

# **Greens rush in?: CleanTech venture capital investments - prospects or hype?**

**Paper for for JAOCC conference  
Aalborg, Denmark, June 8.-10th 2009**

**Track: Cleantech development and green entrepreneurs**

**Associate Professor  
Jesper Lindgaard Christensen  
Dept. of Business Studies  
Aalborg University  
Denmark  
jlc@business.aau.dk**

Abstract.

The paper analyse the cleantech investments in Denmark. The paper speculates why Denmark on the one hand has well-developed technological and industrial strongholds in cleantech but on the other hand have relatively little venture capital available for cleantech investments in this particular segment. International investors account for all the growth in the investments. This indicates that the immature venture capital industry in Denmark, rather than the industrial opportunities, causes the hesitations by investors. The research asks if the characteristics, prospects and drivers of the evolution of the industry is compatible with the venture capital model? Related, the dynamics in how venture capital transfer into or emerge in new industries is dealt with, something scarcely researched. It is found that growth in venture capital investments in this area is hindered by the lack of success stories and –exits. Also that it takes time for the venture capital market to not only spot, but also to exploit emerging opportunities. In addition to financial capital also the human capital in venture capital markets is responding slowly to new market opportunities. It takes competences and networks to invest in a specific industry and the number of entrepreneurs and managers from the industry who have left a company and wants to become investor is limited. This, in turn, has implications for the possibilities to attract financial capital to venture capital funds with a cleantech profile. The back-funding institutions like pension funds etc. are very conscious about the importance of the competences and industry experiences of managers of new funds. Finally, a large public funding of the technological development related to the Danish industrial strongholds within cleantech may contribute to explaining why venture capital investments have been sparse. The strong industrial base of start-ups within the industry may have limited the demand for external competencies of technologies, market and industry from investors; these were already present in the firms. The paper points to the necessity to establish public-private funding partnerships.

Keywords: venture capital, cleantech, industry dynamics

## **1. Introduction**

When Aldrich and Fiol published their influential paper on industry creation, 'Fools rush in? The institutional context of industry creation' (1994) the primary focus was on the hindrances to industry evolution stemming from lack of legitimacy, which may prevent key stakeholders from understanding the nature and potentials of the new types of ventures. This adds to 'normal' constraints for industry evolution such as uncertainty related to new markets, capital constraints, untrained employees etc. Precisely the legitimacy may in this case, cleantech investments, be in place at a macro level of aggregation; it is widely recognized that such investments are needed and render societal value. It may be questioned, though, if the same holds on a micro level. Do investors and funds-of-funds institutions regard cleantech investments as hype and beyond the scope of a purely for profit investment strategy?

There is growing interest in the clean-tech market. Despite this interest there is sparse knowledge on the growth patterns and prospects for this sector. This paper is focused upon the investment processes and –levels in the sector and focuses upon, but is not confined to, venture capital investments. One justification for this focus is the role venture capital has had in stimulating and disseminating technologies in emergent sectors.

The pace of investment in clean-tech companies has in the past decade accelerated, and the market is seeing its first successful initial public offerings and mergers and acquisitions. Until the burst of the IT-bubble the ICT industry was attracting the majority of venture capital investments. Later biotech/life sciences became popular investment targets. The development of the ICT market and long time horizons in biotech investments have led investors to look for other opportunities. The cleantech industry is an obvious candidate for being a future hot spot for venture capital investments. Already now it is the 3<sup>rd</sup> largest venture investment target in the US as well as in several other countries, including Denmark (The Danish Growth Fund, 2009).

The question is if the present trend in investments into the clean-tech industry is just another 'hype', maybe even a case of herding behaviour of venture capitalists? In a broader perspective an additional two more general research questions are underlining the research – what are the investment criteria of venture capitalists and secondly, how does venture capital expand into new industries. Whereas a number of even early papers addressed the investment criteria of venture capital firms (Tyebjee and Bruno, 1984, MacMillan, 1985, 1987, Hall and Hofer, 1993) the dynamics in how venture capital transfer into or emerge in new industries is scarcely researched.

Denmark has had a long tradition for investments into environmentally friendly technologies, but has until now not succeeded to the same extent as in several other countries to attract notable private capital to the cleantech industry. The paper is mapping the investments and assesses prospects for the future development of the industry in Denmark. The paper also speculates why Denmark on the one hand has well-developed techno-

logical and industrial strongholds in cleantech and well-developed markets for innovation finance (ranked 3<sup>rd</sup> in Europe after the UK and Sweden according to The Danish Growth Fund and European Venture Capital Association) but on the other hand have relatively little venture capital available for cleantech investments.

The clean-tech industry not only covers a wide range of different sub-industries it also seems to target very different markets and across countries display rather different patterns. It is of particular interest to both investors and policy makers alike if industries in a country or region develop outstanding competences and market shares. Danish strongholds such as air pollution, filters and catalysts and enzymes have substantial world market shares. A mapping of these strongholds is important to an assessment of prospects for the industry. In a small country there is a narrow limit to how far the specialization of venture capital firms can go in terms of geographical and industry focus. Despite efforts in regions of Denmark to develop cleantech production the question remains if the investment community is ready to follow or if recent trends in financial markets impose conservatism rather than hype. Following this the research asks what are the characteristics, prospects and drivers of the evolution of the industry and whether this is compatible with the venture capital model? Furthermore, as mentioned above, why the Danish cleantech industry seem to have difficulties attracting venture capital funding despite apparently attractive investment opportunities?

The paper proceeds as follows. Section 2 takes a view on world wide developments in cleantech investments and single out in section three important segments and Danish sub-industry strongholds in this. The next section discusses how investments trigger industrial structural change and how and why some industries attract investments rather than others. Section 5 looks into how venture capital may spur industry development. before concluding in section 7 section 6 discusses important investment criteria used by venture capitalists and relate this general issue to the specific cleantech case.

## ***2. The development of investments into the cleantech industry***

Both from a societal point of view and from commercial investors there is now growing interest in what has been denoted the cleantech market. Despite this interest little remains in terms of research and high quality knowledge on the growth patterns and prospects for this sector.

