Emergence of the Clean Technologies Sector in the Baltic Sea Region

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Global Vision

Enabling a Global Vision for the Baltic cleantech industry

Foreword

The Central Baltic INTERREG IV A project 'Enabling a Global Vision for the Baltic Clean-tech industry' (Global Vision) is a co-operation between teams in Estonia, Latvia and Sweden and runs from 2011 to 2013. The purpose is to encourage business development, co-operation and to facilitate exports in clean technology firms in the three countries and also to suggest improvements in public policy. The project covers Estonia, Latvia and in Sweden the regions of Stockholm, Örebro, Östergötland, Uppsala, Gävleborg, Södermanland, Västmanland.

In principal the work is divided into three separate parts. First, analyses of existing firms and policies are conducted with the aim of providing a roadmap for strengthening industry's internationalisation activities. The second part consists of the development and delivery of tailored training for clean technology SMEs as well as trans-regional match-making activities. The third part is an assessment of existing regional relationships and networks with the aim of developing a joint trans-regional model for utilising such contacts for sales activities for the development of the clean-tech industry as well as suggestions of policy improvements.

This report covers the first part – the analyses of regional clean technology industries and their global market reach, and policy initiatives. The report is largely based on interviews with 95 companies in Sweden, Estonia and Latvia. The analyses cover economic-, social- and policy context, including human resources, infrastructure, business climate, support measures and related industries, as well as characteristics and dynamics of the clean technology companies. Each country chapter concludes with the synthesis of strengths, weaknesses, opportunities and threats, and related policy recommendations.

The final editorial work was co-ordinated by Kaija Valdmaa and Tarmo Kalvet in close co-operation with Inga Brieze, Per Frankelius, Sanita Jankovska and Kirsten Krause.

Örebro in November 2011
Claes M. Hultman
Professor, Co-ordinator

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Emergence of the Clean Technologies Sector in the Baltic Sea Region – Executive summary

Tarmo Kalvet • Kaija Valdmaa • Per Frankelius
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Environmental issues and clean technologies

Environmental issues in general, and the climate challenge in particular, have recently become one, if not the, leading issue in the public and private debate.[1] There is much focus on clean technologies (cleantech), which refers to environmentally friendly technologies that represent a diverse range of products, processes and services intended to reduce or eliminate pollution and waste while at the same time improving the effective and responsible use of natural resources. Clean technology comprises of a number of sub-fields like energy technologies, biofuels, material technologies, water purification, waste management, ambient air protection, information and communication technologies related to environmental protection, environmental equipment, green construction, renewable energy and green services. Most clean technologies are technologies that are both new and quite advanced.

The clean technology industry is generally regarded as an arena where business interests and environmental awareness can meet through a mutually strengthening partnership. The purpose of this complementarity is to create sustainable economic growth by making and facilitating investments into new products, services and processes that can generate increased turnover, value-added, employment and exports for the industry. At the same time there are benefits to the environment through reductions in the depletion of finite natural resources, pollution and waste on a national and international level.

Policy makers at a global level, but increasingly also in the Nordic countries and in the Baltic area, have understood the importance of the clean technology field and are developing and implementing policies to support the development of environmental technologies for use and also enhancing the competiveness of the sector. However, the clean technology sector in these countries is dominated by small and medium-sized companies (SMEs) active in local markets, whereas the future growth potential is highest in international markets.

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[1]It has not escaped our notice that the financial crisis to some extent has dampened the political interest in environmental issues in favour of purely economic issues. “Advanced economies are slowing down and the euro area appears to be in a mild recession”, wrote OECD in their Outlook No. 90 (November 28, 2011). Even the U.S. Congress view of environmental issues is pending (despite President Obama’s promotion of the issue – see his “Blueprint for a Secure Energy Future”, The White House, March 30, 2011). At the same time new warnings calls for still more environmental action. According to OECD’s latest analysis, global greenhouse gas emissions are projected to double in the next 40 years (November 24, 2011). This, OECD writes, would result in a 3-6 degree increase of the average global temperature by the end of the century unless governments take decisive action.

The project and methodology

In light of the above, the initiation of the research and training project, Global Vision, had the aim to analyse barriers for business/economic growth through a transregional project with the focus on assessing existing policies, developing tools and approaches, as well as developing new structures and processes, for supporting the growth of the clean technology industry in the Central Baltic area. The following countries and regions are included: Sweden (covering regions of Stockholm, Örebro, Östergötland, Uppsala, Gävleborg, Södermanland, Västmanland), Estonia and Latvia. The project runs from 2011–2013.[2]

More specifically, the project addresses the challenges faced by SMEs that produce technological innovations in the field of clean technologies in reaching global markets with their products and services. By connecting clean technology firms in regions covered (in this study) and by actively promoting co-operation amongst companies, the project aims to make further specialization possible and simultaneously enable the SMEs to take on larger contracts abroad. The project also aims at improving public policies in the field of clean technologies.

The project is divided into three broad steps or phases. The first step consists of an analysis of existing firms and policies and the actual resource demand with the aim of providing a roadmap for strengthening sector's internationalisation activities and/or exports. The second step involves the development and delivery of tailor-made training materials and programmes for SMEs as well as transregional match-making activities for both regional decision-makers and SMEs. The third step consists of the assessment of existing regional relationships and networks with a view to developing a joint transregional model for utilising such contacts for sales activities for the development of the clean technology industry.

The current report is the culmination of the first step of the Global Vision Project, and provides an analysis of regional clean technology industries and their global market reach, and policy initiatives. The report is largely based on interviews with 95 companies in Sweden, Estonia and Latvia. The methodology deployed included mostly face to face interviews, an in-depth study of these interviews along with other company information and annual business reports. Also used were available statistical databases (however data was rather more limited for Estonia and Latvia) and expert workshops. The analytical framework applied in the present study generally followed the model developed by the National Re-

[2] See http://www.global-vision.se for details.

search Council of Canada for the analysis of clusters with some aspects adapted by the authors specifically for the analysis of the clean technology sector.

The analysis covers the economic, social and policy context – including human resources, infrastructure, business climate, support measures, related industries (called current conditions) – as well as the characteristics and dynamics of the clean technology companies (current performance; covering aspects like the nature of clean technology companies, interaction with other stakeholders and internationalization). Each country chapter concludes with a synthesis of strengths, weaknesses, opportunities and threats, as well as related policy recommendations.

On-site visits – like here at Svensk Biogas – and face to face interviews were important parts of the research method in the cleantech cluster study.
Photo: Per Frankelius.

Clean technology sectors and clean technology developers in Sweden, Latvia and Estonia

Sweden

There are 6,530 clean technology companies active in Sweden according to the Swentec database (2009). More than 40% of these companies are related to the sub-field waste management and recycling. About 15% are developing, producing and/or selling technologies for sustainable building and energy efficiency. Other main technology sub-fields engaged in by these companies includes consulting services (15%), water treatment (7%) and bioenergy and biofuels (7%).

For the current research, clean technology developers from seven Swedish counties covered by the project were identified (see the result list below the "Filter" in Figure 1).

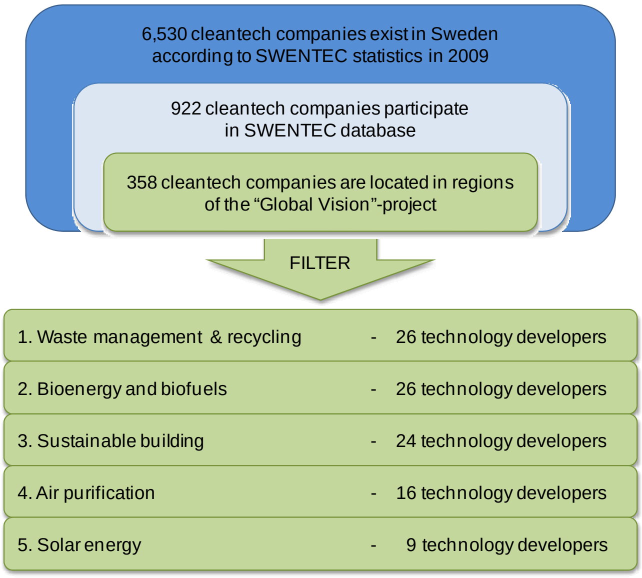

Figure 1: Selection of clean technology developers in Sweden

Source: Authors.

Fifty percent of the clean technology developers identified are located in Stockholm County, other main locations are Östergötland County as well as the counties of Södermanland and Gävleborg (Figure 2). The companies analysed from

Sweden altogether employed 13,860 persons in 2009, corresponding to 33% of all persons employed by Swedish clean technology companies.

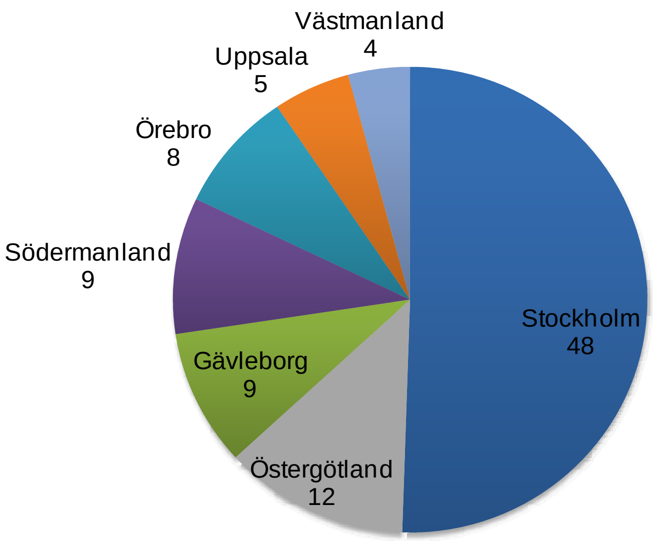

Figure 2: Geographical distribution of regional clean technology companies
Source: Swentec database 2011.

The importance of the regions analysed was also evident by the review of patenting activity. Patents filed by Swedish applicants to the European Patent Office (EPO) indicates that technologies related to pollution abatement and waste management represented most of the patents between 2003 and 2007. 55% of Swedish clean technology patents filed in 2007 have their origin in the concerned regions, and this was slightly higher than the 51% for the period 2003 and 2007 (Figure 3).

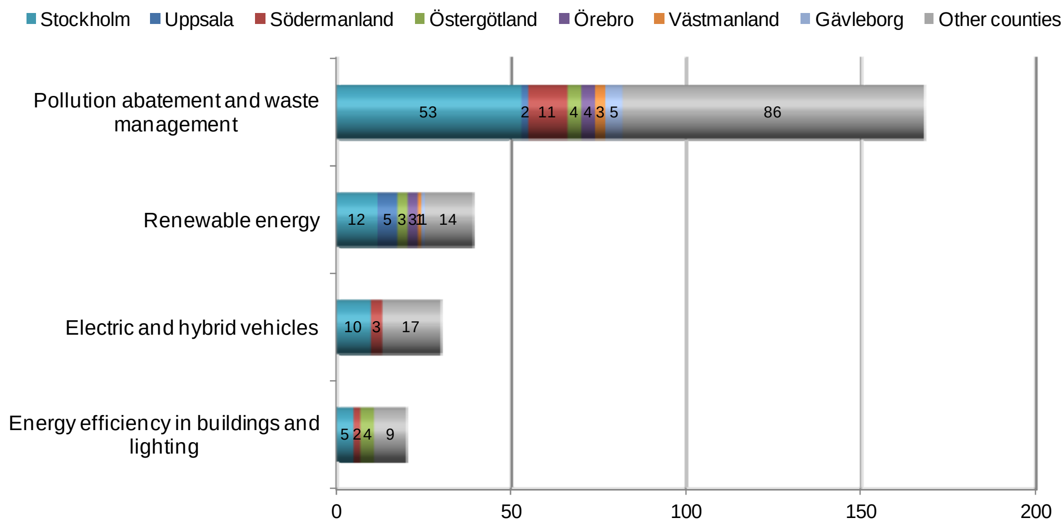

Figure 3: Total patents filed to EPO between 2003 and 2007

Source: OECD 2011.

Estonia

Compared to Sweden, the clean technology sector in Estonia was much smaller. The number of companies that could be related with environmental technologies was approximately 200 to 300, according to some studies. These companies were active in sub-fields like energy technologies, biofuels, material technologies, waste management, water and ambient air protection, green construction, clean technology consulting, environmental research equipment as well as information and communication technologies (ICT).

However, the majority of these companies comprised resellers or representatives of foreign clean technology enterprises or technology users. For the purposes of the current study, 36 clean technology developers were identified. These were the companies in Estonia that were relatively active in the development of new environmentally friendly solutions in the field of clean technologies. Over one third are developing energy technologies (wind turbines, semiconductors, photovoltaics, ultracapacitors, fuel cells, electrical and power engineering, and heat exchangers); the other larger segments are biofuels and clean technology related ICTs (Figure 4). The 36 clean technology developers that were analysed from Estonia employed altogether 911 persons in 2009.

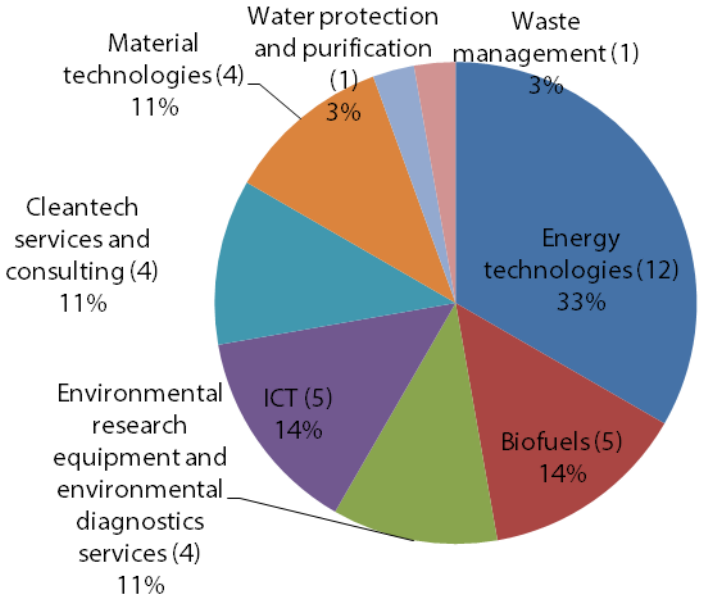

Figure 4: Clean technology developers in Estonia
Source: Authors.

Latvia

The Latvian clean technologies sector was more comparable to Estonia rather than of Sweden. 58 clean technology enterprises were identified for purposes of the current study, although this figure may be susceptible to possible overestimation as the count may include more than just technology developers. The 58 companies analysed from Latvia employed a total of 1,240 persons in 2009.

Emergence of the clean technology clusters

Five clean technology clusters were found in the Swedish regions covered by the study. The map below (Figure 5) illustrates clean technology clusters in the fields of 1) waste management and recycling, 2) bioenergy and biofuels, 3) sustainable building, 4) air purification, and 5) solar energy.

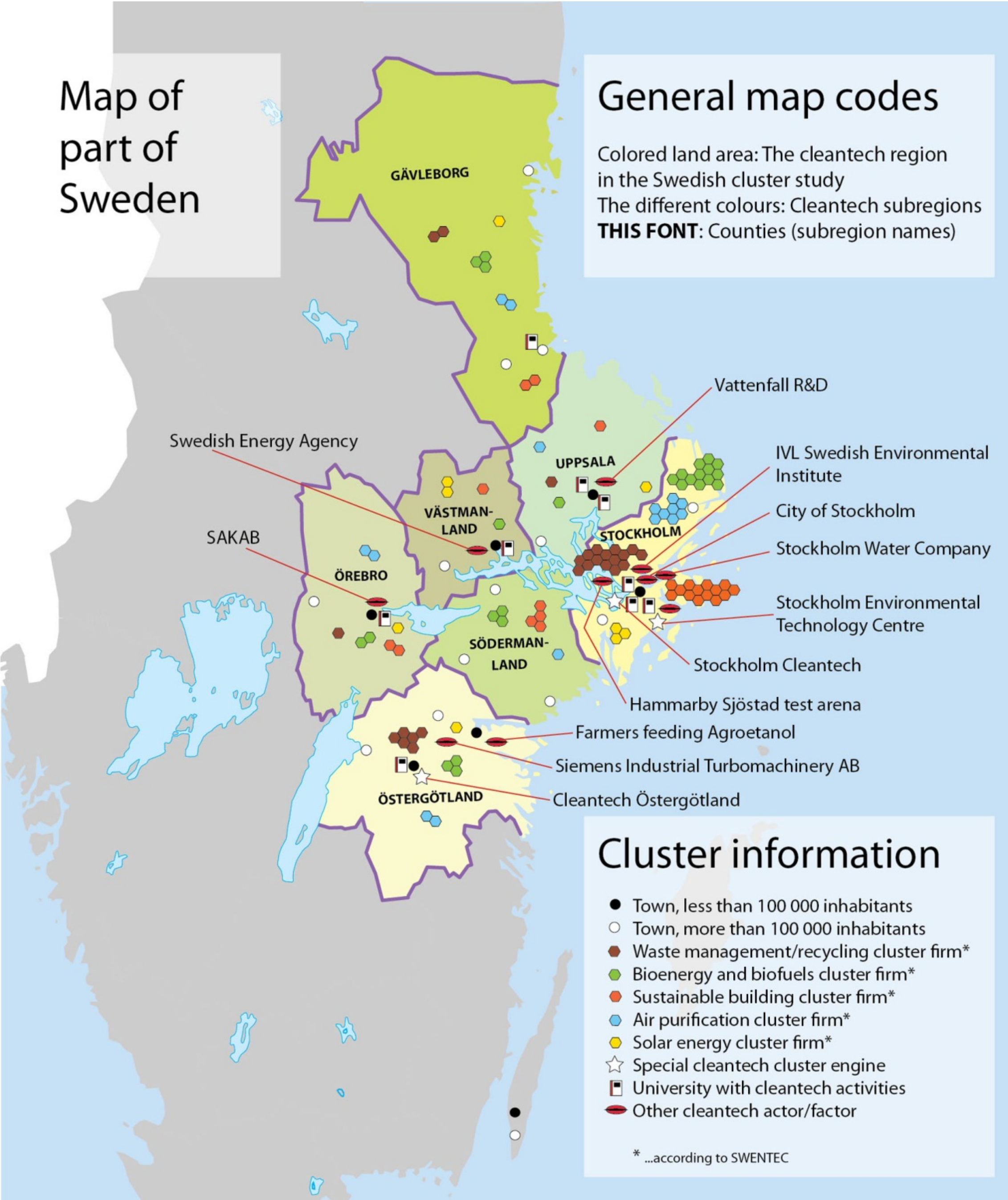

Figure 5: Clean technology cluster and sub-clusters in the region included

Source: Authors.

In Estonia, the majority of clean technology companies develop energy technologies, clean technology related ICTs and biofuels. In Latvia the emerging clusters were in the fields of environmental protection, green services and renewable energies.

Clean technology developers in Sweden, Latvia and Estonia

Company establishment and size

Clean technology developers were the subject of the analysis related here. They tended to be rather young companies. Nearly 60% of the Swedish regional companies analysed were founded in or after 1990. Of the 36 Estonian clean technology developers, 21 companies were founded between 2000 and 2010. Also in Latvia, the founding of new enterprises as well as the activities of the already established enterprises became more active following 2003. This may be attributable to Latvia's accession to the EU and the consequent accessibility of new financial support measures in environmental protection and other fields of clean technology.

In all three countries, the majority of the clean technology companies were micro companies, i.e. employed up to ten employees. Clean technology developers with the largest number of employees in the regions analysed were found in Sweden: YIT Sverige AB (4,578 employees [2009] in Sweden) and Munters AB (4,087 employees, both Stockholm County), as well as Systemair AB in Västmanland County (2,013 employees), but also Camfil Svenska AB in Södermanland County (316 employees), Econova AB in Östergötland (256 employees) and BooForssjö AB in Södermanland (210 employees).

Even the largest clean technology related companies from Estonia – Konesko (312 employees in 2009), Graanul Invest (131 employees) and Estiko-Plastar (128 employees) were rather small in international terms, and of the 36 companies analysed 23 had less than 10 employees. This was also true for Latvia where the field was dominated by micro- and small-enterprises. Only five of the enterprises in Latvia were medium sized enterprises.

Financial characteristics

In 2009, the turnover of the Swedish clean technology companies reached SEK 119.3 billion (EUR 11.2 billion), of which SEK 44 billion (EUR 4.1 billion) was in the counties covered in the project and SEK 25.3 billion (EUR 2.4 billion) in the

93 companies identified through the Swentec database. On the national level, companies active in waste management and recycling together with companies active in sustainable building and energy efficiency generated 50% of the national turnover from clean technologies. Furthermore, one fourth of the turnover was generated by technologies related to bio-, solar-, wind- and water-energy.

For Estonia the net sales volume of the 36 companies studied amounted to EUR 124 million in 2009. Almost 50% came from biofuels (mainly due to one large company, Graanul Invest) and 30% from energy technologies which was the largest Estonian clean technology sub-sector.

For Latvia the turnover of 58 clean technology enterprises totalled EUR 211 million (2009) and the renewable energy group had the highest turnover with EUR 157 million.

Total assets of the 93 regional clean technology companies in Sweden amounted to SEK 17.8 billion (EUR 1.7 billion) in 2009 and reflected the size structure. More than 50% of the companies had total assets of less than SEK 25 million (EUR 2.4 million), nearly 30% had even less than SEK 5 million (EUR 0.5 million). Total assets of the Estonian clean technology companies amounted to EUR 107 million (2009).

Of the 93 Swedish companies analysed, 60% produced a profit from their operating activities in 2009 (total profits amounted to EUR 108.5 million). Most companies which operated in the clean technology sub-fields, namely waste management and recycling, sustainable building, and air purification were successful and their results indicated profits at the financial year end. Most businesses that sustained a loss in 2009 were in the sub-field, bioenergy and biofuels. The total profit of the Estonian clean technology developers amounted to EUR 5.3 million (2009).

The financial results of companies in Estonia and Latvia, in particular, revealed a high degree of stratification. In other words, there were some successful companies according to financial results but a majority of enterprises evidenced rather poor financial performance. But this should be treated with some caution as these firms were mostly, at that point, in the technology development stages.

Exports

In Sweden, one in four clean technology companies exported its products or services to other countries in 2009. Total exports of clean technologies reached SEK

38.9 billion (EUR 3.6 billion), an increase of SEK 18.8 billion (EUR 1.8 billion) or 94% since 2003 (Figure 6) showing the increased competitiveness of Swedish companies in the international market.

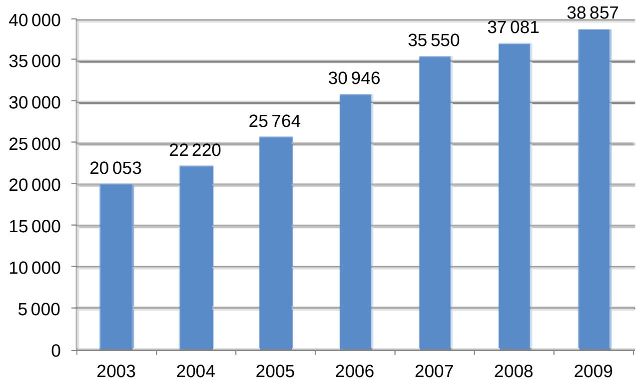

Figure 6: Export of Swedish clean technology companies 2003–2009 (in million SEK)
Source: Swentec 2010.

The sub-fields waste management and recycling had the highest total export value between 2007 and 2009 for Sweden (Figure 7). This accounted for nearly one fourth of the national clean technology exports in 2009. However, as this sub-field also consists of the largest number of clean technology companies (2,764 companies) the high share of clean technology exports was not surprising. In contrast, exports have in recent years also reached a relatively high level for two smaller sub-fields in terms of enterprises engaged, namely sustainable building and energy efficiency (956 companies), and solar, wind and water energy (504 companies). For both clean technology sub-fields, a steady increase of exports had been noted since 2007. Companies with a business related to solar, wind and/or water energy increased their exports by 60% between 2007 and 2009, while the number of employees increased during these years from 2,327 to 2,766.

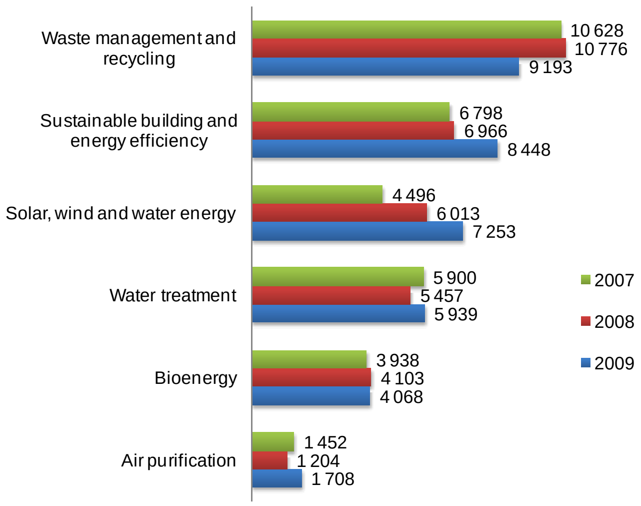

Figure 7: Swedish clean technology companies' export by technology area (in million SEK)

Sources: Swentec 2009; Swentec 2010.

In Estonia, total exports amounted to EUR 124 million (2009) and this trade was dominated by few companies. Out of the 36 companies analysed 16 companies exported their products. Graanul Invest, Konesko, Balti Kaubad ja Teenused and Airel were the export leaders, although Konesko was in the process of developing its wind turbines and as yet had not exported any cleantech products. Graanul Invest exported all its production while Konesko had only a tiny part for domestic consumption. This indicates that export markets were very important for the Estonian clean technology companies (Figure 8).

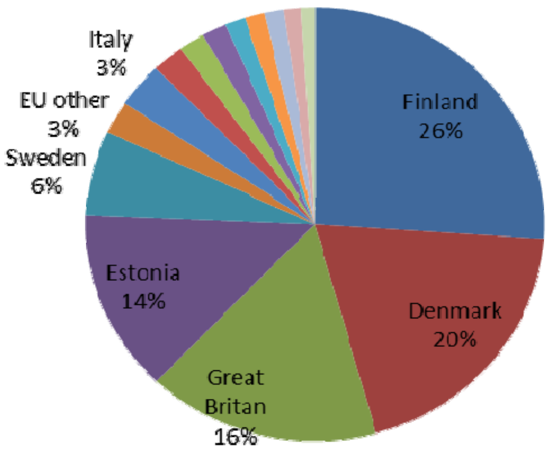

Figure 8: Sales in Estonia and exports of clean technology developers, 2009[3]

Source: Authors.

In Latvia, total exports amounted to EUR 192.4 million (2009). Exports were highest in green services and renewable energies (Figure 9). The relatively large export percentage of the green services segment was due to the activities of one company, Primekss Ltd.

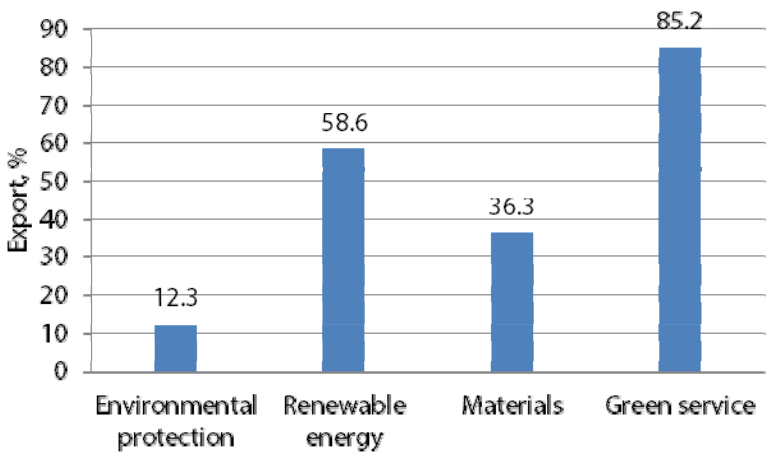

Figure 9: Export share of clean technology enterprise export in different clean technology groups

Source: Authors based on interviews.

The major export destinations of the Swedish clean technology companies are European countries, but also China and the USA. European export destinations

[3]Only destinations with export volume over EUR 1 million are presented.

that were among the top ten export markets together amounted for 50% (SEK 19.6 billion, or EUR 1.8 billion) of the total clean technology export in 2009. Germany was by far the largest export market for Sweden with regard to clean technologies. In addition, all three Nordic countries sharing a border with Sweden (namely Norway, Denmark, and Finland) were important export destinations accounting for nearly 20% of the total clean technology exports.

For the Estonian clean technology developers, the biggest export revenues were from Finland (EUR 136 million in total; 2007–2009), Denmark (EUR 61 million), Great Britain (EUR 25 million), Sweden (EUR 14 million), Spain (EUR 11 million), France (EUR 11 million), Russia, and Latvia (EUR 7 million). In the period 2007–2009, the exports to the EU totalled EUR 356 million and outside the EU EUR 18 million. Outside the EU the biggest export destinations were Russia (EUR 8 million), China (EUR 2.6 million) and Belarus (EUR 1.6 million). For Latvia also, the European Union countries were largely the major export destination.

Supply of human resources in the field of clean technologies

The regions analysed host some of the major universities that offered programs related to clean technologies and thus serviced the needs of companies in the sector with qualified personnel. In Sweden the most important universities were University of Gävle, Uppsala University, Swedish University of Agricultural Sciences (SLU), Stockholm University, Royal Institute of Technology (KTH), Mälardalen University, Södertörn University, Örebro University and Linköping University. In total, approximately 3,100 students were attending programs and courses related to clean technologies in autumn 2010.

In Estonia, there were six higher education institutions that offer altogether 65 curricula associated with environmental technology and clean technologies. Next to the key universities – Tallinn University of Technology and University of Tartu – there were also other institutions, namely the Estonian University of Life Sciences, Euroacademy, Tallinn University, and University of Applied Sciences that host such programs and courses. The number of graduates at the bachelor and master level was between 800 and 900 annually (2007–2011).

In Latvia, seven higher education institutions have study programs related to clean technologies, namely the University of Latvia, Liepaja University, Daugavpils University, Mechanics and Technology College of Olaine, Rezekne Higher Education Institution, Riga Technical University and Latvia University of Agriculture. The number of graduates at the BA and master's level in the related programmes had been between 219 and 268 annually for the period 2007 to 2011.

Government policies and instruments, and support organisations

Government support to clean technologies was most visible in Sweden. A Research Strategy for Environmental Technology was approved by the Government in 2007. The strategy highlights research and development of environmental technologies in six research areas, namely sustainable planning, sustainable transport, environmental protection technology, biological resources, ease and advanced materials, and energy.

Furthermore, there exists an action plan for the Swedish clean technology sector (2010) which was prepared by Swentec on behalf of the state. The Action Plan indicates a focus on five strategic areas: political management, skills for sustainable development, commercialization, business models and partnerships. The action plan includes 82 concrete measures in these areas.

Swedish efforts include the government's national initiative providing SEK 560 million (EUR 52.6 million) for support measures between 2007 and 2010 in the field of clean technologies. For the period 2011–2014, an additional SEK 400 million (EUR 37.6 million) was allocated for the promotion of development and export of environmental technologies.

There are numerous national initiatives and funding programs, e.g. "SymbioCity", "DemoEnvironment", and ”ProEnviro". In addition to governmental initiatives, the regional clean technology sectors are supported in Sweden by a number of private cluster organizations and networks, including the network ”Sustainable Business Mälardalen", Stockholm Environmental Technology Centre (SMTC), and Cleantech Östergötland .

In Estonia, two strategic documents relate to clean technologies on the general level – Estonian National Strategy on Sustainable Development ”Sustainable Estonia 21" – and the Estonian Environmental Strategy. The most important document guiding R&D and innovation is the Estonian R&D and Innovation Strategy 2007–2013 "Knowledge-based Estonia". The strategy identifies three key technologies for Estonia: 1) information and communication technology, 2) biotechnology and 3) material technology. Although some clean technology related prioritization can be found in those strategies, there were no extensive and specific support instruments dedicated to the development of clean technologies in Estonia. While R&D and innovation support organisations were well established in Estonia, there are not specific measures dedicated to clean technologies. However, over the last few years a number of associations and umbrella organisations related to various sub-fields of clean technologies have emerged.

For Latvia, the key policy documents were the National Development Plan 2007–2013 and the National Environmental Policy Plan 2004–2008. Similar to Estonia, there existed no specific support instruments for the development of clean technologies. The government support for enterprises in Latvia was mostly implemented through the Investment and Development Agency of Latvia (IDAL). In the provision of support to new products and technologies and support to the centres of competence and excellence, there were some support measures, similar to those found in Estonia, for clean technologies in Latvia. Another similarity with Estonia was the existence of a number of professional associations in the field of clean technology.

Cooperation between industry and academia

Co-operation between industry and academia was most developed in Sweden. There are regional centres of excellence in the field of clean technologies, e.g. "Svenskt VattenkraftCentrum", Centre for Molecular Devices and the Centre for Renewable Electric Energy Conversion. A majority of the companies interviewed had cooperated with research institutions with the objective of developing clean technologies. A majority of the interviewed companies claimed a moderate or significant contribution of academic and other research organizations in the development of clean technologies. The perception of several companies was that academic participation in clean technology related projects was high. Universities were seen as excellent in various specialized research fields and companies found it important to develop personal contacts with researchers engaged in projects. Interaction with individual researchers was seen as critical. Moreover, company representatives requested a larger focus on knowledge about commercialization of technological products.

For Estonia, the companies' representatives interviewed were familiar mainly with the activities of universities from which they had graduated, where their employees were studying, or with whom they have had some co-operation linkages. A few very active science groups at the leading universities in the field of clean technologies (photo voltages, fuel cells, passive houses) that also work closely together with certain companies exist.

The most common and relevant problems mentioned by the clean technology entrepreneurs during the interviews were that the gaps between the science (undertaken at universities) and entrepreneurship were too wide, universities were not sufficiently cooperative and also frequently made extensive requests for funds in lieu of co-operation. Some companies mentioned that quite often different departments within universities competed with each other and were not working together. Additionally the intellectual property (IP) terms and conditions were seen as restrictive and impeded co-operation between universities and enterprises, even to the extent where foreign universities were believed to be more pragmatic and open to co-operation. Some companies also claimed that the prevailing system did not facilitate co-operation between universities and entrepreneurs, the former were used only for on short-term and project basis.

Approximately half of the company representatives in Latvia confirmed that the collaboration with academic or other research institutions often used state support through grant programmes. At the present, nine grants were related to the clean technology industry. In addition, research institutions carried out projects under various national programmes launched by ministries, EU funded projects and contract research for private companies.

Co-operation with other stakeholders

Co-operation amongst companies with the goal of developing clean technologies was more evident in Sweden than in Estonia and Latvia. In Sweden more than two thirds of the companies were involved in such co-operation at the national level. The main co-operation partners are ClimateWell AB, Solarus Solkraft i Roslagen AB, Chemrec AB, Munters AB, Seabased AB, SkyCab AB and HiNation AB. Most companies have enjoyed extensive interaction with other players in the clean technology field. Moreover the interactions were not limited only to companies in their interactions, around half of the interviewed companies also had links with universities and research organisations.

Such interactions were increasingly evident in Estonia as well. All of the interviewed companies were cooperating with other organizations with an objective to develop clean technologies, but only the very active clean technology developers were related to international networks. However, there were limits to domestic co-operation as competencies sought were sometimes not available within the local R&D and innovation system.

Over half of the cleantech companies in Latvia indicated interactions with government organizations. Most of the clean technology companies were also members of respective professional associations. Partnership between companies was perceived positively and industry players did attempt co-operation. At the same time, partnerships were typically based on short-term contracts and may not in the long run provide substantial benefits to businesses to strengthen their competitiveness.

