managers can be recruited from. One option is for venture managers to come from large companies in the same industry, which is a pattern that can be found in other VC sectors. For energy, this might mean some conflict with the lack of innovativeness in the utility industry discussed above.

"So in energy, where could people come from? They do come from the utilities of course; you could find some good people there. Provided that they have the right mindset. [...] It's tough. If you stayed there for 25 years, you might be very good, but you're a military and you're not an entrepreneur. They could come from equipment manufacturers. I think the single most important source is equipment manufacturers. [...] But we don't see too many people like that. Because it's by definition risky to do that. So only a small proportion of people want to leave their job in GE or ABB and go to a smaller company."

A particular issue that came up in our interviews evolves around the **green image** that might be associated with sustainable and especially renewable energy technologies. We tried to find out whether VCs perceive this to be reflected in the mindset of entrepreneurs in this sector, and if yes, whether that might lead to a cultural mismatch between these "green" entrepreneurs and the primarily financially driven venture capitalists. We found some support for this proposition, most pronounced in the following statement by a VC of Italian nationality:

"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." (...) "Environmentally-oriented people, they see the end of the world coming."

However, asking the question whether this "save-the-world" image of sustainability entrepreneurs is a major barrier to entry for VCs, we received very mixed responses in our survey, ranging from very strong support to very strong rejection. One way to explain this large variance of answers might be that a major change is going on in the way that sustainable energy is perceived – from an almost esoteric dark green niche to an established mainstream business:

"Back in 1992 at the time of the [...] Rio Summit, renewables was still an issue of kind of benevolent action, you know, it didn't make economic sense but it was the right thing to do. I think that's increasingly changing. Both again regulatory driven where utilities are having to buy certain percentages of renewable power, but wind makes sense even without tax credits [in] certain markets [...] as a part of a diversified power mix. [...] I think it will, you know ultimately the market has to recognise it's a place where people are making money and they'll take it seriously. I think with a lot of literacy they saw the industry at some point as a place where people weren't making money for years and years. [...] [Now] solar is getting to a scale were big investors are starting to pay more and more attention. Same thing with wind. It is, I think, very telling that GE got into that business and then Enron was there too. So, it [the green image] will be a label that will be on renewable energy, you know, for a long time. But I think the proof will be when companies start to make serious money out of that."

3.1.4 Regulatory Risk

The main source of regulatory risk, or political risk, is government regulation of the end market(s) that the venture aims to serve. Political risk scored high among the energy VCs participating in our survey, being the second-often mentioned factor when we asked the 26 respondents an open question about reasons for the lower levels of VC investments in energy compared to other sectors. This seemed to be strongly influenced by a perception that it is difficult to predict future government subsidies in the energy sector.

Many sectors are regulated by government in one form or another, but the energy sector is often portrayed as particularly strictly regulated. The electric utility industry as an example has only recently been liberalized in many countries, and in some markets such as Germany or France, new entrants still find it difficult to compete with the former monopolists. Regulatory risk is usually disliked by investors because it seems harder to manage or even outside their area of influence. A closer look at traditional VC target sectors demonstrates that while IT probably enjoys a relatively low level of government regulation, other industries such as telecom or biotechnology are also highly regulated. VCs in the biotech industry, however, may manage this risk by supporting early-stage R&D but then exiting their investments prior to achieving regulatory hurdles like FDA approval for new drugs. Another form of managing regulatory risk is gaining a better understanding of the political system, or even actively lobbying for particular forms of regulation. Yet large incumbent companies are usually better at lobbying for their interests than small start-ups, and venture capitalists seem to be closer to start-ups than to large incumbents with regard to these competencies. Looking at our interview data, it seems that VCs and governments are two worlds apart:

„If there is no clear need for the government, make them stay out of the way."

Other interviewees mentioned that below the surface, i.e. below the immediate reflex of VCs to say that government should stay away, there might be another truth, which is that government-funded R&D lies at the heart of many of the technologies that have become successful investment sectors for VCs:

"On a superficial level, VCs will always say that they go out because it [government involvement] is bad for them. You have to push your research a level deeper, because for instance the reason why Quebec has got a VC industry in life sciences and in IT is because initially there was some heavy-handed governmental intervention. We think it's something like that in the field of energy."

At least one other VC shared the view that government is not necessarily a "bad" thing for VCs, but just another risk that can and should be managed:

"VCs need to have competence in lobbying if they want to succeed in the energy sector, just like the big American mainstream VCs have their guys in Washington DC."

Regulatory risk in the energy sector takes different forms, including subsidies to incumbent forms of power generation based on coal and nuclear energy, traditional government ownership of many electric utilities, and insufficient market liberalization in many countries. On the other hand, government involvement can also be helpful for new technologies, for example by funding basic R&D (for example for military or aerospace purposes) and thereby kick-starting a market. Government support for renewable energy in particular can be seen not only as a risk, but also as an opportunity, as the following statement by a German VC demonstrates:

"We actually think we have a unique opportunity here in Germany with all that government support for renewables. That was one of the reasons for us to invest in a solar cell company."

The sample of European VCs interviewed by Kasemir et al. (2000) listed a number of possible measures by which European governments could support VC investment in sustainable energy, including policy measures directed at market adoption of sustainable energy technologies (such as energy market liberalization, removal of coal subsidies, removal of export credit insurance for fossil-based power plants, energy-efficiency standards in the automotive sector, and an EU carbon tax) as well as measures to support VC investment specifically (such as tax incentives for energy efficiency and renewable energy investment, or state guarantees for realized losses in young energy technology companies).

Beyond indirectly influencing the success of VC-backed energy ventures through energy and climate policies, governments can also directly contribute to the growth of the sustainable energy VC market by investing its own funds. Examples of this include the recent announcement by the largest public pension fund in California, CalPERS, to invest $200m in sustainability or cleantech ventures, as well as government VC funds like Industrifonden in Sweden, which invests part of its capital in sustainable energy ventures. Lerner (1999), in his analysis of the US SBIR program as a government-backed venture capital activity, identifies two rationales for this kind of government intervention in the venture capital sector. First, the social returns from the ventures' R&D expenditures may exceed their private returns – which should be all the more valid in the case of sustainable energy technologies that help to remove the environmental externalities associated with conventional forms of power generation. Second, awarding public grants might be seen as a form of certification of the firm's quality by knowledgeable government officials, which might address the informational asymmetries that might otherwise have precluded private investments.