Whereas a number of definitions are around of what may broadly be termed environmental technologies, there seems to be more consensus around the term “cleantechology” to embrace knowledge-based products and services that optimize the use of natural resources while reducing ecological impact and adding economic value through lowered costs or improved profitability. Such technologies range from alternative forms of energy generation to smart materials and water purification systems. The concept extends beyond environmental technologies that historically dealt more with end-of the-pipe solutions to regulatory requirements than with front-end products that address market needs. Whereas ‘clean energy’ is limited to alternative and renewable energy technologies, cleantech encompasses this but also the entirety of innovations that cre-

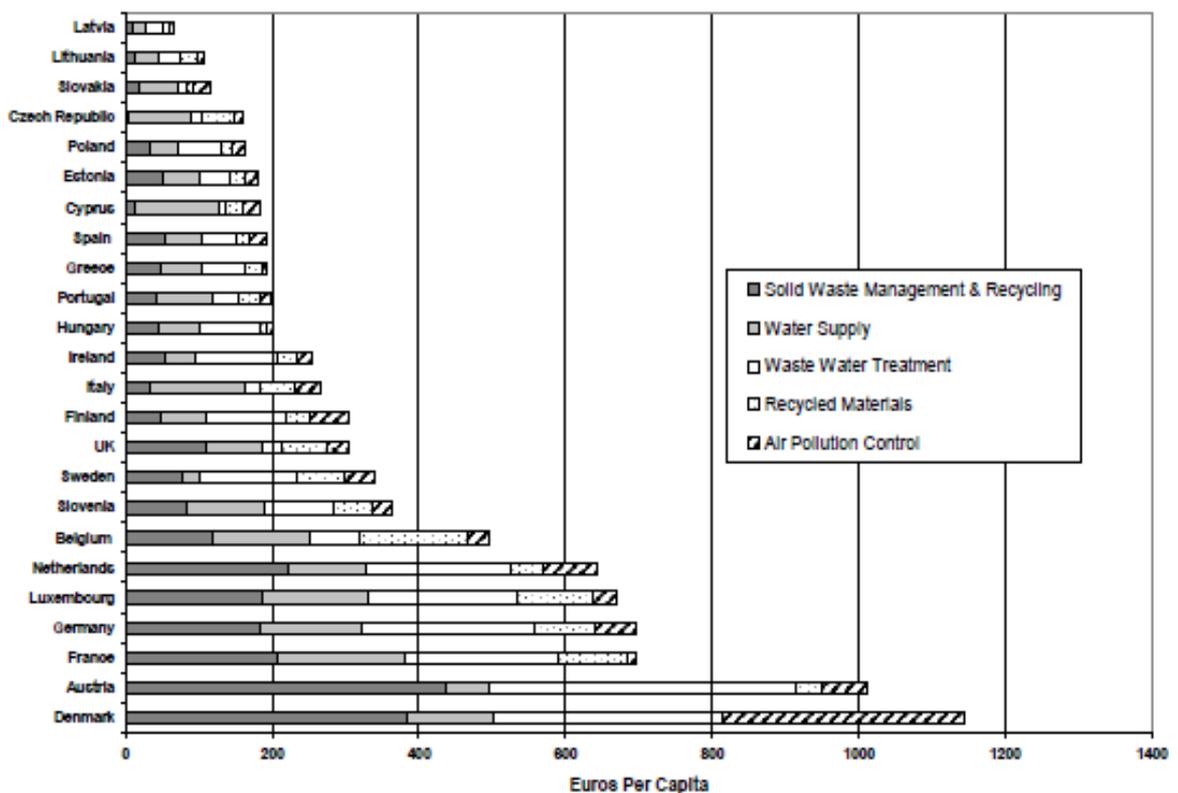
ate economic gains without ecological losses. Many studies make a distinction between energy on the one hand and on the other environmental technologies. Others group the industry into four; energy, water, waste/recycling and others such as filters, enzymes, insulation materials etc. The organisation 'Cleantech' defines cleantech as products, services and processes intended to 'Provide superior performance at lower costs, while greatly reducing or eliminating negative ecological impact, at the same time as improving the productive and responsible use of natural resources' (<http://cleantech.com/about/cleantechdefinition.cfm>). They furthermore list a number of sub-industries specifying further what is included in this industry. These are reproduced in Annex 1. Related concepts include 'Environmental Technology' used by e.g. Eurostat and OECD as technologies that 'produce goods and services to measure, prevent, limit, minimise, or correct environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems. Also 'Eco-innovations' is often used. According to Fundetec (2008) this is 'new production processes, new products or services, new management and business methods, all of whose use or implementation is likely to prevent or substantially reduce the environmental risk, pollution or other negative impacts upon resource use throughout the life-cycle of related activities' (p.21).

Historically venture investors have not been interested in the environmental sector. An industry with heavy regulatory impact is generally not considered interesting in the emergent phase. If bad for many things the burst of the IT bubble in 1999-2000 may have stimulated investor interests for other areas, one of them the cleantech industry. In terms of the size of the cleantech market this has been estimated to at least \$ 200 billion (Fuji-Keizai, 2008). According to Cleantech Group and Clean Edge the water- and waste segments are each around 75 billion \$, energy 45 billion \$ and others less than 10 billion. The broader energy market is much larger and is projected to grow substantially in the near future. In the estimate above only cleantech energy (bio fuel, wind, solar energy as the three large ones, fuel cells a small fraction of those) is included. Likewise, only parts of water and waste are included. From 2000-02 the venture investments in environmental technologies increased by 50%, but remained on a relatively low level of 1% of total venture investments. Whereas there was a decrease in the investment level after 2002 the figures from 2006-07 increased again. The bulk of the increase is accounted for by increases in energy sector investments.

There are substantial differences among countries. Denmark has had a long tradition for investments into environmentally friendly technologies, especially government monies, but has until now not succeeded to the same extent as in several other countries to attract notable private capital to the industry. In the US there is now, and in the past few years, a trend in the market of increasing focus from both public and private investors. Israel has seen substantial investments in this industry in spite of the natural endowments not being in favour of many of the cleantech industries. Israeli venture capital has been known for being heavily geared towards technology investments and has substantial government influence. Chinese investments into this industry are now boosting. Cleantech investment in China increased 147 percent between 2005 and 2006 and has subsequently continued rapid growth. Cleantech ranked as the third largest category for venture capital investment in China, behind only information technology and communications. Moreover, it is projected that the environmental impact of rapid Chinese industrialisation is likely to be intolerable if not cleantechnologies are developed and used.