Perceived development problems

Business development capabilities

All of the interviewed companies from the three countries emphasized the importance of specific competencies (namely technical, marketing and business competence) for success in the clean technologies market. According to them it was essential to develop an appropriate mix of these three competencies to achieve good market performance. Furthermore, experiential and practical competence was seen as valuable but also formal education in specific technical areas. In Sweden, more than the half of the companies interviewed claimed that these capabilities were apparent in their companies. A smaller share stated that these capabilities were partly manifested. Such competences were less present in the Estonian and Latvia companies.

Problems related to exports

In all of the countries concerned, interviewees pointed out the most crucial barriers to exports of their products and services related to customer relations, laws and regulations (in destination countries), and customer contact problems. Deeper discussion of these issues revealed, however, the need for further strengthening of strategic business competences in the companies interviewed. Business competences might be as hard to build up as technical competences.

In Sweden quite many companies pointed at problems with "customer value" as one of the top three problems. That can be interpreted that some companies lacked state of the art product offerings. Many companies pointed at "contact problems" and on "customer relations". It is obvious from this study that relationship management is crucial for exporting clean technology.

Regarding the problems identified concerning laws and regulations as a main challenge to international expansion, it was not possible to reveal, whether the problem concerned laws and regulation per sè or the companies' ability to access and use information about such laws and regulations.

For the Estonian companies the issue of trust and recognition came up as well since Estonia was a small state and rather unknown to the world.

Problems related to financing

The majority of the clean technology companies interviewed planned major investments in R&D, production and market expansion. In Sweden and Estonia many companies claimed that they already had made significant investments in R&D and were currently planning and taking measures for development of production as well as market expansion. This also shows that the majority of the companies interviewed were focused on foreign markets and thus needed to have good strategies for success in these ventures. However, and this is common to all regions, the companies were generally not able to finance such strategic investments by means of their own capital.

The venture capital market in Sweden was considered well developed and some of the best practice cases showed how public support measures could enhance private investments in the clean technology sector.

In Sweden, venture capital for clean technology companies was provided by both private and public funds that either had a very strong clean technology focus or were specialised in a small number of sectors. Five major funds were identified as being officially specialised in clean technology investments, namely: Sustainable Technologies Fund, IKEA GreenTech, Volvo Technology Transfer, Alder Fund, and Midroc New Technology. IKEA GreenTech and Volvo Technology Transfer, in particular, intended to support companies developing or producing technologies or services which may be of future interest for businesses within their company groups.

The analyses of these funds' investments in recent years shows that most of the investments in clean technology companies took place in 2006 or later. Further, it became clear that several funds aimed to act as co-owners. This was particularly true for the public funds like Industrifonden and Fouriertransform. Clean technology companies that were attractive for a number of VC funds and included for example Chemrec, Powercell Sweden, Effpower, and El-forest. Areas of particular importance have been energy efficiency, renewable energy generation, and biofuels.

Due to increasing public awareness of the need for clean technologies as well as Sweden's reputation as a clean technology innovation centre, several new capital venture funds have been created in Sweden in recent years with clean technology as the major investment area. At present, the Swedish Private Equity & Venture Capital Association (SVCA) comprised 40 member organisations investing in businesses related to clean technologies. While venture investments in clean technology companies reached SEK 775 million (EUR 72.8 million) its highest level since 2006, investments showed a decreasing trend in the subsequent years. In 2010, the SVCA's member organisations conducted 66 venture investments in Swedish clean technology companies corresponding to an investment amount of SEK 512 million (EUR 48.1 million).

The circumstances regarding financing prevailing in Sweden was once again quite different from Estonian and Latvian situation. The Estonian venture capital sector was considered to be in formative stages of development. In 2007 the overall volume of venture capital investments in Estonia was EUR 36 million. In 2008 and 2009 the amount of investments invested into Estonian companies decreased drastically, from EUR 15 to 5 million, respectively. The Estonian Private Equity and Venture Capital Association (EstVCA) currently had 16 members who have also invested into clean technology companies. The most active investor in clean technologies was the Estonian Development Fund.

In Latvia, venture capital company Eko investors has been most active in the field of clean technologies. Currently two venture capital funds – BaltCap Management and Imprimatur Capital Baltics – are operating investment programmes.

In Sweden the companies did not state that there was lack of capital on the venture-capital market or other capital markets. However, they argued that it was very difficult and time-consuming to attract capital investments. The main problems, according to the companies, were not the products, technologies or business models in the companies. Rather the problems were related to communicating information about the products, technologies and not least the business models, and the need for the right contacts. The availability of capital generally, and venture capital more specifically, was much more limited in Estonia and Latvia. Further in these two countries the business model development and its communication remained an issue.

Clean technologies related strengths and weaknesses in Sweden, Estonia and Latvia

Strengths

The particular strengths of the Swedish clean technology sector related to human resources and community support.

There were well functioning **higher education institutions** in the relevant regions in Sweden that addressed the sector's future demand for qualified personnel. A range of courses and studies that were demanded by clean technology companies were on offer. Examples of Master's programmes specific to clean technology specific includes "Environmental Science" (Stockholm University), "Sustainable Technology" (Royal Institute of Technology), and "Energy and Environmental Engineering" (Linköping University). More than half of the companies interviewed claimed to have had sufficient access to qualified personnel. However further research is needed as the same companies indicated the need for personnel with more business knowledge and the above educational programs mostly were technology-oriented.

One of the strengths regarding clean technology in Estonia and Latvia lay also in local universities that have strong technical, engineering, chemistry, physics, etc. base which was essential for clean technology development. The relevant companies were satisfied with the overall availability of skilled workforce and held the opinion that there were enough clean technology related programmes at universities.

One of the strengths of the Swedish clean technology sector was related to the comprehensive **community support system.** Examples here include the Swedish government's national initiative providing SEK 560 million (EUR 52.6 million) for support measures between 2007 and 2010 in the field of clean technologies. For the period 2011–2014, an additional SEK 400 million (EUR 37.6 million) was allocated for the promotion of development and export of environmental technologies. Examples of government programmes supporting clean technology companies include “Green Nano”, which promotes research on nano-technologies for a better environment, and “DemoEnvironment” which promotes the testing of new environmental technologies. Moreover, special initiatives were conducted in order to promote the export of Swedish clean technology to Asia (i.e. India and China). An example of this was the establishment of the Centre for Environmental Technology (CENTEC) in China. On a regional level, five community support organizations were of particular importance for the clean technology sector’s development. Here examples were the Stockholm Environmental Technology Centre (SMTC), Cleantech Östergötland and the network “Sustainable Business Mälardalen”.

Again, the Swedish experience was rather different from Estonia and Latvia where such large-scale and clean technology specific support programmes and instruments were lacking. Still, public awareness about the relevance and possibilities of “being green” and developing clean technologies had been increasing in Estonia over the last years as indicated by the thematic conferences that have been organized, cluster initiatives which have been started, community support organizations that were in the process of being established, green public procurement was increasingly discussed, etc. Such developments were largely directed by EU policies and guidelines, as well as co-funded by the Cohesion Fund measures.

One of the overall strengths was that **various clean technology sub-fields** were developing in the regions covered. Sweden was the most advanced with the following existing clusters which were being developed further: waste management and recycling, bioenergy and biofuels, sustainable building, air purification and solar energy. In Estonia, a variety of clean technology sub-fields were represented and were being developed and the largest sub-fields were energy technologies and clean technology related ICTs. For Latvia renewable energies posted the most significant growth. Especially in these specific fields there was also co-operation at national level (including between the academic and industrial sectors) and internationally, expressed both by the exports of the companies as well as their participation in global innovation networks.

Weaknesses

One of the weaknesses regarding the clean technologies sector in all countries was related to **lack of integration of business courses** in clean technology related education. That is, in order to successfully start and drive a clean technology company, specific knowledge about both business administration as well as business development were needed. It was thus seen as a weakness that business-related topics such as marketing were not a major part of studies in the clean technology field. Although a lot of technology development goes on in the companies, this could be much better integrated to business models (i.e., how to profit from the technologies) and business development, and also in communicating these.

Companies in all regions experienced problems with the **acquisition of funds**. This was expressed by the companies interviewed and was regarded as the most serious issue for Estonia. Problems were related to heavy administrative burden, lack of support schemes for some stages of R&D and product development, and the limited presence of the (clean technology specific) venture capital, although this partially could be related to lack of skills in linking the technology to the firm's business model.

Although co-operation between the industry and academia existed in all the countries, the **contribution of academic and other research organizations** to private sector development could be enhanced significantly. In Sweden it was desirable that those academic organisations became more active in commercialization of knowledge as well in patenting activity in the field of clean technologies. In Estonia and Latvia there was also the expectation that universities would offer more services to companies instead of basic research and the production of high-level publications.

In all the regions covered clean technology companies perceived considerable **barriers to exporting and marketing** their products and services. Companies in Sweden, Estonia and Latvia experienced difficulties in finding and contacting customers and building up a long-term relationships with them. In addition, laws and regulations in export markets were seen as a major export and marketing barrier. A more specific aspect related to Estonia was the issue of trust and recognition. The country is small and relatively unknown and this makes successful entrance to other markets even more difficult.

Policy recommendations

The interviews and analysis carried out have led to some of the following ideas about the improvement of policies and undertaking joint actions. These are preliminary policy recommendations and need further analysis and interrogation before being used as a guideline in practice.

Firstly, there was lack of integration of business courses into the clean technology related education curriculum. That is, in order to successfully start and drive a clean technology company, **more knowledge in business administration and development** was needed. Technology development should be located much more substantively to business models (i.e., how to profit from the technologies) and business development, and in communicating it. One option could be joint master's programme driven by a consortium consisting of carefully selected actors in the Baltic Sea region. The primary target group would potentially be the managers in clean technology companies. The pedagogy of such a course ought largely to be employ practical cases with ready application in practice. The intended outcomes would be both a higher level of competence among the participants with a view to enhancing business success.

Second, the forum of clean technology stakeholders from the all regions involved was largely missing. **Better interaction of the support organizations** from Sweden, Estonia and Latvia, and involvement of the other clean technology organizations from the other Nordic countries, is also recommended. One of the actions undertaken could be related to better information exchange and further co-operation between the clean technology companies from Sweden, Estonia and Latvia. This could take the form of match-making events. In a similar vein, many clean technology companies were currently too small to invest enough in export projects on their own. To address this need policy-makers should consider funding allocations towards organizing co-operative trade fair operations, wherein clean technology companies work together. For example this could include integration of their marketing budgets to attend trade-fairs.

Thirdly, joint actions could be initiated in the field of **public procurement for innovation**. Public procurement for innovation means that a public agency places an order for a product that does not yet exist, but which could probably be developed within a reasonable period of time, based on additional or new innovative work. Mostly it is undertaken to solve an existing or emerging societal need, but compared to the procurement of "off-the-shelf" products, public procurement for innovation arguably has a potential to enhance providers' innovativeness and to support economic development. Many governments around the world are currently re-discovering policies that would put public procurement – usually worth 10–20% of countries GDP – explicitly into the service of technology and innovation policies. Since environmental issues are largely cross-border issues and as such are susceptible to joint actions which could be initiated and innovative solutions to societal needs sought. The possibilities are good considering that Sweden has extensive experience in carrying out public procurement for innovation especially since both Estonian and Latvian stakeholders have shown increasing interest in this as well.

Chapter I: Introduction

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1. Global Vision project

Environmental issues in general and the climate challenge in particular have lately become one, if not the, leading issue in the public and private debate. Most researchers and experts agree that a substantial share of environmental events are linked to climate change which can be attributed to human factors. This is evident from the findings of key reports such as the Stern Review on the Economics of Climate Change (2006)[4]. As this debate gains momentum (e.g. on the EU, Baltic Sea area or the BRIC agendas) excellent new market opportunities are being developed for the cleantech industry.[5] Some market observers like the Worldwatch Institute have even compared the potential of the cleantech industry to the boom of information technologies in the 1990's. At a ven-cap-meeting in San Francisco 2007, the former American Ambassador to Sweden, Michael Wood, presented 30 promising Swedish cleantech companies (mostly energy oriented). After Wood's action, many investors believed in finding "future Microsofts" or "future Genentechs" among these companies. But what has happened? Where are the business rockets?

The cleantech industry is generally regarded as an arena where business interests and environmental awareness can meet through a mutually strengthening partnership. The purpose of this complementarity is to create sustainable growth by making investments into new resource-effective products, services and processes that can generate increased turnover, employment and exports for the industry, while at the same time reaping the benefits of environment efficiency (which includes profits for cleantech firms) through reductions in the depletion of finite natural resources, pollution and waste on a national and international level. Also improving the variety and diversity of nature by means of novel concepts is part of the "green visions".

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[4] See also the International Panel of Climate Change, http://www.ipcc.ch/.

[5] There are many terms that refer to solutions for a better natural environment. Examples are clean technology (cleantech), environmental technologies, eco innovation, environmentally sound technologies, eco-industry, green technology (greentech) and environmental technology (envirotech).

A narrow definition of clean technologies refers to low-carbon energy technologies. For present purposes, a broader approach is taken. Clean technoligies is defined as environmentally friendly technologies that represent a diverse range of products, processes (including methods) and services and products intended to reduce or eliminate pollution and waste while improving the effective and responsible use of natural resources. The sub-fields of clean technologies are energy technologies, biofuels, material technologies, water purification, waste management, ambient air protection, information and communication technologies related to environmental protection, environmental equipment, sustainable building, renewable energy and green services.[6] It has not escaped our notice that some solutions of root-problems for damaging natural environments are not included in the lists, despite the fact that solutions on these problems can improve the environment very much. One example: One can make more environmentally friendly fuels for truck transports, and solutions for that are included in the lists. However, the root problem is that there are so many transports in society. If, for example, one company develop meal concepts for schools that are based on local or present season ingredients there is not the same need for transporting food long distances.

Policy makers on a global level, but increasingly also in the Nordic countries and in the Baltic area, have understood the importance of the cleantech industry and are developing and implementing policies to support the development of environmental technologies for enhancing the competiveness of the cleantech sector.

The Baltic region encompassed by the Central Baltic programme represents an excellent breeding ground for small and medium-sized cleantech companies. The region hosts leading research organisations on both national and international level, is characterised by high customer awareness and has a strong SME sector with innovative products and services. In addition, it has certain strong multinationals as direct clients for cleantech companies. There is strong business poten-

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[6] Cleantech Group (2011) provides another, but similar, cleantech industry segmentation. They define cleantech between the following eleven segments: energy generation (wind, solar, hydro/marine, biofuels, geothermal, other), energy storage (fuel cells, advanced batteries, hybrid systems), energy infrastructure (management, transmission), energy efficiency (lighting, buildings, glass, other), transportation (vehicles, logistics, structures, fuels), water & wastewater (water treatment, water conservation, wastewater treatment), air & environment (cleanup/safety, emissions control, monitoring/compliance, trading & offsets), advanced materials (nano, bio, chemical, other), manufacturing & industrial (advanced packaging, monitoring & control, smart production), agriculture (natural pesticides, land management, aquaculture), recycling & waste (recycling, waste treatment).

tial, particularly in areas such as water purification, waste management, new energy sources and sustainable building is therefore substantial.

Despite excellent possibilities for growth, the international demand for new products and services as well as already validated technical solutions and business models, evidence shows that Baltic as well as Nordic cleantech companies have struggled to establish themselves on the international level. The main barrier for growth still resides in the fact that companies in general are too small and lack access to global networks. Simultaneously, suitable support structures are often insufficient or missing at the regional level so as to be in a position to help to stimulate and coordinate the needed actions. This is particularly true for the situation in the Central Baltic area. On one hand, the area hosts competitive companies around the major metropolitan areas. But, on the other hand, to a large extent it lacks stringent policies and continues to struggle for global presence.

The environmental technology sector in the Central Baltic area is dominated by Small and Medium Enterprises (SMEs) active in local markets, whereas the future growth potential is understood to be highest in international markets (in particular in the BRIC-states). Central Baltic SMEs are forced to increase their specialization in order to compete internationally. However, increasing specialization can be accellerated if accompanied by better coordination of resources across regional borders. Public policies strongly impact the market for environmental technologies and services. Governments need to set and implement policies that creates an enabling environment, namely to stimulate industry into pushing products and services and also increase market pull. Such policy development would be most effective on an international level but also in the regional and cross-border context as there are many synergies to exploit, e.g. in sharing experiences on regional policy measures and initiatives, and venture capital access.

In brief, the aim of the Global Vision project is to address and analyse perceived barriers for growth through a transregional project with the focus on assessing existing policies, developing tools and approaches, as well as developing new structures and processes for supporting the growth of the cleantech industry in the Central Baltic area and beyond. The project will be conducted in the Central Baltic area, including regions from Sweden (Stockholm, Örebro, Östergötland, Uppsala, Gävleborg, Södermanland,Västmanland), Estonia and Latvia.

More specificially, the Global Vision project aims to increase growth in small and medium size cleantech companies which are innovative in nature. The project activities will identify perceived barriers for fostering growth, tailor support actions and programmes and provide recommendations as to how these companies could utilise existing international contacts to address growth limiting factors. For sustainability, the project aims to enhance the regional capacity to implement new and successful internationalisation efforts in the future. To be clear, capacity is defined as a means of dissemination of knowledge and experience gained through the project coupled with strengthening existing and building new relationships within the network of key stakeholders identified through this project.

In this way the project seeks to addresses the challenges that companies in the cleantech sector face in reaching global markets with their innovative products and services. Through the means of connecting cleantech firms in different countries of the Central Baltic region and by actively promoting their cooperation the project aims to increase the possibility of further specialization and internationalisation.

Furthermore, the project aims to improve public policies on the environment with a specific focus on the field of cleantech. As the cleantech market is strongly dependent on public regulation and societal drivers it is also very much up to public policy makers to define effective instruments for promoting the cleantech industry. Therefore, the project's additional objective is to contribute to the development and implementation of improved policies to foster both the cleantech sector and increase the utilisation of technologies with low environmental impact of consumers and industry. Both aspects of the project's objective are difficult for an individual region to manage on its own. This holds true in particular for the relatively small economies of the Central Baltic area. Co-operation is therefore a prerequisite for successful development of the sector.

In the light of the main objective, the project is divided into three broad parts. The first comprises an analysis of existing industries, policies and the actual resource demand with the aim of providing a roadmap for strengthening the industry's internationalisation activities. The second part includes the development and delivery of tailored training materials and programmes for the SMEs as well as transregional match-making activities for both regional decision makers and SMEs. Third, existing regional relationships and networks are assessed with the aim to develop a joint transregional model for utilising such contacts for sales activities for the development of the cleantech industry.

The aim of the current report is to analyze and benchmark regional cleantech sectors and their global market reach, and policy initiatives related to recent developments. The outcomes of this report will be used to formulate a longer term strategy for the cleantech sector in the Central Baltic area. This strategy will comprise a vision as well as a roadmap and action plan for strengthening the industry's internationalisation activities for Central Baltic cleantech SMEs. The focus will be on finding a joint path to sustainable economic development of the sector based on cutting edge knowledge, highly skilled labor, innovation and specialization.

2. Methodology

Clusters are increasingly recognized as an essential driver of innovation and economic growth. This has also attracted the interest of regional and national level policymakers who are witnessing that clusters can be effectively fostered through public policys and private sector initiatives. This has created a need for a systematic understanding of the factors that contribute to the creation and development of clusters, and the factors that influence the success or failure of clusters and cluster policy.

According to Porter (1998) a cluster means a geographic concentration of interconnected companies and institutions within the same industry. A cluster comprises linked industries and other entities that are important to achieve competitive advantage.

The chosen method for this research connects to the cluster discussion and covers an in-depth analysis of the regional cleantech industry in the participating regions. According to the model developed by the National Research Council of Canada (NRC)[7] two aspects of national clusters will be taken under consideration: current conditions and current performance (Figure 1.1).

[7] Canada's NRC has been a proponent of cluster-based development since the mid-1990s, it has modified and extended the previous work of Porter (1990, 1998) and designed an approach to analyse the strengths and weaknesses of the clusters in which it is involved, to support policy and industry actions to foster the development of clusters, and to measure the progress of the clusters over time (for further reading see Arthurs et al. 2009).

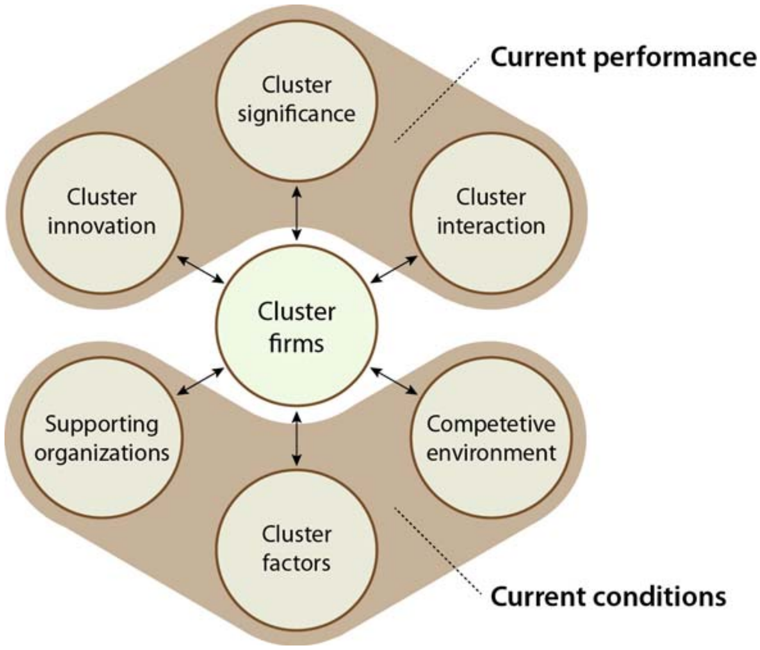

Figure 1: NRC Cluster Framework

Source: Adopted from Arthurs et al. (2009, 269)

Among the different methods and models to analyse and measure clusters, the NRC has elaborated a conceptually grounded and easily replicable set of indicators for gauging the current state and future prospects for cluster development.[8] First, current conditions of national clusters are analysed with the focus on functional economic and policy context and on the policy measures implemented to support the cluster's development (e.g. cluster initiatives). According to the NRC model functional types of factors such as Factor Conditions, Supporting Organizations and Competitive Environment are investigated. Within these constructs, sub-constructs like Human Resources, Transportation, Business Climate, Innovation and Firm Support, Community Support, Suppliers, Local Activity and Firm Capabilities are examined. Second, current performance aspects in clean technologies will be analysed. The NRC framework includes constructs such as cluster Significance, Interaction and Dynamism. Sub-constructs to be analyzed include Critical Mass, Responsibility, Reach, Identity, Linkages, Innovation and Growth. The NRC approach and methodology for cluster development is built on the concept of the cluster lifecycle, recognizing that the role of public institutions as well as the resulting policy outcome can change as clusters evolve through various phases of development (Table 1.1).

[8] For an overview of different cluster benchmarking models see for example Andersen et al. 2006.

Table 1.1: NRC cluster development constructs and indicators

Concepts	Constructs	Sub-Constructs	Indicators	Relative Importance
Current Conditions	Factors	Human Resources	Access to qualified personnel	High
			Local sourcing of personnel	Medium
		Transportation	Quality of local transportation	Low
			Quality of distant transportation	Medium
		Business Climate	Quality of local lifestyle	Low
			Relative costs	Medium
			Relative regulations and barriers	Low
	Supporting Organizations	Innovation and Firm Support	Contribution of NRC	Medium
			Contribution of other research organisations	Medium
		Community Support	Government policies and programs	Medium
			Community support organizations	Low
			Community champions	Low
		Suppliers	Local availability of materials and equipment	Medium
			Local availability of business services	Medium
			Local availability of capital	High
	Competitive Environment	Local Activity	Distance of competitors	Low
			Distance of customers	Medium
		Firm Capabilities	Business development capabilities	High
			Product development capabilities	High
Current Performance	Significance	Critical Mass	Number of cluster firms	High
			Number of spin-off firms	Medium
			Size of cluster firms	Medium
		Responsibility	Firm structure	Low
			Firm responsibilities	Low
		Reach	Export orientation	High
	Interaction	Identity	Internal awareness	Medium
			External recognition	High
		Linkages	Local involvement	Medium
			Internal linkages	High
	Dynamism	Innovation	R&D spending	Low
			Relative innovativeness	Medium
			New product revenue	Low
		Growth	Number of new firms	High
			Firm growth	High

Source: Arthurs et al. (2009, 270)

As innovation systems are different in Canada and Europe and also among the regions under study (Sweden, Latvia and Estonia) we have slightly amended the framework. Namely, it is not rational to strictly follow the NRC framework and the indicators in the structure of the current analysis and as the basis of the interview questions, and to do exact measuring of the results. In the initial model quantitative results for each indicator are converted from the survey to a scale from 1 (low or poor) to 5 (high or good). The model also uses weightings to aggregate indicators to sub-constructs, and sub-constructs to constructs. The ratings are based on what has been found to be important in many clusters across Canada and around the world. In the current research the number of cluster participants was small. Accordingly the model was adapted to deploy a more flexible and qualititative approach in the selection and analysis of the indicators.

It is also clear that clean technologies are as an emerging technology field and thus the national innovation system based analysis is more proper than a strict cluster and cluster initiative analysis. The difference between cluster initiatives and clusters is that cluster initiatives are generally self-identified clusters which in many cases participate in national schemes, whereas clusters are industrial agglomerations identified by standardized statistical information. In the following we take a broader approach when referring to clusters including also cluster initiatives under the term. This is precisely the case in Estonia and Latvia as these countries do not have any theoretically and practically reasonable cleantech clusters.

The analysis is centred on two areas - current conditions and current performance. Under "Current Conditions" we analyse constructs like human resources (access to qualified personnel, availability of cleantech-related education and number of graduate students), community support (government policies and programmes, supporting organisations and funding), innovation and firm support (contribution of academic and other research organizations and the availability of venture capital) and firm capabilities (relevant business and product development capabilities).

The section "Current Performance" comprises of an analysis of enterprises in the cleantech sector with regard to their specialisation, characteristics, export orientation and problems with marketing and exporting cleantech products and services, interaction with other organizations, innovation dynamics, growth dynamics over the period of 2007 to 2009 (developments their financial features), and financial needs. As not much data is available at a comparable level it has been necessary to collect data through both national statistical offices and through tailor-made surveys addressing the more intangible aspects of cluster performance like entrepreneurship, innovation, or networks.

Relating local cleantech companies´ performance with current conditions regarding the sector of clean technologies is important because the performance of the cluster as a whole is dependent on the success of the individual firms and moderated by the local environment (available human resources, community support, innovation and firm support and firm capabilities). There is a temporal relationship between conditions and performance – current conditions impact future performance and current performance is the result of past conditions.

In the three countries, companies developing clean technologies (so called cleantech developers) have been identified through secondary sources and interviews with experts at major public and private sector actors operating in the field of clean technologies. In order to analyse the information necessary to describe the clusters' "conditions" and "performance" the methodology included desk research, statistical analyses and interviews with 95 representatives of cleantech developers from Sweden, Latvia and Estonia. Specification of the needed information was only possible through interviews and consulting with core stakeholders. The questions were structured according to the modified NRC framework (see above) and were open-ended and aimed at providing an insight into the internal dynamics and processes of the cluster. "Softer methods" were chosen (vs hard-core quantifiable approach) to understand the underlying factors and features that affect the performance of cleantech companies and the industry as a whole.

The current report is divided into five chapters. The in-depth analysis of cleantech sectors of involved regions from Sweden, Estonia and Latvia are presented in chapters two to four. The fifth chapter concludes with the comparison of the three countries and brings forth the growth barriers of cleantech companies, clarifies the need for funding in different stages of company development, uncovers best practices of effective regional policy measures and of enhancing private investments in the industry facilitated by public support measures.

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Chapter II: Emergence of the Clean Technologies Sector in Sweden

Per Frankelius and Kirsten Krause

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The part study on research and education on cleantech at universities in the chosen region was made by Conny Johanzon in the spring 2011.

The survey of 47 cleantech companies was conducted in late spring and summer 2011. Adaption of survey questions into the Swedish context was primary done by Frankelius and Claes Hultman, and translation consultation by Gabriel Linton. The in-deph interviews were conducted by Conny Johanzon, Claes Gunnarsson and Claes Hultman(all at Örebro University) together with the master students Jonas Ståhlberg, Tobias Lindebring, Gabriela Mihai and Mattias Macak.

The compilation of the interview data and data from statistical and desk research into text based on the report structure (agreed among the Global Vision partners) was a large part of the project, and made by Kirsten Krause. The investigation and analysis of the five clusters, including the general section about the cluster terminology, was made by Frankelius, except statistical data that were compiled by Krause.

The section including best practice study on funding (green venture fund cases) as well as analysis of strength and weaknesses was compiled by Kirsten Krause. The policy recommendations were formed by Per Frankelius with support from Conny Johanzon, Claes Gunnarsson and Kirsten Krausse.

The final process including editorial work was made by Kirsten Krause and Per Frankelius.Frankelius was also project leader of the Swedish part of the Global Vision cluster study project. During the whole process we had a very fruitful dialogue with Kaija Valdmaa and Tarmo Kalvet from the Estonian team as well as Inga Brieze and Sanita Jankovska from the Latvian team.

Örebro, August 2011

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Professor

Introduction

The project Global Vision comprises the following seven counties in Sweden: Stockholm, Örebro, Östergötland, Uppsala, Gävleborg, Södermanland, Västmanland. The term ‘region’ is used interchangeably for these geographical areas. The single counties in this region are also referred to as ‘sub-regions’.

The information presented in the following is based on desktop research as well as interviews with representatives at 47 Swedish cleantech companies. These companies were selected on the basis of the chosen geographical area as well as a focus on five cleantech sub-fields that are of particular importance for the export of Swedish environmental technologies (sustainable building, air purification, solar energy, bioenergy and biofuels, waste management and recycling). A list of the interviewed companies is available in the appendix.

1. Current conditions in clean technologies

1.1 Human Resources

The majority of interviewed cleantech companies (60%) claimed to have sufficient access to qualified personnel. As much companies find it further necessary to integrate marketing courses in cleantech related educational programmes. However, more than the half of all interviewed company representatives finds it very difficult to clearly accentuate if the education system pays enough attention to cleantech related programs.

Most interviewees see a lack of precision when discussing the concept of cleantech as an educational issue. They claimed that there is probably nothing exceptional with cleantech education as compared to higher education in various kinds of engineering, business and marketing. Relevant cleantech knowledge probably exists in different contemporary educational courses and programs.

Through desktop research, those regional universities were identified that offer cleantech-related studies and thus give companies in the sector access to qualified personnel. These universities are:[9]

[9] Stockholm School of Economics does not offer any research or studies with cleantech relevance, however may provide cleantech companies with personnel educated in management-related issues.

University name	Website
University of Gävle	www.hig.se
Uppsala University	www.uu.se
Swedish University of Agricultural Sciences (SLU)	www.slu.se
Stockholm University	www.su.se
Royal Institute of Technology (KTH)	www.kth.se
Mälardalen University	www.mdh.se
Södertörn University	http://webappl.web.sh.se/
Örebro University	www.oru.se
Linköping University	www.liu.se

In the following, each university is shortly presented with regard to its efforts in cleantech-related education.[10] Furthermore, an overview is provided of those academic education programs offered in the autumn term 2010. Sources of information were the university websites as well as the Swedish Agency for Higher Education Services (VHS).

University of Gävle

The University of Gävle (HiG) has about 13,000 students and its Faculty of Engineering and Sustainable Development is of high cleantech relevance. Through this faculty the research and educational profile of 'Built Environment' is fostered. By topics like building, energy, environment, climate and industrial development, the faculty responds to major needs in society and the economy. Two master programs are offered within the faculty: in electronics and in energy systems.

Uppsala University

Uppsala University is the oldest university in Sweden and has approximately 45,000 students. Policy documents of education and research do not emphasize environmental technology as a distinctive area of excellence. However, there are at least 15 different research areas that relate to cleantech. Ten of these areas ad-

[10] The research was based on identifying courses that had an explicit label of environmental technology or cleantech. The majority of courses at SLU has been excluded from the analysis as they are available in several locations, e.g. a course in ecology. Thus, it was not possible to assign these courses to an explicit region.

dress the area of energy, one is explicitly focused on cleantech and four are in general related to environmental issues. Furthermore, the university offers five Master's and 38 different bachelor courses that could be associated with cleantech.

Swedish University of Agricultural Sciences (SLU)

SLU has about 4,000 students and is located in four Swedish cities, amongst others in Uppsala. SLU is probably the most outstanding university in Sweden in the area on sustainable development, environmental research and education. The university's strategic vision is to develop the understanding, sustainable use and management of biological natural resources. Thirteen of the university's scientific research areas address directly clean technologies. These research fields relate in particular to energy, climate and ecology. It is reasonable to assume that research and education at SLU comprise several additional research areas with indirect cleantech relevance. The educational outline includes eight different programs with explicit environmental focus as well as 52 courses at basic or advanced levels.

Stockholm University

Stockholm University (SU) is one of the largest universities in Sweden with approximately 50,000 students attending various courses. At SU, the most comprehensive research program in Sweden on climate and the environment is based. Seven research areas can be identified as related to environmental issues or cleantech. One of the research areas addresses energy, two regard ecology, three the field of climate, and one research area addresses protein chemistry.

The university's educational profile comprises five programs and 11 courses with cleantech-relevance. For example, a Bachelor's and a Master's program in Environmental Science is offered at the Department of Applied Environmental Science (ITM). Educational activities at this department include further a first cycle course in Introductory Environmental Science and second cycle courses in e.g. Environmental Science, Modelling, Ecotoxicology, Atmospheric Science and organic environmental chemistry.

Royal Institute of Technology (KTH)

The Royal Institute of Technology (KTH) in Stockholm has approximately 13,000 students. KTH is characterised by an exceptionally narrow technological profile as compared to the other universities included in this section. One of KTH's strategic multidisciplinary research platforms is 'Energy', where the university also collaborates with Linköping University and Stockholm University. Overall, four fields of research, eight educational programs and 13 courses address cleantech or environmental sustainability. Also the university's policy and strategic guidelines emphasize solutions for environmental sustainability. At KTH, the profile unit 'KTH Sustainability' has been established for the period 2011-2015 in order to promote research and education for the development of environmental-friendly solutions.

An example for KTH's cleantech-related efforts is the participation of nearly 400 students in the Master's program 'Sustainable Energy Engineering' (SEE) during the academic years 1997/98 and 2007/08. SEE has the specialisations sustainable power generation, sustainable energy utilization in the built environment, and solar energy. In addition, the following Master's Programs are offered amongst others: Sustainable Technology, Water System Technology, Innovative Sustainable Engineering, as well as Sustainable Urban Planning and Design. The Department of Energy Technology includes further the KTH Energy Centre with 100 professors and senior researchers as well as 150 postgraduate students.

Södertörn University

Södertörn University has about 12,000 students and is located is the south of Stockholm. Research covers many different disciplines, amongst others 'environmental studies'. The multidisciplinary profile combines approaches in order to achieve deeper knowledge and understanding of the causes, scope and management of problems relating to the environment and natural resources.

Cleantech-related research at Södertörn University is divided into three interacting themes: Environmental Change and Ecological Processes, Environment and Development, and Environmental Governance. The educational outline includes one Master's program ('Environmental Science, Communication and Decision-making'/'Miljö och utveckling') and 11 courses that aim to provide qualified personnel to the cleantech sector. It is further worth mentioning that the university has an aspiration to strengthen its environmental profile towards the Baltic area.