3.1.5 Exit Risk

The opportunity to exit investments after some years is a key part of the venture capital cycle, because it allows VC investors to get a quantitative measure for the VC fund manager's skill, and it allows the VC to reapply his competencies to a specific part in the life cycle of a company's development where he adds most value (Black and Gilson 1998). Exits can take five forms (see for example Cumming and Macintosh 2003, similarly Gladstone 1989), of which the first two are most relevant: (1) a public offering of the company's shares (IPO), (2) a trade sale (or acquisition), where a larger company acquires the shares of the venture, (3) a secondary sale, where the VC sells its share in the company to a third party like a strategic investor or another VC, (4) a buyout, where the VC sells its share to the entrepreneurial firm or its management, and finally, but less desirable, (5) a write-off in case of the venture's failure. As Wright and Robbie (1998) point out, most previous research has focussed on IPOs as the exit route (for example Barry et al. 1990, Gompers and Lerner 1999, Lange et al. 2001), while the trade-off between acquisitions and IPOs seems to have been largely overlooked by academic research (Hellmann 2004). Yet Amit, Brander and Zott (1998) show for a sample of Canadian VC-backed companies that trade sales are more than twice as common as IPOs. Their explanation is that due to informational asymmetries, strategic acquirers (or the firm's management in the case of a buyout) are in a better position to understand the value of a high-tech venture than an average outside investor. Megginson (2004) points out that exit routes strongly differ between the US and Europe, with IPOs being the preferred exit route in the US, but only 5 % of European Private Equity deals being exited through IPOs in 2002, while trade sales and write-offs accounted for 30 % each. One explanation for these international differences is that most countries outside the US lack a similarly well-established stock market for early-stage high technology companies (Black and Gilson 1998, Kuemmerle 2001). In addition to geography, the relative importance of exit routes also changes over time. During the technology boom in the late 1990s, IPOs were much more likely to occur than in the past three years, when the IPO window was essentially closed in many countries and so VCs willing to exit had no other choice than to look for a trade sale buyer.

Among the few authors investigating trade sales as an exit route, Petty et al. (1994, cit. in Wright and Robbie 1998) point to the fact that trade sales provide more immediate liquidity, but may not satisfy the objectives of the entrepreneur. Black and Gilson (1998) stress that same point when they argue that exit through IPO provides a unique match of the interests of both the entrepreneur to reacquire control over the company and the VC to reduce his monitoring cost.

In stark contrast to the focus on exit through IPO in the (mostly North American) venture capital literature, our survey of energy VCs showed that exit through trade sale is expected to be much more frequent in this sector in Europe. On average, the VCs in our sample expected 80 % of their current portfolio companies to exit through trade sale, and just 20 % through IPO.

In terms of possible trade sale buyers for VC-backed energy technology companies, electric utilities seem to be a natural option, given that many European utilities are active in this space with their own Corporate Venture Capital units (Teppo and Wüstenhagen 2004). However, the electric utility industry does not enjoy a reputation of being overly innovative among the VCs we interviewed. One interviewee explained why utilities have traditionally been successful with low levels of innovative activity, and contrasted this to pharma companies as typical trade sale buyers for VC-backed companies in the biotechnology sector:

"In energy, you make money in two ways, either by selling raw services – generation, transmission or distribution – or by arbitraging the price difference between two regions, that's basically trading. So new technologies or innovation don't play a role as a way to engage in continuous growth. So therefore it is in fact tougher to sell to energy companies because they don't have the mindset." - "Pharma companies [...] have to innovate to survive. In three years, 60 % of what you are selling now will be down to 20-25 % on sales. [...] If you don't innovate, if you don't find something new, you're dead. It's simple as that."

Utilities' risk aversion was quoted as another factor that makes them unlikely candidates for VC exits in the energy technology sector:

"The other characteristic of this industry [...] might be that 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. Utilities don't seem to approach it that way [working with a diversified portfolio of small companies]."

Another interviewee points out that in the pharmaceutical sector, there is a better understanding of investing in small ventures:

"[Big pharma companies act] like a VC, (...) they have a portfolio approach"

Yet another interviewee points out that utilities may not be the only, and in fact perhaps not the most likely trade sale buyers in the energy venture capital sector. Instead, power technology manufacturers constitute an alternative route to market.

"They [power technology manufacturers like GE, ABB] are the ones that ultimately are much more focused on innovation 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 [...] they are just in the core business of selling, you know, electrons. And there's no big changes that have happened [...] since the beginning of last century that has really changed the way that wholesale power has been delivered to costumers."

This view was confirmed by a majority of participants in our survey, who saw power technology manufacturers such as GE, Siemens and ABB as the most likely trade sale buyers for energy technology ventures, clearly more important than electric utilities and oil companies (see Figure 3). Two other categories of potential trade sale buyers, namely financial investors in general and sustainability-oriented mutual funds specifically, were ranked at the end of the list. Whether the expectations of the VCs vis-à-vis power technology manufacturers will be met in reality remains to be seen. As of now, GE is the only one of these companies that has made a handful of significant acquisitions in the sustainable energy sector, buying the wind turbine manufacturing business from Enron, the Austrian biogas and CHP specialist Jenbacher, and the assets of Astropower, the US solar cell manufacturer. Notably, none of these three deals was a case of successful exit for a VC. Both Enron and Astropower had gone bankrupt at the time that GE made the acquisitions, and Jenbacher was a publicly traded company prior to GE's purchase. One of the few examples of a successful trade sale for a European energy VC so far was FKI's acquisition of DeWind, the German wind turbine manufacturer, from MVV's corporate venture capital fund. Other power technology manufacturers seem to have a stronger tendency of inhouse R&D. Understanding the likelihood of these companies to actually acquire VC-backed energy technology start-ups in the future would be an important area for further research from a practical energy VC perspective.