The cleantech industry is likely to increase and also to make up a substantial contribution to the overall economy. Already now, several countries benefit from a relatively large industry as displayed in figure 1. For example, around 3% (7 bill. USD) of Danish GDP stems from investments (of all kinds, not only venture capital investments) in this industry. The average growth rates 1999-2004 were 20%.

Figure 1. Turnover per capita, 2004, by sectors, recycling, waste, water, air.



Source: EU-Commission 2006.

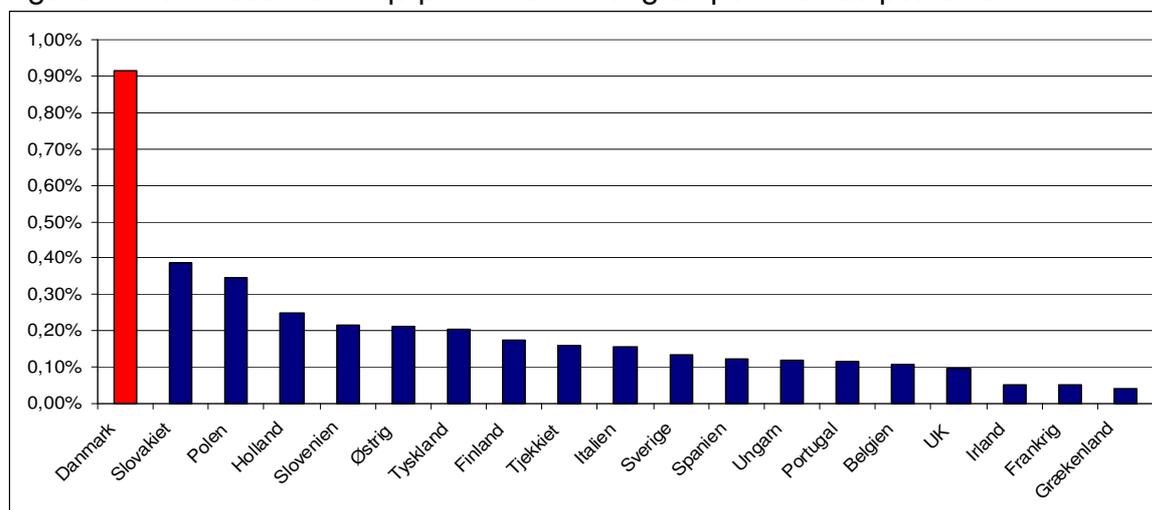
For venture capital firms the overall growth of the markets is important to their assessment of deals. The size also is important because venture capital firms are looking for investment proposals that are scalable or represent front-end technologies that may render revenues based on licensing. Moreover, they value industry specific networks that are more easily developed in large markets. Finally, they need a critical mass of investment opportunities, which is not necessarily there in narrow technologies. However, it is still important that venture capital go into potential niches where countries or regions may develop front-end competences and industrial strongholds.

### 3. Strongholds – attracting investments and policy interest

It is of particular interest to both investors and policy makers alike if industries in a country or region develop outstanding competences and market shares. Emerging technologies seem to entail the most frequent examples of such competences, and cleantech is no exception.

In Denmark a number of strongholds have emerged, many of which originate from regulation. Wind mill subsidies have been instrumental in the development of this industry in Denmark, now making up one of the largest export industries in Denmark. Other important regulatory drivers are the Law on Environmental protection from 1982, a number of water environment action plans, limitations on use of chemicals and pesticides and regulation of waste. Danish strongholds in this industry include also air pollution, filters and catalysts, originated from inventions in the university sector in the 1980s (figure 2).

Figure 2. Revenues from equipment for limiting air pollution as pct. of GDP.



Source: EU-Commission 2006

Another stronghold is within enzymes with 60% of world production. Also waste water cleaning, fuel cells, recycling, bio mass, and wind are important Danish strongholds. Many of these strongholds were stimulated by government funded research. It may thus be concluded that both the political interest and the funding for development of these technologies were present. From the patent statistics it is evident that the Danish industry in cleantech and renewal energies broadly has been successful also in taking the technologies to a commercialization stage (OECD, 2008).

### 4. A segmented industry?

The cleantech industry not only covers a wide range of different sub-industries. It also seems to be targeting very different markets and across countries and regions display rather different patterns. According to the Danish Growth Fund (2008) the geographical dis-

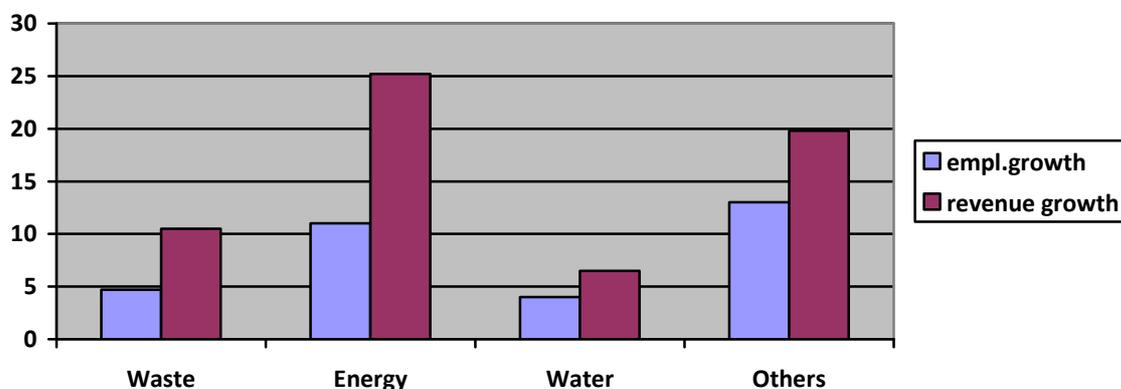
tribution shows that Copenhagen has around half the cleantech firms, roughly corresponding to the share of firms in general. The Danish Growth Fund (2008) estimate that there are at least 120 cleantech firms in Denmark.