Mälardalen University

Mälardalen University is located in the cities of Eskilstuna and Västerås. It has more than 13,000 students and has been the first university in the world to become ISO1400 certified. Research at Mälardalen University is conducted within six prioritized areas. Two of them are particularly relevant for the cleantech sector: 'Environment, Energy and Resource Optimization' and 'Sustainable Development, Working Life and Management'. The educational outline includes 21 courses in environmental sustainability and cleantech as well as Master's programs in 'Energy Optimizations for Buildings', 'Sustainable Energy Systems', and 'Inland Water Quality Assessment'. In addition, a Bachelor program in 'Environmental Science" is offered.

Örebro University

Örebro University is one of the fastest growing universities in Sweden with more than 16,000 students. The university's research profile includes the field of Environmental Science. One of the research centres at Örebro University is the Man-Technology-Environment (MTM). The centre's research scope covers environmental chemistry and health as well as ecotoxicology. MTM comprises further a graduate school for studies with cleantech relevance.

As far as the educational outline of Örebro University is concerned, no Master's programs are offered that can directly be linked to the development of clean technologies, however to the administration of companies in the field ('Health and Environmental Economics'). In total, three courses at the university address the field of cleantech.

Linköping University

The campuses of Linköping University are situated in the cities of Norrköping and Linköping. It is a multi-faculty university and the third largest in the region with about 28,000 students. Both research and education at Linköping University are based on its explicit environmental policy that emphasizes sustainable societal development. An example is the division 'Energy Systems' addressing cleantech research in collaboration with Uppsala University and Stockholm University. Another research group with cleantech relevance is the division 'Environmental Technology and Management' with 25 employees and 900 students.

Moreover, the centre of Water and Environmental Studies was established at the university in order to conduct multi- and interdisciplinary research and education. The probably most salient cleantech research at Linköping University is conducted in the field of 'Logistics for Sustainability'. The division is e.g. managing one of Sweden's largest research projects in environmental logistics and supply chain management in collaboration with among others Karolinska Institutet.

In addition to the research conducted, Master's programs are e.g. offered in 'Energy and Environmental Engineering' and 'Science for Sustainable Development'.

Number of graduating PhD-students in cleantech

Figure 2.1 shows the total number of PhD-students that finalised their studies in environmental technology at universities in the region during the last couple of years.

Number of students in educational courses

Programs and courses in cleantech are summarized in the table below. In total, approximately 3,100 students were attending cleantech-related programs and courses in autumn 2010. Due to the fact that some courses from SLU were excluded from the analysis it is however estimated that the real number might be slightly higher.

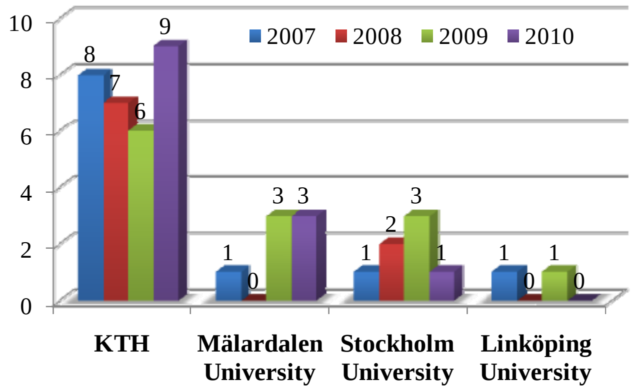

Figure 2.1: Number of researchers finalizing their PhD-studies in environmental technology (by year and university)

Source: Statistics Sweden, www.scb.se

Table 2.1: University programs related to cleantech in autumn 2010[11]

University	Program name	Capacity	Number admitted	Stud.	Course	Total years	Year 1	Year 2	Year 3	Year 4	Year 5	Totalt
University of Gävle	Construction engineering, spec. in architecture and environmental science	30	35	30	10	3	40	36	32			108
	Energy/HVAC - Higher education within engineering	30	25	30	10	2	40	36				76
KTH	Electrotechnology engineering	40	57	40	13	5	53	48	43	43	43	230
	Energy and enironmental engineering	40	55	40	13	5	53	48	43	43	43	230
Linköping University	Engineering and managemenet in energy and environment	30	42	30	10	5	40	36	32	32	32	173
	Environmental science	45	95	45	15	1	60					60
Mälardalen University	Energy systems engineering	30	18	18	6	5	24	22	19	19	19	104
	Energy engineering	40	20	20	7	3	27	24	22			72
	Bachelors program in environmental science, health, work	30	24	24	8	3	32	29	26			87
	Master program in helth science with focus on sustainability	0	0	0	0	2	0	0				0
	Master program in environment- and helth prevention	0	0	0	0	2	0	0				0
Stockholm University	Bachelors in enironmental science	32	28	28	9	3	37	34	30			101
	Master program in environment- and helth prevention	40	28	28	9	2	37	34				71
	Masters program in ecology	0	5	5	2	2	7	6				13
	Master program in environment- and helth prevention	16	12	16	5	1	21					21
	Master program i environmental analysis and environmental administration	0	0	0	0	2	0	0				0
	Masters in enironmental science	0	0	0	0	2	0	0				0
	Masters program in enironmental care and physical planning	10	7	7	2	2	9	8				18
SLU	Biologi och environmental science - bachelors program	0	23	23	8	3	31	28	25			83
	Nature, health and garden - masters program	0	39	39	13	2	52	47				99
Södertörn University	Environment and development	40	55	55	18	3	73	66	59			198
Uppsala University	Energy systems engineering	0	75	75	25	5	100	90	81	81	81	432
	Environmental and water enginering	0	70	70	23	5	93	84	75	75	75	403
	Molecular biotechnologly engineering	0	70	70	23	5	93	84	75	75	75	403
	Masters program in biology, ecology and evironmental administration	0	4	4	1	2	5	5				10
	Masters program in biology, ecological admin. of drainage areas i Europe (Ecocatch)	0	3	3	1	2	4	4				8
	Masters program in renewable electricity generation engineering	0	8	8	3	2	11	10				20
	Masters program in sustainable development	0	20	20	7	2	27	24				51
	Masters program in chemistry for renewable energy	0	1	1	0	2	1	1				3
TOTAL												3072

Source: Website of the Swedish Agency for Higher Education Services (VHS), www.hsv.se

[11] The number of available student-places on different courses is presented with the exception of those cases where the actual number of attending students is lower than the available number of student-places. If so, the number of attending students is presented. Consideration has been taken to the number of study years for each program. In order to compensate for those students that does not fulfill their studies, an additional adjustment of minus 10% has been undertaken for the number of students of the second year as well as additional minus 10% for the third year.
In addition to those students attending educational programs, an estimation has been done for students attending different cleantech-courses as single courses. In these circumstances, the number of students attending single courses is counted to one third of the number of program-students in accordance with the guidelines of Swedish National Agency for Higher Education (HSV). One problem with using this measure is that one university can offer courses within an area while there is no corresponding program, e.g. like at KTH and Örebro University.

1.2 Community support

The results from the interviews indicate a somehow pessimistic view on the Swedish government support with regard to cleantech. Although some companies expressed an encouraging view on the idea of community support (13 of 47 companies), the main part disapproved its implementation (23 of 47 companies), see table below.

Table 2.1: Cleantech companies' opinion on community support

Community support posture	The idea	The implementation
Positive	13 companies	0 companies
Negative	3 companies	23 companies

Source: Author based on company interviews.

Critics concerning the current implementation of governmental support measures include that some government programs may generate unbalanced market forces. Furthermore, many programs are seen as too small in order to be effective. Projects should be larger in size and have an international or global outlook. According to the interviewed companies, government institutions should not support small local projects within a narrow cleantech sector e.g. biogas plants. Instead, they should apply a systems perspective which includes powerful business actors to achieve high environmental and business performance outcomes. Other respondents stressed the importance to have a clear understanding of the sector's customers. It is seen as critical to clearly identify customers and to outline a customer oriented concept in order to succeed in various projects.

In the following government policies and programs are presented as well as regional community support organizations.

1.2.1 Government policies

Between 2007 and 2011, in particular the following policies of the Swedish government are relevant for companies in the cleantech sector:

Research strategy for environmental technology (2007)

A common research strategy for environmental technology was published by the Government in 2007.[12] The strategy was developed by Formas and VINNOVA in cooperation with industry and other stakeholders. The strategy should be a complement to other research support with relevance for environmental technologies and formulates a common vision for the sector. Furthermore, the strategy highlights research and development of environmental technologies in six research areas; sustainable planning, sustainable transport, environmental protection technology, biological resources, ease and advanced materials, and energy. In addition, the strategy addresses the application of research and development results through initiatives in different parts of the innovation chain (e.g. demonstration projects, market launch) and highlights the importance of collaboration for research on environmental technology.

Swentec - a delegation for environmental technology

In 2008, the Swedish Environmental Technology Council (Swentec) was appointed by the Swedish Ministry of Industry as a special delegation for environmental technology. Between 2008 and 2010 Swentec had the mission to develop a more effective governmental structure to strengthen Swedish cleantech companies. Swentec further supported the authorities and other stakeholders with information in order to start and implement initiatives in the field of environmental technology. In 2010 Swentec ended its assignment with the submission of an action plan to the Government (see below).[13]

The Delegation for Sustainable Cities

From 2008 to 2010, the Government appointed the Delegation for Sustainable Cities, a national arena for sustainable urban development that is part of the Environmental Advisory Council.[14] The delegations task was to work for the sus-

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[12] Formas/VINNOVA, 2007, Forskningsstrategi för miljöteknik - Redovisning av regeringsuppdrag till Formas och VINNOVA, available at http://www.vinnova.se/.

[13] The website of SWENTEC (http://www.swentec.se/) contains further information on the Swedish cleantech sector and SWENTEC's efforts. More information about SWENTEC's appointment can be found in "SWENTEC AB - för en nationall kraftsamling på svensk miljöteknik" (2004) published by the Swedish Government.

[14] For more information, please visit http://www.hallbarastader.gov.se.

tainable development of cities, urban communities and housing areas. Examples for the delegation's activities are the management of grants for the development of sustainable cities as well as the promotion of export of environmental technology as well as of international cooperation on the development of sustainable cities. The Government supported sustainable urban development projects and new models with SEK 340 million in 2009 and 2010.

Action plan for the Swedish cleantech sector (2010)

On behalf of the Government Swentec prepared an action plan for the Swedish cleantech sector, which was submitted during the climate summit COP15 in Copenhagen in 2010.[15] In the action plan Swentec suggests a focus on five strategic areas:

1. Political management
2. Skills for sustainable development
3. Commercialization
4. Business models
5. Partnerships

The action plan includes 82 concrete measures in these areas aiming to provide those conditions for the cleantech sector that are needed in order to deliver world class solutions to a sustainable future. Furthermore, the action plan highlights the importance of an effective structure for the Swedish cleantech sector, which may be achieved through an action-oriented, national unit coordinating the efforts of different authorities.

National initiative on the cleantech sector

In 2007 the Swedish Government earmarked SEK 560 million for an initiative on environmental technologies during the period 2007-2010.[16] The main measures of the initiative are:

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[15] SWENTEC, 2010, Handlingsplan för svensk miljöteknik. Available at the website of the Swedish Government (http://www.sou.gov.se).

[16] More information about this national initiative can e.g. be found in the publication SWENTEC, 2008, Svenska strategier och initiativ för främjande av miljöteknik.

- SEK 245 million were provided for research on environmentally friendly vehicles as well as development of technologies for renewable fuels (mainly coordinated by the Swedish Energy Agency)
- VINNOVA received SEK 40 million for research and competence development within three areas:
  - IT and cleantech
  - Research in connection with "SymbioCity" (se national initiatives below) and
  - Sustainable urban planning and incubator activities with a focus on environmental technologies (in collaboration with Innovationsbron AB)

- The Swedish Agency for Economic and Regional Growth (Tillväxtverket) was in 2008 assigned to support small and medium-sized Swedish companies in environmentally-driven markets through business development. The government support amounted to SEK 35 million and measures included e.g. advice to companies with goods or services in the commercialization phase.
- Invest Sweden received SEK 10 million between 2008 and 2010 in order to promote investments in the field of environmental technology. Activities included for example the contribution of Invest Sweden to strategic alliances between foreign and Swedish companies as well as to foreign equity investment in Swedish growth companies.
- The Swedish Trade Council received SEK 30 million during the period 2007-2009 in order to promote exports of small or medium-sized cleantech companies, as well as further SEK 14.5 million to promote exports of small cleantech companies. Measures included support for the selection of new international markets as well as for the establishment in selected markets. In 2011 the Government provided additional SEK 48 million for small cleantech companies during the period 2011-2014. Thus, the Swedish Trade Council will during the next years support small cleantech companies when selecting and entering new markets, carry out certain actions within the framework of the concept "SymbioCity" as well as coordinate the reception of international visiting delegations in the field of environmental technology.

1.2.1 Government programs

The above mentioned policies result in a number of national initiatives and funding programs, which are presented in the following.

"SymbioCity"

SymbioCity is an initiative of the Swedish Government and Swedish Industry and is administrated by the Swedish Trade Council. SymbioCity is a marketing concept and communication platform with the aim to internationally promote Swedish systems expertise and the environmental technology sector. Today, a network of over 200 Swedish companies and organisations is connected to SymbioCity.[17]

"Cleantech Inn Sweden"

Cleantech Inn Sweden is a national initiative of the Swedish Ministry of Industry aiming at accelerating the commercialization of cleantech innovations. The project is owned by Innovationsbron and receives funding from VINNOVA, the Swedish Agency for Economic and Regional Growth (*Tillväxtverket*), Region Skåne as well as the Region of Västra Götaland. Cleantech Inn Sweden focuses on cleantech innovations in an early stage that stem from companies with growth potential.[18]

Programs promoting the export of Swedish clean technologies to Asia

In particular Asian countries are interested in Swedish clean technologies. Collaborations with these countries are therefore also of interest for Sweden. One example is China, where close cooperation has been established on environmental technology, renewable energy and sustainable urban development. During the last years a few initiatives were started in order to foster export of Swedish cleantech companies to China and India, as well as to promote Swedish environmental technology cooperation with these countries.

[17] For further information please visit http://www.symbiocity.org/.

[18] For further information about Cleantech Inn Sweden please visit http://www.cinns.se/.

Energy and Environmental Technology (EET) Program; the three-year EET program has been started in October 2008 with the aim to make it easier for Swedish cleantech companies to do business in India. Concrete goals of the program are amongst other to:

- finance projects for Swedish cleantech companies that are interested in doing business in India
- investigate and report on developments in the cleantech market in India
- Find and actively communicate business opportunities for Swedish companies in India
- Create and maintain a network of contacts in the Indian cleantech market

The program is led by a team of specialists at the Swedish Trade Council's offices in India (Energy & Environmental Technology Office) closely cooperating with the Swedish embassy in New Delhi.[19]

"Swedish Environmental Technology in China"; In order to facilitate contacts and collaboration between Swedish and Chinese players in the fields of environmental technologies and sustainable urban planning, the website www.swedenvirotech.se was launched in 2010. A Chinese version of the website is planned to be launched in 2011. The website is the official platform for two organizations coordinating the Swedish Government's tools and resources to promote Swedish environmental technology cooperation with China; CENTEC in Beijing and the Sino-Swedish Environmental Technology Cooperation in Stockholm.

- *CENTEC - Centre for Environmental Technology;* CENTEC was set up in 2007 at the Embassy of Sweden in Beijing. The centre introduces Swedish know-how and solutions to relevant actors in China, for instance through arranging business meetings and seminars, organizing Swedish national pavilions at important exhibitions, and facilitating Swedish involvement in significant Chinese projects. Thereby, CENTEC aims to facilitate and promote a sustainable urban development and environmental technology export to China.[20]

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[19] More information about the program is available at the website of the Swedish Trade Council (http://www.swedishtrade.se).

[20] For more information about CENTEC please visit http://www.swedenabroad.com.

- *Sino-Swedish Environmental Technology Cooperation;* The mission of the Sino-Swedish Environmental Technology Cooperation is to intensify knowledge and technology exchange between China and Sweden in order to promote Swedish companies on the Chinese market for environmental technology. The cooperation is a joint initiative from the Swedish Ministry of the Environment, the Ministry for Foreign Affairs and The Ministry of Enterprise, Energy and Communications.[21]

"DemoEnvironment"

The program "DemoEnvironment" (*DemoMiljö*) provides support for agencies, municipalities, institutions and companies to test new environmental technology solutions in 40 of Sida's partner countries. The countries currently prioritized in the program are: Botswana, Namibia, South Africa, Indonesia and China. Sectors eligible for funding are those contributing to sustainable urban development like renewable energy and waste management. The aim of DemoEnvironment is to give Sida's partner countries the opportunity to prove modern environmental technologies as well as Swedish companies to demonstrate their knowledge and products. Within the framework of DemoEnvironment financial support between SEK 500,000 and SEK 3 million is offered for:

- demonstration projects, i.e. funding of equipment or system knowledge that provide the partner country with new knowledge or technology, which may be further spread,
- pilot studies for project development and project identification, which in turn can lead to an application for a demonstration project.

The DemoEnvironment program is run by the Swedish Agency for Economic and Regional Growth (*Tillväxtverket*) commissioned by Sida. The program has been evaluated in 2010 and will - based on this assessment - be further developed during 2011.[22]

[21] Further reading about the initaitive is available at http://www.swedenvirotech.se.
[22] For more information visit http://www.tillvaxtverket.se.

"Environment-driven Markets"

In 2008, the Swedish Agency for Economic and Regional Growth (*Tillväxtverket*) has launched the program "Environment-driven markets" (*Miljödrivna marknader*). The call for proposals has in 2011 a total budget of approximately SEK 10 million. The aim of the project is to support networks of small and medium-sized businesses (up to 249 employees) in enhancing their competitiveness, developing their business and increasing their sales of goods and services in environment-driven markets.[23]

"Green Nano"

In 2008, VINNOVA implemented the call "Green Nano" (*Grön Nano*) in order to facilitate and fasten the commercialization of research results using nanotechnologies for better environment. Furthermore, the call aims to promote research on nanotechnologies in areas that are of special interest for business and society, e.g. through cooperations between society, academia and industry. The call has a total budget of about SEK 35-40 million over a period of three years.[24]

"Innovations for a Sustainable Future"

In order to promote the introduction of new, environmentally-adapted solutions, which contribute to sustainable production and consumption, VINNOVA launched the program "Innovations for a Sustainable Future" (*Innovationer för en hållbar framtid*). The first call within the program - "Environmental Innovations" (*Miljöinnovationer*) - was implemented in 2009 and has a total budget of up to SEK 150 million over a period of five years. The call targeted also innovations contributing to sustainable transport within the framework of VINNOVA's program "Safe and Sustainable Transport".[25]

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[23] More information is available at http://www.tillvaxtverket.se/miljodrivnamarknader.

[24] For more information please visit http://www.vinnova.se/sv/Verksamhet/Gron-Nano/.

[25] Please visit http://www.vinnova.se/sv/Verksamhet/Innovation-for-en-hallbar-framtid/ for more information about the program.

"Sustainable Energy and Transport Systems 2050"

Between 2008 and 2012 the program "Sustainable Energy and Transport Systems 2050" (*Hållbara energi- och transportsystem 2050 - HET*) will aim at showing alternative paths for the sustainable development of Swedish energy and transport systems. The program is funded by VINNOVA, the Environmental Protection Agency (*Naturvårdsverket*), the Swedish Energy Agency (*Energimyndigheten*), and the Swedish Transport Administration (*Trafikverket*). Within the framework of the program research is supported that may contribute to political and administrative decisions. Moreover, the research program LETS ("*Govering transitions towards Low-Carbon Energy and Transport Systems for 2050*") at Lund University will receive a grant of SEK 29 million.[26]

"ProEnviro"

The programme "ProEnviro" aims at promoting innovative research ideas for environmentally friendly products. In particular small and medium-sized enterprises are supported in developing products that are characterised by high risk, significant potential and significant environmental content. ProEnviro has a total budget of SEK 60 million, which is provided by the Foundation for Strategic Environmental Research (Mistra) and the Swedish Foundation for Strategic Research (SSF). The program ended in 2010.[27]

"E4 Mistra - Energy efficient reduction of exhausts from vehicles"

The program "E4 Mistra" aims to develop new knowledge and methods used in energy efficient aftertreatment systems for diesel engines. These methods are independent of fuel (e.g. biodiesel, fossil diesel) and generate acording to analyses the lowest CO2 quantities in the use of renewable fuels. The program runs from 2006 to 2014 and is financed by the Foundation for Strategic Environmental Research (Mistra) with SEK 20 million. Main contractor of "E4 Mistra" is Volvo Technology AB.[28]

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[26] For more information please visit http://www.vinnova.se/sv/Verksamhet/HET-2050/.

[27] More information about ProEnviro is available at http://www.proenviro.se/.

[28] More information is available at http://www.mistra.org/.

"Vindforsk"

The program "Vindforsk" aims to increase knowledge about wind-related issues and to strengthen Swedish wind energy expertise through basic and applied research. As result wind energy should be promoted and the conditions created that wind energy can effectively be operated in the Swedish power system. The program is planned to run from 2009 to 2012 and has a total budget of ca SEK 80 million. The Swedish Energy Agency funds one half of the costs, while companies associated with wind energy finance the other half.[29]

Innovation support of the Swedish Energy Agency

In order support innovation and commercialisation in the energy sector, the Swedish Energy Agency (*Energimyndigheten*) is providing three different forms of support:

- *Capital*, i.e. offering conditional loans to persons or companies with an interesting business concept
- *Knowledge*, i.e. letting innovative persons/companies taking part in the agency's expertise in business development in the energy industry
- *National and international networks*, i.e. connecting innovative persons/companies to stakeholders in the innovation system, existing companies in the energy sector and potential private investors

Moreover, the Energy Agency conducted already five times the Swedish Cleantech Business Award. The winning company receives support for its international business development, worth max SEK 100,000.[30]

1.2.3 Regional community support organizations

In addition to governmental initiatives, the regional cleantech sectors are supported by a number of private cluster organizations and networks. The organiza-

[29] More information about Vindforsk is available at http://www.vindenergi.org/.
[30] The website of the Swedish Energy Agency provides further information at http://www.energimyndigheten.se/.

tions active in the Swedish regions concerned in the Global Vision project are described in the following.

Network "Sustainable Business Mälardalen"

In 2006 the Chamber of Commerce Mälardalen created the triple helix network "Sustainable Business Mälardalen" (Susbiz) including SMEs, Mälardalen University and the County Administrative Board of Stockholm. The network aims to support SMEs in creating new business opportunities for sustainable products and services.

Activities of Susbiz include for instance the organization of seminars on themes such as wind power. The network's efforts focus however on the implementation of the project "CLEAN" coordinating the research related development of new products and services in the environmental technology area. The project is owned by Mälardalen University and focuses on the following areas: soil remediation and water treatment, climate-friendly constructions, recycling and renewable energy. The commercial part of the project is bundled in the semi project "CLEAN Export Mälardalen", which is led by Susbiz. "CLEAN Export Mälardalen" started in 2008 with the aim to foster exports of environmental technology through cooperation between the region's universities, businesses and the Swedish Trade Council. Until September 2012 the project will develop commercial partnerships between companies that complement each other in the field of environmental technology. Offers from participating companies will be combined into attractive packages for selected export markets. This semi project is financed by the Swedish Agency for Economic and Regional Growth (*Tillväxtverket*), the European Union, the Swedish Trade Council as well as regional and municipal funding sources.[31]

Stockholm Environmental Technology Centre (SMTC)

On an initiative of IVL Swedish Environmental Research Institute, the Stockholm Environmental Technology Centre (SMTC) was established in 2005. SMTC is a network of ca 35 cleantech companies, research institutes and public actors in the Stockholm region. The networks aim is to enhance the cooperation between its

[31]Sustainable Business Mälardalen, 2011, http://www.susbiz.se/.

members in the environmental technology area. SMTC has been ranked number nine on a list of leading cleantech cluster organisations in the world.

In cooperation with the Foundation IVL is SMTC currently conducting the project "Environmental Technology for Growth" ("*Miljöteknik för Tillväxt*"). The project runs from 2009 to 2011 and is financed by EU's regional funds, the Foundation IVL, Stockholm Business Region Development and the Swedish Agency for Economic and Regional Growth (*Tillväxtverket*). The total budget of the project is SEK 22.5 million. The project's aim is to stimulate the development of new products, processes and competitive offerings as well as to increase sales and exports from existing environmental technology companies through the development of new market channels. Furthermore, the project aims to encourage more business start-ups as well as to build a network in order to establish a strong region cleantech cluster.[32]

Stockholm Cleantech

Stockholm Cleantech is a business network aiming at strengthening its member companies from the cleantech sector in the Stockholm region. In order to secure the supply of the cleantech industry with needed competences, the network further aims to stimulate young people's interest in an education in engineering and natural sciences. Member companies of Stockholm Cleantech receive support with regard to new business opportunities, financing, as well as R&D and competency matching. The network is financed by Kista Science City AB, KTH Royal University of Technology, Stockholm Business Region, and Stockholm Innovation & Growth (STING). Stockholm Cleantech cooperates amongst others with the Stockholm Environmental Technology Centre (SMTC).[33]

Cleantech Östergötland

Cleantech Östergötland is a business-oriented collaboration arena for activities in Östergötland concerning environmental technology. Today, about 85 regional companies and interested organisations are member of Cleantech Östergötland. The aim of the initiative is to coordinate the region's business and development activities in environmental technology, to support business and product devel-

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[32] For further reading please visit http://www.smtc.se/.

[33] For further information about Stockholm Cleantech please see http://www.stockholmcleantech.com/.

opment, and to generate visibility of the regional strengths in the area. The non-profit association Cleantech Östergötland is managed by Miljöteknikcentrum i Östergötland AB, a company which was formed for only this purpose and which is owned by Linköping municipality (40 %), Norrköping municipality (40 %) and Linköping University (20 %).[34]

"Environment-driven product development Östergötland"

The regional project "Environment-driven product development Östergötland" (*MDPU - Miljödriven produktutveckling Östergötland*) was implemented in the years 2008 to 2010 and aimed to strengthen companies working with environment-driven product development and processes. Within the framework of the project methods and models were developed that more effectively support companies in their product development process with regard to environmental issues. Moreover, the project aimed to implement product development projects in 25 SMEs as well as to create a regional network of companies interested in environmentally-driven product development. The project has been implemented by County Administrative Board of Östergötland in cooperation with Almi Företagspartner Östergötland, Linköping University and Miljöteknikcentrum i Östergötland AB. The project started in March 2008 and was concluded in December 2010.

1.2.4 EU funds allocated to cleantech sectors

The thematic areas of the Sixth and Seventh Framework Programme (FP6 and FP7) are an important funding source for research, development and demonstration projects in cleantech sectors. The Swedish participation in these programmes is summarised below focusing on those thematic priorities with a particular relevance for clean technologies.

FP6 - Sustainable Development, global change and ecosystems

Within FP6 (2002-2006), research, technological development and demonstration of clean technologies is mainly funded under the thematic area "Sustainable Development, global change and ecosystems". In total, 28 projects with participa-

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[34] Cleantech Östergötland provides further reading at http://www.cleantechostergotland.se/.

tion of a Swedish organization received funding under this FP6 theme, whereof 10 under the thematic sub-priority "Sustainable Energy Systems". As this sub-priority is particularly relevant for the support of clean technologies their funding volume and thematic focus area is presented in Table 2.3.

Table 2.2: FP6-projects funded by cleantech area

Cleantech area	Number of projects	Total project funding(in million EUR)
CO_2 capture and sequestration	2	12,16
Sustainable energy systems - general	2	10,88
Renewable energy technologies - Biomass	2	9,99
Cost-effective supply of renewable energies	2	3,12
Fuel cells and their application	1	8,81
Alternative motor fuels	1	8,00

Source: Author based on project database of CORDIS, http://cordis.europa.eu/.

All these projects were coordinated by a Swedish organization. From the Swedish regions concerned in the Global Vision project, the following actors were involved in projects funded under FP6 "Sustainable Energy Systems":

Table 2.3: Regional organizations that received FP6-funding for cleantech-related projects

Type of organization	Name of the Swedish project participants	County
Company	Vattenfall AB	Stockholm
	Vattenfall Research and Development AB	Uppsala
	Midsummer AB	Stockholm
	AB Storstockholms Lokaltrafik	Stockholm
	VG Power AB	Västmanland
	Teknikgruppen AB	Stockholm
	Opcon Autorotor AB	Stockholm
	TPS Termiska Processer AB	Södermanland
University	KTH Royal Institute of Technology	Stockholm
	Centre for Built Environment, University of Gävle	Gävleborg
Other organization	Swedish Energy Agency	Västmanland
	City of Stockholm, Environment and Health Administration	Stockholm

Source: Author based on project database of CORDIS, http://cordis.europa.eu/.

FP7 - Environment (including climate change)

Also FP7 provides funding for research in a number of thematic fields relevant for the cleantech sectors, e.g. environmental protection, waste management, sustainable development as well as water resource management. Since 2007, 282 projects have received funding through the programme theme "Environment". Swedish organizations were represented in 94 of them.

With regard to research and development of clean technologies, 18 projects with a Swedish participation were identified. The main focus of these projects as well as there total project funding is shown in the table below. As the figures show, actors from the concerned regions are mainly participating in projects focusing on technologies for soil remediation, sustainable building and waste management, whereas not in a project regarding water treatment.

Table 2.4: FP7-Environment projects by cleantech area

Cleantech area	Number of projects*	Total project funding(in million EUR)
Soil remediation	5 (5)	14,41
Sustainable building	4 (3)	10,96
Water treatment	3 (0)	19,59
Waste management and recycling	3 (3)	7,23
Clean technologies in general	3 (3)	15,66

* Number of projects with at least one actor participating from the concerned regions in brackets.

Source: Author based on project database of CORDIS, http://cordis.europa.eu/.

Two projects are coordinated by a Swedish organization, namely:

- "Contaminant-specific isotope analyses as sharp environmental-forensics tools for site characterisation, monitoring and source apportionment of pollutants in soil" (Coordinator: Stockholm University; Participants: IVL Swedish Environmental Institute, ALS Scandinavia AB),
- "Flexible Processes and Improved Technologies for Urban Infrastructure Construction Sites" (Coordinator: Chalmers University of Technology; Participant: NCC AB).

In total, 19 different Swedish actors from industry, academy and research are involved in the 18 projects. 13 of these actors are localised in the seven Swedish regions concerned in the Global Vision project and are listed below.

Table 2.5: Regional organizations that received funding through FP7-Environment

Type of organization	Name of the Swedish project participants	County
Company	NCC AB	Stockholm
	ABEM Instrument AB	Stockholm
University	Örebro University	Örebro
	KTH Royal Institute of Technology	Stockholm
	Uppsala University	Uppsala
	Stockholm University	Stockholm
	Swedish University of Agricultural Sciences (SLU)	Uppsala
Research institute	IVL Swedish Environmental Institute	Stockholm
	Swedish Geotechnical Institute (SGI)	Östergötland, Stockholm
	Swedish National Road and Transport Research Institute (VTI)	Östergötland
	SWEREA IVF	Stockholm
	INNVENTIA AB (formerly STFI-Packforsk AB)	Stockholm
Other organization	The Swedish Research Council Formas	Stockholm

Source: Author based on project database of CORDIS, http://cordis.europa.eu/.

FP7 - Energy

Under FP7 funding is further provided to research projects concerning future energy solutions, e.g. CO_2 capture and storage technologies, biofuels as well as technologies to improve energy efficiency and saving. So far, 185 projects have been awarded funding, of which 44 with a Swedish participation. Of the projects with Swedish participation, 36 were identified as projects fostering the development of clean technologies (see table below).

Table 2.6: FP7-Energy projects by cleantech area

Cleantech area	Number of projects*	Total project funding(in million EUR)
Renewable fuel production	13 (6)	79,55
CO_2 capture and storage technologies	9 (8)	34,05
Renewable electricity generation	5[35] (5)	18,80
Smart energy networks	3 (3)	14,24
Renewables for heating and cooling	3 (2)	13,34
Energy efficiency and savings	2 (0)	13,26
Horizontal programme actions	1 (0)	1,73

* Number of projects with at least one actor participating from the concerned regions in brackets.

Source: Author based on project database of CORDIS, http://cordis.europa.eu/.

A Swedish organization takes the role as project coordinator in five projects:

- three in the field of renewable fuel production (coordinated by Lund University, Uppsala University and Volvo Powertrain AB) and
- two concerning technologies for CO_2 capture and storage (coordinated by Chalmers University of Technology and Uppsala University).

An overview of the different actors located in the concerned regions gives the following table.

[35] Of these five projects, two are related to solar energy, two to ocean energy and one to photovoltaics.

Table 2.7: Regional organizations that received funding through FP7-Energy

Type of organization	Name of the Swedish project participants	County
Company	Vattenfall Research and Development AB	Uppsala
	Alstom Power Sweden AB	Östergötland
	Scandinavian GtS AB	Stockholm
	Nykomb Synergetics AB	Stockholm
	Lantmännen Energi AB	Stockholm
	ClimateWell AB	Stockholm
	Skandinavisk Kemiinformation AB	Stockholm
	Preem Petroleum AB	Stockholm
	Chemrec AB	Stockholm
	Vattenfall AB	Stockholm
University	Uppsala University	Uppsala
	KTH Royal Institute of Technology	Stockholm
	Linköping University	Östergötland
Research institute	INNVENTIA AB	Stockholm
	SWEREA IVF AB	Stockholm
	SGU Geological Survey of Sweden	Uppsala

Source: Author based on project database of CORDIS, http://cordis.europa.eu/.

Vattenfall Research and Development is with nine project participations the most active organization in the regions concerned, followed by Uppsala University with project five participations, of which two as coordinator. Vattenfall Research and Development is in particularly involved in projects regarding CO_2 capture and storage technologies as well as smart energy networks.

Regional companies' opinion regarding EU-funding possibilities

Several interviewees pinpointed some critical aspects of applying for EU-funds. Nearly 65% of them find the application and implementation process of EU-funded projects too time consuming and bureaucratic. Thus, it is seen as a too expensive, complicated and resource demanding to apply for such funds. Only a very small number of the interviewed companies have enough time and resources required to apply for EU-funds, while a few exceptional examples use consultants to apply for grants.

1.3 Innovation and firm support

1.3.1 Contribution of academic and other research organizations

Performance in general and participation in projects

A majority of the interviewed companies (26) claimed a medium or significant contribution of academic and other research organizations to the development of clean technologies. Several companies (15) also perceived academic participation in cleantech related projects as high. But the interviewees typically underlined that only technical and no commercialization knowledge was offered. Universities are seen as excellent in various specialized research fields and companies find it important to develop personal contacts with researchers in projects. However, the interaction with individual researchers is seen as critical. Moreover, company representatives requested a larger focus on knowledge and concern about commercialization of technological products.

Thus, the academic and research institutions performance was perceived as high by the interviewed companies, however lacking knowledge about how to achieve market success for technological innovations.

Academic and other research organizations contribute to the development of clean technologies amongst others through their collaboration with industry and governmental institutions at so called centres of excellence. Examples for regional centres of excellence in the field of cleantech are:

- ”Svenskt VattenkraftCentrum” in Stockholm; a competence centre for research and education in the areas of water energy and dams. Regional actors participating in the centre are the Royal Institute of Technology (KTH) and Uppsala University as well as companies like Vattenfall Research and Development.
- Centre for Molecular Devices, a centre of co-operation between KTH in Stockholm, Uppsala University and the industrial research institute Swerea IVF in Mölndal. The work at the centre is focused on research and development of the dye-sensitized solar cell.