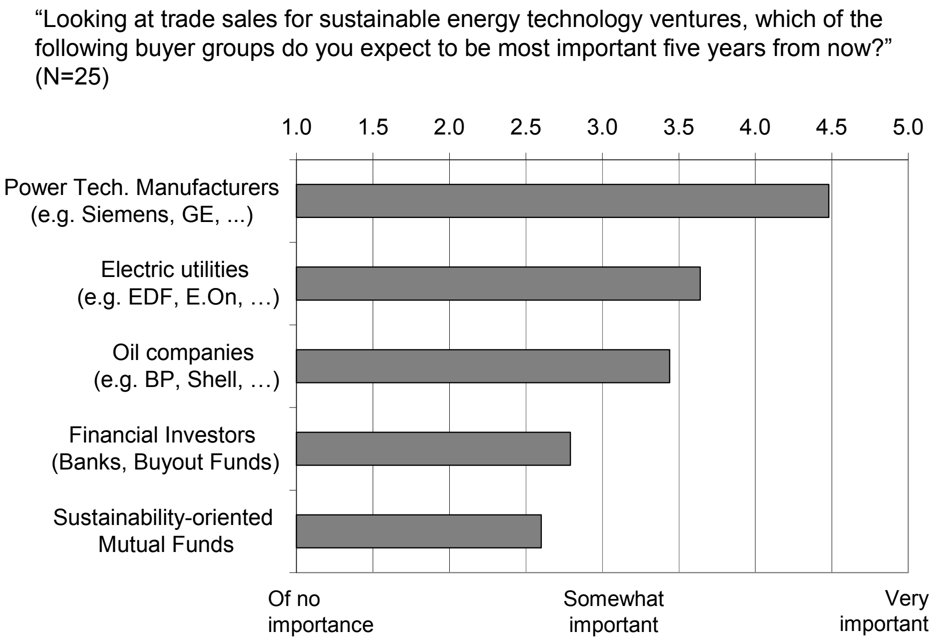

Figure 3: Power technology manufacturers are seen as the most important trade sale buyers for energy technology ventures

Finally, going back to our research question about the relevance of each of the risks we discussed in this section for the future growth of VC investments in the energy sector, exits have an important function in that they draw other investors' attention to the opportunities in energy venture capital. With that regard, the energy VCs we interviewed appeared to be fairly sceptical about the sector that they invested in:

"There aren't that many success stories, [and] the few success stories that there were three years ago [...] created a huge bubble in the energy sector"

The perception of "few success stories" expressed here is shared by participants in our survey. Of the 26 responding European energy VCs, only nine could answer our question about the most successful exit for an energy VC in the past decade. A total of seven different companies were named, one of which was not an energy company. In another case, there actually was no exit because the planned IPO of the company had failed, and yet another case described a company without VC-backing. Of the remaining four truly successful energy VC exits named by our survey respondents, three companies were located in North America (Plug Power, Capstone and Ballard) and can justifiably be attributed to the energy technology bubble in 1999/2000. The only European company that was mentioned was Vestas Wind Systems of Denmark. It comes as no surprise then that "success stories of VCs exiting energy investments" was the top scorer in our survey when we asked respondents to judge the importance of each of 13 fostering factors that could accelerate growth of sustainable energy VC investments over the next five years.

This leads us to take a closer look at the other side of the risk-return equation in the following chapter.

3.2 Return

From a venture capitalist's perspective, a return on investment is realized at the time of exit. We will briefly discuss the variables determining VC returns (3.2.1) with regard to possible answers on our research questions, i.e. understanding differences in VC investment levels in energy technology compared to other sectors. Subsequently, we take a look at actual VC returns in the energy sector (3.2.2).

3.2.1 Factors influencing energy VC returns

On the level of an individual portfolio investment, VC returns are basically a product of three variables: 1) The price the VC paid at the time of investing; 2) The sales price at the time of exiting the investment by selling shares on the public market or to a trade sale buyer; and 3) the time between 1 and 2, i.e. between investment and exit. Obviously, the best return will be achieved by buying low, selling high, and doing so quickly.

The first part of the equation, the **purchasing price** for energy VC investors, depends on a number of factors, including supply and demand for energy VC deals, and the reputation of the VC (Black and Gilson 1998). All things being equal, more supply (i.e. entrepreneurial firms seeking funding) should lead to lower prices, because VCs can choose from a larger variety of investment opportunities, and increasing demand (i.e. VCs looking for investment opportunities) should lead to higher prices (Gompers and Lerner 2000). Anecdotal evidence from the energy technology industry does not seem to support any substantial supply-demand imbalances compared to other VC sectors. On the supply side, specialist energy VCs report a ratio of deal flow to actual investments in the order of magnitude of 100:1, which is comparable to standard VC ratios. On the demand side, recent articles from industry journals indicate increasing excitement among some of the mainstream VCs about opportunities in the energy sector, which should lead to better prices for the entrepreneurial ventures, hence somewhat diminishing the prospects for good VC returns. However, this seems to be far from a hype that would see many VCs compete for energy deals and driving up prices. Anecdotal evidence suggests that, at least in Europe, even in cases where deals have reached substantial publicity, the number of knowledgeable VCs truly interested in investing seems to match with, but not greatly exceed the financing needs of the venture. The reputation of the VC might have an effect on its negotiating power, hence resulting in a cheaper price for the investment (Hsu 2002, cit. in Kaplan and Schoar 2003). Some specialist VCs in the energy sector have indeed managed to build up a good reputation for their industry expertise, but this should not have an impact on the sector as a whole, but rather give those VCs a competitive advantage over some of their peers, just as other sectors have seen a tier of top-quartile VC funds persistently outperform their peers (Kaplan and Schoar 2003).