Across industries different investment preferences in different countries may be observed although in Denmark there seems to be an equal distribution of the firms on segments (The Danish Growth Fund, 2008). In the US waste treatment and water is preferred, although water is only beginning to catch up with waste treatment (VentureSource, 200 ). Differences may be explained by specific, local factors such as debate in California about difficulties in getting enough clean drinking water and regulatory changes in Europe about chemicals.

The trend is towards still more investments in the energy segment. One explanation may be the liberalization, another may be the increases in prices and subsequent interests in alternative energy sources. It may, though, be anticipated that we will see a rising investor involvement in areas beyond the currently popular energy-tech segment, such as water purification, transportation and logistics, agriculture and nutrition and clean industrial technologies.

In Denmark the growth by sub-industries show clear differences among sub-areas. The high growth in energy is consistent with the general trend. 'Others' cover industrial biotech, among others.

Figure 3: Growth rates 2006-2007 for Denmark in employees (blue bar) and revenues by sub-industries (Waste, Energy, Water, Others).

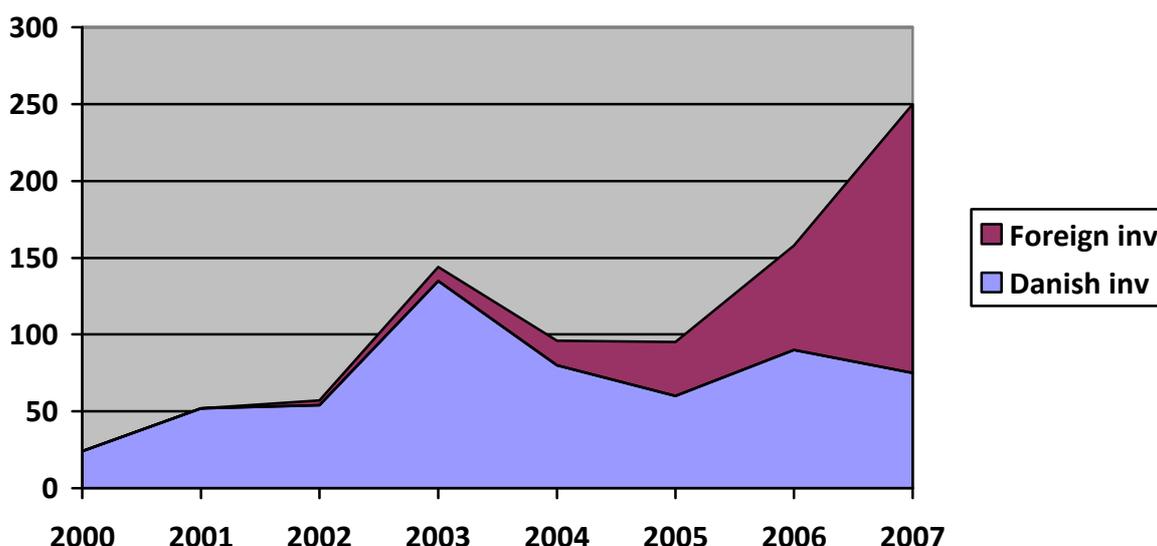


Source: Vækstfonden, 2008 and BusinessView.

Despite these different properties of the sub-industries, there are some common denominators, which may indicate the opportunities of this industry. The technological development has both been early and taken to a commercialization stage, which has prompted the development of industrial competences within existing firms as well as spin-offs from research. In this setting public money, regulation and governance may contribute to establishing an innovation platform from which private (venture-) investments may develop national or regional strongholds.

As mentioned, in Europe the development has been more fluctuating and includes a broader range of segments. In Denmark it is remarkable that investment activity has followed the general trend but with lighthouses of specific segments showing superior performance and market shares. This is particular appealing to venture capital investors and should intuitively attract Danish venture capital investors. The investments into the industry has indeed increased. However, disaggregating the investments on type of investors it is clear that the rise may be ascribed solely to foreign investors, as depicted in figure 4.

Figure 4: Cleantech investments by investor type.



Source: Vækstfonden, 2008

Following this, it seems as if Danish investors have opportunities for investments that fit the venture capital model, but are reluctant to excel in these investments. The question remains why this may be so? A first explanation links to the previous discussion on specialisation and competence building in financial institutions. This is discussed in depth later in the paper; first we need an account of how venture capital may impact on the emergence of industries.

## ***5. Drivers of industrial and cleantech development***

### **5.1 Emergent industries**

A number of scholars have speculated how new industries emerges (e.g. Klepper and Graddy, 1990). It is a key issue in studies of industrial dynamics. Historical, backward-looking studies have provided us with context- and history specific evidence of how and why certain industries and/or regions developed as they did. Some of these studies also incorporate the role of venture capital (e.g. Saxenian, 1994). At the other end of the scale

foresight models have tried to come up with scenarios for likely evolutions in technologies and industries. It is beyond the scope of this paper to research industry evolution in general, but a few general factors may be extracted that are relevant to the understanding of the evolution of the cleantech industry and how it became attractive to venture capital firms as an investment opportunity.

The first feature to highlight is – perhaps somewhat contradictory to the ambition above to pinpoint general features – the chaotic and apparently random character of the evolution. Some industries never develop beyond the industry-wannabe stage, some have been important and stable industries for a hundred years. Some industries grow and thrive in particular places, the same industries never really takes off in other regions. One among many examples is the solar energy industry that a quarter of a century ago was the big thing but lost development momentum. Now it is (again) seen as a prosperous investment area. In a more general manner Klepper and Graddy, (1990) find differences in key drivers of the evolution of industries, some of which are exogenous. The reason why the US automotive industry is located in Detroit and the tire industry in Akron is not easily explained by common, general factors.