- ‘Centre for renewable electric energy conversion’ (CFE, ’Centrum för förnybar elenergiomvandling’) at Uppsala University focusing on amongst others wave and wind power.

Patenting activity

Even though the academic and research institutions’ performance was perceived as high, their patenting activity in the field of cleantech was not seen as sufficient. 12 companies expressed problems or low performance with regard to patenting, whereas seven companies have made very good experiences. 21 respondents had no opinion, typically because they had no particular experiences in patenting.

How active the Swedish cleantech sector is in patenting has been analysed based on available statistics from the OECD. The organisation provides patenting statistics on a county level for four fields of clean technologies:

- Pollution abatement and waste management
- Renewable energy
- Electric hybrid vehicles
- Energy efficiency in buildings and lightning

For those patents filed to the European Patent Office (EPO), technologies relating to pollution abatement and waste management stood for most of the patents between 2003 and 2007. About 32% of these patents have applicants resident in Stockholm and 7% in Södermanland. Stockholm County is also the residence in the region with the largest share of patents in the remaining three clean technology fields. Overall, applicants resident in the region stood for 46 patents in the four technology fields that were filed to the EPO in 2007. Between 2003 and 2007, this number amounted to 131. Thus, 55% of Swedish cleantech patents filed in 2007 and 51% between 2003 and 2007 have their origin in the concerned region.

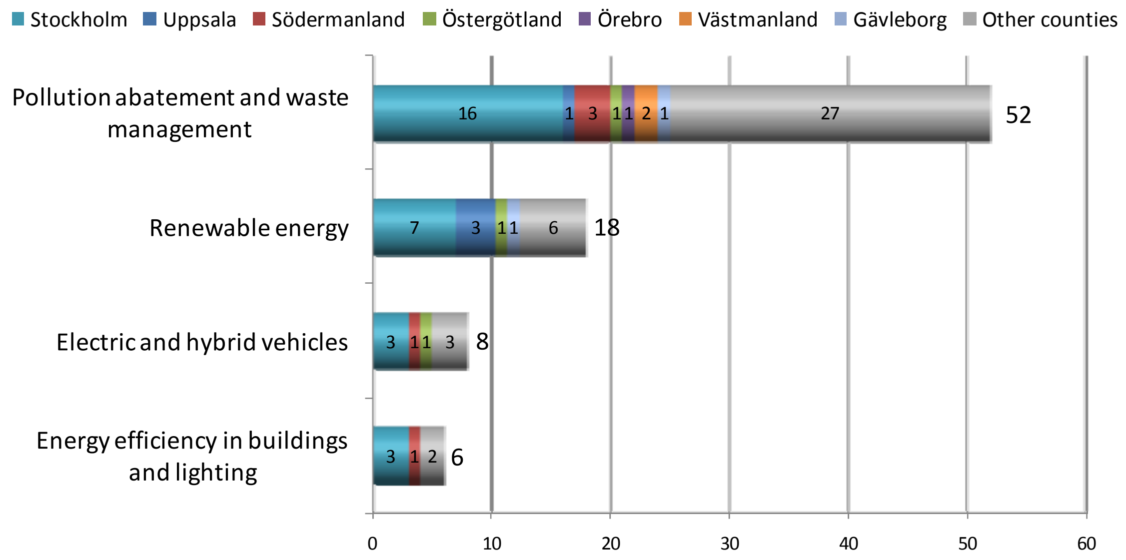

Figure 2.1: Total patents filed to European Patent Office in 2007 (by applicant's county of residence and technology)

Source: OECD.Stat (http://stats.oecd.org), data extracted on 14 Jun 2011.

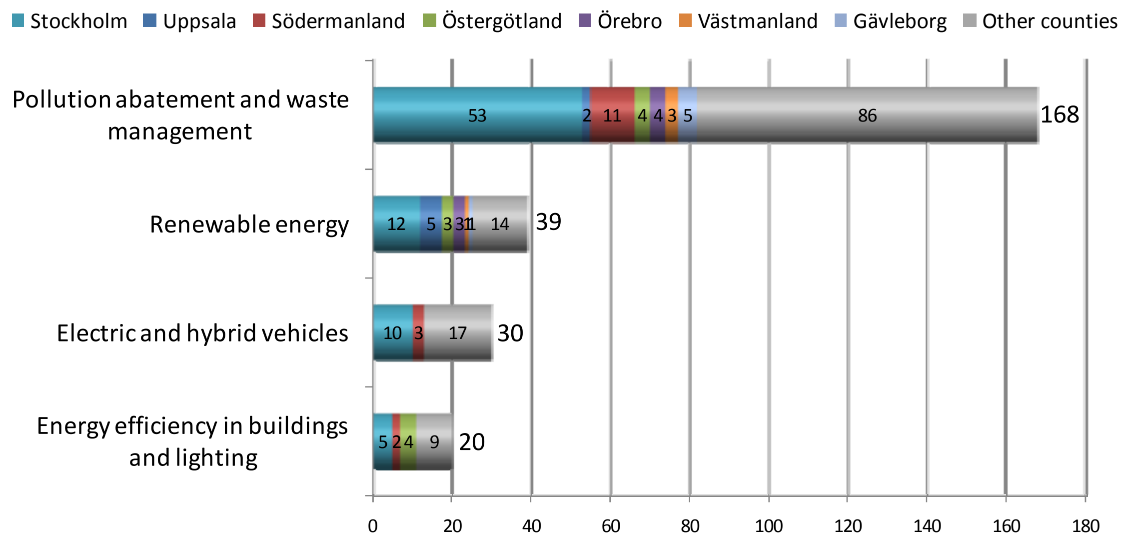

Figure 2.2: Total patents filed to European Patent Office between 2003 and 2007 (by applicant's county of residence and technology)

Source: OECD.Stat (http://stats.oecd.org), data extracted on 14 Jun 2011.

1.3.2 Availability of Venture Capital

As a result of the increasing public awareness for clean technologies as well as Sweden's good reputation as a cleantech innovation centre, several new capital venture funds has been created in Sweden in recent years with cleantech as a major investment area. Today, the Swedish Private Equity & Venture Capital Association (SVCA) comprises 40 member organisations investing in cleantech-related businesses.[36]

During the last years, the development of investments in the venture of Swedish cleantech companies has been strongly influenced by the financial crisis in 2008 aggravating the situation for many Swedish venture capital funds (see figure 2.4).[37]

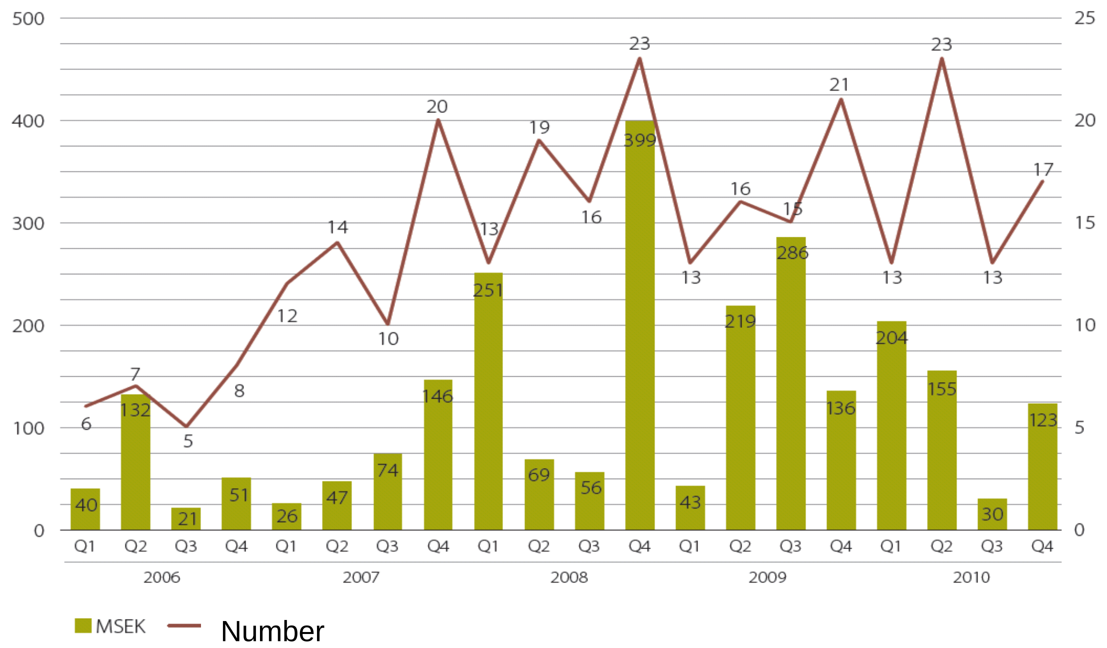

Figure 2.3: Investments in the venture of Swedish portfolio companies in the cleantech sector

Source: Swedish Private Equity & Venture Capital Association, 2011, Riskkapitalåret 2010: 23.

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[36] SVCA, 2008, Riskkapitalåret 2008; SVCA, Database of investing member organisations available at www.svca.se.

[37] Due to changing positions at the Swedish Venture Capital Association, statistical data on a regional level were not available for the cleantech sector.

While venture investments in cleantech companies reached with SEK 775 million its highest level since 2006, investments were decreasing in the following years. In 2010, the SVCA's member organisations conducted 66 venture investments in Swedish cleantech companies corresponding to an investment amount of SEK 512 million. Thus, investments in venture of Swedish cleantech companies decreased by 34% from 2008 to 2010. However, investments in the cleantech sector did not decrease as much as the sum of available venture capital in Sweden as a whole (minus 54%). Furthermore, the sector's share of total venture investments increased from 14% in 2008 to 19% in 2010, reflecting the undiminished importance of cleantech as an investment area for venture capital funds.[38]

The findings of the interviews with regional cleantech companies indicate that the availability of venture capital is easier for companies that have reached a stabilized commercialization phase in their businesses as compared to companies struggling to reach the commercialization phase. One respondent said: "You have to convince the investor that your business and products generate increased customer performance in terms of monetary value and not rely on governmental quality standards infused by environmental regulations and laws".

1.4 Firm capabilities

1.4.1 Business development capabilities

The company representatives primarily emphasized the importance of technical competence (15), marketing competence (14), and business competence (10)[39]. It was essential to develop an appropriate mix of these three competences to achieve high market performance. Furthermore, experiential and practical competence was seen as valuable but also formal education in specific technical areas. Respondents had some difficulties to point out any particular 'cleantech compe-

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38 SVCA, 2008, Riskkapitalåret 2008: 10; SVCA, 2009, Riskkapitalåret 2009: 4, 7; SVCA, 2010, Riskkapitalåret 2010: 23; PricewaterhouseCoopers, 2008,Riskkapitalets syn på möjligheteroch tillväxt i CleanTech-sektorn.

39 The respondents were asked to name some capabilities that are of special importance to develop cleantech companies.

tence' as this differs among industries, companies, products and product application areas. The distribution of the broad spectrum of relevant capabilities is presented in figure 2.5.

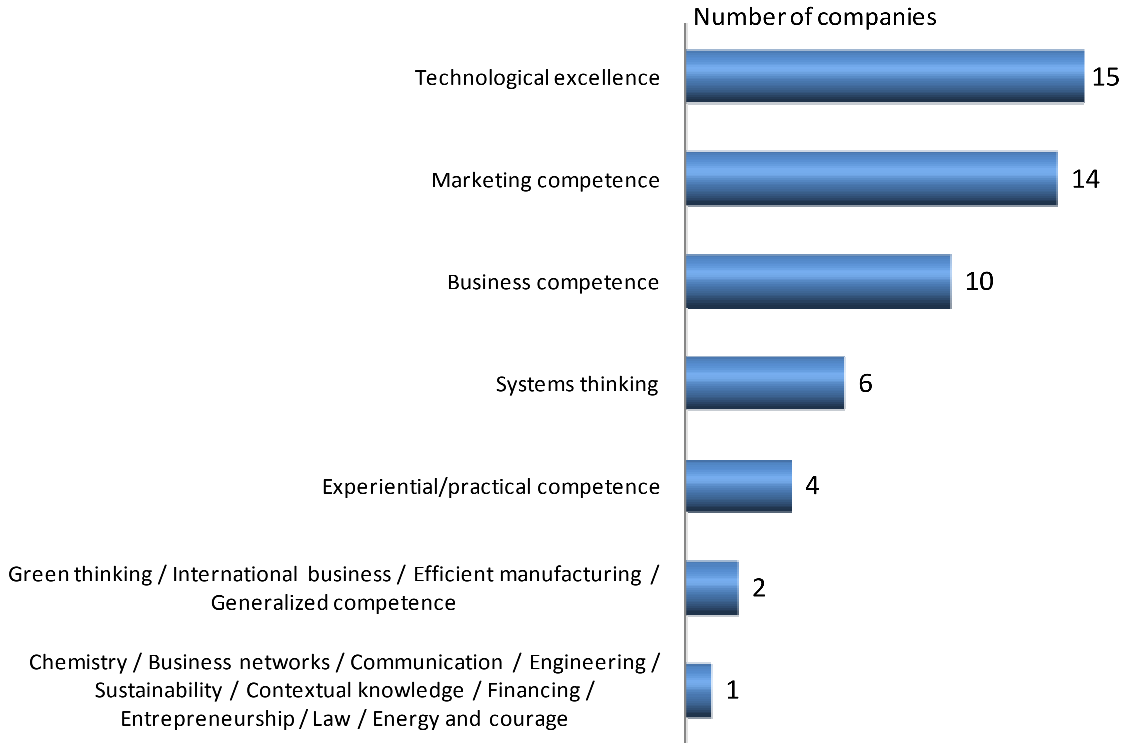


Figure 2.4: Business development capabilities
Source: Author based on company interviews.

More than the half portion of the companies (28) claimed that these capabilities were apparent in their companies whereas some companies (15) stated that these capabilities were partly manifested.

1.4.2 Product development capabilities

Respondents were asked which capabilities they perceived as most critical for product development in cleantech businesses. The distribution of answers is presented in the figure 2.6 (several answers were possible).

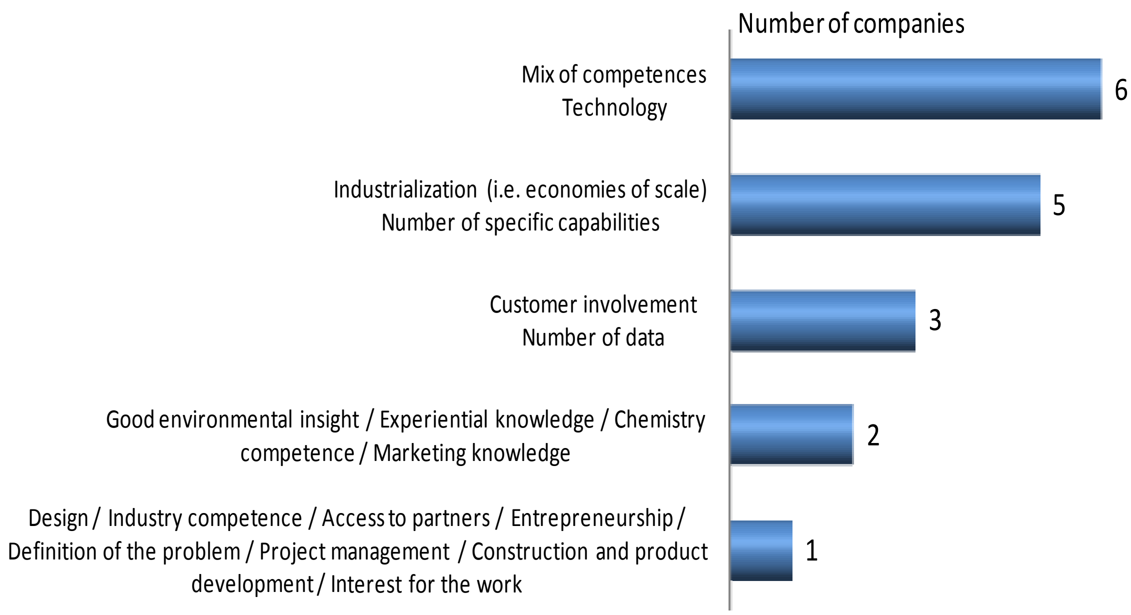


Figure 2.5: Perceived critical product development capabilities

Source: Author based on company interviews.

As can be seen in the figure, a mix of competences and technology are the most frequent answers. In addition, the respondents emphasized the process from prototype development and commercialization towards cost-efficient production.

2. Current performance in clean technologies

2.1 Enterprises in the cleantech sector and their specialisation

According to statistics from the Swedish Environmental Technology Council (SWENTEC) 6,530 cleantech companies were active in Sweden in 2009. More than 40% of these companies are related to the sub-field waste management and recycling. About 15% are developing, producing and/or selling technologies for sustainable building and energy efficiency. Another main technology sub-fields are consulting services (15%), water treatment (7%) and bioenergy and biofuels (7%).

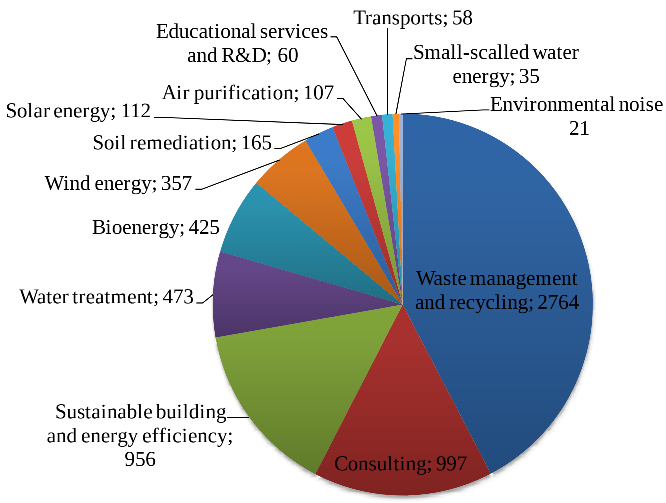


Figure 2.6: Number of Swedish cleantech companies per cleantech area (2009)
Source:SWENTEC, 2010, Svensk miljöteknik i siffror 2009: 7.

In spring 2011, SWENTEC published a database with 922 suppliers of clean technologies as well as 142 visit plans. Within the framework of the Global Vision project the economic data for those cleantech suppliers were analysed that are

- located in the seven Swedish counties chosen for the Global Vision project (Örebro, Stockholm, Södermanland, Uppsala, Östergötland, Västmanland, Gävleborg),

- active in at least one of the following cleantech fields[40]: (1) waste management & recycling, (2) bioenergy and biofuels, (3) sustainable building, (4) air purification, (5) solar energy,
- working with the development of clean technologies ("Technology developers"),
- registered in the Swedish company register (*Bolagsverket*) as an active company as of June 2011.

Based on these selection criteria, 95 cleantech companies were identified for a further analysis on a regional level. Six of these companies are active in two different cleantech areas[41], while the others can be assigned to only one cleantech area. The distribution across the different cleantech areas is shown in the figure to the right.

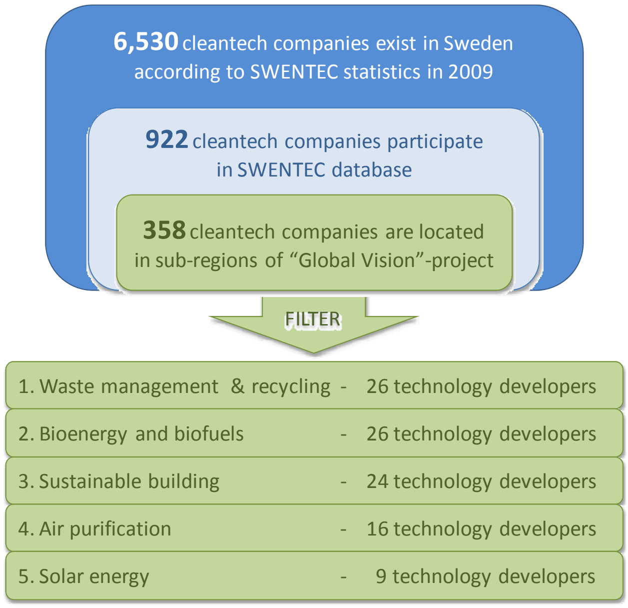


Figure 2.7: Selection of regional technology developers

Source: Compiled by the author.

Of the 95 identified technology developers are 50% located in Stockholm County (see also figure below). Other main locations for the cleantech companies of the region are Östergötland County (13%) as well as the counties of Södermanland and Gävleborg (9% each).

Nearly 60% of the analysed regional companies were founded 1990 or later. A correlation between the year of foundation and the cleantech sub-field has partly been identified. Half of the companies with a business related to solar energy as well as bioenergy and biofuels were started between 2000 and 2011 with a peak during the years 2005 to 2007. Furthermore, 44% of the companies concerning air purification were founded during the 90s.

40 Due to the large amount of cleantech companies in the seven Swedish regions concerned, five cleantech fields were chosen by the Swedish project team. Criteria for this selection were mainly the exportorientation of the sub-fields, the importance of the sub-fields for the region and the number of companies located in the region.

41 Of these six companies, five are located in Stockholm County and one in Gävleborg County.

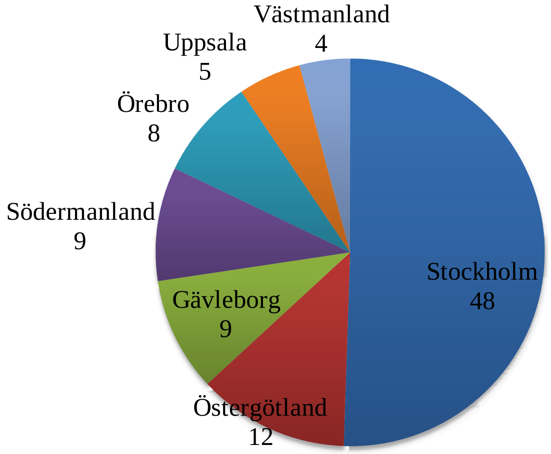


Figure 2.8:Geographical distribution of regional cleantech companies (total: 95)
Source: SWENTEC database, available at http://swentec.se/en/Start/find_cleantech/, visited in May 2011

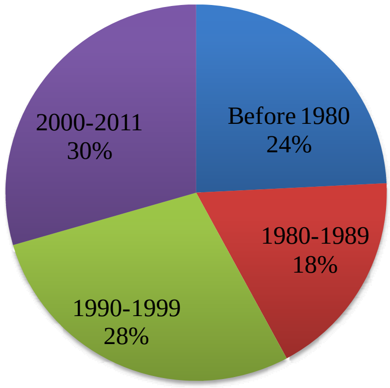


Figure 2.9: Year of foundation of regional cleantech companies (total: 95)
Source: Public company database

As one of the identified company was founded in 2011 and one is a private company without the need of publish annual reports, financial data are not available for them and the economic analysis in the following chapter includes thus 93 cleantech companies.

2.2 Characteristics of regional cleantech enterprises[42]

Number of employees and labour costs

In Sweden, a majority of the cleantech companies are micro companies, i.e. they have up to ten employees. Small and medium-sized companies account for about 15% of the Swedish cleantech companies. Amongst those companies analysed on

[42]For the Swedish cleantech sector, data on ownership (domestic or foreign) as well as government grants on a company base were not available.

a regional level, micro companies are slightly underrepresented, while more small and medium-sized companies are part of the analysis. The companies with the highest number of employees are YIT Sverige AB (4,578 employees in Sweden) and Munters AB (4,087 employees, both Stockholm County), as well as Systemair AB in Västmanland County (2,013 employees). Other larger companies that are included in the regional analysis are Camfil Svenska AB in Södermanland County (316 employees), Econova AB in Östergötland (256 employees) and BooForssjö AB in Södermanland (210 employees).

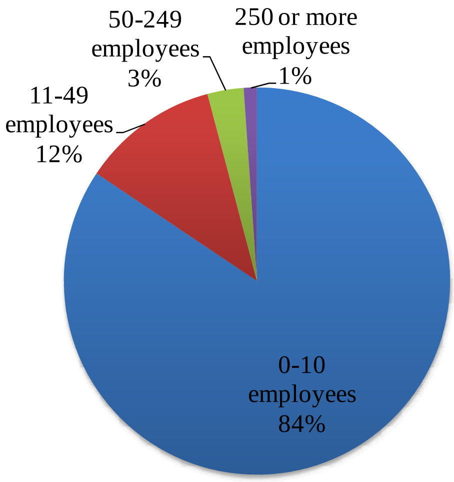


Figure 2.10: Size of cleantech companies in Sweden (2009)

Source: SWENTEC, 2010, Svensk miljöteknik i siffror 2009: 6.

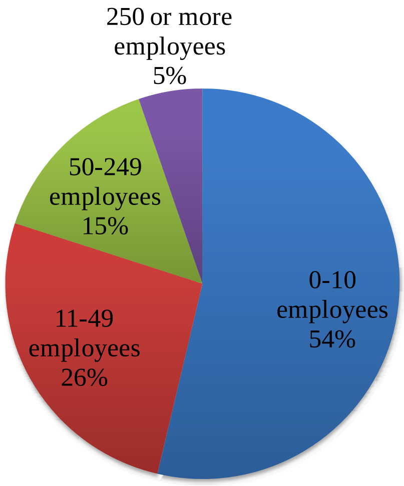


Figure 2.11: Size of cleantech companies in the region concerned in project (2009/2010)

Source: Public company database

In total, Swedish cleantech companies employed 41,420 persons in 2009, of which 14,939 or 36% in the seven concerned counties. The analysed 93 companies employed together 13,860 persons in 2009, corresponding to 33% of all persons employed by Swedish cleantech companies. The average labour costs of these companies in 2009 amounted for SEK 537,000 per employee, ranging between SEK 20,000 (SenSiC AB) and SEK 1,202,000 (Lantmännen Energi AB) per employee.

Turnover

In 2009, the turnover of Swedish cleantech companies reached SEK 119,344 million, of which SEK 43,961 million in the counties concerned in the project and SEK 25,332 million in the 93 companies identified through the SWENTEC database. These companies thus stood for 20% of the total turnover of cleantech companies in Sweden. The geographical distribution of the national turnover of cleantech companies is visualised in the figure below. Accordingly, the counties of Stockholm, Östergötland and Västmanland amount in the concerned region for the largest share of the national turnover with 14%, 8% and 6% respectively.

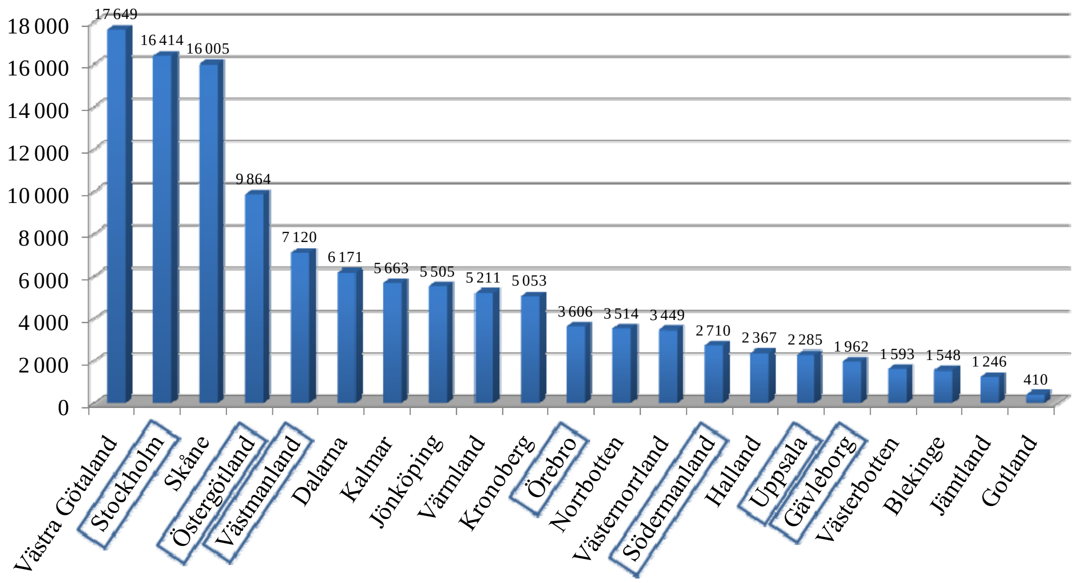


Figure 2.12: Turnover of cleantech companies by county (2009, in million SEK)

Source: SWENTEC, 2010, Svensk miljöteknik i siffror 2009: 8.

As far as the different technology areas are concerned, the national turnover of cleantech companies is distributed as shown in figure to the right. Thus, companies with business in waste management and recycling stood 2009 together companies active in sustainable building and energy efficiency for 50% of the national turnover with clean technologies. One fourth of the turnover is further generated by technologies related to bio-, solar, wind and water energy.

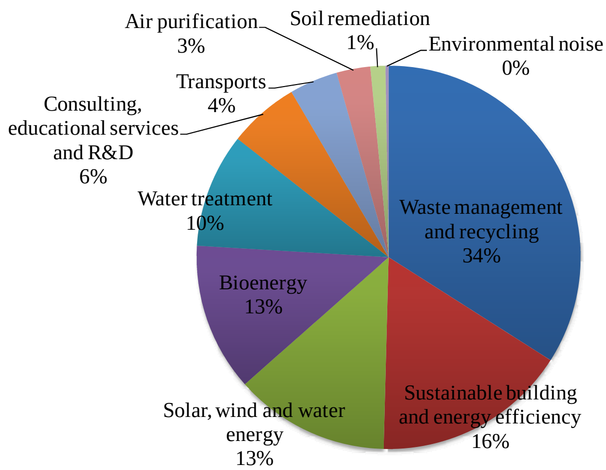


Figure 2.13:Distribution of the turnover of cleantech companies by technology area (2009)

Source: SWENTEC, 2010, Svensk miljöteknik i siffror 2009: 7.

Total assets

The sum of the total assets of the 93 regional cleantech companies amounted to SEK 17.8 billion in 2009. More than 50% of the companies had total assets of less than SEK 25 million, nearly 30% even less than SEK 5 million (see figure below). Only five companies (5%) had assets of more than SEK 1 billion, namely Neova AB, Lantmännan Agroetanol AB, YIT Sverige AB, Systemair AB and Munters AB. The three latter are large companies with more than 2,000 employees each, while the other two are medium-sized companies with less than 250 employees.

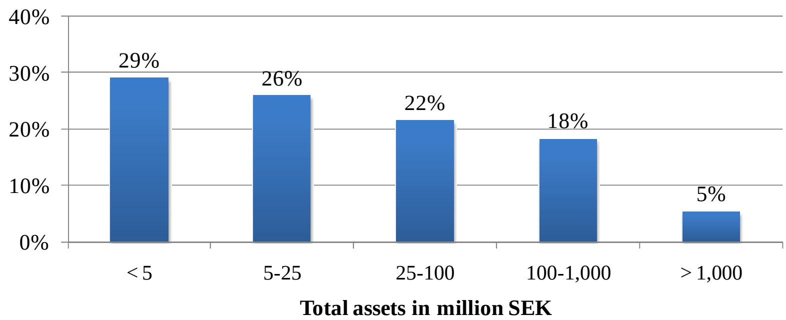


Figure 2.14: Total assets of regional cleantech companies (2009)

Source: Public company database

Total profit/loss

Of the 93 companies analysed, 60% experienced a profit from their business activities in 2009. A majority of these companies had a profit below SEK 1 million or between SEK 1 and 10 million. The companies with the highest profit in 2009 were YIT Sverige AB, Systemair AB and Munters AB. The general tendency could be noted that most companies in the cleantech sub-fields waste management and recycling, sustainable building, and air purification succeeded to finish their business year with a profit. Most businesses with a loss in 2009 had in contrast the sub-field bioenergy and biofuels (e.g. Lantmännen Agroetanol AB, KMW Energi AB, Chemrec AB, Scandinavia Biogas Fuels AB, BooForssjö AB).

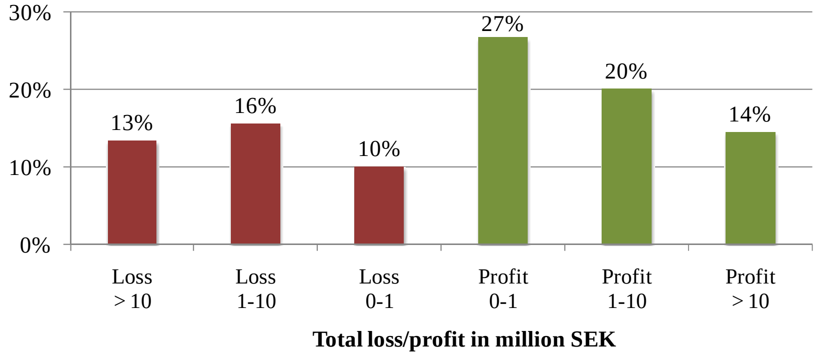


Figure 2.15: Total profit/loss of regional cleantech companies (2009)

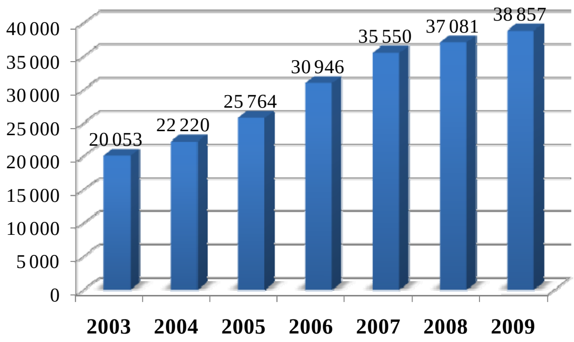
Source: Public company database

2.3 Export of cleantech products and services and associated problems

Export characteristics of cleantech companies

According to SWENTEC, every fourth cleantech company in Sweden exported their products or services to other countries in 2009.[43] In the same year, total exports of clean technologies reached SEK 38.6 billion, an increase by SEK 18.8 billion or 94% since 2003 (see figure below). While the national export value nearly doubled between 2003 and 2009, the share of export of the companies' turnover increased only slightly from 27% to 33% during the same period. This may be an indication for the remaining importance of the domestic market for cleantech companies, even though exports have an increasing importance for them.

[43]SWENTEC, 2010, Svensk miljöteknik i siffror 2009.



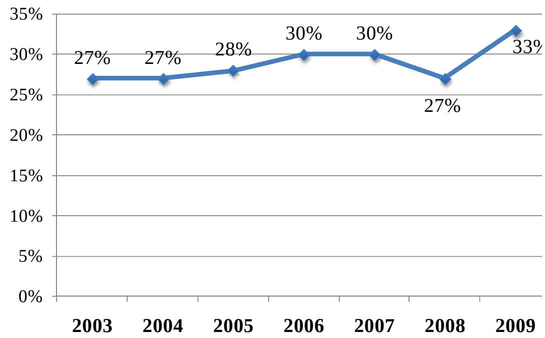


Figure 2.16: Export of Swedish cleantech companies 2003-2009 (in million SEK)
Source: SWENTEC, 2010, Svensk miljöteknik i siffror 2009: 5.

Figure 2.17:Development of the share of export of turnover (2003-2009)
Source:SWENTEC, 2010, Svensk miljöteknik i siffror 2009 - Diagram: 11.

Companies located in Stockholm County stood with SEK 3,648 million for 9% of the national cleantech exports in 2009. After a decrease of the export value of cleantech companies in Stockholm from SEK 3,596 million in 2007 to SEK 3,061 million in 2008, exports reached a higher value than in 2007.

Cleantech companies from East Middle Sweden with the counties Uppsala, Södermanland, Östergötland, Örebro and Västmanland experienced in contrast steadily increasing exports from SEK 6,950 million in 2007 to SEK 7,244 million in 2008 and SEK 7,833 million in 2009. Together with Stockholm County, this region thus amounted for about 30% of the national cleantech exports in 2009.