The second part of the equation, the **price at exit**, looks differently for the exit routes discussed above. In the case of exit through IPO, the VC's return depends to some extent on the IPO price. However, venture capitalists, as well as other insiders such as the entrepreneur, usually have to agree to a lock-up period during which they are not allowed to sell their shares. This lock-up period is usually 180 days after the IPO event. Even then, VC investors cannot immediately sell all of their shares without having a serious impact on the company's share price performance. This is particularly true for early-stage technology companies, where the liquidity of the stock may be low. Therefore, divestment typically occurs in multiple stages, and total holding periods can be as long as 1-3 years after the IPO.[15] Obviously, share price performance post-IPO depends on various factors, including company news but also overall market trends that cannot be managed by the VC. The typical fluctuations in stock markets also mean that returns that can be realized through this exit route will be highly cyclical in nature, with VCs making better returns when the particular sector is in favour of the market, and vice versa.

In the case of exit through trade sale, the price and therefore the return to the VC depend not only on the fundamental value of the venture, but also on its strategic value to the acquirer. For example, a gas turbine manufacturer may be prepared to pay a premium for acquiring a fuel cell venture if he sees this as a potential threat to its incumbent business. As a tendency, more competition on the level of potential acquirers should drive this premium up, while it should be lower in monopolistic or oligopolistic markets. Looking at the energy sector, competition does not seem to be particularly intense both on the level of electric utilities, as potential users of sustainable energy technologies, as well as on the level of power technology manufacturers. This might negatively impact the price that can be achieved in trade sales. However, these are just preliminary considerations that need further scrutiny. For example, a comparison of trade sale performance of VC deals across different sectors, combined with an analysis of the level of market concentration among the trade sale buyers in these sectors could provide deeper insights here.

The third and final part of the VC return equation, the **time between investment and exit**, is important because even if VCs neither pay higher prices for investing in energy deals, nor achieve less favourable terms when exiting their investment, the annualized return may still be worse than in other sectors when the investment cycle is significantly longer. This leads back to the issues of capital intensity and long technology lead times discussed in the section on technology risk above (3.1.2), and will therefore not be discussed in further detail here. An empirical investigation of average holding periods for energy VC investments compared to

[15] In a sample of 433 VC-backed IPOs in the 1978-1987 time period, Barry et al. (1990) found that VCs had only reduced their shareholdings by an average 28 % one year after the IPO.

biotech or ICT investments might be a fruitful exercise to shed more light on this issue, but will be challenging to do at this point of time given the short history of energy VC investments in Europe.

3.2.2 Early empirical evidence on past energy VC returns

A simple and common form for investors to estimate expected returns from venture capital investment in a certain sector is to look at IPO performance of previous venture-backed firms. In the energy technology sector, this provides a not too promising picture at first sight. Figure 4 below gives four examples of US-based, VC-backed energy technology companies: Evergreen Solar, a solar cell manufacturer, Beacon Power and Active Power, both developers of energy storage technology (flywheels), and Plug Power, a fuel cell company. All of these were backed by some of the most prominent US energy venture capital firms prior to their Initial Public Offerings (IPO) in 1999/2000 and traded between 63 and 95 % below their IPO price on September 3, 2004.

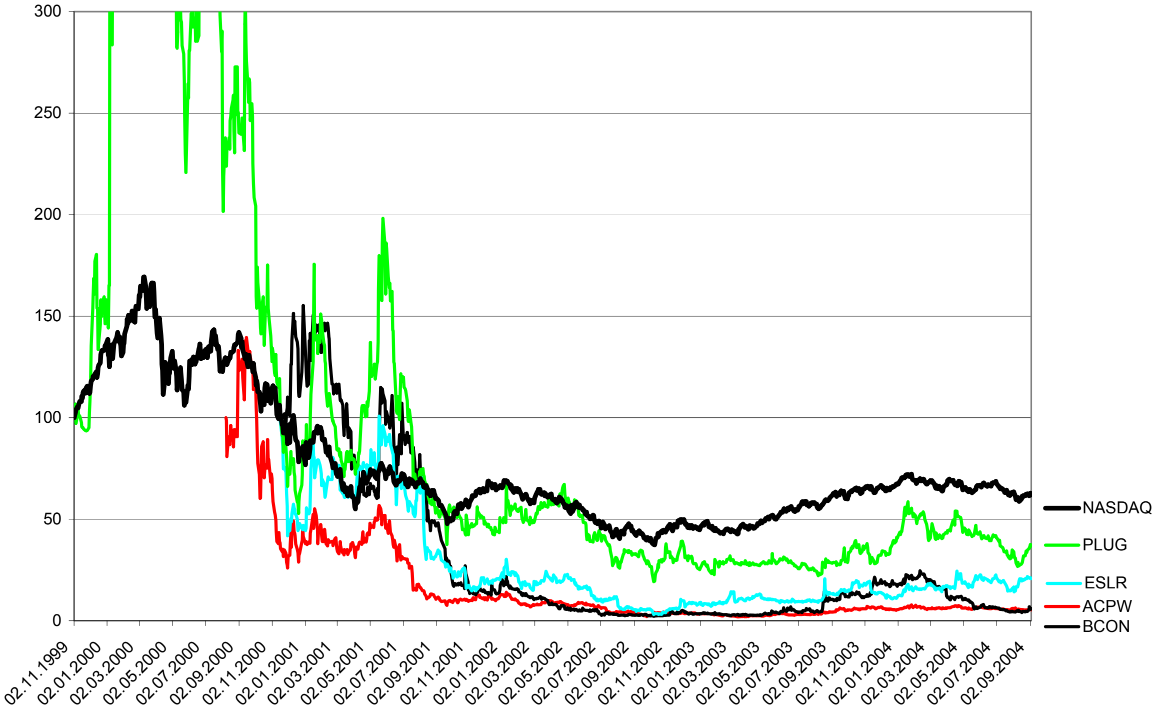

Figure 4: Post-IPO Price Performance of VC-backed Energy Technology Companies versus NASDAQ Index (Source: own calculation based on share price data from finance.yahoo.com)