## 5.2 Cleantech drivers

Likewise, the drivers of the specific, contemporary cleantech industry make up a range of different factors. First, it is obvious that a number of environmental problems and concerns call for new, more effective solutions both with respect to environment and energy including supply concerns. The population and economic growth has rendered a number of pressures on water, waste, climate change and related, consumption of limited fossil fuel. Secondly, the huge fluctuation in prices of the latter is an important driver of this part of the cleantech industry<sup>1</sup>. A third important driver is regulation. Virtually all segments of the cleantech industry are subject to regulation. This goes way back in history, for example there was waste management regulation in large cities such as London more than 200 years back. The industrial stronghold of Danish windmill production is often partly explained by a strong domestic incentive for consumers to demand wind power because of a subsidy for this energy source. In the past few years the energy market has undergone extensive deregulation, which has been seen as an important driver for venture capital investment into this industry. Innovations have been driven a large share of the evolution of the industry resulting in increased productivity within the industry as well as introduction of a range of new products. This has lowered prices for clean energy, and increased efficiency in environmentally friendly solutions – waste management, soil and water cleaning, recycling etc.

Increasingly firms are actively seeking a ‘green’ image, and many firms today incorporate environment protection, energy and carbon dioxin saving etc. in their CSR-policies. In fact, within cleantech investments it is now clear that there is also what might be denoted ESR – Entrepreneur Social Responsibility. A number of succesfull entrepreneurs have now entered the industry not only with ideas for new businesses but also acting as

---

<sup>1</sup> The oil crises in 1973 and 1979 likewise spurred a whole range of explorations of new types of production of energy.

business angels supporting new ventures on the grounds of a wish to contribute to socially beneficial achievements<sup>2</sup>. Other drivers of the industry evolution includes that there is increased political pressure for sustainable development<sup>3</sup> as well as consumer demand for environmentally friendly products and production processes.

An enabling factor for industry development is the fact that the technologies involved are usually not particularly sophisticated and expensive; rather there is a large element of technology spillovers and adaptation from other industries<sup>4</sup>. As a result of the above drivers of the industry many cleantech segments are fast growing and large markets, something particular attractive to venture capital firms who typically are looking for scale-able, high-growth opportunities.

### 5.3 Is Venture capital a driven force in the evolution?

In this setting the venture capital firms in cleantech may be grouped into three. The first group is those who are dedicated, specialised funds for cleantech or segments hereof; there are a very limited number of these funds, for example there is currently no Danish fund dedicated especially to cleantech. A second group is those who have diversified parts of their activities into the cleantech industry, which is by far the majority. Finally, there is a group of corporate venture capital funds that are dedicated to cleantech.

Even if supplying only a fraction of monies going into the technology sector, venture capital may have disproportionate catalyst effects. Venture capital firms may enhance a wave of technological development that may challenge or re-direct the existing technological trajectory. While the impact of venture capital firms may not be strong enough to actually create new technological trajectories then they are important in catalyzing the commercialisation of newly developed technologies in their emerging phase. They are in this sense part of the commercialisation and wider diffusion of the technologies developed.

*“Given that a significant proportion of venture capital-backed companies are in technology sectors, venture capital plays a direct and significant role in the process of innovation and technology-based development in modern industrial economies”.*  
(Mason & Harrison, 1999, p.1).

The citation above illustrates the importance of venture capital in the innovation and entrepreneurial process. Even if venture capital overall is only financing a very small proportion of firms and hence may seem of neglectable importance, then venture capital may be important for certain segments of firms (Valentin et al., 2008), in particular those in focus here, cleantech firms. It may be argued that the venture community is at the forefront of spurring this as a new cleantech industry, one that is closely connected to a new era of environmental social responsibility.

---

<sup>2</sup> A number (25) of examples are provided in Cooke (2009).

<sup>3</sup> The instruments for reaching these ends may include regulation but may also be tradable permits, R&D-programmes, policy agreements and targets for e.g. reduction of carbon dioxide.

<sup>4</sup> Danish numbers (The Danish Growth Fund, 2008) shows that in comparison with high-tech start-ups a relatively large share of firms are started from an industrial base rather than as independent entrepreneurs.

On the other hand, recent trends at the venture capital market show that venture capital firms have focused on still larger companies and on second round financing of existing portfolio companies rather than new investments. This indicates that the industry as a whole has become more risk averse and is more reluctant to pursue new investments. Indeed the traditional perception of venture capital as being particular risk takers has been questioned. Thus, Zider (1998) claim that in an industry evolution perspective you would see venture capital firms preferring to enter in the middle of the s-curve where the initial turbulence and uncertainty has decreased.

This picture may be changed by reducing risks associated with new investments. The reduction of risk may be pursued by increasing competences through specialisation. This may help reducing risk in the initial selection of investment opportunities and it may increase the quality of the post-investment monitoring and advising process. Additionally, risk for ventures may be reduced by leveraging the networks of venture capitalists (Christensen, 2007, 2008). Therefore, many venture capital firms have specialized and this has been a persistent trend. Even 20 years ago Bygrave (1987, pp.139-140) predicted that a majority of venture capital firms are likely to increase specialisation. By way of the analogy of department stores and boutiques, he claimed that only very big venture capital firms will be 'stores' able to invest in all types of companies. The bulk of venture capital firms will be 'boutiques' investing in specific types of firms or geographical regions.

Despite this specialization of venture capital firms the gradual development of such focus areas is usually taking place within or closely related to existing investment areas. It is less often the case that funds are set up as green field funds without prior experiences in the industry in question. Indeed, the experience so far also shows that this specialization has not developed that far. Fundetec (2008) report that their research shows that very few banks and other institutional investors has a desk for environmental technologies. It may, though, be useful to go further into why and how investors may decide to invest in new industries as it is less well understood how this transformation of attention from investors takes place. To get closer to this, we need to go deeper into the assessment of investment opportunities made by venture capital firms as well as how they strategize with respect to the scale and scope of activities.

## ***6. Ability and willingness to invest in new industries***

### **6.1 Specialisation and competence building**

It was indicated above that the degree of specialization of venture capital firms is closely linked to the building up of competencies. The ability to assess investment proposals, and especially to monitor and assist management ex post the investment decision, requires the building up of skills, which in turn is stimulated by specializing in particular segments of the market. The investments involved in building up such competencies are substantial, however. The total portfolio of the venture capital firm may entail less risk, achieved through the risk reduction due to diversifying into a new segment such as cleantech. But a net result is not easily calculated. Initial costs may be reduced over time when diversifying into another area of investment many costs cannot be eliminated.