As far as the different cleantech sub-fields are concerned, exports are distributed as visualised in the figure below. Accordingly, waste management and recycling is the sub-field has the highest total export value between 2007 and 2009. It stood for nearly one fourth of the national cleantech exports in 2009. As this sub-field however also consists of the largest number of cleantech companies (2,764 companies) the high share of cleantech exports is not surprising. In contrast, exports have in recent years also reached a relatively high level for two smaller sub-fields in terms of enterprises: Sustainable building and energy efficiency (956 companies), and solar, wind and water energy (504 companies). For both cleantech sub-fields a steady increase of exports can been noted since 2007. Companies with a business related to solar, wind and/or water energy increased their exports by 60% between 2007 and 2009, while also the number of employees increased during these years from 2,327 to 2,766. Enterprises within the sub-field "sustainable building and energy efficiency" increased their exports by SEK 1,650 million or 24% since 2007.

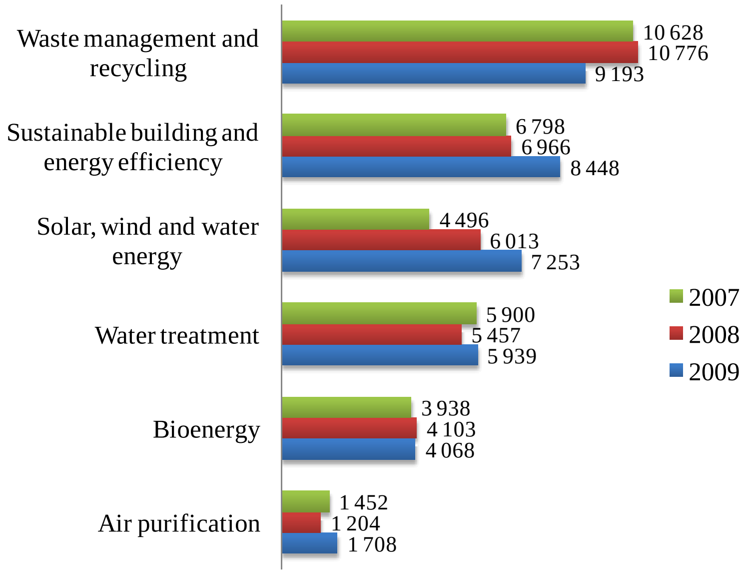


Figure 2.18: Swedish cleantech companies' export by technology area (in million SEK)

Source: SWENTEC, 2009, Svensk miljöteknik i siffror 2008: 6; SWENTEC, 2010, Svensk miljöteknik i siffror 2009: 7.

The major export destinations of Swedish cleantech companies are European countries with the exceptions of China and the USA. Those countries from Europe that are among the top ten export destinations amount together for 50% (SEK 19.6 billion) of the total cleantech export in 2009. Germany is by far the largest export destination with regard to clean technologies. In addition, all three Nordic countries with a border to Sweden (Norway, Denmark, Finland) are important destinations standing for nearly 20% of the total cleantech exports.

Table 2.8: Regional export distribution of Swedish cleantech companies (2009)

Ranking of destination		Share of total cleantech export	Export(in million SEK)
1.	Germany	16 %	6 047
2.	Norway	9 %	3 553
3.	China	7 %	2 760
4.	USA	6 %	2 499
5.	Denmark	5 %	2 120
6.	France	5 %	1 801
7.	Finland	5 %	1 800
8.	Great Britain	4 %	1 556
9.	Italy	4 %	1 404
10.	Spain	3 %	1 303

Source: SWENTEC, 2010, Svensk miljöteknik i siffror 2009: 10.

The figure below presents the distribution of exports ratio in net sales amongst cleantech companies interviewed in the region.

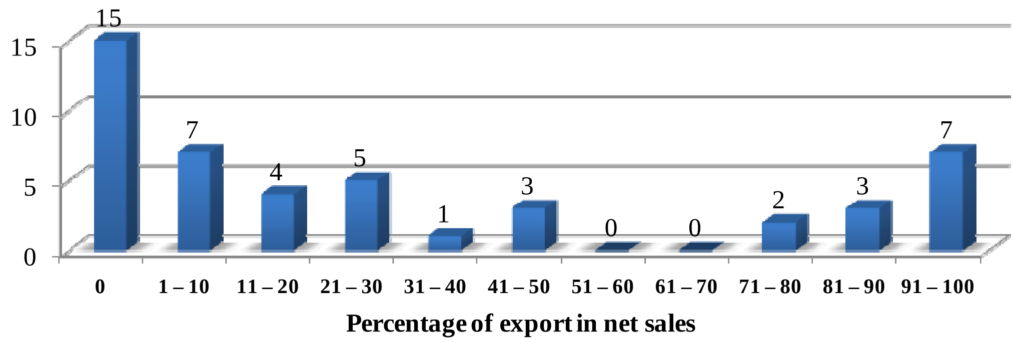


Figure 2.19: Export ratio in net sales

Source: Author based on company interviews.

As can be seen in the figure above, four groups of companies are identified: 15 companies have no export. Some of these non-exporting companies expressed no aspiration for export; 7 companies have a very small amount of export (<11%); 13 companies have a moderate level of export (11-50%); and 12 companies have a very large export ratio (>70%).

Associated problems with exporting and marketing of cleantech products and services

The issue of problems in export is very central in the Global Vision project, because the overcoming of these problems are important success factors for business growth and the dissemination of environment-friendly solutions.

The interview respondents were asked to identify and discuss the top three perceived marketing problems in doing business in other countries. The distribution of marketing problems is presented in Table 2.10.

Table 2.9: Export and marketing barriers

Perceived marketing problem areas	No. of companies
Customer relations	25
Laws and regulations	18
Customer contact problems	17
Customer value	13
Negotiations	9
Understanding customer desires and demands	5
Lack of adequate resources	5
Governmental issues (Swedish government)	2
Currency issues	2
After market service	1
Internal organization inertia	1
Political processes	1
Communication across time-zones	1

Source: Author based on company interviews.

From the table we can see that 13 companies pointed at problems with "customer value" and that can be interpreted that some companies have not state of the art product offerings. 17 pointed at "contact problems" on the export markets and 25 pointed at "customer relations". It is obvious from this study that relationship management is crucial for exporting clean technology. However, much more research is needed to uncover the root causes of the "symptom" called relationship problems. Has it to do with the company in question? Has it to do with the counterparts in other countries? Has it to do with bad match of market actors (the selection of the actors which the Swedish companies approach)?

There are, yet, some clues already in the table above. As many as 17 companies pointed explicitly on “contact problems”, which may be related to the methods for finding the right prospects on the international market. 18 pointed at laws and regulations as a main problem when it comes to international expansion. From the available data, it is however not possible to reveal, whether the last problem concerns laws and regulation per se or the companies’ information about the laws and regulations. One way to understand the finding is to connect it with a selected theory:

In 1945 Herbert Simon’s *Administrative Behaviour* was published. His point of departure was managers’ dedication to rational decision making. This involves choosing among alternatives by relating them to goals and understanding the consequence of every choice in relation to a particular goal, which Simon describes as the necessity to ‘calculate consequences’. In the real world, however, no-one has full knowledge about every possible alternative and its various outcomes. Reality, therefore, is characterized by uncertainty, which in turn is caused in part by limited information and in part by limited thinking capability (i.e. limited capacity to understand and interpret existing information). As a result, Simon maintained that people are irrational. This was shocking to traditional economists, who had always assumed that market actors were rational – based on the assumption of perfect information. Simon showed that people try to be rational within the frame of limited information and limited understanding of causality. He called this phenomenon bounded rationality, for which he was awarded the Nobel Prize in 1978.

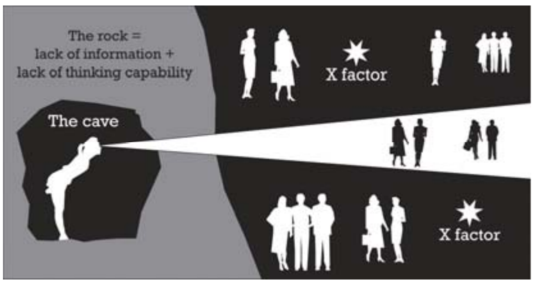


Figure 2.20: The cave model

The cave model (figure 2.21) is based on Simon's theory.[44] This model makes the metaphorical assumption that all innovation actors, such as our cleantech companies, are housed in a dark cave. The rock surrounding represents lack of information and lack of thinking capability. The cave entrance provides a restricted view of the outside world, for instance, including some buyers on the international market. Beyond this, but hidden from the actors in the cave, are multiple factors that are affecting or could affect current (or potential) business. These include potential customers that really would appreciate the offers from the specific cleantech company. The good news is that the entrance to the cave can be widened to allow the cleantech company to view more of the outside world. There are two ways that they can expand their view.

The first is simply to search for more (relevant) information. Because notwithstanding modern tools, such as external databases (e.g. ABI/Inform, Ei Compendex, Pharmaprojects) we can reconsider Simons's idea that cleantech companies should be forever stuck in irrational darkness. Some companies are very professional in searching for information. The company Swedish Biogas in Linköping, for example, invests many resources in finding information of the rest of the world.[45]

The issue of problems regarding international business expansion is, or should be, related to the issue of competence need as well as existing competence at the company level (see figure 2.22).

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[44] Per Frankelius: *Simon's theorem reconsidered – towards a theoretical framework for competitive intelligence*. ECIS 2009, The Third European Competitive Intelligence Symposium, Stockholm, Sweden, June 1–12, 2009.

[45]The second way to coop with the cave problem is brain-training, to thinkabout things from new angles. We leave that part in this publication.

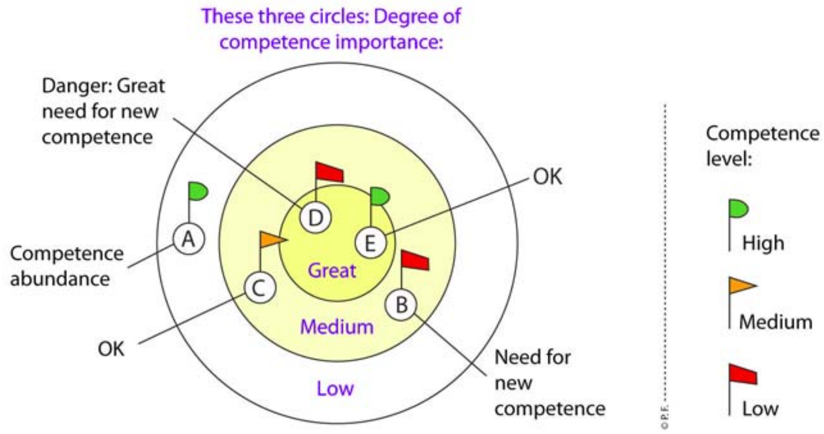

Figure 2.21: Competence needs vs. existing competence level in a cleantech company: A model for further analysis.

As mentioned in the section “Firm capabilities „the company representatives primarily emphasized the importance of technical competence (15), marketing competence (14), and business competence (10). If we put these together 15 pointed at technical issues wile 24 pointed at either marketing or business competence. Our hypothesis, therefore, is that business competence is as much important and as much hard to build up as technical competence. On the contrary most policy makers seems to believe that universities and other knowledge promoters primary should focus on helping the companies with technical or product development. Maybe it’s time for a paradigm shift? Moreover, the nature of business or marketing competence is very important to understand, and from the discussion around the cave model, we can assume that strategic information searching is a critical part of that competence. One thing is clear: It is very important to go further with the analysis of competence needs (mirroring strategic problems) and existing competence profiles in specific cleantech companies. Therefore we suggest using the model in figure 2.22 for further work.

2.5 Interaction with other organizations

The companies were asked if they are co-operating with any companies with the goal of developing clean technologies. The distribution of answers is illustrated in the following table. However, the majority of company representatives could not reveal the name of collaborative company-partners because of confidentiality issues. In some cases it was further mentioned that the cooperation partner is part of the same company group.

Table 2.10: Interactions with organizations

Answer	No. of companies
Yes	34
No	13

Source: Author based on company interviews.

Even though the name of the partner companies could be revealed, 27% of the interview respondents were able to name other companies in the sector. Those companies that were stated more than once are: ClimateWell AB, Solarus Solkraft i Roslagen AB, Chemrec AB, Munters AB, Seabased AB, SkyCab AB and HiNation AB.

The companies were additionally asked if they are co-operating with any research institutions with the aim to develop clean technologies. The result is shown in the Table 2.12. Some of the mentioned research organisations were LTH, MTM (at Örebro University), ÅL, SIX, Chalmers University, Lund University, SEC Borlänge, Borlänge University, Gävle University, JTI, Defence research agency (FOI), IVL/SMCT, Stockholm University, Luleå University, Umeå University and Uppsala University . They also pointed at research organisations in Germany and other countries. Unfortunately, many of the companies wanted us to treat this kind of data confidential. Therefore, we cannot offer any details around this.

Table 2.11: Interactions with research organizations

Answer	No. of companies
Yes	29
No	17
No answer	1

Source: Author based on company interviews.

Furthermore, the companies were asked if they are co-operating with any government institution with the goal of developing clean technologies. The distribution of answers is illustrated in the following table.

Table 2.12: Interaction with government institutions

Answer	No. of companies
Yes	21
No	22
No answer	4

Source: Author based on company interviews.

From these data we conclude that most companies have quite much interaction with other players in the cleantech field. Moreover, there are not only companies in their interaction, but in fact around 50 % also interacted with universities and research organisations.

One interesting question arises: Are the cooperative partners possible to define as members of "cleantech clusters", or are they not? We will come back to this issue in the analysis of five Swedish cleantech sub-clusters (see below). The answer partly is a result of how we define clusters.

2.6 Innovation dynamics

The companies were asked the number of patents applied and received. The distribution of answers is illustrated in the table below.

Table 2.13: Patenting of regional cleantech companies

Number of patents	No. of companies
0	18
1 – 5	20
6 – 10	4
11-30	1
31 – 100	3
100+	1

Source: Author based on company interviews.

2.7 Growth Dynamics

According to statistics from SWENTEC 6,530 cleantech companies were active in Sweden in 2009, 847 companies or 15 % more than in 2003. In 2007, the number of cleantech companies identified reached a peak of 6,753, but decreased slightly during following years.[46]

In line with the increasing number of cleantech companies in Sweden also the companies' turnover and number of employees rose in recent years with 61% and 17% respectively. A peak was reached in 2008 with 41,807 employees in the sector and sales of SEK 135,487 million. In 2009, Swedish cleantech companies employed 41,420 persons and generated a turnover of SEK 119,344 million.

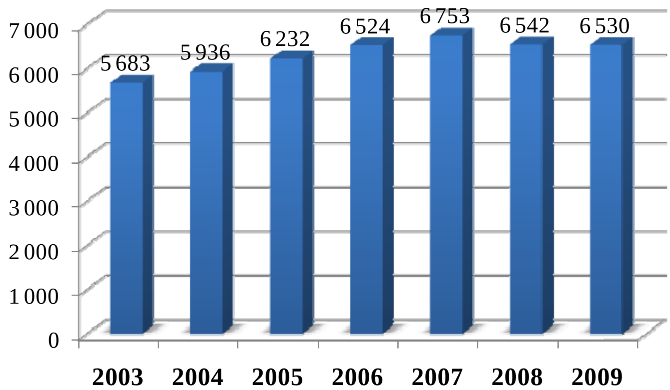

Figure 2.22: Number of cleantech companies in Sweden(2003-2009)
Source: SWENTEC, 2010, Svensk miljöteknik i siffror 2009: 5.

Companies located in the seven concerned counties[47] underwent a similar development between 2007 and 2009 with regard to their turnover and number of employed. The turnover of these companies rose by 12% to SEK 50,469 million in 2008, but decreased again with 13% to SEK 43,961 million in 2009 reaching a slightly lower level than in 2007. This development is also true for the number of employed in the region being with 14,939 in 2009 at a similar level as in 2007 (14,950 employed).

[46] The number of cleantech companies by county was not publically available and its development in recent years thus could not be analysed as part of this report.
[47] Stockholm, Örebro, Östergötland, Västmanland, Södermanland, Uppsala, Gävleborg

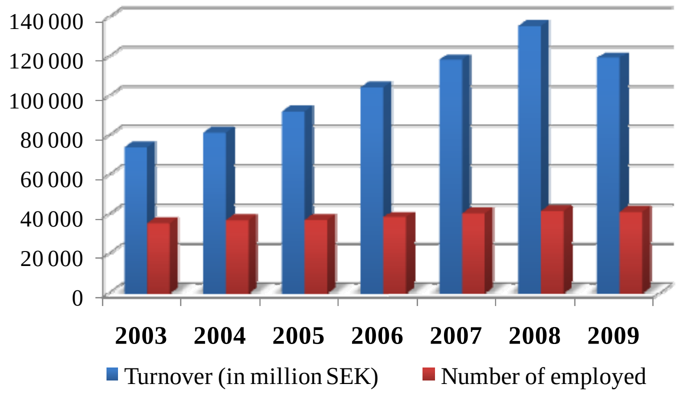

Figure 2.23: Development of the turnover and number of employed of cleantech companies, Sweden

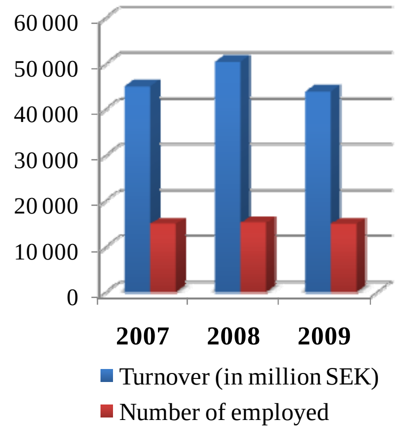

Figure 2.24: Development of the turnover and number of employed of cleantech companies, Counties concerned in the project

Sources: SWENTEC, 2010, Svensk miljöteknik i siffror 2009: 5-9; SWENTEC, 2009, Svensk miljöteknik i siffror 2008: 9.

With regard to the seven Swedish counties concerned in this project, the largest turnover in 2009 was generated by cleantech companies located in Stockholm (37% of the total regional turnover), in Östergötland (22%), and Västmanland (16%).

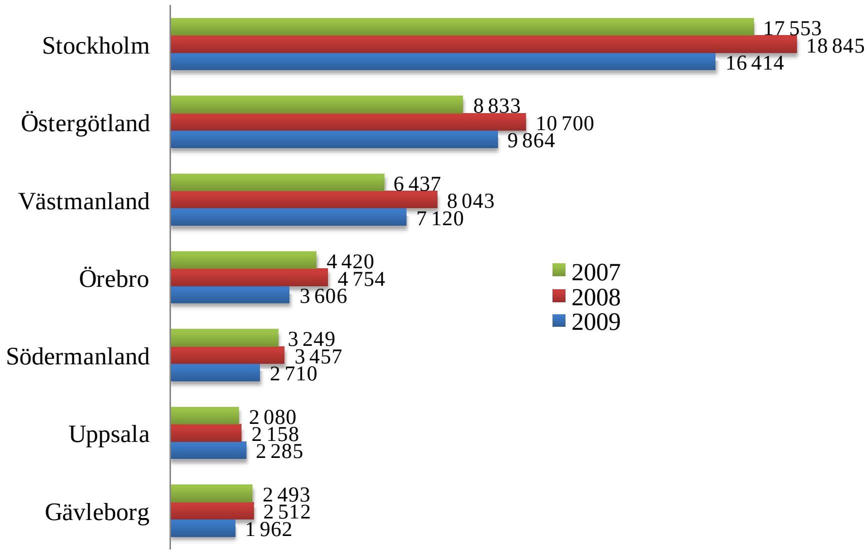

Figure 2.25: Development of regional cleantech companies' turnover by county, 2007-2009 (in million SEK)

Total turnover in the region: 45,065 million SEK (2007); 50,469 million SEK (2008); 43,961 million SEK (2009).

Sources: SWENTEC, 2010, Svensk miljöteknik i siffror 2009: 9; SWENTEC, 2009, Svensk miljöteknik i siffror 2008: 9.

As far as the different fields of clean technologies are concerned, waste management and recycling amount with 34% for the main part of turnover at Swedish cleantech companies, followed by sustainable building and energy efficiency with 16%. The turnover of companies active in the sub-field of solar, wind and water energy increased steadily between 2007 and 2009. Thus, the turnover of this technology area has developed differently from the other areas, which were characterised by a higher turnover in 2008, but a lower one in 2009 (reaching about the level of 2007).

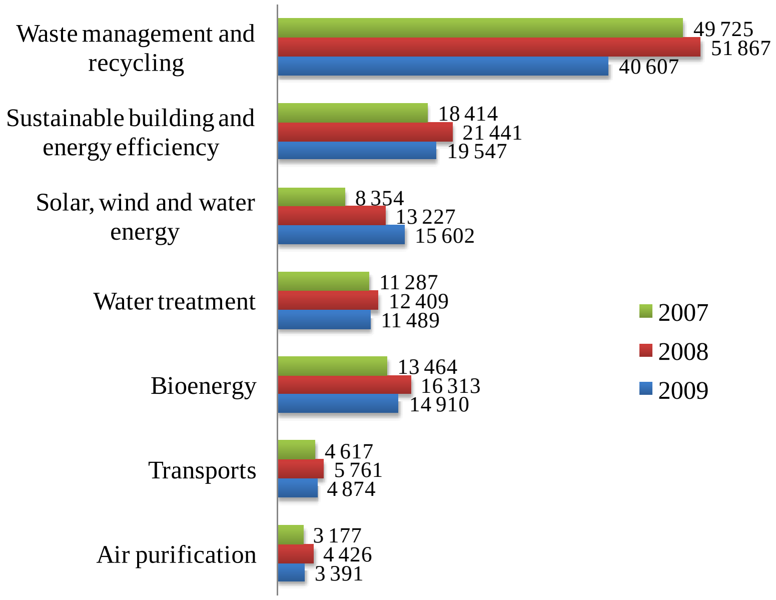

Figure 2.26: Turnover of cleantech companies by technology area (2007-2009, in million SEK)

Sources:SWENTEC, 2010, Svensk miljöteknik i siffror 2009: 7; SWENTEC, 2009, Svensk miljöteknik i siffror 2008: 6.

The number of employed at regional cleantech companies remained stable between 2007 and 2009. However, in Stockholm County 280 persons more were employed by cleantech companies in 2009 than in 2007. In the other counties of the region, the number of employed at cleantech companies did not change in a larger degree, or decreased slightly during the same time period.

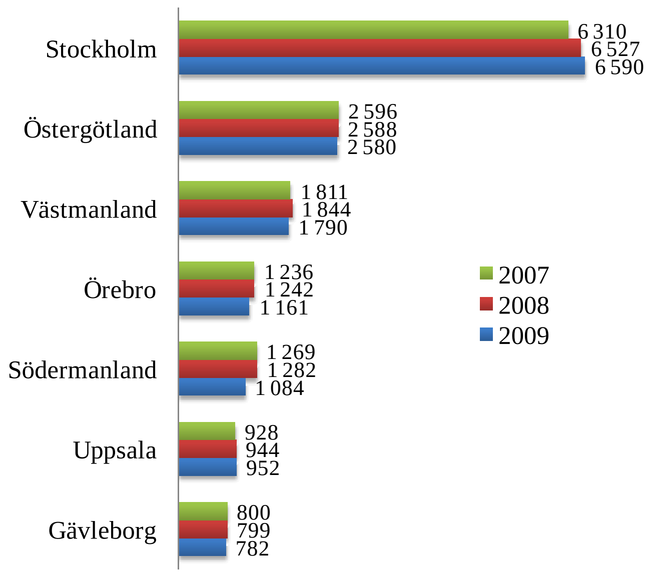

Figure 2.27: Development of regional cleantech companies' number of employed by county, 2007-2009 (in million SEK)

Total number of employed in the region: 14,950 (2007); 15,226 (2008); 14,939 (2009).

Sources: SWENTEC, 2009 and 2010, Svensk miljöteknik i siffror: 9.

In order to be able to show the development of the labour costs of cleantech companies in the region, data from 93 local companies have been collected and analysed. In 2009, the average labour cost of these companies was with SEK 537,860 per employee about 9% lower than in 2007 (see left figure below). In contrast, the sum of the labour costs of all analysed companies increased slightly from SEK 43.1 million in 2007 to SEK 46.3 million in 2009. This is however due to the fact that data for 13 more companies were available in 2009 than in 2007. Therefore those 70 companies with available data for all three compared years were analysed separately. Their average labour cost per employee decreased by only 4% (see right figure below).

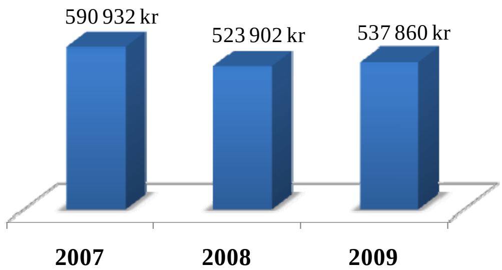

Figure 2.28: Average labour cost per employee of regional cleantech companies (all 93 analysed companies)

Source: Public company database

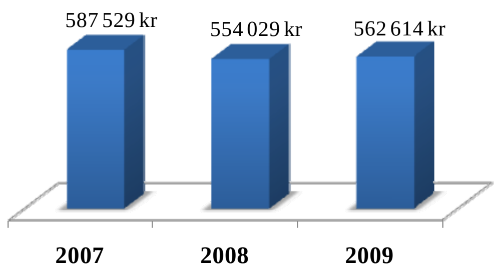

Figure 2.29: Average labour cost per employee of regional cleantech companies (Analysed companies with published annual reports for all three years)

Source: Public company database

We would have like to make an analysis regarding innovativeness of the companies in relation to R&D-spending and other factors. This has to be a mission in future work in the Global Vision project.

2.7 Financial needs

The companies were asked if they plan major investments in any of the following areas. The distribution of answers is presented in the table below (multiple selections were possible).

Table 2.14: Planned investment areas

Investment area	Answers	No. of companies
R&D	Yes	21
	No	26
Production	Yes	27
	No	20
Market expansion	Yes	31
	No	15
	No opinion	1
Other	Yes	21
	No	25
	Partly	1

Source: Author based on company interviews.

Several companies claimed that they already had made significant investments in R&D and were currently planning and taking measures for production development as well as market expansion.

Can the companies finance the investments by means of their own capital? 21 of the companies answered yes, and 25 answered no. About half of them, thus, can finance their investments on their own.

The following table presents what the respondents view as the external capital provider that is of the highest importance for the company (can be more than one).

Table 2.15: Capital providers

External capital provider	Yes	Partly	No
Banks	5	3	29
Venture capital firms	10	1	25
Business angels	3	1	29
Public or semi-public organizations	10	0	25
Customers or suppliers	13	1	21
Share holders	10	0	25
Other	7	0	26

Source: Author based on company interviews.

The respondents were asked if the company had experienced problems in getting the required funds. The distribution of answers is provided in the table below.

Table 2.16: Perceived funding problems

Answers	No. of companies
Yes	20
No	24
Partly	3

Source: Author based on company interviews.

About half of the respondents pointed at problems in getting the required funds. We have talked much about this after the interviews were conducted. Our overall interpretation is the following: The companies do not generally say that there is lack of capital on the venture-capital market or other capital markets. However, they argue that it is very difficult and time-consuming to attract the capital. The main problems, according to the companies, are not the products, technologies or business models in the companies. On the contrary, the problems are related to the work of describing and communication the products, technologies and not least business models and the need for the right contacts.

We can assume that some of the companies in fact have some problems with "the substance" and if so, it is not surprising that they find it hard to make persuading and convincing presentation orally and in written form.

3. Swedish cleantech sub-clusters

Introduction to the "cluster" term

As indicated earlier, it is obvious that Sweden has many cleantech companies (in relation to the country size), and lots of them are situated in the region considered in the Global Vision project. It is further obvious that some cleantech areas are stronger than others. However, the appearance of "cleantech clusters" is not as clear and thus not unproblematic to apply on our empirical data. Only 15 of the 47 interviewed companies could refer to one or more "clusters", whereas more than two third of the companies could not refer to any. The interviews as well as special investigations on clusters ended up in the conclusion that a more general discussion of the term "cluster" is needed before qualitatively describing some existing sub-clusters.

Remindings from the cluster literature

So what, really, is a cluster? Many answers have been offered over the years. Research on geographic concentrations of companies goes under various terms, including industrial networks, industrial districts, clusters and innovation systems. These concepts have to some extent different meanings, but there is more that unites than divides.

One background of the cluster analysis is the idea of so-called industrial districts that Alfred Marshall launched the 1919.[48] Marshall related mainly to areas in cities with densification of certain types of businesses, such as jewellers. In his *Principles of Economics*, he noted that the geographic concentrations of firms contribute to:

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[48] Alfred Marshall: *Industry and Trade.* London: Macmillan, 1919.

- Facilitate labour specialization,
- Facilitate the development of specialized inputs and services,
- Enable and facilitate the transfer of technology, information, and “tacit knowledge”

Many researchers proceeded with the concept “industrial district”[49], but over time the concept ”clusters” became popular. According to Michael Porter a cluster means a geographic concentration of interconnected companies and institutions within the same industry. A cluster comprises linked industries and other entities that are important to achieve competitive advantage.[50]

Porter's diamond model is perhaps the best-known cluster model.[51] It was primarily developed for analysing at country level but has also been utilized for and by regions in the sense parts of countries. Porter's model consists of four parts: 1) the factors of production, 2) demand, 3) complementary services and products and 4) industry structure.

Deep down, also Porter himself seemed to not be completely satisfied with the model. Therefore, he supplemented it with some other factors that, according to Porter, are "necessary to complete the picture" (p. 73). He called them “chance” and “government”. By chance, he referred to events such as new inventions, wars or anything that could influence. In our own research we have had such factors not as peripheral factors in the model but in focus of the model. We have called them ”X factors”.[52]

[49] Compare G. Becattini: *Industrial districts: a new approach to industrial change*. Cheltenham: Edward Elgar, 2004.

[50]M-E. Porter: Clusters and the New Economics of Competition, *Harvard Business Review* (November – December), 1998, pp. 77-90.

[51] M-E. Porter: *The competitive advantage of nations*. London: Macmillan, 1990.

[52] The first published of our books focusing on the “odd factors” was P. Frankelius &C-G. Rosén:*Företaget & Omvärlden* (The Company and the Surrounding World). Malmö: Liber, 1993. The term “X factor” was central in P. Frankelius, *Kirurgisk marknadsföring. Skapande av möten och relationer i en föränderlig värld* (Surgical marketing. Creation of meetings and relationships in a world of changes).Malmö: Liber, 1997.

Our view of different kinds of clusters

From literature, our own experience and deductive reasoning we conclude that it is fruitful to distinguish two main types of clusters, which we call alpha and beta-clusters. *Alpha-clusters* are defined as geographical accumulations of organizations with similar business orientation. *Beta-clusters* are defined as cooperating geographical accumulations of organizations with similar business orientation.

The geographic areas can be defined at different levels such as a neighbourhood area within a town, a whole town, a municipality, a county region, a country, an area overlapping two or more countries (like Öresund region) or a continent.

Regarding business orientation, we can depict clusters at different abstraction level of business orientation such as"environmental technology" vs. "solar cells". In short we talk about "general cluster areas" and "specific cluster areas". Moreover – and this is important – one can define business orientation as different lines of business, for example "ethanol production" vs. "the production of equipment for ethanol production". The way one define business orientation will have great impact on what kinds of cluster one will uncover in any investigation.

The beta-cluster category is a more sophisticated form of cluster. Such more sophisticated clusters are about systems of actors (private companies but sometimes also public or non-profit actors) that within a limited geography create added value in a certain area through systematic interaction.

Within these beta-clusters, we in turn derive two degrees of interaction. The first is interaction in the context of customer-supplier relationships. In contrast to the linear "value chain" this interaction occurs in "value constellations".[53] The basic idea is that value is created sometimes simultaneously by multiple parties in the value chains. The customers can thus be as much a creator of value as the suppliers.

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[53] Traditional value-chanes is central in M.E. Porter: *Competitive strategy: techniques for analyzing industries and competitors*. New York: Free Press, 1980. The newer perspective and the term "valie constellations" is described in Richard Normann& Rafael Ramirez: From value chain to value constellation,*Harvard Business Review*, Vol. 71, No. 4, 1993, pp. 65–77.

The second, more sophisticated, form of beta-cluster is about a kind of cooperation, which is much broader than cooperation in the classic customer-supplier relationships, and therefore beyond both value-chains and value constellations. We call this form “beta-expanded-clusters” (in contrast to beta-narrow). These more profound dynamic collaboration and interaction of some beta-clusters can have different expressions. Some are just working together, without any “dirigent”. But sometimes the interaction is stimulated actively by a dirigent, sometimes called “cluster engine”. A dirigent or cluster engine can, in some cases, be one of the cluster member (an influential player among the cluster firms), which we call “part member dirigent”. But it can also be a dedicated cluster organization sponsored by the organizations in the cluster and/or public organizations (which we call “special mission dirigent”). An example is the famous cluster engine RTI International, which coordinates and runs processes in technology cluster in the Research Triangle Park.[54]

”Cluster initiatives” is another key concept. This refers to discrete, organized efforts to increase growth and competitiveness of a region or a sector by means of cluster development. Cluster initiative usually involves both cluster companies and public actors, including research institutions.[55] Beside dirigents these initiatives sometimes also include political support packages, such as special funding of specific research areas connected with the initiatives. Examples of cluster initiatives were presented earlier in the section on community support organizations.

Table 2.18 sum up some of the discussion so far. Notice that there are 10 kinds of different cluster types according to the analysis. Reality is still more complicated, because also narrow beta-clusters can be divided in the categories “no dirigent”, “part member dirigent” and “special mission dirigent”.

[54]See Per Frankelius:*Örebroregionen - igår och idag* (The Örebro region today and in history)(Rapport 2010:05). Örebro: Örebro Regional Council, 2011.
[55]Joakim Falkäng at Learning Objects, personal communication at many occasions during 2011 and earlier.

Table 2.17: A "periodic system" of cluster definitions.

	Alpha-clusters	Beta-clusters			
		Narrow	Expanded		
			No dirigent	*Part member dirigent*	*Special mission dirigent*
General	1	3	5	7	9
Specific	2	4	6	8	10

Source: Compiled by the author.

The cluster definition for the present cleantech study

We have showed some of the variety of cluster phenomena. It is now time to present the cluster definition used in this specific cleantech cluster study.

In this particular study, we look for aggregations of companies and businesses with similar orientation within a geographical area (with or without systematic cooperation among the cluster actors). In other words, the alpha-cluster definition is used as a base.

However, accumulations of similar businesses are existing in almost all geographic areas, for example of wastewater facilities. Therefore, our definition of accumulation refers to a *relatively* larger accumulation than what is common in most other European regions.

The regional area chosen in this study (as mentioned) is located in eastern central Sweden, which represents seven Swedish counties. The counties included are Östergötland, Södermanland, Örebro, Uppsala, Gävleborg, Västmanland and Stockholm. Comments on the accumulation emphasis among these seven sub regions will to some extent be given in the following section.

The cleantech clusters in the region: Overview

Within the framework of the Swedish cluster study not only a specific part of Sweden was selected, but also five of the cleantech areas found in this region. The map below (figure 2.31) gives a general picture about the geographical region covered in the Swedish cleantech study, and the seven sub-regions (counties).The map does not illustrate all cleantech clusters or all relevant actors in the cleantech field in the selected region. Instead, the map focuses on the five cleantech areas chosen to be described as "cleantech sub-clusters":

1. Waste management and recycling
2. Bioenergy and biofuels
3. Sustainable building
4. Air purification
5. Solar energy

The selection of these five sub-clusters was mainly based on their importance with regard to their size in the region as well as their export orientation. Their definition is in line with the EU Environmental Technologies Action Plan (ETAP).[56]

[56] European Commission, http://ec.europa.eu/environment/etap/etap/faqs_en.html (March, 1, 2011).