Then again, looking at the stock price performance post-IPO may not tell the full story. VCs typically invest well before the IPO event, and at lower prices than the IPO price. Also, they are usually free to divest the stock after the lock-up period expired, so even if the long-term performance of these shares looks less than promising, a VC investor who divests at the right time may realize a decent return. Measuring actual energy VC returns is complicated by the fact that the exact timing of the divestment is not publicly available information. To get a clearer picture of at least the theoretical returns that a VC investor could have realized had he sold his shares at the first day after the end of the lock-up period, we calculated the annualized internal rate of return (IRR)[16] for VC investors in the four companies mentioned above. We gathered data about the purchasing price that investors paid for the company's shares in various pre-IPO financing rounds from the companies' IPO prospectuses. On the other side of the equation, we determined the share price at 180 days after the IPO, the end of the lock-up period for VC investors.[17] We then annualized these returns by taking into account the time between the various financing rounds and the end of the lock-up period. The results for the four energy technology companies are shown in Figure 5 below, providing quite a different picture: The lowest IRR in the 15 financing rounds that we looked at was 49 % p.a. for investors in Evergreen Solar's early stage (Series B) financing, which is still well in the range of typical VC return requirements of 30-50 % p.a. All other rounds exceeded this, with investors in Plug Power's pre-IPO (series E) financing round making a comfortable 5231 % IRR. We have to acknowledge that the Plug Power case may be exceptional because the end of the lock-up period in late April 2000 coincided with the peak of the technology bubble and also benefited from a fuel cell hype at the time. Another indicator for the influence of the bubble is that returns for these four companies increase over the subsequent financing rounds of each company. One would expect exactly the opposite: Early-stage investors usually have higher hurdle rates due to the higher risk they incur, while IRR should decrease for later stage financing rounds.

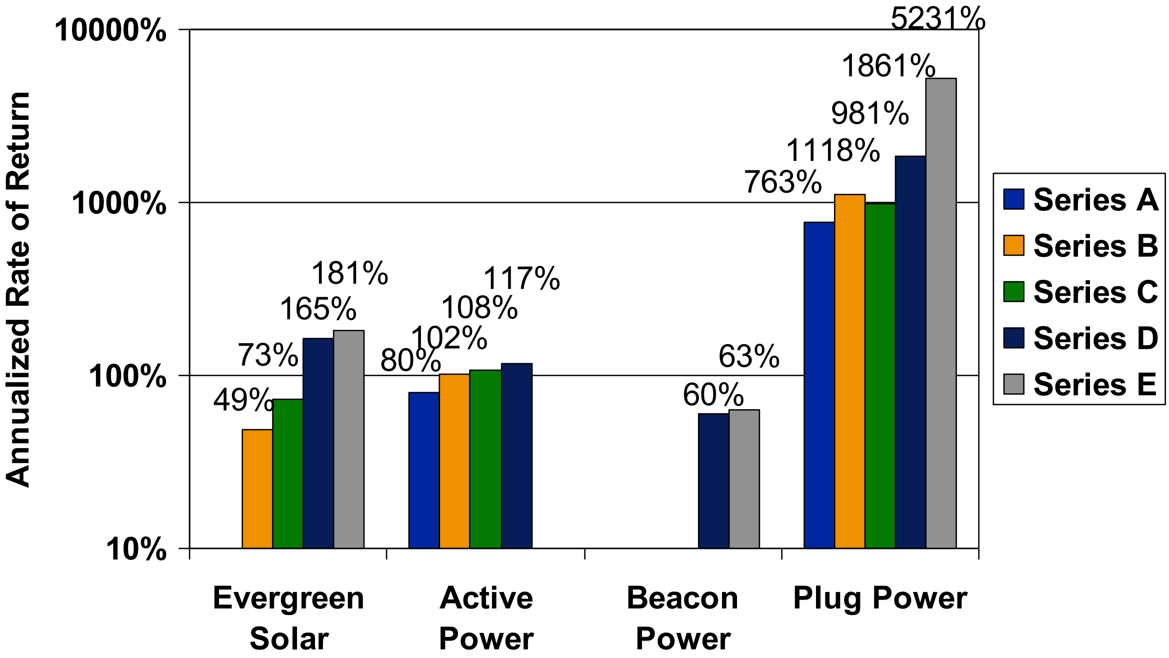

Figure 5: Theoretical VC returns for selected energy technology companies (Source: own calculation based on VC investment data from IPO prospectuses and share price data from finance.yahoo.com)

Again, this analysis indicates some room for further research. First, the sample of just four companies that we looked at here for reasons of convenient data availability needs to be expanded in a broader analysis (Moore and Wüstenhagen 2004). Second, a more comprehensive analysis needs to include non-US companies. Third, any analysis of VC returns that looks at successful IPOs is inherently subject to a survivorship bias, even if this is

[16] See Kaplan and Schoar (2004) for an extensive discussion about IRR and alternative performance measures for venture capital funds.

[17] We acknowledge that by assuming an exit at IPO plus 180 days, and given the negative share price development for these companies since then, we probably overestimate actual returns to a certain extent. Also, transaction cost for liquidating the investment is not included in our analysis.

to some extent already considered in the VCs' return requirements that account for the risk of failure in some of their portfolio companies. Fourth, trade sales need to be added to get a full picture of exiting energy VC investments, even if data is even harder to come by than in the case of IPOs. Ultimately, energy VC returns will be more accurately measured by looking at overall fund returns (cf. Kaplan and Schoar 2003, as well as (all cited ibid) Gompers and Lerner 1998, Jones and Rhodes-Kropf 2003, Ljungqvist and Richardson 2003). This, however, can only accurately be done after a fund has been liquidated. Therefore, such an analysis is subject to a time lag of about a decade after energy technology VC funds are first set up, which makes it difficult to apply to the emerging European energy VC sector before the 2010 timeframe.

Acknowledging these limitations, we can still conclude that there is at least anecdotal evidence for attractive returns by venture capitalists in the energy sector. Our exploratory analysis shows that a common perception – even among the energy VCs that we interviewed – of energy as a conservative sector where high tech investors are unable to make money may need some revision, at least for the period in 2000/2001 where public financial markets provided a favourable environment for energy technology stocks. This means that rational risk-return considerations can apparently only explain part of the story when we ask for reasons that determine the lower level of VC investments in energy compared to some of the other industries. In chapter 4 below, we therefore turn to factors that are beyond the immediate rationality of risk and return.