In addition to the pure costs in diversifying into new investment areas there is a time perspective issue. You can make a woman give birth to a child in 9 months but you cannot make 9 women give birth to a child in one month. Even in a completely different sphere somewhat the same principle applies in venture capital diversification. The big issue is not perhaps raising the funds. Rather it takes time to build up the networks necessary to assist decisions on screening investment opportunities, to monitor investments, and to secure a deal flow. Networks build up in another setting/industry are not easily transferred as they are often sector specific. Likewise, the technologies are not understood in depth by venture capital firms upon entering a new investment area. Although the contribution from venture capital firms is not in assisting directly with technologies then on the other hand venture capital firms and angels alike do want a basic understanding of the technologies involved. Again, this takes time to build. Finally, the majority of the venture capital industry is often not known to be a pioneer in the push for new technology and investment areas. A few lighthouses of the industry, together with successful exits, lead the way in where the venture capital industry is going. It goes without saying that indeed the exits require time to make up success stories. In this context the development of and maturing but 'thin' venture capital markets like the Danish may be hindered by the fact that venture capital funds have now prepared many of their portfolio companies for exit, however, the financial crises has eroded the profitability or even possibility of existing in some cases. Finally, back-funding institutions may be conservative even if venture capital firms may recommend new opportunities.

## **6.2 Risks associated with cleantech investments**

Moving to the level of the individual and looking into the decision making with respect to investments into the cleantech industry, we need to look into the investment criteria applied in venture capital.

Generally, the behavioural economic theories describe economic decision making, and have informed some of the studies on investment criteria. Just as doubts has been raised with respect to how rational, stage organized and planned venture capitalists decision making processes really are (Zacharakis et al, 1998, 2001, Shepherd, 1999), it may be questioned if decisions to invest in the cleantech industry are based on solid due diligence and forecasts or just expectations of further investor interest and rising share prices of this particular type of firms. It may thus be argued that the growth in investment pace into cleantech is perhaps based upon expectations that are not necessarily well documented. A herding behaviour may prevail (Fundetec, 2008). In spite of this even when the most thorough due diligence and information sourcing is applied, this cannot reveal all uncertainties. But it is important to venture capitalists to know about what uncertainties remain.

For the initial screening and the subsequent monitoring venture capitalists need information on the uncertainty related to the prospects of the firm. This entails uncertainty that may be divided into two, the technical uncertainty and market uncertainty. The sources of the technical uncertainty are mainly three.

First, the magnitude and number of technical problems in the development process is often difficult to predict. Even for technical production plans have been made beforehand, new, and unforeseen problems often emerge during the production process. This is likely to delay the process and make it more costly. In emerging technologies and industries this may be reinforced due to lack of standardized ways of production, experimentations etc.

Secondly, the design of a product or service often changes several times before the final stage. The date of marketing the end-product is often unknown because of the above unforeseen technical problems and related organizational and production line changes. In cleantech a second-order such issue may be relevant. It is not only the case that cleantech firms are producing products and solutions they also need to gear their own production processes towards a 'green' profile. This is necessary in order to be credible in their marketing of production or solutions.

Thirdly, exogenous changes may affect decisions to market and produce the product. In effect, the costs and time perspective of an innovation project is difficult to predict and most often underestimated. One of the most obvious examples relevant to cleantech is the rapid and radical changes in energy prices, which may erode the relevance of new innovations or change profitability and break-even of current innovations thus making planning of new product development more difficult.

Market uncertainty originates from that the market value of the single end-product is unknown both because time has passed from the launching of the project to the completion (as also explained above re the energy prices example) and because users are not accustomed to the new product and may not be willing to pay the calculated price. Another source of uncertainty is about the development of competing and/or substituting products.

### **6.3 Investment criteria**

It may also be relevant to make clear that even if all investors assess the ability of firms to survive and thrive (and above all pay back the loan) the investment criteria of venture capital firms differ from those of banks and other financiers. An extensive amount of literature has evolved on credit-scoring and other models for aiding investment decision. These may be useful when assessing loan applications in banks in relatively known industries, and in firms where collateral may be provided. Contrary, venture capital investments usually involves investments in firms with non-deployable assets as well as greater uncertainties. This implies greater need for sensitivity analyses, and careful examination of the value of the firm in an exit situation, rather than the cash flows. Another fundamental difference is that investments by traditional corporate financiers are done at a one-time basis, whereas venture capital investments are multi-stage investments often undertaken as either performance based milestone payments or options of re-investment specified at the time of the initial investment and based upon the results from close post-investment monitoring.

The literature on how venture capitalists assess a deal proposal has researched this issue by presenting a range of criteria to venture capital managers and asks them to rank and group these. Naturally the resulting typologies vary somewhat between studies, but they most often include the capabilities of the business management as one of the top priorities. It is a general perception that this is by far the most important criteria<sup>5</sup>. Venture capitalists place enormous importance to the human capital aspect of the investment criteria. A trustworthy and competent business management team is key. A good management team can turn a mediocre quality idea into a success, but a good idea with a bad management team is likely to fail. There are, in other words, a number of risks associated with the entrepreneurs themselves.

Whereas this is obvious and well researched on the micro level of aggregation it is in fact also the case on an industry level. Zider (1998) claim that indeed the management is decisive, but they are to be in the right industries, those that are growth industries and have good exit options. Additionally, and as already mentioned, it takes time and effort to build a competence base with experienced managers and subsequent possibilities for syndication, exits, synergies among companies and network benefits. The possibilities for mutual learning increases with industry mass.

The service or products and business model is also part of the due diligence. This includes assessment of the IPR, threats from incumbents and entrants, sensitivity to exogeneous events like regulation and changes in business cycles. Other important investment criteria include an assessment of the market – the structure, access, growth. It seems, though, as if assessing the industry, and in particular in cases of new industries, is usually done by applying a base-line, which indicates a 'normal' state, and then applications within certain industries may render a down-grading by their mere industry area. This may not only be new industries such as cleantech but also industries that historically have shown poor performance.

For venture capitalists these types of risks may also entail uncertainties not only related to the sales of the products produced in their portfolio companies but the sales of the portfolio companies themselves. The lack of history and success stories of cleantech exits may be a hindrance to venture capital to enter this market in the first place and of course likewise for the investments already done now. The biotech sector has not suffered from this to the same extent because venture capital typically only takes biotech companies to a certain stage and then exit (Zider, 1998). The risk of restricted exit routes varies over time. The IPO option may e.g. be easily accessed in certain periods whereas the stock market may turn 'sour' in other periods of time. Despite this, the potential exit route may have an impact back to the way the business is run and exposed to the environment. IPO and trade sales are different with respect to e.g. the necessary information and contacts, exposure to potential buyers etcetera.