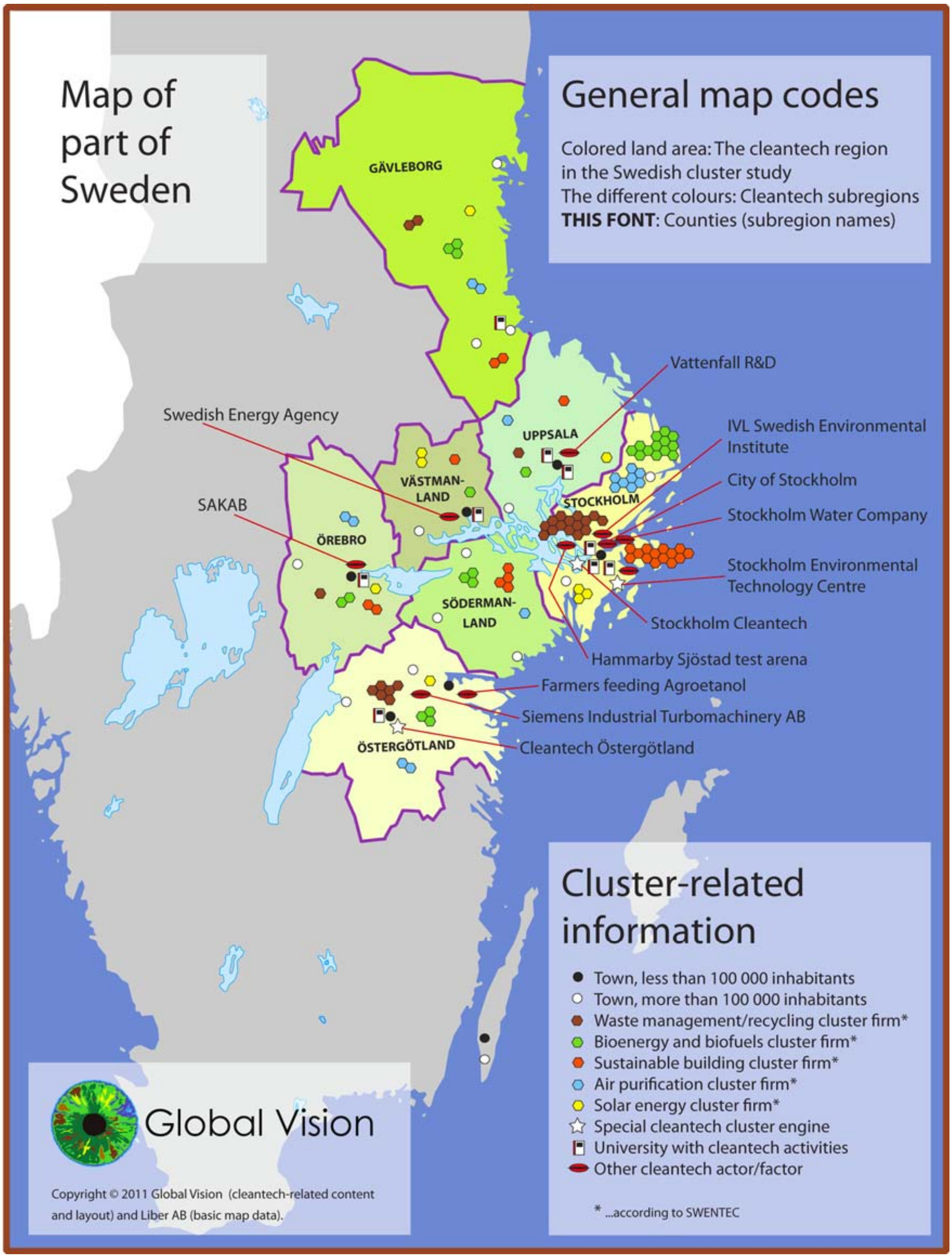

Figure 2.30: Cleantech cluster and sub-clusters in the region included

Source: Compiled by the author.

Given the framing (geographical and cleantech sub-areas), the map shows only part of what exists in reality. Even if the map is not exhaustive, it illustrates some of the relevant parts of the cleantech sub clusters in the region and its sub regions.[57]

In the following sections both "soft data" and statistics regarding each chosen sub-cluster is presented and discussed.

Sub-cluster 1: Waste management and recycling

According to the EU Environmental Technologies Action Plan (ETAP), waste management and recycling comprises collection, treatment, biological treatment, recycling, energy recovery and landfilling.[58] In 2009, Swedish companies active in these fields generated a total turnover of SEK 40,607 million (see also figure 2.32).[59]

In the region considered in the Global Vision project, 26 technology developers from this sub-cluster have been identified from the SWENTEC database.[60]
58 % of these companies are located in Stockholm, 23 % in Östergötland and the remaining 19 % in Gävleborg, Örebro, Uppsala and Södermanland. Together, these companies stood for 18 % of the

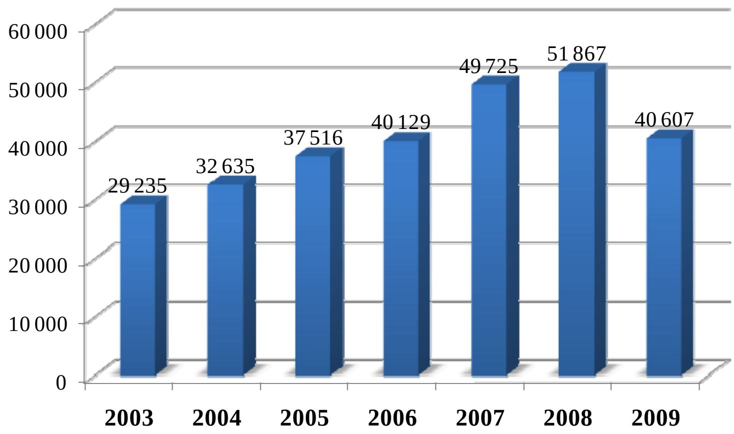

Figure 2.31: Development of the turnover of Swedish companies active in waste management and recycling (in million SEK)

Source: SWENTEC (2009/2010), "Svensk miljöteknik i siffror 2008/2009"

[57] The firm symbols on the map (see the box "Cluster-related information") are placed geographically correct on sub regional level. But they are not placed exactly at their true places (street addresses). The aim here was to show the intensity of each sub cluster in each sub region.
[58] http://ec.europa.eu/environment/etap/etap/faqs_en.html (March, 1, 2011).
[59] SWENTEC, 2010, Svensk miljöteknik i siffror 2009.
[60] One of these companies was founded in 2011 and economic data are thus not yet available.

national turnover in 2009. Between 2007 and 2009, the regional companies of the sub-cluster waste management and recycling increased their turnover by 6 %, while the number of employed increased by 11 % to 5,277 during the same period.

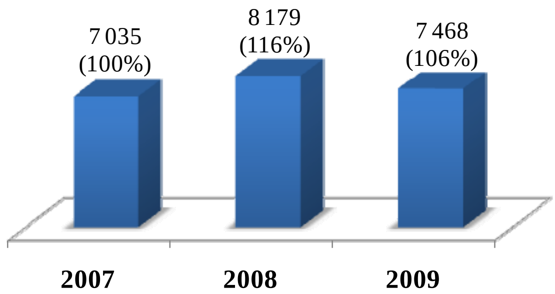

Figure 2.32: Total turnover of regional companies operating in waste management and recycling (in million SEK)

Source: Public company database

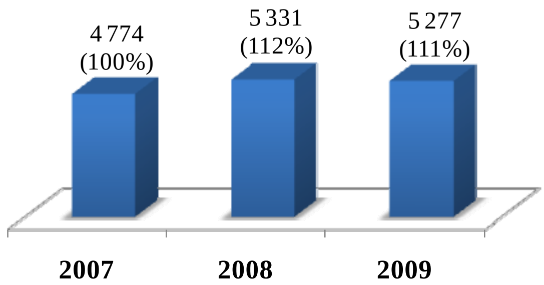

Figure 2.33: Number of employed at regional companies in waste management and recycling

Source: Public company database

With regard to these statistical data, the sub-cluster of waste management and recycling companies seems to have its epicentre in Stockholm County. However, some activity persists in the other parts too, for example in Örebro County. Peter Åslund at Örebro Regional Council concludes:

"Örebro region is not known as a region with a large environmental engineering sector or well-known clean-technology companies. On the contrary, Recycling Park Kvarntorp was for many years in 1990 and into 2000 a relatively well-known organization that collaborated with companies and business units in recycling and waste management. There was talk then of a 'cluster' of companies in the industry in the region."[61]

Already in 2005 there were many companies involved in waste management and recycling in this region, and these employed around 350 people at that time. Among the most well-known are SAKAB in Kumla and Ragn Sells Specialavfall AB in Sköllersta. In Kumla there is one national unique facility for the incineration of hazardous waste. Another example is Minpro AB in Ståssa recovering metals from waste from e.g. smelters.

[61] Peter Åslund: *Miljötekniken växer – men ger den Örebroregionen tillväxt?* Örebro Universitet, Regionförbundet Örebro (memorandum from the course Regional Utveckling och strategiskt tillväxtarbete). Örebro: Örebro University, 2010, p. 5.

As a result of the presence of relevant companies in Örebro County, the subjects "environmental science" or "Man-Technology-Environment" has been a profile at Örebro University since 1996 thanks to Professor Bert Allard, the company SAKAB and others.[62] Furthermore, a special sub-cluster has formed around the theme non-organic waste. One mission has been to develop methods for extracting valuable metals from the waste at old mines in Bergslagen and elsewhere.

Moreover, waste from biogas production (sludge) is a focus area. There are tons of valuable metals in this waste (for example phosphor), but there are not yet any economically functioning concepts to activate these hidden potentials. Among the projects in this field are the EU Project Umbrella, Bergskraft Berslagen (also EU project), CLEAN (a network driven by "Sustainable Bergslagen", MinNovaton (EU project), OMSLAK (project with support from SAKAB and Kumlastiftelen), InnoMin (Innovative mineral technology) with support from Vinnova and Project Kvarntorp.

The sub-cluster waste management and recycling is also intensive in Östergötland County.[63] According to studies of Mats Eklund and Olof Hjelm, there are about 400 companies in the cleantech sector with waste management and recycling as a large part of it. The city of Norrköping is for example location for a centre for recycling industry called Econova. Furthermore, companies like Fiskeby, IL Recycling, Mirec, and Miljösäck are located there. In Linköping, famous organizations in this field are Tekniska Verken and Svensk Biogas. Also the municipalities, the regional council (Östsam) and County Administrative Board (Länsstyrelsen) are very much involved in promoting the cleantech sector.

Östergötland's strength in waste management and recycling is further encouraged by the presence of the formal cleantech cluster engine "Cleantech Östergötland" located in Linköping.[64] Cleantech Östergötland is connected to "Cleantech Park Östergötland", a business park with mainly small companies with recycling and environmental commitment.[65]

[62] This section is based on personal mettings with Bert Allard, Mattias Böckström (Berskraft) and others 10 and 21 June, 2011.
[63] See Mats Eklund and Olof Hjelm: *Miljöteknik i Linköping: inventering av företag och förslag på åtgärder för utveckling*. Linköping: Industriell miljöteknik, IKP Linköpings universitet, 2005.
[64] For more information about Cleantech Östergötland, please see chapter X.
[65] Modified and translated text from http://www.cleantechostergotland.se/index.php?page_show=17&sub_to=15 (August, 4, 2011).

One reason for Östergötland's focus on waste management and recycling is its good logistical position, creating great interest to the logistics-intensive recycling industry. Therefore, the county is a hub for the national collection of waste such as newsprint, cans and PET bottles.

Figure 2.34: The logo of the cluster engine in Linköping and one of the projects in Örebro

Sub-cluster 2: Bioenergy and biofuels

According to ETAP, bioenergy is referring to production, collection and transfer of energy from renewable sources such as biomass. Regarding biofuels it is, simply enough, about renewable fuels. There are lots of companies in the field of bioenergy and biofuels and the SWENTEC database comprised 26 enterprises that are actively developing clean technologies.[66] Even though the number of technology developers in the region is comparable with the sub-cluster of waste management and recycling, the turnover in this sub-cluster is more than SEK 2,000 million higher in 2009. However, the number of employed is with 5,518 in 2009 only slightly higher than in the waste management and recycling sub-cluster.

[66] One of the 26 companies is a sole proprietorship without any public annual reports.

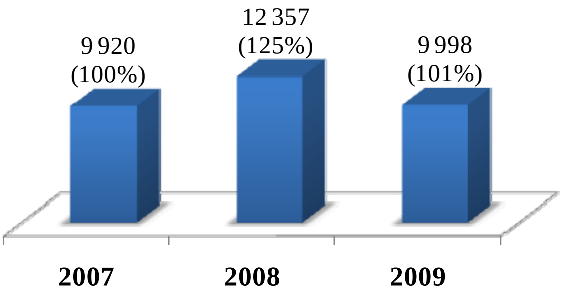

Figure 2.35: Total turnover of regional companies in bionergy and biofuels sub-cluster (in million SEK)

Source: Public company database

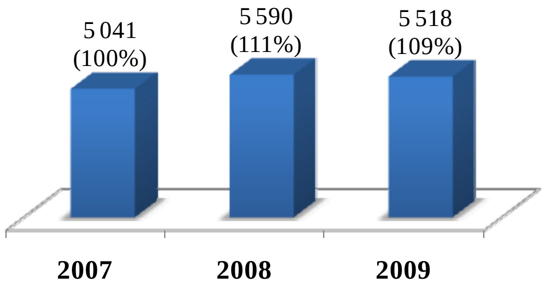

Figure 2.36: Number of employed at regional companies in in bioenergy and biofuels sub-cluster

Source: Public company database

Half of the identified technology developers are located in Stockholm, three in Östergötland, Gävleborg and Södermanland each, two in Örebro and one in Västmanland and Uppsala each. Like in the sub-cluster waste management and recycling, a geographical conglomeration of companies regarding bioenergy and biofuels exists in Stockholm County.

Examples of companies in the sub-regions are Scandinavian Biogas in Uppsala, Bruks Klöckner AB, eKontroll AB and Neova in Gävleborg, Ecoil in Västmanland and Götene Gårdsgas in Södermanland. Besides Stockholm, where many companies of the sub-cluster are located, Östergötland seems to be an active place:

”Production and research on renewable fuels is a heavy field of competence in the region. The renewable fuels in use today are all in production in this region. The world's most energy-efficient corn ethanol is produced here, biogas is extracted from a variety of substrates and biodiesel is produced through a regional innovation - small-scale biodiesel plants.

In Linköping, the international goal, that 5 % of all vehicle fuel sold should be renewable, has already passed by the municipality being early in the development of biogas production and the introduction of biogas fuel on market. Other cities in the region follow this example with both tank facilities and production facilities.”[67]

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[67] Modified and translated from http://www.cleantechostergotland.se/index.php?page_show=17&sub_to=15 (August, 4, 2011).

This is the story in brief of the biogas cluster formation in Östergötland: Linköping Biogas was funded 1996 by Tekniska Verken AB (an energy company owned by Linköping Municipality), Sweden Meats and LRF.[68]Linköping had in the 1980s air quality problems in the city because of traffic. Meanwhile, the slaughterhouse industry had to deal with their waste products. Linköping Biogas started with the idea to produce biogas for inner-city buses in Linköping and to deliver a quality assured fertilizer for agriculture. At the same time, the slaughterhouse industry found a market for their organic residues. Tekniska Verken later took over the shares from the other owners, and in 2003 the business was transformed to Svensk Biogas AB. The company established nodes also in Örebro, Norrköping, Mjölby, Motala, Katrineholm and Nyköping.

The then CEO at Tekniska Verken, Stig Holm, was visionary. He wanted national expansion in the biogas field. However, a Swedish municipality must not, according to law, conduct business outside its own territory if the same municipality owns 50 or more per cent of a company. At the same time Linköping municipality did not want to let in new owners. This situation led to the formation in 2005, by Holm, of a new company, Swedish Biogas. AB The business mission was to export the extensive process knowledge that had evolved in Linköping on a national and international market. Thanks to experienced, skilful and enthusiastic people (Jonas I. Stenfelt and others) the company became very successful in Sweden and on the international arena.

But also other entrepreneurial ventures formed. The process manager and patent holder, Jörgen Ejlertsson, quit from Tekniska Verken in 2005 and the same year he funded Scandinavian Biogas in Stockholm (together with Erik Danielsson, earlier CEO at Pharmacia). This company too has been very successful and is now expanding much.

[68] The following section is based on personal communication with Ulrika Werner at Svensk Biogas, April, 19, 2011, Malin Enockson 10 August, Jonas I. Stenfelt at Swedish Biogas AB 11 August 2011, and Jörgen Ejlertsson at Scandinavian Biogas 11 August 2011.

Left: Eskil Fornander and Carl-Johan Carlsson at the top of the silo at Svensk Biogas August 10, 2001. Right: One of the customers at the biogas pump station in Linköping. Photo: Per Frankelius.

Also in the Norrköping area (still in Östergötland) there are many activities in the bioenergy and biofuel cluster. One central actor is Lantmännen Agroetanol, Sweden's only large-scale producer and supplier of grain-based fuel ethanol. Agroetanol processes grain into ethanol for motor fuel market, and protein products for animal feed market (as a residue product). The production capacity is approximately 210 million litres of ethanol and 175,000 tonnes of protein feed. The company, as the name indicates, is owned by Lantmännen, in turn owned by more than 36,000 Swedish farmers.[69]

Agroetanol is situated on the island Händelö nearby the city Norrköping. Some facilities work together on this island. Besides Agroetanol, these include E.ON and Svensk Biogas. E.ON. has a biofuel-driven production plant (CHP) for heat energy (Händelöverken, which earlier was part of Norrköping municipality), and Agroetanol makes use of lots of hot steam from this plant in the Agroetanol production system (a direct steam pipeline has been installed). In fact, Agroetanol is an as much important customer to E.ON. As the group of customers connected with the municipality’s district heating system. Svensk Biogas plants in Norrköping make use of the residues from Agroetanol and develop it to engine gas.

Some observers argue that E.ON’s biofuel-driven CHP is the essence of the formation of this energy cluster.[70] We argue that Agroetanol, the suppliers of grain

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[69] This section is based on personal communication with Bengt Olof Johansson, CEO at Lantmännen Agroetanol (8 August, 2011) and Eva Willstrand inApril 2011.

[70] Compare Simon Carlsson and Marcus Carlsson: *Lokalisering och samverkans betydelse för lönsamheten av biodieselproduktion* (Exam work), Linköping: Institutionen för ekonomisk och industriell utveckling, LinköpingUniveristy, 2010.

(the farmers) as well as big customers are as much important for this cluster centre. During the interview with CEO Bengt Olof Johansson, he said "I see a tractor and grain wagon right now delivering tons of grain outside my window". In fact, Agroetanol collects as much as 15 per cent of all grain from the Swedish farming sector. Among the farmers, the ones in Östergötland are important because they are close and because Östergötland is an important agriculture district in Sweden.

According to Johansson the mentioned actors are important for Agroetanol's business. Furthermore, there are other not typically cluster-related factors with great importance for the company, for example the public opinion on using grains for energy instead of food. Thus, policy-making in Sweden and Europe is very important for the bioenergy plants.

The farming land in Östergötland is important for the energy cluster. The left photo shows grain on Hollstad outside Norrköping (Photo: Per Frankelius). The other shows Lantmännen Agrotetanol's plant on Händelö (Photo: Lantmännen Agroetanol AB, used by permission).

Besides Agroetanol, the farmers, E.ON, Norrköping Harbour and Svensk Biogas there are other actors that are said to be linked to the cluster's centre on Händelö.[71] One is Ageratec, a company founded in 1996 having a production plant at Herrebro gård between Norrköping and Linköping. The founder David Frykerås worked for Siemens in the offshore industry and caught his eyes on the rising oil prices. That observation, in combination with his technical competence, formed the business idea. The company has today around 17 employees, but because it was sold to Alfa Laval in 2010 many more people are working with its business.

[71] Simon Carlsson and Marcus Carlsson: *Lokalisering och samverkans betydelse för lönsamheten av biodieselproduktion* (Exam work), Linköping: Institutionen för ekonomisk och industriell utveckling, Linköping Univeristy, 2010.

Ageratec is a global provider of modular prefabricated multi feedstock biodiesel processors scalable for a capacity of 2,000 to 340,000 litres per day. The company offers a complete solution for the entire production chain of biodiesel. Ageratec has up to now sold its products to countries like USA, Australia and Colombia. In total it has installed plants in 23 countries. Ageratec was also one of the 50 Swedish companies that caught the attention of the American ambassador Michael Wood in 2007 as an "interesting cleantech company".

As far as cluster dynamics are concerned, the company has much in common with Agroetanol and E.ON.It is part of the bioenergy sub-cluster, but the cluster dynamics (in beta-cluster sense) cannot obviously be derived from the statement of Ageratec's CEO: "We have no connection to Agroetanol. The only one is Linköping University. But to be honest, it has not generated much business for us. One aspect, however, is that the connection has helped us with a few recruitments."[72] Also Agroetanol's CEO confirmed that the two companies have not entered into cooperation.

The analysis of this sub-cluster has further shown that different sub-clusters are interconnected with each other. The company Svensk Biogas is for example both part of the sub-clusters "Bioenergy and biofuels" as well as "Waste management and recycling".

Sub-cluster 3: Sustainable building

According to ETAP sustainable building is about sustainable cities, building envelope, heating as well as land renovation of homes and offices.24 technology developers were identified in SWENTEC's company database and analysed. The companies' turnover amounted to SEK 11,284 million in 2009 and did only slightly increase since 2007. The sub-cluster's total turnover is thus the highest amongst the five sub-clusters analysed. Like the turnover, also the number of employed has increased with 2 % since 2007 reaching 6,900 in 2009.

[72] David Frykerås, personal communication, August 5, 2011.

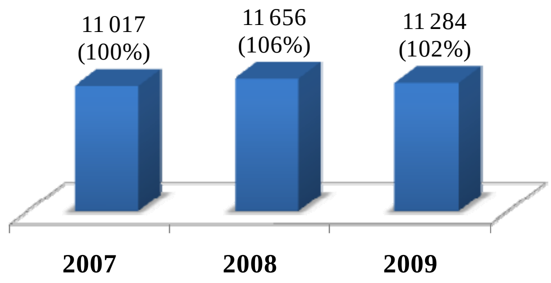

Figure 2.37: Total turnover of regional companies in sustainable building sub-cluster (in million SEK)

Source: Public company database

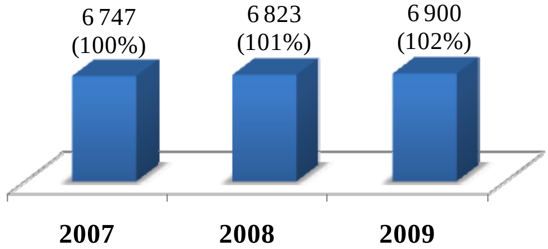

Figure 2.38: Number of employed at regional companies in sustainable building sub-cluster

Source: Public company database

58 % of the analysed technology developers are registered in Stockholm County, 17 % in Södermanland and the remaining six companies in Örebro, Gävleborg, Västmanland and Uppsala. This geographical concentration is also reflected by a number of regional and national initiatives in this sub-sector. In 2009, the Swedish government dedicated SEK 340 million for ”sustainable cities”. The aim was to stimulate urban projects that contribute to an improved environment and reduced climate impact while at the same time facilitating the Swedish environmental technology exports. The investment was intended to create new Swedish showcases for climate-friendly buildings with environmental technology and based on advanced planning.

One of the most famous activities in this sub-cluster during the last years was the project Hammarby Sjöstad in Stockholm. It is an example of how the market (in this case the municipality) can boost innovative processes in the field of sustainable building. In other words, it is a good example of market driven cleantech cluster formation.[73]

Hammarby Sjöstad has illustrated how a new district can be built with significantly lower environmental impact compared to the standard for newly constructed neighbourhoods. The way the area was planned became unique and was the key to the project success. When the district was built up, the city building owners were encouraged to find their own solutions within a common framework, where low energy and self-production of energy were included. The result

[73] The following description is based on Ulf E. Andersson (Ed.): *Svenska strategier och initiativ för främjande av miljöteknik. En nationell översikt för genomförande av EU:s miljöteknikplan ETAP.* Stockholm: Swentec.

was an area not only with many parks and green areas. It developed fast and attractive low-carbon-emission public transport solutions, a car pool and cycle routes. Renewable fuels were used where possible. To reduce heating costs emphasis was on energy efficiency and reuse of sewage water heat. Furthermore, new technologies were used to save water and clean drains and provide efficient waste collection system to recycle as much material and energy as possible.

Hammarby Sjöstad has attracted international attention and is visited annually by over 12,000 industry representatives and policy makers from around the world. The site has acted as a demonstration facility for Swedish cleantech and has been important for several companies' clean-technology sales.

Another cluster initiative of particular importance for the sub-sector Sustainable Building is "Miljöteknik för tillväxt"(MFT, Environmental Technology for Growth), running between 2009 and 2011.[74]

Even though no technology developers have been identified that are located in Östergötland County, business activities regarding the sub-sector sustainable building are also going on in this part of Sweden. Many companies in the sustainable building sub-sector offer solutions that contribute to energy and resource efficiency as well as reduced emissions to land, water and air. Environmental consultant's account for a large proportion of this cluster in the region. The proximity to and tradition of working with Linköping University is a positive ground for the development of products and services.[75]

Sub-cluster 4: Air purification

According to ETAP the field of air purification is about air emission control, treatment and/or removal of air pollutants. In the region, 16 companies have been identified through SWENTEC's database that is active in developing technologies for air purification. The companies' turnover increased in recent years

[74] For further information about the project, see description about Stockholm Environmental Technology Centre above.

[75] Modified and translated text from http://www.cleantechostergotland.se/index.php?page_show=17&sub_to=15 (August, 4, 2011).

with nearly 70 % to SEK 1,929 million, while the number of employed decreased during the same period with 4 % to 590 persons (see figures below).

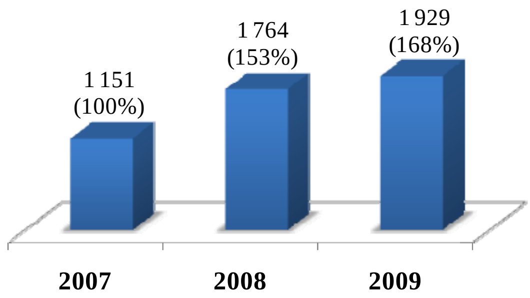

Figure 2.39: Total turnover of regional companies in air purification sub-cluster (in million SEK)

Source: Public company database

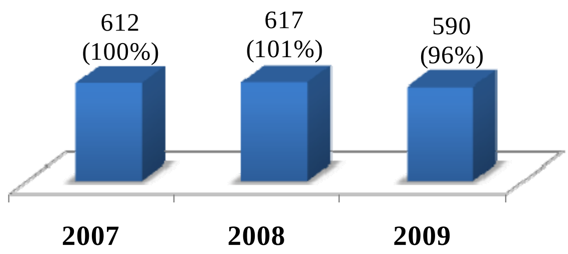

Figure 2.40: Number of employed at regional companies in air purification sub-cluster

Source: Public company database

Half of the identified companies are located in Stockholm, but the others are spread all-over the entire region. Examples for companies working in the sub-sector air purification are: Handelshuset Toveko AB and SenseAir AB in Gävleborg County, Camfil Svenska AB (with over 300 employees) in Södermanland County, System Separation AB in Uppsala County, as well as Nildust AB and Scandab Plåtproduktion AB in Örebro County. Östergötland is further the base for Foster Wheeler Energi AB and Pilum Polyproject AB. In Stockholm there are naturally are some more companies. Examples are AVL MTC Motortestcenter AB, CentriClean Systems AB, Ecomb AB, Ecotraffic ERD AB, Ekströms Värmetekniska AB, Micatrone AB, Pilum Engineering AB, and Rehact AB.

Trying to uncover more systemic cluster cooperation did not have any sufficient results. It is thus supposed that this sub-cluster is - like most other sub-clusters-of an alpha type in our terminology.

Sub-cluster 5: Solar energy

According to ETAP the area solar energy is about production, collection and transfer of energy from the sun. It seems to be obvious, from the country's longitudinal position on the planet point of view, that Sweden is not the best place for solar energy development. There are however some sub-areas in which Sweden in fact have a strong position in an international perspective. More well-known examples are big companies such as ABB or Siemens (Finspång plant, former known as Stal), but there are even some not so well known ones.

Solar energy is the sub-cluster with the smallest number of analysed technology developers. Only nine companies from the SWENTEC database have been identified that develop technologies with regard to solar energy. Like in the sub-cluster of air purification, the turnover of the regional technology developers developed differently from the number of employed. While the turnover decreased with 5 % between 2007 and 2009, were 2009 49 persons more employed in this sub-cluster than in 2007.

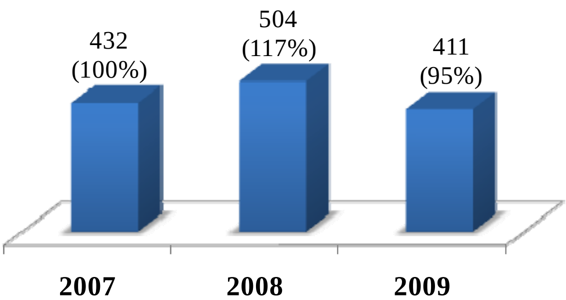

Figure 2.41: Total turnover of regional companies in solar energy sub-cluster (in million SEK)

Source: Public company database

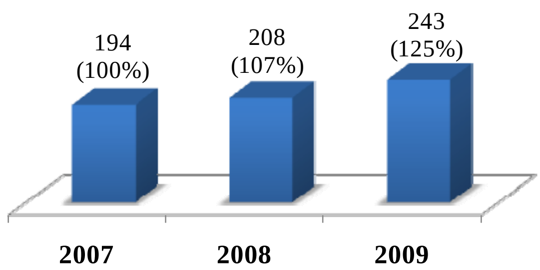

Figure 2.42: Number of employed at regional companies in solar energy sub-cluster

Source: Public company database

The location of the analysed enterprises is rather spread and it thus seems that this advanced cleantech field is not accumulated at one specific place in Sweden. Rather, there are many sites and lots of co-operation.

One dynamic player in this sub-cluster is S-Solar in Finspång, Östergötland. S-Solar develops manufactures and delivers absorbers for solar collectors under the brand Sunstrip. The core is an absorber with high total efficiency worldwide patented since 1980. The absorber is made of aluminium with a joined metallurgical copper tube. Sunstrip Absorber is thus used as a component of solar collectors that other companies produce. The company cooperates with several other players within the sub-cluster, for example Uppsala University. Also customers are important for both technology development and concepts dissemination (which is true for many companies). These include several real estate companies in the region.[76]

The most interesting solar sub-cluster in Sweden is one connected to Stirling engines in combination with solar panels. It refers to using the sun for driving a heat engine that in turn produces electricity. Here is the background in brief:

In 1938 the Philips Company started a Stirling engine project. After developments, production started in 1951. There were 150 engines produced but they soon understood that the price would be too high. In the late 1960s signals pointed to that Sweden should boost the submarine program. Equally important was the fact that Sweden wanted new future export products. Therefore United Stirling AB was established in 1968 by FFV (United Defence Works, Linköping site), Kockums and Husqvarna. The platform was built on a licence agreement with Philips and the target applications were submarine engines but also bus engines and auxiliary power units. Later the (old) idea of using sun panels for feeding Stirling engines with heat formed.

Today, commercial Stirling engine solar plants are exported worldwide. The cluster based on these visions is distributed around many regions in Sweden (and abroad), but much of it started in Östergötland. Moreover, lots of investments (and political decisions) are done, and are still done, by the region of Stockholm. The Swedish team of the Global Vision project has an on-going in-depth study of this Stirling-sun project and the plan is to complete it in approximately one year. Some parts have already been published at an international cleantech conference in June 2011 and can be downloaded from the Global Vision website.[77]

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[76] http://www.ssolar.com/Omoss/tabid/189/Default.aspx

[77] Per Frankelius, Claes Hultman, Gabriel Linton, ConnyJohanzon and Claes Gunnarsson: ”The cleantech mystery: A new theoretical model for understanding export capabilities in small and medium-sized innovative cleantech companies”. The R&D Management Conference 201: R&D, Sustainability & Innovation, the need for new ideas, initiatives and alliances, Norrköping, Sweden 28-30 June, 2011.

A Stirling Engine and a point focal parabolic dish. Photo: Randy Montoya at Sandia National Laboratories (used by permission).

Regarding solar energy it has to be mentioned that many other sub-clusters can be defined as solar energy clusters. Consider for example Agro ethanol and other companies in the bioenergy and biofuels cluster. They are basically offering methods for using plants to transform solar energy into chemical energy.

Discussion

The interviews with cleantech companies showed that only 15 of the 47 interviewed companies could refer to one or more geographical clusters. Regarding universities, most of the companies stated that the academic world did not fulfil their expectations. The study of five Swedish cleantech sub-clusters seems to confirm this picture. The company Agro ethanol in Norrköping can - as a typical cleantech business - be used as an example for a further illustration:

Agro ethanol uses rentable energy sources to produce ethanol, which can be used instead of fossil fuels. These targets are very much in the centre of what cleantech is about. The operation is technically intensive and the business is full scale. Please have in mind the “periodic system” of cluster types described earlier. On general level, Agro ethanol can be regarded as part of the regional “renewable fuel cluster”. On a more specific (detailed) level, Agro ethanol is part of a *business system,* which includes both traditional business factors like suppliers and customers and X factors like opinion making from lobby groups. See our (simplified) model of this case in the figure 2.44.

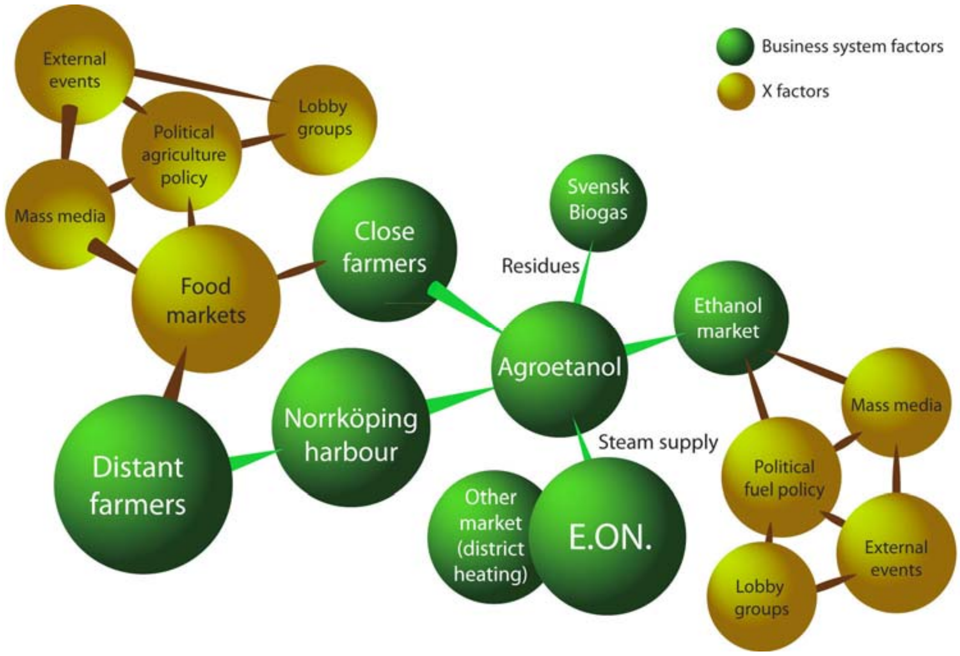

Figure 2.43: Some important parts of the business system around Lantmännen Agro ethanol. The model is constructed by means of a visual language published elsewhere.[78]

A close look at this case shows that Agro ethanol seems not to have any substantial cooperation with other ethanol-making organisations in the region. Instead, the company is connected to international arenas. The university world is not central in the picture either. These observations can be an indication of the fact that Agro ethanol is not part of a beta-cluster with systematic cooperation among players with the same business orientation. In other words: On the specific level, a beta-cluster cannot be identified.