3.3 Results from our Survey – Understanding the Relative Importance of Factors influencing sector-specific VC investment levels

To get a sense for the relative importance of the risk and return aspects we discussed so far, we compare the data from our qualitative interviews with the results of our survey among European energy VCs at the 2003 European Energy Venture Fair[18] (Table 1). Our questionnaire included three questions that were related to the importance of various factors in explaining the difference in investment levels between energy and sectors like IT and biotech. The first question was openly asking for factors that respondents find relevant:

"1) Information technology, biotechnology and telecommunications are the three most popular areas for VC investment, absorbing two thirds of all VC money. Energy typically accounts for 1-3 % of VC investments only. In your opinion, why is there so little VC investment in sustainable energy technologies?"

We aggregated the 65 responses[19] that we received in a qualitative cluster analysis, which resulted in the 17 factors listed in Table 1.

The second question addressed the same issue with a different type of question, suggesting 13 possible factors that might explain the difference in investment levels and asking respondents to assess their relative importance.

"2) Other people have mentioned the following factors as having an influence on this difference in sector-specific VC investments. How important do you rate each of them on a scale from 1 (of no importance) to 5 (very important)?"

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[18] http://www.europeanenergyfair.com

[19] This number is higher than the total number of respondents because several factors were named per respondent.

Finally, another question asked for fostering factors that might help the sustainable energy VC market grow in the future. Again, respondents were asked to assess the importance of each of the 13 factors suggested on a scale from 1 to 5.

"6) Below is a list of fostering factors that could help the market for VC investments in sustainable energy technologies to grow faster than it does today. In your opinion, how important is each of these factors in accelerating the growth of sustainable energy VC investments in the next five years?"

As regards the open question, in line with our observations from the qualitative interviews, the conservative nature of the energy industry was a very popular theme when it came to explain the difference in VC levels compared to biotech and ICT. Issues related to political (or regulatory) risk were the second-often mentioned factor, mainly with regard to the difficulty to predict future government subsidies in the energy sector. Long technology lead times and high capital intensity compared to biotech/ICT were also mentioned frequently.

When we suggested some factors in the second question, a lack of successful exits found most support as being an important barrier to energy VC market growth. A factor related to market adoption, namely the level of competition in the energy market, was seen ambiguously. While many respondents agreed that more competition would accelerate market adoption of sustainable energy technologies, particularly UK respondents pointed out that too much competitive pressure might have the opposite effect.

When we turned the question around and asked about factors that would help accelerate the growth of sustainable energy VC investments in the next five years, there was a strong consensus in that many VCs seem to think that market growth will be directly connected to success stories of energy VC exits. IPO markets picking up were also seen as important, even though most VCs expect trade sales to be more important than IPOs for exiting their current portfolio companies, probably because valuation levels in trade sales are linked to publicly listed peers.

In addition to reporting the frequency with which certain factors where mentioned (question 1) and the relative importance attributed to such factors (questions 2 and 6), we also attributed these factors to the risks discussed in chapter 3.1 above (Table 1). The following observations can be made from this exercise:

- All of the five types of risk that we discussed ranked among the most important factors mentioned by VCs.
- Which risk was considered most important differed somewhat between the questions. While asked for reasons that could explain (past and current) differences in investment levels, issues associated with market adoption and technology risk scored higher, the question about fostering factors for (future) growth of the energy VC market saw exit risk rank highest.
- Among the five risk types, issues related to people risk were the only ones that did not make it to one of the top two positions in any of the three rankings.

Question 1: Barriers (Open Question)			Question 2: Barriers				Question 6: Fostering Factors			
Factor	Type of Risk	n	Factor	Type of Risk	Average importance	Stand. dev.	Factor	Type of Risk	Average importance	Stand. dev.
Market power of incumbents / Conservative Industry	M	11	High capex and long investment cycles in the energy sector	T	3.96	1.04	Success stories of VCs exiting energy investments	E	4.20	0.96
Political risk	R	7	Lack of a track record of successful exits	E	3.81	0.94	IPO market picking up again	E	4.08	0.88
Lack of success stories	E	6	Longer technology lead times compared to e.g. internet companies	T	3.81	1.06	Increased capital inflow from institutional investors	-	4.04	0.79
Long technology lead time	T	6	Market power of incumbent energy providers	M	3.58	0.90	Better management teams for energy ventures	P	3.96	1.06
High capital intensity	T	5	Lack of competitive pressure in the energy market slows adoption rate of new technologies	M	3.56	1.19	Price spikes in fossil fuels	M	3.76	0.88
Early market	-	5	Large energy corporations as potential trade sale buyers lack a venturing culture	E	3.46	1.03	Tax incentives for sustainable VC investments	-	3.48	1.19
Low returns / low growth	E	4	Not enough consistent government commitment to sustainable energy	R	3.42	1.17	Education of mainstream VCs about energy issues	-	3.48	1.05
Immature technologies	T	3	Lack of internalization of external cost, subsidies for conventional energies	R	3.28	1.17	Improved technology transfer from universities	T	3.44	0.87
Lack of good management / entrepreneurs	P	3	Sustainability entrepreneurs want to change the world instead of making money	P	3.21	1.28	More government funding for energy R&D	R	3.32	1.14
Lack of deal flow	T	3	Lack of competent VCs	-	3.08	1.20	Improved availability of project finance	M	3.32	0.99
Self-fulfilling prophecy / lack of awareness	-	3	Not enough good deal flow	T	2.96	1.08	Increasing evidence of climate change	-	3.20	0.96
Lack of VC $$ / institutional investors	-	2	Electricity as a low-involvement product not important enough to customers	M	2.65	1.13	More business angel funding for energy start-ups	-	2.96	0.98
Lack of VC competence	-	2	Sustainable energy technologies not „high tech“ enough (e.g. solar thermal)	T	2.42	1.27	Better engineers for energy ventures	P	2.60	1.12
Unreasonable investments in the past	-	2								
Electricity = commodity	M	1								
No clear exit path	E	1								
Statistical error	-	1								

Table 1: European Energy VCs' Assessment of Barriers and Fostering Factors

N = 26. Types of Risk: M = Market Adoption, T = Technology, E = Exit, P = People, R = Regulatory Risk, - = other risks. Importance: 1 = of no importance, 5 = very important.