Specifically for investing in cleantech a number of issues are relevant to consider, some of which are comparable to the literature on venture capital investment criteria referred to above, and some that are specific to cleantech investments. The latter category includes,

---

<sup>5</sup> See other investor criteria related to assessing cleantech companies e.g. in Fundetec (2008, p.78).

broadly speaking, some additional risk factors other than those referred to earlier as technological and market risks.

For cleantech specifically the risks evaluated by venture capital firms may therefore entail also whether the investments are suitable for the venture capital model partly described above including whether they are sufficiently scale able and whether there is some familiarity to previous or existing investment foci. Lack of such relatedness may be a real hindrance to expansion by venture capital firms into the cleantech area. It was mentioned above that regulation and the heavy policy governance and influence on price structures is, if not incompatible with the venture capital model, then these factors are generally disliked by venture capitalists. Other characteristics of cleantech investments may scare venture capital away. In some segments, especially within energy, both the long time horizon involved and the amount of capital needed for development is often substantial and above what venture funds will be prepared to or able to pay. Because many cleantech technologies are applications of existing technologies to new areas it is often difficult to achieve IPR protection. This may also be of concern for venture capital firms. On the other hand, quite a few patents are taking out in this industry, and Denmark seems to be particular active in this. For example, OECD (2008) finds that Denmark is dwarfing any other OECD country in patenting in renewable energy sources normalized either by GDP or overall patenting activity. Related to the often limited radicality of the technologies and innovations it is for venture capital often not attractive to go into these types of investments; the risk-return metric does not match (Fundetec, 2008). This may be particularly true if venture capital invest in later stages of the venture. On the other hand, risks are often too large on immature and unproven technologies creating what is sometimes referred to as a 'valley of death', where the business has developed beyond the development stage and thus is no longer qualified for government finance, but on the other hand is still too risky for private investors.

## ***7. Discussion and conclusions***

One of the most important barriers to growth in venture capital investments in this area is undoubtedly the lack of success stories and –exits. Linking to the above about the evolution of where venture capital investors place their funds another major barrier is the fact that it takes time for the venture capital market to not only spot, but also being able to exploit emerging opportunities. Both changes in the supply and demand for venture capital is typically involving substantial inertia (Gompers and Lerner, 1999). This has to do with the nature of the investee companies. These are typically long-term investments, and the back-funding for venture capital is therefore secured for a long time period, often in the form of a dedicated fund running for 10 years.

In addition to financial capital also the human capital in venture capital markets is responding slowly to new market opportunities. As it takes competences and networks to invest in a specific industry it is only natural that it takes time to build such competences and that the number of entrepreneurs and managers from the industry who have left a company and wants to become investor is limited. This, in turn, has implications for the possibilities to attract financial capital to funds with this profile. The back-funding institu-

tions like pension funds etc. are very conscious about the importance of the competences and industry experiences of managers of new funds. They recognize that not only the abilities to screen potential deals, but also the value-added activities and competencies of venture capital firms can influence performance in the long run. Cumming et al. (2005) find that, in the Australian market, pension fund managers are paying attention to the extent and nature of value-added contributions from Venture capital firms when choosing to allocate new capital to venture capital.

Venture capital has the image of being exceptionally prone to take risks and exploit new opportunities. It may be questioned if venture capital is a key driver of the development but some observers claim that venture capital is a critical factor in the commercialisation of new research into viable businesses. According to this perception there should not be any strong path dependencies in how venture capital is allocated on industries. In practise considerable conservatism persist. Of course there are a number of fund managers who take in new types of investment areas and maybe even have visions of expanding whole new industries. However, the mix between these conservative venture capitalists and their more visionary colleagues is probably difficult to influence and dependent upon a number of factors. Moreover, there is likely to be an element of herding behaviour in venture capital. A few prominent players within the industry are setting the path to follow and the rest is following.

The question remains why Danish venture capital markets are particular slow in excelling investments; why the inertia referred to above is greater than elsewhere. The Danish case showed remarkable strongholds in specific technologies and markets. Regulation, public and semi-public research institutions and government funding were explanatory factors. The high growth rates in an emergent market, and the fact that ICT and biotech did not render general success for venture capital speaks in favour of venture capital investments into Danish cleantech. However, international investors account for all the growth. This indicates that the immature venture capital industry in Denmark, rather than the industrial opportunities, causes the hesitations by investors. Intuitively the small size of the Danish market may explain why venture capitalists refrain from operating in Denmark through dedicated funds. However, the strongholds explained above and the option of exporting technologies and know-how may be a counter-argument. The success story of the Danish wind mill industry shows that it is possible to develop such industrial positions to global successes in spite of seemingly relatively high costs of production and small domestic market.

The fact that Denmark has seen a large public funding of the technological development related to the now industrial strongholds within cleantech may contribute to explaining why venture capital investments have been sparse. Also the strong industrial base of start-ups within the industry may have limited the demand for external competencies of technologies, market and industry from investors; these were already present in the firms. Even if a demand was there investors would probably not be able to meet this demand as there is currently an only limited investor competency in this industry. Included in this argument is that investors also have only limited industry specific networks. In the cleantech industry networks may be particular important because b2b sales rather than b2c is the rule, and this requires networks for penetrating new markets.

The prospects of increased venture capital into the Danish cleantech industry may not be very good, even if there is an obvious need for the industry itself and even if there is some hype around it. One reason is that the exit possibilities are not yet transparent and well used and could be expected to be further hampered by the current financial crises. Some evidence indicate that the cleantech industry is more heavily hit by downswings than other industries (Fundetec, 2008, p.69). Looking at the other end of the time spectrum – the creation of venture capital funds – this may also be influenced by the financial crises. The structure of most venture capital funds is a limited partnership with a number of fixed-end funds usually confined to 10 years. This means that a fund manager will concentrate investments in the very first years of the life of the fund leaving the remaining years to add value, exit, raise new monies for the next 10 year period. This will not generate gaps in the supply of finance if this takes place continuously. However, in periods of time such as now, where the supply of funds-of-funds to venture capital is heavily constrained there is a risk that gaps will appear in the future because the start of the pipeline may be hampered. On the other hand, the increasing focus upon the need to reduce emissions of carbon-dioxin and other environmental problems may stimulate the public or public-private partnership investments into this industry. Public venture capital may, in the current situation, have a particularly important role to play in the market. When markets fail and private capital is reluctant and/or withdrawing in some areas, then there is room for a more proactive government<sup>6</sup>. The ‘hype’ has, or will be, cooled down due to the above-mentioned reasons.