There are two possible and contradicting conclusions that can be drawn from these observations. The first one is that the companies are wrong and should work harder to create cluster dynamics. The second conclusion is that the companies are right and much of the policy perspective (promoting cluster initiatives) is on the wrong track.

More research is needed to uncover the true answer, but the cases of Agro ethanol and Ageratec (in the biofuel sub-cluster) indicate that cluster dynamics may be a bit overestimated as a powerful force for business development. There are

[78] See for example Per Frankelius: Questioning two myths in innovation literature. *Journal of High Technology Management Research*, Vol. 20, No. 1, 2009, pp. 40–51.

many discussions about the importance of "cluster initiatives", "collective visions", "test beds", "innovation support" and alike. In reality, high performance seems to be the result of (also) many other factors; not least investments by heavy organisations like Lantmännen or entrepreneurial initiatives like the funding of Ageratec. However, if we stick to the alpha-cluster definition, there is a fact that many companies with likewise business orientation are allocated to certain geographical places such as Stockholm and Östergötland. More research is needed both to understand these issues and to investigate if cluster dynamics could add value to businesses such as Ageratec despite the fact that the company has shown successful international performance without obvious cluster dynamics.

What then are the success factors for the cleantech clusters studied (in the alpha-cluster sense)? Our hypothesis is that business competence is as much important and as much hard to build up as technical competence. On the contrary most policy makers seems to believe that universities and other knowledge promoters primary should focus on helping the companies with technical or product development. Maybe it's time for a paradigm shift?

4. Best practice study on funding: Green venture fund cases

A number of venture capital organisations located in Sweden have specialised in investing in cleantech companies. The most important ones are presented below in order to give a more detailed picture on the funding possibilities for Sweden's cleantech companies. Furthermore, some of the best practice cases show how public support measures can enhance private investments in the cleantech sector.

The next section focuses on venture funds with an explicit specialisation on investments in cleantech companies, while an overview of other venture funds, which also invest in other sectors but still are of high relevance for the Swedish cleantech sector, is given in the successive chapter.

Venture funds with special cleantech focus

Sustainable Technologies Fund

Founded in 2007, the Sustainable Technologies Fund is a 58 million EUR private equity expansion capital fund specializing in growth investments. The fund is managed by the US-based company Sustainable Technologies Management Limited and has offices in Stockholm (Sustainable Technology Partners Nordic AB) and Pittsburgh, Pennsylvania. Fund investors are the Swedish National Pension

Funds Three and Six, the Öhman-group, Kåpan Pensioner, and the Heinz Family Philanthropies as well as private individuals.[79]

With the current financial volume the fund seeks to invest in approximately ten cleantech companies until 2018. Primary targets for the fund's investments are cleantech companies in the Nordic region having the potential of growing internationally, in particular in the US market. Furthermore, the fund is mainly interested in the following cleantech fields: energy efficiency, renewable energy generation, bio fuels, sustainable materials and chemicals, energy storage, and energy transmission.

The fund's initial investments are aimed to take place during the companies' growth and expansion phase and lie between one and three million euro. Each portfolio company is typically receiving between three and seven million euro within a period of three to six years.

One of the investment criteria of the Sustainable Technologies Fund is that the prospective companies should have an annual turnover between two and seven million euro. The fund prefers to take minority positions and an active board seat in its portfolio companies.

The portfolio of Sustainable Technologies Fund comprises currently seven cleantech companies: Triventus, Eco 2 Energy, Havgul Clean Energy, REAC Fuel, Innotech Solar AS, Pemtec AB and Hexaformer AB. Further information about the companies is provided in Table 2.1.

[79] For the whole chapter please see: BloombergBusinessweek, 2011-09-02, Profile of Sustainable Technologies Fund; Anders Frisk, 2010, Sustainable Technologies Fund, presentation at Uppsala Energy Club 2010-11-24; Website of Sustainable Technologies Fund, visited on 2011-09-02 and 2011-09-06, www.stechfund.com.

Table 2.18. Cleantech investments made by Sustainable Technologies Fund in recent years

Year of investment	Company name	Area of investment	Investors	Investment size
2007	Swebo Bioenergy AB*	Energy efficiency: Develops, produces and markets environmentally friendly and carbon neutral bioenergy systems for larger residential houses.	Sustainable Technologies Fund (STF)	n.a.
2008	Suncore*	Solar energy: Manufactures and sells polymer-based solar panel.	STF	30 % of the company's stocks
2008	Havgul Clean Energy	Renewable energy generation: Develops wind power projects.	STF, Investor, Harald Dirdal	Total 50 million NOR
2009	Swebo Bioenergy AB*	(reinvestment)	STF, Norrlandsfonden	Total 15 million SEK
2009	Hexaformer AB	Energy transmission: Develops, manufactures and sells efficient transformer and reactor solutions.	STF, Innovations-kapital	Total 35 million SEK
2009	Pemtec AB	Energy efficiency: Develops, manufactures and sells innovative ground source heat pump collectors.	STF	10 million SEK
2009	Innotech Solar AS	Solar energy: Classifies and up-grads non-prime c-Si solar cells within the solar industry.	STF, Northzone Ventures	Total 6 million EUR
2010	Havgul Clean Energy	(reinvestment)	STF, Vale & Dirdal AS	25.5 million NOK
			Investinor	24.5 million NOK
2010	REAC Fuel	Renewable energy generation: Develops a new method of extracting fuel from converts lignocellulosic biomass.	STF, British Petroleum, Vantage Point	Total 30 million SEK
2010	Eco 2 Energy	Renewable energy generation: Independent provider	STF, Paron Ventures,	Total 34 million SEK

Year of investment	Company name	Area of investment	Investors	Investment size
		of heat from renewable sources.	Maximianus	
2011	Triventus	Renewable energy generation: Wind power generation.	STF	50 million SEK
			Industrifonden and founders	66 million SEK

* No longer in the Sustainable Technologies Fund's Portfolio.

Sources: Website of Sustainable Technologies Fund (www.stechfund.com), 2011-09-02; NyTeknik, 2008-07-02, "Norrländsk solfångare får ketchuppengar"; NyTeknik, 2009-09-02, "Grön riskkapitalist satsar på bergvärme"; Navigant Capital Advisor, 2010, "Quarterly Dialogue Fourth Quarter 2010 - Renewable Energy"; Innotech Solar, press release 2009-07-08, "ITS has secured 6 EUR Million in funding to finance production ramp up"; Energinyheter.se, 2009-05-13, "Swebo tar in 15 miljoner kronor"; Swebo Bioenergy AB, press release 2009-05-13, "Swebo Bopenergy tar in 15 miljoner kronor i expansionskapital"; InnovationsKapital, press release 2009-05-09, "Sustainable Technologies Fund invests in Hexaformer AB"; CisionWire, press release 2009-09-01, "Sustainable Technologies Fund investerar 10 MSEK i Pemtec AB".

IKEA GreenTech AB

IKEA GreenTech AB is a venture capital investment fund owned by the IKEA Group and located in the Swedish city Lund. The fund was founded in 2008 by initiative of Peter and Jonas Kamprad with a disposal sum of 500 million SEK for new investments. IKEA GreenTech sources its new capital through its balance sheet. The fund concentrates on early, mid, and late venture investments, but it is also interested in investing in expansion capital. The aim of IKEA GreenTech is to invest in innovative cleantech companies in the Nordic region developing technologies that have the potential to be used for products sold at IKEA. Cleantech areas of particular importance for the fund are energy efficiency, energy generation and recycling technology.[80]

IKEA GreenTech's overall aim is to have a portfolio of up to ten companies, each with an investment value of 50 to 100 million SEK over the investment's lifetime. With this comparatively smaller portfolio the fund intends support the cleantech companies more actively during a longer time. Any return on investments will be

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[80] Bloomberg Businessweek, 2011-09-02, Profile of IKEA GreenTech; MiljöAktuellt, 2008-08-12, "Ikea: 'Billiga, bra solpaneler till alla' ".

returned to a general pool with the intention to keep a continuous supply of available investment capital in the fund.[81]

Originally, the plan was to undertake four to five investments during the fund's introduction phase in 2008. However, the first (and so far only) investment was conducted as late as 2010, when IKEA GreenTech invested 20 million SEK in the Swedish company Alelion Batteries AB. By this investment the fund became the second largest stakeholder of Alelion after the state-owned venture capital company Fourier transform that had invested 28 million SEK a couple of months earlier. Founded in 2006 Alelion Batteries manufactures complete energy storage systems based on Li-ion batteries. IKEA GreenTech has the intention that Alelion Batteries will - within a couple of years - be able to develop a battery that can store energy from solar cells and that may be sold worldwide at IKEA.[82]

Volvo Technology Transfer AB

Volvo Technology Transfer (VTT) is a corporate venture capital firm with the aim to create value by supporting and developing new firms with relevance for the Volvo Group. All investments undertaken by VTT have to be in line with Volvos core values (quality, safety and environment), making cleantech an important investment area. Having been active in venture investments since 1983, the Volvo Group founded Volvo Venture Management in 1996, which was transformed to VTT in 1997. The fund has its office in Gothenburg, Sweden, and has currently 1,000 million SEK under management.[83]

It is important for VTT to have a balance between the different investment phases in the value chain, from research to the early stage of product and process development. If it is possible, the fund tries to syndicate with other co-investors when making an investment. The goal is to successfully develop the companies and in the future make an exit. The fund's investment size is between 10 and 50 million SEK per portfolio company. The fund is interested in international as

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[81] MiljöAktuellt, 2008-08-12, "Ikea: 'Billiga, bra solpaneler till alla' "; Website of IKEA GreenTech, visited 2011-09-06, http://ikea.greentechab.com.
[82] MiljöAktuellt, 2010-11-01, "Första investeringen för Ikea Greentech"; MiljöAktuellt, 2008-08-12, "Ikea: 'Billiga, bra solpaneler till alla' "; Website of Fouriertransform, visited 2011-09-02, www.fouriertransform.se.
[83] Website of Volvo Group, visited 2011-09-05, www.volvogroup.com; Volvo Technology Transfer AB, 2011, presentation "VTT - Volvo Group Venture Capital".

well as Scandinavian companies. 75% of VTT's turnover is related to clients within the Volvo Group and Volvo Car Corporation. For this matter, the economic situation has a large influence on the fund.[84]

Currently, VTT has 25 companies in its portfolio, seven of them with cleantech related businesses.[85] These investments are presented in Table 2.2.

Table 2.19. Cleantech companies in the portfolio of Volvo Technology Transfer (2011)

Year	Company name	Cleantech product/service	Main investors	Development stage
1999	Effpower	Energy systems and bipolar LIC batteries for hybrid electronic vehicles	VTT, Swedish Industrial Fund, Gylling Invest	Development
2006	El-forest	Hybrid technology to reduce amongst others fuel consumption and carbon dioxide emission	VTT, Fouriertransform (since 2010)	Development
2007	Chemrec	Transforms with the help of black liquor gasification technology pulp and paper mills into bio refineries	VTT, Vantage Point Venture Partners, Environmental Technologies Fund and Nykomb Synergetics	Start-up
2007	Proxio	Software tool reducing transportation costs and CO_2 emissions	VTT, KTH Chalmers Capital	Development
2008	Powercell Sweden	Environmentally friendly fuel cell system based on a patented reformer technology that provides electrical power	VTT, Fouriertransform, Midroc New Technology, Swedish Energy Agency, OCAS	Start-up
2008	Terracastus Technologies	Clean and upgrading of biogas or landfill gas to compressed biogas, liquefied biogas or pipeline gas	VTT	Start-up
2008	i-tech marine paint	Marine paint industry environmentally friendly antifouling substances	VTT, Mintage Scientific AB, Innovationsbron	Start-up

Source: VTT, 2011, presentation "VTT - Volvo Group Venture Capital": 8-10; Websites of the portfolio companies.

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[84] Volvo Technology Transfer AB, 2011, presentation "VTT - Volvo Group Venture Capital"; Volvo Technology Transfer AB, 2011, Annual Report 2010; Website of Volvo Group, visited 2011-09-05, www.volvogroup.com.

[85] Websites of Volvo Group and the portfolio companies, visited 2011-09-05.

Alder Fund

Established in Stockholm in 2010, Alders Fund I AB is a growth capital investor seeking to invest in the environmental technology sector in the Nordic countries. The fund's main focus is to invest in established companies with a turnover of up to SEK 500 million or in companies that are showing great growth potential and have a turnover above SEK 30 million. Alder Fund has one billion SEK under management with investors such as the Seventh Swedish National Pension Fund, Folksam and Kyrkans pensionskassa.[86]

In May 2011, Alder Fund made its first investment by acquiring 62% in the biomass company The Järnforsen Group. The company's business idea is to build plants for the generation of heating and energy from forest residue with the aim of increasing renewable energy. Järnforsen's main customers are heating plants and sawmills. The Järnforsen group has annual revenue of SEK 200 million and an operating profit of SEK 11 million. The investment of Alder Fund is intended to enable The Järnforsen Group to focus more on export in order increase its turnover within the next three to four years.[87]

Midroc New Technology AB

The Swedish private equity fund Midroc New Technology AB (MNT) was registered as in 2005 as part of Midroc Europe. The fund's office is located in Sundbyberg, Sweden.

The fund is interested in early stage investment which has the potential of growing internationally. To increase the potential for a successful investment, MNT seeks to acquire a large ownership share and to actively engage in the business operations during the first year of the investment. Besides biomedicine, cleantech is one of the fund's to focus areas. Currently, MNT's portfolio comprises ten

[86] Website of Alder, visited 2011-09-02, www.alder.se; Kyrkans pensionskassa, press release 2011-05-17, " Alder investerar i Järnforsengruppen - en storsatsning på export av svensk bioenergiteknik"; Alder, 2011, Annual Report 2010.
[87] Alder, press release 2011-05-17, "Alder acquires Järnforsen Energy Group".

cleantech companies with an investment horizon between eight and ten years. The companies are listed in Table 2.3.[88]

Major investments regarding companies with other large investors include for example Lamera in 2008 (Volvo Technology Transfer, Chalmers University), where MNT acquired an owner share of 9%.[89] In 2009 MNT conducted one of its largest investments when investing in Powercell Sweden AB. Together with Volvo Technology Transfer, Ocas Venture and the Swedish Energy Agency MNT raised 200 million SEK.[90]

Since MNT's start of operation, the fund has also been undertaken successful exits for its portfolio companies. For example, MNT sold its shares in TranSiC AB to the American company Fairchild Semiconductor in 2011. TranSiC develops and manufactures Bipolar Power Transistors in Silicon Carbide used to control electric motors.

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[88] Midroc New Technology AB, 2011, Annual Report 2010; Website of Midroc New Technology AB, visited 2011-09-06; E24, 2011-06-08, "Cleantech är ingen bubbla".

[89] Chalmers Innovation, pressrelease 2008-02-22, "Midroc New Technology satsar pengar i ny sandwichplåt".

[90] Midroc New Technology, 2010, Annual Report 2009; Website of Volvo Group Global, visited 2011-09-06, www.volvogroup.com.

Table 2.20. Cleantech companies in the portfolio of Midroc New Technology (2011)

Year	Company name	Cleantech product/service
2007	Air to Air Sweden	Heat and moisture exchanger
2007	Minesto	New concept for tidal power plants
2007	ReoSense	New measurement technique for process control of moulded rubber goods
2007	Jensen Devices	Products based on high performance gas discharge tube technology
2008	HCCI Technology	Multi-fuel, HEV-compatible, HCCI combustion engine
2008	Lamera	Ultra-light stainless composites
2008	Crossborder Technologies	Light pallets
2009	Powercell	Advanced fuel cell systems
2010	SolarWave	Solar powered water purification and desalination systems
n/a	Microfluid	Equipment for controlling and measuring thin fluid layers for the manufacturing industry

Source: Websites of Midroc New Technology, the portfolio companies as well as NyTeknik.

Other venture funds of importance for the cleantech sector

Pegroco Invest

Pegroco Invest was founded in 2007 as a private equity and venture capital firm. Its offices are located in Stockholm and Gothenburg, Sweden. With a focus on the Nordic region, Pegroco invests in established companies with great potential for development and growth. At present, the fund has twelve companies in its investment portfolio. The fund does not have a specific focus area, but cleantech is an important and highlighted are and the fund has undertaken several investments within the sector. The fund's investment size lies usually between one and ten million SEK during an investments lifetime. The fund sources its capital through its balance sheet.[91]

Currently, Pegroco Invest has three cleantech companies in its portfolio:

- Flexenclosure developing turn-key shelter solutions based on renewable energy sources,
- Symbrio developing, producing and distributing efficient and eco-friendly lithium-ion battery systems,
- Scandinavian Environmental Systems offering turnkey recycling plants and core-technology required to recycle used tires.[92]

Industrifonden

Industrifonden was established in 1979 by the Swedish state with the aim of helping companies with funding. The fund is an independent foundation and has offices in Stockholm, Gothenburg, Malmö and Linköping. Industrifonden invests mainly in sectors like ICT, electronics, life sciences and industrial technology, and since 2007 also in cleantech. Its initial funding volume amounted to SEK 300 million and today, Industrifonden manages SEK 3 billion, of which half have already been invested in about 90 companies.[93]

The fund's investment focus lies on small and medium sized Swedish companies with less than 250 employees, a maximum in sales of SEK 400 million, and a potential to grow internationally. Industrifonden invests both directly in companies and indirectly via cooperating regional venture capital organizations. Investments have mainly the form of equity capital, but the fund provides also loans and guarantees. Furthermore, the fund seeks an ownership interest between 15% and 50% with total investments in each company lying between SEK 5 million and SEK 100 million. Single investment may not exceed 5% of assets under management, which today is 150 million SEK.[94]

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[91] Bloomberg Businessweek, 2011-09-07, Profile of Pregroco Invest AB;Website of Pregroco Invest AB, visited 2011-09-07, www.pegrocoinvest.com.

[92] Website of Pegroco Invest, visited 2011-09-12, www.pegrocoinvest.com.

[93] Website of Industrifonden, visited 2011-09-12, www.industrifonden.se.

[94] Ibid

If possible, the fund wants to syndicate with other co investors. It is an active co-owner which besides the capital, also offer technical and business competence and network. Return from an investment is always reinvested in new projects.[95]

Currently, Industrifonden has nine cleantech companies in its portfolio, which are presented below.

[95] Ibid

Table 2.21. Cleantech companies in the portfolio of Industrifonden (2011)

Year	Company name	Cleantech product/service	Investment volume
2002	ClimateWell	Solar air conditioner equipment with the unique ability to store energy and convert hot water to cooling and heating	n/a
2002	Effpower	Energy systems and bipolar LIC batteries for hybrid electronic vehicles	SEK 42 million[96]
2006	Ecoil	Biofuel that is completely comparable to standard heating oil	n/a
2007	Jensen Devices	Products based on high performance gas discharge tube technology	SEK 30 million together with VTT and Midroc New Technology[97]
2008	Flexenclosure	Turn-key shelter solutions based on renewable energy sources for usage in the telecom industry	SEK 8 million[98]
2011	SEEC	Energy systems to heat and cool large properties and industrial facilities based on efficient energy storage in the ground	SEK 5 million[99]
2011	Airec	Compact and highly efficient plate heat exchangers that allow for substantial energy savings and reduced emissions	SEK 25 million together with RWE Innogy[100]
2011	Triventus	Design, construction and sale of wind power plants	SEK 100 million together with Sustainable Technologies Fund[101]
2011	Sol Voltaics	High-efficiency solar cells using guided self-assembly of nanowires in the gas phase	SEK 18.5 million[102]

Source: Website of Industrifonden, visited 2011-09-12, www.industrifonden.se.

[96] Industrifonden, presentation “Industrifondens finansiering av tillväxtföretag i energisektorn”, Anders Eklund

[97] Industrifonden, press release 2007-11-14, “Industrifonden, Volvo Technology Transfer och Midroc New Technology investerar i Jensen Devices”

[98] Website of Flexenclosure, visited 2011-09-12, www.flexenclosure.com; Industrifonden, press release 2007-11-14, “Industrifonden investerar i Flexenclosure – Sol, vind, bränsleceller och biobränsle ska driva mobilnät där el inte finns”.

[99] STING, press release 2011-08-18, ”Industrifonden investerar i SEEC”

[100] Industrifonden, press release 2011-03-14, “Industrifonden investera i Airec”

[101] Industrifonden, press release 2011-05-30, “Industrifonden och Sustainable Technologies investerar i vindkraftsbolaget Triventus”

[102] Cisionwire, pressrelease 2011-06-30, “Industrifonden investerar i solcellsbolaget Sol Volatics”.

Fouriertransform

Fouriertransform is a state-owned venture capital fund established in 2008. The fund manages over SEK 3 billion and sources its investments from its balance sheet. The investment focus lies in the automotive industry, focusing on sustainable vehicles, smart vehicles and more efficient production. The fund seeks to be an active owner and take a permanent position in the invested companies without a predetermined exit. Fouriertransform invests in companies from the early development stage until they have become mature. Until September 2011, Fouriertransform has invested SEK 418 million in 12 companies. The smallest investment amounted to SEK7 million and the largest to around SEK 104 million. Single investments may not exceed 5% of assets under management, which is SEK 150 million SEK. Usually, the fund owns a maximum of 49% of a company's shares.[103]

Currently, Fouriertransform has seven cleantech companies in its portfolio. The first investment in a cleantech company was conducted in 2009 when Fouriertransform invested SEK 60 million in Powercell ABdeveloping and distributing fuel cell systems for the transportation industry. The other investments were taking place in 2010, five of them regarding companies in an early development phase and one in the expansion phase (see Table 2.5). The single investment volume varied from SEK 9 million to approximately SEK 100 million.[104]

[103] Website of Fouriertransform, visited 2011-09-12, www.fouriertransform.se.

[104] Website of Fouriertransform, visited 2011-09-12, www.fouriertransform.se; Fouriertransfrom, press release 2009-10-27, "Fouriertransform investerar i Powercell Sweden AB"; Fouriertransform, 2011, "Our business activities 2010"; Fouriertransform, pressrelease 2010-10-21, "Fouriertransform investerar i Alelion Batteries AB"; Fouriertransform, pressrelease 2010-02-19 "Fouriertransform investerar Effpower"; Fouriertransform, pressrelease 2010-06-30,"Fouriertransform investerar El-forest AB"; Fouriertransform, pressrelease 2010-12-21, "Fouriertransform investerar Applied Nano Surface", 2010-12-21; Fouriertransform, pressrelease 2010-02-04, "Fouriertransfrom investerar 40 MSEK I NovaCast Technologies och blir delägare med 33% av kapitalet och 24% av rösterna".

Table 2.22. Fouriertransform's investments in cleantech companies in 2010

Company name	Cleantech product/service	Investment volume	Development phase
Alelion Batteries	Energy storage system for the automotive industry	SEK 28 million	Early stage
Effpower	Efficient battery for hybrids	SEK 40 million	Early stage
El-forest	Forestry machinery using series electric hybrid technology	SEK 20 million	Early stage
Norstel	New technology for hybrid vehicles	EUR 10.5 million	Early stage
Applied Nano Surfaces	Unique technology for reducing friction losses	SEK 9 million	Early stage
NovaCast Technologies	Casting systems and products	SEK 40 million	Expansion

Sources: Website of Fouriertransform, visited 2011-09-12, www.fouriertransform.se; Fouriertransform, 2011, "Our business activities 2010"; Fouriertransform, pressrelease 2010-10-21, "Fouriertransform investerar i Alelion Batteries AB"; Fouriertransform, pressrelease 2010-02-19 "Fouriertransform investerar Effpower"; Fouriertransform, pressrelease 2010-06-30,"Fouriertransform investerar El-forest AB"; Fouriertransform, pressrelease 2010-12-21, "Fouriertransform investerar Applied Nano Surface", 2010-12-21; Fouriertransform, pressrelease 2010-02-04, "Fouriertransfrom investerar 40 MSEK I NovaCast Technologies och blir delägare med 33% av kapitalet och 24% av rösterna".

KTH Chalmers Capital

The fund KTH Chalmers Capital was founded in 2006with the aim to mainly invest in early-stage companies. KTH Chalmers Capital is managed together with the KTH Seed Capital Investment with a total funding volume of SEK 284 million. The fund's investors are Wallenbergstiftelsen, SEB, Industrifonden, KTH and Chalmers. The investment focus lies on IT, internet technology, material technology and cleantech.[105]

KTH Chalmers Capitalhas currently six companies in its portfolio, two of them from the cleantech sector:

[105] Website of KTH Chalmers Capital, visited 2011-09-12, www.kthchalmerscapital.se.

- MyFC manufacturing micro fuel cells, which can replace Lithium batteries for home electronics (Together with other investors, KTH Chalmers Capital investedUSD 6.7 million USD in 2011.),[106]
- Xylophane producing a biodegradable material, which could replace plastic and aluminum in packaging (The investment was conducted together with Innovationsbron Väst and the owners Chalmers Innovation.).[107]

Summary

Even though less venture capital was available for cleantech companies since the financial downturn, the sector's share of total venture capital investments has been increasing. In Sweden, venture capital for cleantech companies is provided by both private and public funds that either have a very strong cleantech focus or specialise on a small number of sectors. Five major funds have been identified being officially specialised in cleantech investments, namely: Sustainable Technologies Fund, IKEA GreenTech, Volvo Technology Transfer, Alder Fund, and Midroc New Technology. IKEA GreenTech and Volvo Technology Transfer intend in particular to support companies developing or producing technologies or services which may be of future interest for businesses within the company group.

Analysing the funds' investments in recent years shows first that most of the investments in cleantech companies were taking place 2006 or later. Second, it becomes obvious that several funds aim to act as co-owners. This is in particular true for the public funds like Industrifonden and Fouriertransform. Cleantech companies that were attractive for a number of funds are for example Chemrec, Powercell Sweden, Effpower, and El-forest.

As far as the cleantech sub-fields are concerned, areas of particular importance have been energy efficiency, renewable energy generation, and bio fuels.

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[106] Stockholm Innovation and Growth, press release 2011-07-15, "myFC raised USD 6.7M to lanch innovative mobile phone charger".
[107] KTH Chalmers Capital, press release 2005-06-15,"Nytt kapital till biobaserad förpackningsfilm".

5. Analysis of strengths and weaknesses of Swedish policy measures in the cleantech sector

From the above presented information, some strengths and weaknesses within the Swedish cleantech sector are arising. They were in particularly useful for the creation of a policy guideline (see next chapter) aiming at developing suitable regional cluster policies. Furthermore, they allow for the identification of areas where the project partners from Estonia, Latvia and Sweden may learn from each other.

Strengths of the Swedish cleantech sector

Two areas were identified as specifically strong in the cleantech sector: Human resources and community support.

Access to qualified personnel

Even though it is seen as difficult to accentuate whether the Swedish education system pays enough attention to cleantech, more than half of the interviewed companies (60%) claimed to have sufficient access to qualified personnel.

A major role for the cleantech-related education in the concerned Swedish regions play the nine established universities. They offer a range of courses and studies that are directly or indirectly demanded by cleantech companies. Examples for cleantech-specific Master's programmes are "Environmental Science" (Stockholm University), "Sustainable Technology" (Royal Institute of Technology), and "Energy and Environmental Engineering" (Linköping University). Universities that are characterised by a cleantech research profile are Örebro University with its Research Centre Man-Technology-Environment and Royal Institute of Technology with e.g. its research unit "KTH Sustainability".

In autumn 2010, approximately 3,100 students attend cleantech-related programs and courses at regional universities. Thus, a good base has been built to ensure the sector's future demand of qualified personnel.

Comprehensive community support

The Swedish cleantech sector is supported by comprehensive government policies. Examples are the government's national initiative providing SEK 560 million for support measures between 2007 and 2010. For the period 2011-2014, additional SEK 400 million is allocated for the promotion of development and export of environmental technologies. The Swedish Trade Council will receive SEK 48 million of this amount. Also the work of SWENTEC, operating between 2008 and 2010 as a delegation for environmental technology, has been important for the sector's development.

Government policies are in particular implemented by means of government programmes supporting cleantech companies. Examples for such programmes are "Green Nano" promoting research on nanotechnologies for better environment, and "DemoEnvironment" promoting testing of new environmental technologies. Moreover, special initiatives were conducted in order to promote the export of Swedish cleantech to Asia (i.e. India and China).An example is the establishment of the Center for Environmental Technology (CENTEC) in China.

On a regional level, five community support organizations are of particular importance for the cleantech sector's development. Examples are the Stockholm Environmental Technology Centre (SMTC), Cleantech Östergötland and the network "Sustainable Business Mälardalen".

Weaknesses of the Swedish cleantech sector

In spite of the strong support from government and private community support organizations, the analysis of the Swedish cleantech sector showed some weaknesses. These are shortly presented below.

Lack of integration of business courses in cleantech-related education

In order to successfully start-up and drive a cleantech company, certain knowledge in business administration is needed. It is thus seen as a weakness, that business-related topics such as marketing are still not a major part of studies in the cleantech field.

Implementation of community support measures

Even though the cleantech sector is characterised by strong community support, half of the interviewed companies disapproved the implementation of support measures. Further investigations are thus needed in order to examine this result.

Contribution of academic and other research organizations

The performance of academic and other research organisations in general and in specific projects is by the majority of interviewed companies perceived as high (55%).However, their commercialization knowledge as well as their patenting activity in the field of cleantech is not seen as sufficient.

Existence of export and marketing barriers

The interviewed cleantech companies still perceive some barriers for exporting and marketing their products and services. Most often the companies experience difficulties in contacting customers and to build up a long-term relation with them. In addition, laws and regulations are seen as major export and marketing barrier.

Companies experienced problems with acquiring funding

About half of the interviewed companies from the regional cleantech clusters pointed at problems to acquire funding. The main reasons are that it is both difficult and time-consuming for them to apply for funding, e.g. within the framework of EU-programmes, and that they have difficulties in communicating their business model in such a way that it attracts investors.

6. Policy guideline for developing suitable regional cluster policies

The policy recommendations presented below have two important objectives. First, the policy recommendations should make a difference for the business performance among cleantech firms. Therefore, the recommendations are kept as specific and concrete as possible.

Second, taxpayers in Europe and especially Sweden, Latvia and Estonia, should be winners at the end. It is always easy to make suggestions under the assumption that the funding of them shall be made by other people's money, i.e. taxpayers' money. Therefore, it is important to be careful when proposing policy programmes that are connected with economic costs. In the case of cleantech, we are not only considering the economic consequences for the taxpayers, but also other kinds of values, not least positive impact on the natural environment.

At the same time, our opinion is that society, led by policy-makers, should engage in strategic programmes because the "invisible hand" will not do all the things that have to be done if one want to make giant leaps in areas such as cleantech promotion. Below, six policy recommendations are presented for promoting the cleantech sector in the Baltic Sea region.

1. Create a new kind of management programme for cleantech companies

Our investigations indicated that business competence is as much important and as much hard to build up as technical competence. On the contrary, most policy initiatives in the innovation field until today have been directed towards technical or product developments (with some exceptions). In our conclusions regarding weaknesses we pinpointed human resources and argued that it is necessary to integrate marketing courses in cleantech-related educational programmes. This is a good idea, but we want to extend this idea as follows:

We suggest a massive investment in high-level business education connected with cleantech. This investment should be made as a co-operative master programme driven by a consortium consisted by well-chosen actors in the Baltic Sea region.

The primary target group should be managers in cleantech companies searching for new knowledge injections. This master programme should be based on the philosophy of learning and training by means of working in "sharp modes". For example the participants should use their own companies as real-time cases during the competence programme. This is in line with the American pragmatists and their device "learning by doing".[108] The result will be both a higher level of competence among the participants (this has structural and long-lasting impact), and more business success during the time of the programme (short time effect). This programme will of course also integrate research-based knowledge. One interesting area is for example patenting as we pin-pointed in our analysis of weaknesses. Another area is the making of professional business plans, not least for the persuasion of financial actors.

This vision of a new kind of a master programme will demand quite heavy financial resources both in the developing and execution phase. An important part of this policy recommendation is therefore the idea of collective funding and collective execution among countries in the Baltic Sea region.

Another idea is that the programme provider may write a contract with the participants regarding the benefit from the revenues generated by businesses by means of the programme in the short run. We are aware of the difficulty of measuring the direct and indirect results of the programme, but also of the fact

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[108] John Dewey, *The School and Society: the child and the curriculum*. Mineola, N.Y: Dover Publications, 2001; Charles Saunders Peirce, "How to Make Our Ideas Clear", *Popular Science Monthly,* volume 12, January, 1878, p. 286–302.

that small cleantech companies cannot afford expensive fees that often are demanded for high level executive master programmes.[109]

2. Investigate cluster dynamics to motivate and chose support measures

In our analysis, we stated that beta-expanded clusters could be identified in the cleantech field. There are two possible and contradicting conclusions that can be drawn from this observation. The first one is that the companies are wrong and should work harder to create cluster dynamics. The second conclusion is that the companies are right and much of the policy perspective (promoting cluster initiatives) is on the wrong track.

Therefore, we suggest policy makers to make an in-depth analysis of how cluster dynamics affect business. After this investigation is fulfilled, new policy decisions can be discussed (for example initiatives like the Research Triangle Park project in North Carolina, USA).

Nota bene: The concept of value constellations, discussed earlier in this report, has a focus on co-operation among business partners as suppliers and buyers, i.e. actors doing business with each other. The concept of beta-expanded cluster dynamics includes such co-operation but also other kind of co-operation such as idea-exchange among competitors (who are not formally doing business with each other). Another difference is that beta-expanded clusters are geographically defined, while value constellations are not.

3. Establish a trade-fair cooperation promoter

Boosting export is important and trade-fairs are strategically important in this process, because they are portals to interesting markets in regions such as Asia, Africa and North America. Many cleantech companies are too small to invest enough in trade fair projects on their own. Therefore, we suggest policy-makers

[109] The idea here was put forward by Conny Johansson and Claes Gunnarsson at Örebro university.

to allocate funding towards organizing co-operative trade fair operations, in which cleantech companies work together and for example integrate their marketing budgets in connection with trade-fairs. Actors such as Export Councils and Trade Fair Councils in Latvia, Estonia and Sweden should be involved. We also suggest the non-profit trade-fair organization Fair link to be co-ordinator or primary consultant in this line of activity.[110] Some activities are already made in this direction but we suggest a huge up scaling. Just one example:

On October 4 to 7 in 2011 a number of Swedish companies active in energy and environmental technology will jointly participate in the world's largest trade fair for sustainable building, Green Build Expo (this year in Toronto, Canada). It is already the third year that the Swedish Energy Agency and the Swedish Trade Council organize a Swedish delegation to the fair.[111]

This policy recommendation is not about supporting one or a few sporadic trade-fair trips. It is about creating a dedicated team of people that establish a co-ordinating and promoting platform for trade-fair activities. This team should make a list of all export-oriented cleantech companies, and then pinpoint important fact on each other, such as kinds of customer offers (products and services) and kinds of export strategies (country or region focus). From this information, the team can match relevant companies for each specific trade-fair. From a company point of view harvesting synergy effects with other companies offering complementing products may exist.