- Our categorization of risks seemed to match well with VCs' perception of important factors, since aspects that could not be attributed to any of the five categories (indicated with an "-" in the "Type of Risk" columns in Table 1) usually ended up in the lower end of the spectrum for all three questions, with two notable exceptions that we will discuss in the context of path dependencies in VC investing in chapter 4 below: 1) The perception that energy VC is simply an early market which needs more time to develop. 2) Aspects related to the capital supplied to venture capital funds, such as the investment behaviour of institutional investors. One respondent argued that this means that there might be a self-fulfilling prophecy at play: Not enough money for investments leads to slower development of energy ventures, leads to poor returns, which attracts again less investment to the sector etc.

4 The Time Factor: Path Dependencies in VC Investing

The previous chapter has highlighted some of the differences in perceived risk and expected return that can help explain how venture capitalists consider the attractiveness of sustainable energy technologies compared to other sectors. However, we did not find sufficient evidence to support the order-of-magnitude difference observed in VC investment levels, and hence answer our research question. So we digged deeper in both our interview transcripts as well as VC literature, and identified a factor that can perhaps be more clearly understood in an evolutionary perspective: The time it takes for the venture capital market to adapt to changing opportunities, and the inherent path dependencies (cf. Pierson 2000a; 2000b; 2000c; North 1990; Goldstone 1998; Hay and Wincott 1998; Krasner 1984; Tilly 1994 for a discussion of this concept in the political and historical sciences). A process is path dependent if what has happened in the past has an impact on the choices that are available in the present.

Gompers and Lerner (1999) point out that, unlike most financial markets, the VC industry adjusts very slowly to shifts in the supply of capital or the demand for financing. They argue that this is due to the nature of the companies that they invest in, which usually require long-run illiquid investments. VCs need to secure funds from their investors for periods of a decade or more, and consequently the supply of venture capital cannot adjust as quickly as for example mutual or hedge funds. Another factor that is difficult to adjust according to Gompers and Lerner is the supply of venture capitalists, since it is difficult and time-consuming to acquire the skills needed for successful VC investing. Also, raising new funds without a track record is a challenging task, which inherently slows down adjustment of VC investment levels to changes in investment opportunities. Black and Gilson (1998), in their attempt to explain differences in the development of VC markets between the US and other countries, concur that experienced VCs as well as investment bankers experienced in taking early-stage companies public are critical institutions that will not develop quickly. They conclude that a "strong venture capital market thus reflects an equilibrium of a number of interdependent factors, only one of which is the presence of a stock market." Adding to this discussion of interdependent factors, Kuemmerle (2001), in his comparison of the evolution of VC industries in the US, Germany and Japan, points out that "an active venture capital industry is arguably more difficult to create than an active buy-out industry because the former typically requires not just a functioning financial system, but a fertile technology system and a climate conducive to entrepreneurship." As much as we felt that these authors addressed issues that were important for answering our research question, it should be noted that the statements quoted here are usually qualitative side notes in the VC literature, but have hardly been put to the forefront of rigorous academic analysis. Questions about the process of adjusting demand and supply in the VC market and changing sector allocation seem to be a gap in previous research. We believe that addressing this gap in future research is important in order to understand how new market sectors for VC investment emerge.

We can provide some early evidence from our interviews about the points raised here. Maybe the most striking example of path dependencies that we encountered is the fact that VCs tend to invest in areas where they feel competent, and this in turn is a function of their previous experience – in other words: money flows where money knows. As one of our interviewees, partner of a VC fund with focus on IT and biotech, has put it:

"I think [...] there is one reason [for the low level of energy VC investment] which has to do with the capabilities of people and funds. 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, is different compared to where the market is, to other things on the market. And most of the funds have people that come either from three sectors, IT, telecom, or life sciences." – "Look at [my colleague] here, coming from a very successful IT company, founded by probably Canada's four most successful entrepreneurs. You know, he has a network, has people he can call and check. He knows people telling him something about wireless, people he can talk to. And I can call people in biotech, and suddenly have an answer. Many funds don't have those networks [in energy], so when they 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 the expertise, 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 – the lack of people in funds who have a network in the energy sector."

Then again, the conventional wisdom of VCs is that they are not just spending their money where they have spent their money before, but that they are if not geniuses, than at least visionaries to some extent and as such by definition immune against path dependencies. According to one of our interviewees, however, this picture may be the exception rather than the rule in the energy sector.

"The other is, are VCs competent enough to see, to think in a contrarian fashion and see the opportunities that aren't obvious in the market today? Because that's ultimately where VCs, where the really good venture capitalists make their money, because they are investing their time where nobody sees it coming. And that may be just an issue of there aren't enough practitioners in the energy area. How many, you know, 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 it. Right!?"

As a conclusion, growing the energy VC market would mean that the amount of visionaries in the energy VC community needs to increase, which might be a challenging or time-intensive endeavour. As one interviewee put it, alluding to the inevitable trial-and-error process that marks the way towards making competent investment decisions in a new sector:

"It takes 10 million dollars to educate a VC."

Perhaps somewhat typical for an evolutionary perspective, the question remains whether anything can be done about these issues, or whether the result of the analysis is simply to increase the reader's patience, because we know now that these things need time to be resolved, but are ultimately going to happen.[20] Taking the apparent lack of visionaries as an example: Can government or any other invisible hand direct more visionaries to the energy VC sector? Maybe not. A more realistic view seems to lead us back to our risk/return considerations: Demonstrating that there are opportunities to make good returns, and understanding how to manage the risks will probably be a particularly promising way to increase energy VC investment levels. Also, further research that improves our understanding of drivers behind the shifts in VC supply and demand might help to bring the process closer to

[20] This seems to be the conclusion from population ecology approaches to explaining growth of the VC market in several European countries (Manigart 1994).

a speed that would be desirable from a societal point of view, or simply rational from a pure risk/return perspective. Such research can address three levels: 1) The supply of capital, 2) the supply of venture capital professionals, and the 3) demand for venture capital. On the capital supply side, research should be directed at investors in VC funds (pension funds, financial investors, strategic investors), aiming at understanding how they perceive opportunities in the energy sector and how this translates into their sector allocation within the VC asset class. On the VC level, tracking the background of energy VC professionals might be a first step to improve our understanding of where the required competence for VC investments in energy has come from so far, and where more of it may come from in the future. Finally, on the demand side, research should compare the energy innovation system with the innovation system in biotechnology and IT, for example taking Kuemmerer's (2001) question of whether there is a climate conducive to entrepreneurship from a country level to an industry level.