Research is sparse in this area as well as the availability of data. Future research may expand on the role investors play in the evolution of the cleantech industry. In particular, the current financial crises may pose a problem for fulfilling policy ambitions unless all financial capital going into the industry should end up stemming from government sources. Whereas this is not a problem in itself it may be questioned if that would dismantle the capital from the industrial competence base necessary to complement the financial capital. Therefore, establishing public-private investor partnerships are immensely important in the current situation. The environmental problems will continue to grow and the development of environmentally friendly solutions will be still more ‘big business’. In this setting it is important to not only leave the funding to governments as diverse sets of competences are needed to select and nurture the businesses.

---

<sup>6</sup> The mission of The Danish Growth Fund, which is a government funded venture capital institution, is to ‘step in where other market participants are reluctant’.

## **Annex 1**

In terms of sectoral delimitations the following sub-industries may be included herein and may be expected to entail firms and research organizations that comply to the definition in the paper.

### Cleantech sub industries

#### Materials

Nanomaterials, biomaterials, chemical, other

#### Agriculture & Nutrition

Natural pesticides, land management, aquaculture

#### Air & Environment

Cleanup/safety, emissions control, monitoring/compliance, trading and offsets

#### Energy Generation

Wind, solar, hydro/marine, biofuels, geothermal, others

#### Energy Infrastructure

Management, transmission

#### Energy Storage

Fuel cells, advanced batteries, hybrid systems

#### Energy Efficiency

Lighting, buildings, glass, other

#### Manufacturing/Industrial

Advanced packaging, monitoring and control, smart production

#### Recycling & Waste

Recycling, waste treatment

#### Transportation

Vehicles, logistics, structures, fuels

## **References**

- Aldrich, H. E. And Fiol, C. M., 1994. Fools rush in? The institutional context of industry creation, *Academy of Management Review*, Vol. 19, no. 4, pp. 645-670.
- Christensen, Jesper L. (2008) Venture capital – filters, hubs and catalysts for entrepreneurs? Paper for ECEI conference ‘Entrepreneurship and Innovation’, Winchester, UK, 15.-16.september 2008
- Christensen, J. L. (2007): The development of regional specialization of Venture capital, *European Planning Studies*, Vol.15, no.6, pp.817-834.
- Clean Edge (2008): Clean Energy Trends 2008.
- Cooke, P. (2009): Transition regions: green innovation and economic development. Paper for DRUID conference, Copenhagen, june 17.-19<sup>th</sup>.
- Cumming, D., Fleming, G. and Suchard, J.-A. (2005), Venture capitalist value-added activities, fundraising and drawdowns, *Journal of Banking and Finance*, 29 (295-331).
- Fuji-Keizai, 2008. Cleantech – current status and worldwide outlook.
- Fundetec research consortium (2008): Comparison and Assessment of Funding Schemes for the Development of New Activities and Investments in Environmental Technologies. European Commission, Brussels.
- Gompers, Paul and Josh Lerner (1999). *The Venture Capital Cycle*. Boston, MA: MIT Press.
- Hall J. & Hofer C. 1993. Venture capitalists’ decision criteria in new venture evaluation. *Journal of Business Venturing* vol.8 p.25-42.
- Klepper, S. and Graddy, E., 1990. The evolution of new industries and the determinants of market structure. *RAND Journal of Economics*, no.21, pp.27-44.
- MacMillan, I.C., Siegel, R. and Subba Nirisimha, P.H., 1985, Criteria used by venture capitalists to evaluate new venture proposals, *Journal of Business Venturing* vol.1 p.119-128.
- MacMillan, I.C., Zeman, L. and Subba Nirisimha, P.H., 1987, Criteria distinguishing successful from unsuccessful ventures in the venture screening process, *Journal of Business Venturing* vol.2 p.123-137.
- Mason, C. M. and Harrison, R. T. (1999) Editorial.Venture capital: rationale, aims and scope, *Venture Capital*, 1(1), pp. 1–46.

OECD, 2008. Environmental Policy, technological innovation and patents. OECD studies on environmental innovation, Paris.

Saxenian, Annalee (1994). Regional Advantage: Culture and Competition in Silicon Valley and Route 128, Harvard Business School Press.

Shepherd., D. A. (1999). "Venture Capitalists' Assessment of New Venture Survival." Management Science 45(May 1999): 0621–0632.

Tyebjee, T.T. and A.V. Bruno (1984). A Model of Venture Capitalist Investment Activity. Management Science, 30(9), 1051-1066.

Valentin, F., Jensen, R. L., and Dahlgren, H., 2008. How venture capital shapes emerging bio-clusters – a cross-country comparison. European Planning Studies, Vol.16, no.3, pp.441-463.

Vækstfonden (The Danish Growth Fund) (2006). Energisektoren I Danmark – perspektiver for iværksætteri og venturekapital.

Vækstfonden (The Danish Growth Fund) (2007). Miljøsektoren I Danmark – perspektiver for iværksætteri og venturekapital.

Vækstfonden (The Danish Growth Fund) (2008). ABC til internationalisering og vækst – perspektiver for venturekapital til danske cleantech virksomheder.

Vækstfonden (The Danish Growth Fund) (2009). Analyse 4.kvartal 2008 – Det danske venturemarked - investeringer og forventninger.

Zacharakis, A. L. and D. A. Shepherd (2001). "The nature of information and overconfidence on venture capitalists' decision making." Journal of Business Venturing 16(4): 311–332.

Zider, B. (1998). "How Venture Capital Works. The Discipline of Innovation." Harvard Business Review 76(6): 131–139.