5 Conclusions and Further Research

Discussing the risk and return of VC investing in sustainable energy technologies compared to other sectors, we have identified a number of relevant sector-specific risks. Technology risk is high compared to typical information technology deals (due to capital intensity and long technology lead times), but not fundamentally different from many biotechnology deals. Exit risk is an important factor, especially looking at trade sales as the expected dominant exit route, because the major industrial companies that would be natural candidates for acquiring VC-backed entrepreneurial energy firms are portrayed as being more conservative than their counterparts in pharma/biotech or IT. The same factor, conservatism of the industry, is also quoted as having an influence on market adoption risk for sustainable energy technologies. People risk seems to be an issue with regard to a perceived (yet not undisputed) lack of qualified energy management teams (rather than engineers), especially in Europe. Also, some VCs perceive the "green" image of sustainable energy and entrepreneurs in this sector as increasing people risk. Finally, regulatory risk seems to be particularly relevant in the energy sector, and few VCs seem to believe that the regulatory opportunities created by climate and renewable energy policies compensate for that. In discussing each of those risks, we also pointed to ways of managing them. On the return side, a majority of the VCs we talked to were unable to name successful previous exits in the sector, although our quantitative analysis of a few cases showed that this is not necessarily the full picture. So to conclude our analysis on risk and return, we have identified a number of gradual differences between energy and the more popular VC sectors, but those alone seemed to be insufficient to fully explain the difference observed in VC investment levels. Extending the question from mere risk-return considerations to an evolutionary perspective gave us the opportunity to understand some of the path dependencies involved in venture capital investing. Overcoming those will be an important challenge for entrepreneurs, financiers and government officials who have an interest in seeing the market for sustainable energy VC grow. At the same time, the fundamental changes in the energy sector and the associated investment opportunities may lead optimists to believe that a growing energy VC market is a matter of time rather than anything else, where the typical self-induced growth that characterizes other VC sectors has simply not accrued yet.

We want to conclude our paper with some thoughts about limitations of our study, which can be the starting point for further research on the emerging energy venture capital market. First, we have mainly interviewed "believers", i.e. those who are already investing in energy. Our rationale in focussing on this group initially was that these specialists arguably have particularly good knowledge of the risks and returns involved in energy VC investing. Also, there is an issue of accessibility: Energy VCs are more likely to be willing to spend some of their time talking to researchers in that sector, while VCs with a completely different investment focus will rather want to spend their time closer to where they invest. However, in focussing on "believers", we might have missed some of the barriers that keep other VCs away from the energy sector. A broader survey **including "non-believers"** who do not invest in energy might provide more insights into the barriers to energy VC investing. This will be particularly insightful if it targets those venture capitalists who are on the edge of investing in energy, i.e. who are seriously considering entering this sector or who have after serious consideration decided not to invest there, rather than those who have never even thought about this as a possible investment area.

Second, our emphasis in this paper has been on a rational risk-return analysis as the conceptual framework for explaining the relatively small amounts of VC investments in sustainable energy. As we have briefly discussed, some explanations of VC investment behaviour seem to lie beyond purely rational risk-return considerations. We have referred to this as path dependencies in VC investing in this paper, however, additional insights might be gained by applying **behavioural finance** theory or institutional theory to this phenomenon.

Thirdly, another extension of our analysis of risk in explaining levels of VC investing across sectors might be to dig deeper into factors influencing **industry-specific perception of risk** and failure. For example, one might assume that organisational culture in large electric utilities is very risk averse, especially when the utility operates nuclear power plants, because the effects of failure would be devastating. Pharma companies, on the other hand, might have a natural inclination to look at the upside rather than the downside of risk, because taking a risk might lead to finding a cure for a disease that might otherwise have fatal consequences. If indeed one could identify such industry-specific perceptions of risk embedded in the organisational culture of large companies of the energy sector vs. other sectors, it might have an influence on their propensity to engage in venturing activities, which in turn impacts the venture capital market (via market adoption and exit risks).

Fourth, when we talked about shifting **VC sector allocation**, we did not differentiate two conceivable paths: New specialist funds with an energy sector allocation might be raised, or existing generalist funds (or those with a different sector specialisation) might extend their line of business to making energy investments. Both options have different challenges to overcome, and it might be worth investigating them separately. Our preliminary conclusion is that for early-stage investments, raising new funds will be the more likely option, whereas for later-stage investments, some of the mainstream generalist funds are beginning to acquire energy competence within their existing operations.

Fifth, and finally, the topic of **government involvement in sustainable energy venture capital** would also deserve future research. Government policies to induce sustainable innovation should be informed about VC activity. VCs could leverage policy efforts for sustainable energy if these policies are carefully designed. For example, policies that primarily aim at large players (such as Emissions Trading) could be combined with a venture component (see the UK Carbon Trust[21] as an example).

[21] http://www.thecarbontrust.co.uk

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TEKNILLINEN KORKEAKOULU
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Managing Sustainable Energy Innovation: The role of Entrepreneurship, Corporate Venturing and Venture Capital

A Research Programme at the University of St. Gallen, Switzerland (2003-2006)

The energy sector is facing a major challenge. Due to the coincidence of several trends, including climate change, environmental regulation, market liberalization, new technologies, and energy security concerns, a large part of the world's current energy system will have to be replaced by more sustainable energy sources over the next few decades. This provides huge investment opportunities, as well as challenges for governance and management. Against this background, our research team at the University of St. Gallen with partners from Helsinki University of Technology and other European research centres has initiated a major research effort to increase the understanding of three key processes that may facilitate this development: entrepreneurship, corporate venturing, and venture capital finance.

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