Of course, information search and trade-fair mapping is part of the mission. Moreover, a trade-fair strategy is not only about buying trade-fair stand space and co-ordinating groups of companies in each trade-fair and exhibition stand area. It is also about targeting potential customers and inviting them on beforehand to the trade-fair event in question.

[110] See http://www.fairlink.se/web/Startsida.aspx

[111] Swedish Energy Agency, press release 2011-08-23, “Svenskt deltagande på mässa för hållbart byggande i Toronto”

4. Create reference projects for valorisation of knowledge on the very edge of cleantech possibilities

This policy suggestion is about ”put a man on the moon projects”. We suggest policy makers to direct a substantial part of their procurement budgets towards future-oriented reference projects like the Hammarby Sjöstad-project, however, on a higher level. These future projects should be directed towards targets that can be fulfilled only by using knowledge on the edge of international cleantech research. One thinkable example of such a future project could be to create a system for local production and use of bio-diesel.

5. Realise a new kind of annual co-operation arena

We believe in the idea of forming a new meeting and co-operation arena for cleantech companies and cleantech customers in the Baltic Sea region.

We suggest policy makers to invest in supporting such a meeting arena, for example in form of one annually two-day conference and matchmaking event on a ship on the Baltic Sea. This new platform has more than one function:

- Alone is not strong enough, and this platform could be an interesting way for capacity extension for small innovative cleantech firm.
- This event can be an effective market for cleantech in our home region, i.e.the Baltic Sea region. Professor Michael Porter and others have pointed at the importance of a strong home-market and this initiative is a way to create a collective “home market” based on all countries around the Baltic Sea.[112]
- The meeting arena addresses some of the identified export and marketing barriers, namely the difficulties to get in contact with customers and to establish long-term customer relations. There is also a possibility that such an annual Baltic Sea Cleantech event can attract interesting actors from

[112] M. E. Porter, *The competitive advantage of nations*. New York: Free Press, 1990.

other parts of the world. For them, this arena can be an effective way for creating the right contacts.

There are a few initiatives already existing that aim at establishing business platforms. One example is RECO Baltic 21 Tech, a project focusing on waste management.[113] We propose co-operation with such initiatives.

6. Establish a proactive funding office for the cleantech sector

In our analysis, financial needs turned out to be an important issue. About half of the respondents pointed at funding problems. It was, according to the companies, difficult and time-consuming to acquire capital and they had problems in communicating their business model.

We thus recommend to establish a very service minded ”funding office” for the cleantech businesses. This office should provide competence and practical help for applications of EU funds and other kinds of funds. Moreover this office should keep an eye on different calls for proposals that can be interesting for cleantech companies.

The physical address of this office is not decisive as communication is possible via mail and phone etc.

[113] See http://www.recobaltic21.net/

Annexes

Annex 2.1: List of interviewed companies

No	Company	Number of employed	Turnover 2009 (TSEK)	Profit/loss 2009 (TSEK)	County	Cleantech sub-sector
1	Ekströms Värmetekniska AB	9	69 942	4 024	Stockholm	Air purification
2	Fasadglas Bäcklin AB	72	224 619	13 740	Stockholm	Sustainable building
3	Ingenjörsfirman R Sjöstrand	5	9 100	-211	Stockholm	Waste management and recycling
4	Munters AB	29	6 500	-42 000	Stockholm	Sustainable building
5	Byggvesta Bo AB 1)	10	14 616	41 005	Stockholm	Sustainable building
6	Dustcontrol AB	67	102 915	-1 744	Stockholm	Air purification
7	KMW Energi AB 2)	38	78 714	-55 335	Stockholm	Bioenergy and biofuels
8	San Sac AB	14	140 267	20 536	Östergötland	Waste management and recycling
9	Swedish Weight Technology AB	8	9 093	-3 890	Stockholm	Waste management and recycling
10	Swedish Biogas International AB	11	21 720	39	Östergötland	Bioenergy and biofuels
11	Wassara AB	19	56 175	-3 398	Stockholm	Sustainable building
12	ClimateWell AB	19	40 313	-16 504	Stockholm	Solar energy
13	Pilum Engeneering AB 3)	5	14 308	-1 948	Stockholm	Air purification
14	SolTech Energy AB	8	894	-9 407	Stockholm	Solar energy
15	Cortus AB	2	8	-144	Stockholm	Bioenergy and biofuels
16	Aquasol AB	12	17 685	1 502	Örebro	Solar energy
17	EnPlant AB	1	384	251	Stockholm	Bioenergy and biofuels
18	Götene Gårdsgas AB	3	4 134	-546	Södermanland	Bioenergy and biofuels
19	JAR Luftvård AB	2	15 710	169	Södermanland	Sustainable building
20	Björnax AB	7	8 898	1 777	Örebro	Sustainable building
21	Vesam AB	21	23 183	633	Södermanland	Sustainable building
22	Allan Bruks AB	8	62 817	3 034	Stockholm	Bioenergy and biofuels
23	Eko Systems AB	2	2 265	3	Stockholm	Waste management and recycling

No	Company	Number of employed	Turnover 2009 (TSEK)	Profit/loss 2009 (TSEK)	County	Cleantech sub-sector
24	CompoNordic System AB	2	5 380	932	Stockholm	Waste management and recycling
25	AB Micatrone	14	17 230	3 280	Stockholm	Air purification
26	OptiBag Systems AB	9	100 794	4 741	Östergötland	Waste management and recycling
27	Logiwaste AB	3	2 089	5	Stockholm	Sustainable building
28	ReformTech Sweden AB	3	2 089	5	Stockholm	Bioenergy and biofuels
29	NLAB Solar AB	2	2 352	39	Stockholm	Solar energy
30	SEEC AB	0	2 704	-3 406	Stockholm	Bioenergy and biofuels
31	Solarus Solkraft i Roslagen AB	1	254	-1 474	Stockholm	Solar energy
32	Entrans AB	0	0	-166	Östergötland	Bioenergy and biofuels
33	Exim Strömturbiner AB	0	0	-830	Stockholm	Water
34	Svenska Aerogel AB	1	142	-169	Stockholm	Air purification
35	HiNation (avser 2008)	0	317	101	Stockholm	Solar energy
36	Seabased AB	0	0	-9 225	Uppsala	Water
37	Skycab AB	1	315	30	Stockholm	Sustainable building
38	Chemrec AB	13	11 067	-43 912	Stockholm	Bioenergy and biofuels
39	Xzero AB	2	253	-1 704	Stockholm	Water
40	Ekomarine AB	4	1 274	-5 538	Stockholm	Water
41	Rehact AB	2	146	-351	Stockholm	Air purification
42	Centriclean Systems	4	594	-908	Stockholm	Air purification
43	AerosolTrap	1	0	0	Örebro län	Air purification
44	S-Solar	2	0	-14 338	Stockholm	Solar energy
45	Kopparbergs pigment	1	366	10	Östergötland	Waste management and recycling
46	SAKAB	155	393 547	27 176	Örebro län	Waste management and recycling
47	Ställbergs Makadam AB	2	1 876	-428	Örebro län	Waste management and recycling

Chapter III: Emergence of the Clean Technologies Sector in Estonia

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[114] Authors are especially grateful to Lauri Matsulevitš (Estonian Development Fund) for extensive feedback and assistance in interviewing. Authors are also grateful to Rainer Kattel, Leno Saarniit, Liisi Ilu (all Tallinn University of Technology) and Nadim Taoubi (Enterprise Estonia Foundation) for their research assistance and suggestions regarding the improvement of the report.

Introduction

In 2010 Cleantech Scandinavia published a report about the emerging cleantech sector in the Baltics (Cleantech Scandinavia 2010). In the section covering Estonia the report shed light upon its leading companies like Clifton, Yoga, Crystasol, Elcogen, BiotaP and Goliath. It presented a summary of the most important public support organizations - Estonian Development Fund, Enterprise Estonia, Environmental Investment Centre - and public universities active in the area (Tallinn University of Technology, University of Tartu and University of Life Sciences). In addition, the report also identified the most active private investors in the field of cleantech - BaltCap, WNP Project and Askembla Asset Management – as well as incubators and start-up support organisations - Tehnopol, Tartu Science Park and SeedBooster.

Earlier research commissioned by the Ministry of Environment has indentified over 200 companies that can be related with environmental technologies in Estonia (HeiVäl Consulting 2008). They are active in cleantech sub-fields like energy technologies, biofuels, material technologies, waste management, water and ambient air protection, green construction, cleantech consulting, environmental research equipment as well as ICT. However, the majority of these companies are resellers or representatives of foreign cleantech enterprises and they sell environmentally friendly and energy efficient products and processes developed in foreign countries. This list of 200 includes also enterprises that use environmental technologies developed elsewhere in their own production processes and include many consulting companies that offer services (like energy audits, energy efficiency calculations, etc). The initial starting point for the current study was this list of cleantech related companies, but the list was reviewed and and only cleantech developers were included. This new list was discussed with (policy) experts, representatives of academic community, entrepreneurs and community support organizations. As a result, of all companies related to clean technologies in Estonia, 36 cleantech developers were identified. These are the companies in Estonia that are more or less actively developing new environmentally friendly solution in the field of cleantech (see Annex 3.1 for the overview of enterprises developing clean technologies in Estonia).

We also base ourselves to the studies available. HeiVäl Consulting (2008) has identified five research papers relevant to environmental technologies.[115] Since 2008 the number of studies commissioned by different governmental institutions has not substantially increased. Namely, seven addition research papers have been published:

- HeiVäl Consulting (2008) "*Rakendusvalmite keskkonnatehnoloogilise innovatsiooni lahendite turunduslik analüüs*". Final Report for the Ministry of Environment.
- HeiVäl Consulting (2008) "Keskkonnatehnoloogilise innovatsiooni perspektiivsuundade ja pakutavate lahendite rakendusvalmiduse hindamine". Final Report for the Ministry of Environment.
- Eesti Keskkonnajuhtimise Assotsiatsioon (2008) "*Suurtööstuse ressursisäästlikkusele suunamine ja senise töö tulemuslikkus*". Final Report for the Ministry of Environment.
- Technopolis Consulting Group Belgium sprl (2008) "*Ettevõtete tehnoloogiainvesteeringu teostatavuse analüüsi lõppraport*". Innovation Studies. Commissioned by the Ministry of Economic Affairs and Communications
- Säästva Eesti Insituut (2009) "*Keskkonnatehnoloogilise innovatsiooni arendamine*". Final Report for the Ministry of Environment.
- Kalvet, T., Karo, E., Kattel, R. (2010) "*Eesti ettevõtete uued võimalused – ärimudelid, avatud innovatsioon ja riigi valikud*". Innovation Studies. Commissioned by the Ministry of Economic Affairs and Communications.
- Kauhanen, L., Ristinen, T., Heino, M., Ojapalo, A., Kuusisto, M. (2011) *Feasibility study for an Estonian Materials Technology Programme*. Innovation Studies. Commissioned by the Ministry of Economic Affairs and Communications.

Based on the study report "Keskkonnatehnoloogilise innovatsiooni perspektiivsuundade ja pakutavate lahendite rakendusvalmiduse hindamine" by HeiVäl Consulting (2008) an Environmental Technology Atlas has been put together. It consists of a list of environmental technology developers, both research institutions and companies. The list also includes further information on the environ-

[115] For more information see HeiVäl Consulting (2008). *Rakendusvalmite keskkonnatehnoloogilise innovatsiooni lahendite turunduslik analüüs. Final Report for the Ministry of Environment.*

mental technology that is being developed or the cleantech subfield where the company operates.[116]

Also, over the years there have been several conferences and seminars on the clean technology sub-fields. Topics of those conventions and seminars for instance have been: waste management, green economy, energy efficiency, bioenery and biogas, renewable energy/clean energy/alternative energy, energy efficient building and green IT. Few examples of the conferences are:

- Rohevik – in September of 2011 a conference on economical and environmentally friendly lifestyle is going to take place. The conference focuses on such topics are electric vehicles, modern eco-cities, and smart energy and clean transport. Conference is organized by several partners, including Estonian University of Life Sciences.[117]
- Information Society – annual conference held by the Ministry of Economic Affairs and Communications. In 2010 one of the main topics of the conference was green IT. The following questions were addressed: what is Green IT, what are the associated challenges and opportunities in Estonia.[118] Renewable energy research and use – annual conference held by the Estonian University of Life Sciences in cooperation with Archimedes Foundation. The conference focuses on renewable energy resources, their production and use.[119]
- Green economy – new challenges and opportunities 2011 – conference organized by the University of Life Sciences. The conference focused on production and storage of energy, organic agriculture, green transportation, green building, green jobs, and environmental taxation issues. [120]
- Green business opportunities in Estonia 2010 – organized by the Estonian Roundtable for Development Cooperation. Following topics were discussed: what is the Estonian business impact on climate change and developing countries, should they change their thinking about environmental friendliness and social responsibility and how to make business greener.[121]

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116 For further reading visit www.ippc.envir.ee

117 For further information visit http://keskkonnafestival.ee/en/rohevik/mis-on-rohevik/

118 For further reading visit http://143323.edicypages.com/

119 For further reading visit http://tek.emu.ee/teuk-konverentsid/

120 For further reading visit http://www.greengate.ee/?page=5&id=29544

121 For further reading visit http://www.terveilm.net/?id=339&year=2010

- A Clean Energy Future 2009 – conference organized by the Danish embassy and the Parliament's Environment Committee.[122]
- The green economy and energy efficiency in the long term - Estonia's development model 2009 – organized by the Estonian Greens, Legislative Centre Foundation and the Ministry of Economic Affairs and Communications. The conference discussed environmentally responsible management, energy use and energy source issues.[123]
- Biomass and Bioenergy 2008 – initiated by the Ministry of Agriculture. The conference focused on biomass production, bioenergy production, biomass and bio-energy use, funding, policy and international cooperation, and research and development.[124]

In the following, current conditions and current performance in clean technologies in Estonia are analysed based available research, but also on additional secondary data (including financial analysis of the 36 companies[125]). In addition 20 of these companies were interviewed during June and July 2011 (Companies interviewed are underlined in Annex 3.1).

[122] For further reading visit http://www.riigikogu.ee/index.php?id=55354
[123] For further reading visit http://www.erakond.ee/vana/roheline-poliitika/rohelised-suendmused/390-rahvusvaheline-konverents-oekoloogiliselt-vastutustundlikust-majandamisest
[124] For further reading visit http://www.bioenergybaltic.ee/?id=1668
[125] Only companies with available data before 2009 are used in the financial data analysis. E.g. my!Wind was established in 2010 and there is no financial data to analyse is development dynamics. The company is still included in the general analysis. At the report writing time there was also no 2009 financial data for Selefon, therefore it is also left out from relevant comparisons of 2009

1. Current conditions in clean technologies

1.1 Human resources

There are 33 educational institutions in Estonia where it is possible to obtain higher education. Six of them can be related to offering environmental technology and clean-tech related courses (Table 3.1).

Table 3.1: Educational institutions which offer clean-tech related programmes, the name of the program and the number of graduates.

Educational institution	Program name	Graduates			
		2007/2008	2008/2009	2009/2010	2010/2011
Estonian University of Life Sciences	Engineering - bachelors program	53	48	49	55
	Production Engineering - masters program	11	10	7	16
	Renewable Energy Resources - masters program[126]				
	Natural resources management - bachelors program	31	29	32	25
	Natural resources management - masters program	6	5	13	14
	Environmental protection - bachelors program	45	59	67	55
	Environmental Sciences and Applied Biology – PhD				
	Engineering Sciences – PhD				
Euroacademy	Environmental protection - bachelors program	9	17	20	13
	Environmental protection - masters program	5	6	5	13
	Environmental protection and environmental policy – PhD				
Tallinn Uni-	Environmental management - bachelors program	14	18	12	24

[126] New curriculum, first graduates in 2012.

Educational institution	Program name	Graduates 2007/ 2008	2008/ 2009	2009/ 2010	2010/ 2011
versity	Environmental management - masters program	5	4	8	10
	Physics - bachelors program	0	3	3	2
	Physics - masters program	7	0	1	1
	Physics – PhD				
Tallinn University of Technology	Environmental management and cleaner production – masters program	4	12	8	4
	Chemical and environmental technology - bachelors program	24	21	14	24
	Chemical and environmental technology - masters program	18	10	20	13
	Environmental engineering – engineering program	15	14	34	23
	Environmental engineering – masters program	12	4	3	4
	Electrical power engineering – bachelors program	39	44	36	42
	Electrical power engineering – masters program	10	16	26	29
	Geotechnology – bachelors program	3	7	6	4
	Geotechnology – masters program	4	5	10	3
	Materials technology – bachelors program	25	13	8	19
	Materials technology – masters program	10	21	14	12
	Materials and Processes for Sustainable Energetics – masters program	0	0	0	12
	Thermal power engineering – bachelors program	15	12	13	9
	Thermal power engineering – masters program	5	14	14	9
	Industrial Engineering and Management – masters program	11	11	6	10
	Mechatronics – bachelors program	19	17	20	26
	Mechatronics – masters program	1	13	16	15
	Industrial Ecology – bachelors program	0	7	9	11
	Industrial Ecology – masters program	2	2	1	9
	Product development and production engineering – bachelors program	66	76	55	66
	Product development and production engineering – masters program	41	48	39	47
	Technical physics – bachelors program	11	6	12	10
	Technical physics – masters program	6	7	6	4

Educational institution	Program name	Graduates 2007/ 2008	2008/ 2009	2009/ 2010	2010/ 2011
	Fuel technology – applied higher education program	0	7	11	8
	Production engineering and entrepreneurship – applied higher education program	13	21	22	9
	Power engineering – applied higher education program	0	0	0	10
	Mechanical Engineering – PhD				
	Chemical and materials technology – PhD				
	Power engineering and geotechnology – PhD				
	Civil and environmental engineering – PhD				
University of Applied Sciences	Technoecology – applied higher education program	21	11	20	21
	Engineering materials and marketing - applied higher education program	35	20	18	18
University of Tartu	Environmental technology - bachelors program	41	43	28	24
	Environmental technology - masters program	15	33	25	34
	Materials science - bachelors program	9	13	17	4
	Materials science - masters program	7	6	3	11
	Environmental management and planning/Environmental science – applied higher education	66	38	35	22
	Physics – bachelors program	20	20	17	13
	Physics - masters program	10	9	11	11
	Chemistry – bachelors program	18	16	14	25
	Chemistry – masters program	17	15	16	8
	Geology - bachelors program	6	11	12	10
	Geology - masters program	4	5	9	4
	Environmental technology – PhD				
	Engineering and technology – PhD				
	Materials science – PhD				
	Physics – PhD				
	Chemistry – PhD				
Total bachelors program		**448**	**480**	**444**	**461**
Total applied higher education		**135**	**97**	**106**	**88**
Total masters program		**226**	**270**	**295**	**316**
Total		**809**	**847**	**845**	**865**

*The number of PhD graduates is not currently available.

Source: Authors based on data available on the official websites of the educational institutions, and data gathered through sending out information requests to the institutions.

There are 64 curricula which can be associated with the topic of environmental technologies and clean-tech (Table 3.1). Out of these study programmes 20 are offered at undergraduate/bachelor's level, 24 at master's level, 14 at doctorate-level and 6 curriculums are offered at applied higher education level. Six curricula out of 64 seem to deal with the subject of clean technologies directly, while other curricula have more indirect relations. For instance, at the Tallinn University of Technology there are three curricula, one at master's level, called "Environmental management and cleaner production", and the other at undergraduate and master's level called "Chemical and environmental technology". Or, at the University of Tartu there is a curriculum at all three levels (BA, MA, PhD) titled "Environmental technology".

While looking at the subjects taught within these programmes, it becomes evident that most of them do not have any subjects on marketing or finance. Marketing can be found in only eight curricula. One of them with the most explicit role attributed to it is a program taught at the Tallinn University of Technology and which can be considered to be the most related to the subject of clean technology – "Environmental management and cleaner production". Still, most curricula include subjects like fundamentals of economics, project management, business administration and management.

A total of 3,366 students have graduated from the clean-technology programmes during the period from 2007 to 2011 (Table 3.1). Over the years the number of graduates has fluctuated slightly, but is generally rather stable.

According to the interviews made with 20 cleantech developers in Estonia, most of the companies are generally satisfied with the availability of general skilled workforce. University of Tartu (UT) and Tallinn University of Technology (TUT) are the most common higher education institutions that have produced employees for cleantech companies under the focus. Still, the majority of the companies emphasized the lack of people with good specialist knowledge (chemistry, physics, informatics, semiconductor engineering, etc.) coupled with good business and marketing education. This may be due to the fact that many of the companies under study are university spin-offs. One energy technology company even financed a new curriculum at the UT to have better access to qualified workforce. Another company argued that a very relevant special program (for them) related to semiconductors was closed down at TUT.

Companies interviewed claimed that usually the products are so unique that it is very hard to sell them without understanding the technology behind it. Therefore, there is a need for people who understand the technology and have good educational background as well as experience in marketing and exporting. Highly qualified production and export managers were the most needed employees among all and one company also emphasised the lack of qualified programmers. Some energy technologies companies have also recruited specialists from abroad – engineers from Switzerland, UK, Austria and Germany, but also head of development from Finland. Although there are support measures for hiring highly skilled persons from abroad, one company still emphasised and suggested that there should be an even easier and more extensive support to bring good talents to Estonia.

Most of the companies agreed that there are enough cleantech related programs at the universities. The awareness of the activities of universities, however, was limited to those from which key people had graduated and remained in contact with. Based on the interviews it can be concluded that there is no need for additional general cleantech education programs but for increasing specialization to have really qualified specialists among the graduates. The entrepreneurs also agreed that there is no need to have compulsory additional business and finance courses as the existing finance and marketing courses serve the overall goal. Also, those who want can take additional courses have the options.

> *"It is more related with the choices of people than the availability of business courses" (An ICT company).*
>
> *"Will and interest are the drivers and also restrictors" (A material technologies company). "*
>
> *A MBA after a specialist BA would complete the overall understanding of making the idea into a business" (An ICT company).*

Thus, while on one hand the companies feel the need for people with specialist education and good marketing knowledge, on the other hand they do not see that this problem could be solved by just adding necessary marketing and finance courses to curriculums related with cleantech.

1.2 Community support: Government policies and programs

There are approximately 90 strategic documents in Estonia which can be associated with the field of environmental technologies (HeiVäl Consulting 2008, 9). Two of the strategic documents can be considered to be the umbrella strategies: *Estonian* National *Strategy* on *Sustainable Development* – „Sustainable *Estonia* 21“ - and the Estonian Environmental Strategy.[127]

The most important document guiding R&D and innovation is the Estonian Research and Development and Innovation Strategy 2007-2013 “Knowledge-based Estonia”. The strategy identifies three key technologies for Estonia: 1) information and communication technologies, 2) biotechnologies and 3) material technologies.

On the basis of this strategy national R&D programmes are prepared and launched.[128] Those national research and development programs are especially designed to promote the development of R&D and innovation, also to promote cooperation between R&D institutions and businesses, and to conduct high standard research in key areas for the country (Eesti teadus- ja arendustegevuse… 2008, 5).[129] The programmes have been initiated by the Ministry of Economic Affairs and Communication and the Ministry of Education in cooperation with other ministries (Estonian Research and… 2007, 4)[130] and carried out according to the implementation plan of the “Knowledge-based Estonia 2007-2013” strategy.[131] At the time of composing the report two programmes in the areas of energy technology and biotechnology have been implemented. Both of these programmes are being implemented by the Ministry of Economic Affairs and Communications and Enterprise Estonia.

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[127] For more information on strategic documents related to environemntal technologies, see HeiVäl Consulting (2008) *Keskkonnatehnoloogilise innvoatsiooni perspektiivsuundade ja pakutavate lahendite rakendusvalmiduse hindamine*, and visit the official website of the Estonian Government www.valitsus.ee.
[128] For more information, see the Estonian Research and Development and Innovation Strategy 2007-2013 “*Knowledge-based Estonia*”, www.hm.ee/index.php?popup=download&id=5771.
[129] Eesti teadus- ja arendustegevuse ning innovatsiooni strateegia 2007-2013 „*Teadmistepõhine Eesti*” rakendusplaan (2008). Available at:
http://www.mkm.ee/failid/TAI_strateegia_rakendusplaan_2008_20128.pdf
[130] Estonian Research and Development and Innovation Strategy 2007-2013 “*Knowledge-based Estonia*”
[131] For further reading visit http://www.mkm.ee/riiklikud-teadus-ja-arendusprogrammid/

One of the programmes can be considered to be directly linked with clean-technologies - the **Estonian Energy Technology** programme. The programme was started in 2008 and is the first national R&D programme initiated in Estonia.[132] The programme is run under a steering committee of related ministries (Ministry of Education and Research, Ministry of Environment, Ministry of Economic Affairs and Communications, Ministry of Agriculture) and the implementing agencies. The programme has three focus areas: oil shale, renewable energy and nuclear energy.[133]

The Third program which is not yet being implemented is the **Estonian Information and Communication Technology** programme. This programme has been developed by the Ministry of Education and Archimedes Foundation, but now is being developed by the Ministry and the Estonian Information Technology Foundation. An important part of this programme is the Green ICT strategy[134] – development and use of green ICT solutions.

In addition to the previous programmes, several programmes, which can be considered relevant to clean technologies, have been launched under the National strategic reference framework 2007-2013, in particular under the economic environment program:

The first is the **Environmental Conservation and Environmental Technology** programme. The overall objective of the program is to build/increase Estonia's capacity in environmental protection and technology by R&D supporting in those areas. Respective fields are climate and environmental changes, ecological balance in the use of natural resources, biodiversity and conservation of natural areas, evaluation of environmental risks, environmental data acquisition and reduction of contamination.[135] This programme is implemented by the Research Cooperation Centre of the Archimedes Foundation.

Business incubation programme 2008-2013 aims to support the emergence and sustainable development of innovative enterprises with growth potential, reduce

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[132] Eesti teadus- ja arendustegevuse ning innovatsiooni strateegia 2007-2013 „*Teadmistepõhine Eesti*" rakendusplaan (2008). Available at:
http://www.mkm.ee/failid/TAI_strateegia_rakendusplaan_2008_20128.pdf

[133] Eesti Energiatehnoloogia programm. Available at:
http://www.eas.ee/images/doc/ettevotjale/innovatsioon/energia/etp_programmdok.pdf

[134] Priit Tamm, Archimedes Foundation,
Research Cooperation Cenre, Head of National Programmes, 2. August 2011, e-mail.

[135] Haridus- ja Teadusministeerium. Ministri käskkiri 25.märts 2011 nr 290.

the risk of failure, and accelerate the growth and development of innovativeness, so that the companies would be viable and independent when they leave the incubator. Enterprise Estonia is the implementer of the programme.[136]

High-potential innovative business development program “Start-up in Eesti/Estonia” aims to increase the influx of innovative business ideas with high potential and accelerating the development of enterprises. Enterprise Estonia is the implementer of the programme. [137]

Additionally, an R&D programme is going to be launched in materials technology. A feasibility study has been completed and work has started on preparing the programme. However no exact starting date has been set yet. The programme is being prepared by the Ministry of Economic Affairs and Communication, and different partners and interest groups.

The Ministry of Environment is responsible for the **Green public procurement** project. The main goal of green public procurement is to reduce the environmental impact caused by products and services, resulting in their production, use and decommissioning harnessing the possibility to reduce risks to human health and the environment.

1.3 Community support: Targeted Financing

Targeted financing is an instrument operated by the Ministry of Education and Research following the recommendation of the Estonian Research Council. It is the most important research funding tool, it is open to all fields and all research groups - both basic and applied research is funded.

Four of the previously identified educational institutions and one research organization have received targeted financing (Table 3.2).

[136] For further reading visit http://www.eas.ee/index.php/ettevotjale/alustamine/ettevotlusinkubatsiooni-programm-2008-2013/ueldjutt
[137] For further reading visit http://www.eas.ee/index.php/ettevotjale/innovatsioon/start-up-eesti/ueldist

Table 3.2: Total targeted financing of academic and other research organization relevant to clean technologies (in Euros).

Educational institution	2007	2008	2009	2010	2011	Total
University of Tartu	9 030 473	12 056 191	12 056 191	11 247 178	11 405 556	55 795 590
Tallinn University of Technology	4 579 238	6 240 768	5 943 822	5 526 868	5 406 920	27 735 963
Tallinn University	1 034 257	1 500 652	1 513 620	1 355 413	1 325 000	6 728 941
Estonian University of Life Sciences	1 574 604	1 946 436	1 880 038	1 708 774	1 706 150	8 816 001
National Institute of Chemical Physics and Biophysics	711 043	468 472	923 581	849 514	841 610	3 794 220

Source: Authors on the basis of data from the targeted financing lists from the Ministry of Education and Research.

The University of Tartu has received the biggest amount of money through grants during the period of 2007-2011. However, research projects at the Tallinn University of Technology are more linked with clean technologies and encompass subjects like technological processes, sustainable usage of energy resources, solar energy and fuel processing technologies. In addition, the Estonian University of Life Sciences and National Institute of Chemical Physics and Biophysics stand out. In 2007 and 2008 the Estonian University of Life Sciences received financing for projects related to clean technologies, namely for developing environmentally friendly plant protection technologies. From 2009 to 2011 the National Institute of Chemical Physics and Biophysics has received grants for projects called chemical energy technology and strategy for environmentally sound use of solid waste produced from oil shale.

1.4 Public support organizations

Five key public support organizations can be identified. **Enterprise Estonia (EEF)**[138] established in 2000 by the Ministry of Economy, promotes business and regional development in Estonia. Enterprise Estonia is one of the largest institutions within the national support system for entrepreneurship, providing finan-

[138] For further reading visit www.eas.ee

cial assistance, advisory, cooperation opportunities and training for entrepreneurs, research establishments, public and third sector. EEF offer clean-tech related grants, e.g. innovation voucher grants, start-up support, R&D grants, product development grants. In addition, EEF manages such support-programmes as technology investment programme, cluster development programme and competence centre programme. Most of the EEF programs and grants offered are co-financed from the EU structural funds.

Estonian Development Fund[139] was launched in April 2007. It was created by the Estonian Parliament with the purpose of initiating and supporting changes in the Estonian economy and society that would accelerate modernization of the economic structure, lead to growth in exports and contribute to creating new jobs requiring high qualifications. In order to achieve these goals, Estonian Development Fund organizes foresight projects and, in cooperation with private investors, makes venture capital investments into Estonian companies that are innovative, expanding and have international potential. Estonian Development Fund has already invested in such clean technology companies as Goliath Wind, my!WIND and BioTap.

Archimedes Foundation[140] is an independent body established by the Estonian government in 1997 with the objective to coordinate and implement different EU programmes and projects in the field of training, education, research, technological development and innovation. For instance, the Research Cooperation Centre of the Archimedes Foundation implements the Environmental Conservation and Environmental Technology R&D program.

Environmental Investments Centre (EIC)[141] was founded in 2000 by the Ministry of Finance. The main activities of EIC are to channel the proceeds from the exploitation of the environment into environmental projects, to perform as the implementing agency for the environmental projects funded by the European Regional Development Fund, the European Social Fund and the Cohesion Fund and to lend money for the implementation of environmental projects. The funding opportunities offered by EIC are aimed at protection and conservation of environment, and thereby also promoting the use of clean technologies (e.g. the usage of renewable energy sources).

[139] For further reading visit www.arengufond.ee
[140] For further reading visit www.archimedes.ee
[141] For further reading visit www.kik.ee

The Estonian Science Foundation (ETF)[142] was established in 1990 by the Estonian Government. It is an expert research-funding organization and its main goal is to support the most promising research initiatives in all fields of basic and applied research. It awards peer-reviewed research grants to individuals and research groups on a competitive basis from state budget appropriations. Although there are no direct grants for the development of clean-technologies, there is a possibility for the foundation to support research projects that are related to or are about environmental or clean technologies.

1.5 Competence centres, clusters and associations

Three of the existing **competence centres** have been identified as relevant to clean technologies. The first two can be directly link to clean technologies, while the third one is more indirect. All of the competence centres have received funding from the competence centre programme managed by EAS. The competence centres are as follows:

Competence Centre of Innovative Building and Lifestyle[143] aims at introducing alternative energy sources, economical and ecological architecture and human habitat to general public. The objective of the Competence Centre is to accumulate excellence in the field of innovative building and lifestyle/human habitat as a whole, and ensure public access to the information, as well as quick and widespread distribution of knowledge. The competence centre has 15 partners, including three research institutions – University of Tartu, Tallinn University and Tallinn University of Technology.

Smart House/Intelligent Building Competence Centre[144] focuses at the development of intelligent and smart technologies for the use of home and office equipment, automated building systems and for the building management. These technologies can increase the quality of people's lives and their surrounding environment, also environmental friendliness and energy efficiency. The competence

[142] For further reading visit www.etf.ee
[143] For further reading visit www.solarbase.ee/kopetentsikeskus
[144] For further reading visit www.rakveretarkmaja.ee

centre has 29 partners, including three universities – Estonian University of Life Sciences, Tallinn University of Technology and Tallinn University, and 26 companies of which one, Yoga OÜ, is included in the current research.

Oil Shale Competence Centre[145] focuses on four areas of action: oil shale mining, processing, oil shale chemistry and oil shale energetics. The competence centre also concentrates on the related environmental protection issues. The competence centre has 11 partners, including Tallinn University of Technology and three other educational institutions.

Five of the existing **clusters** have been identified as somewhat relevant to clean technologies. The first three clusters have a direct connection to clean-technology, while the later two clusters with potential to develop solutions in the cleantechfield. All of the clusters have received funding from the cluster development programme managed by EAS. The clusters are as follows:

The Wind Power Cluster[146] was born of Estonian companies' wish to be involved in the rapidly and innovatively evolving wind power sector. The cluster is committed to the development of a development strategy for the Estonian wind power industry sector and enabling its partners to participate in international energy production and technology cooperation projects. In addition, wind power cluster co-operates with other communities who share a common interest in the wind energy sector. The cluster has 11 partners of which two are universities – Estonian University of Life Sciences and Tallinn University of Technology, and nine are companies, one included in the current survey, Euriko OÜ.

Estonian ECO Cluster: Solarbase.ee[147] unites entrepreneurs, who in active cooperation with The Institute of Ecology, concentrate on raising the competitive advantage of their products and services by making them more economical and enhancing their ecological characteristics. The planned common product from this cooperative exercise is a passive house, an energy efficient building. The Estonian ECO Cluster develops products and services, which enable to decrease heating expenses. The cluster has nine partners comprised of one research institution, Tallinn University, and eight companies of which none is included in the current study.

[145] For further reading visit http://mi.ttu.ee/pkk/
[146] For further reading visit www.estonianwindcluster.eu
[147] For further reading visit www.solarbase.ee

Waste Recycling Cluster[148] unites 18 companies (none included in the study) and three research and education institutions - Estonian University of Life Sciences, Tallinn University of Technology and Tartu University. Main objectives of the cluster are to increase the amounts of waste recycled in Estonia, to produce from waste products compliant to quality standards and certified, to increase production capacity and volumes, joint marketing, to increase sales of the product- services and export, and international competitiveness. In addition, the activities include mapping and improving the technologies used in waste recovery.

Estonian ICT Cluster[149] has 15 partners, 14 companies and one university – Tallinn University of Technology. The main goal of the cluster is to increase exports of ICT products and services. At the same time, increase exports in other key economic sectors in Estonia through development and deployment of wider and more efficient ICT-based solutions. None of the companies included in the current report are members of the cluster.

ICT Demo Centre[150] which aims at showcasing the nation's ICT solutions all in one facility, providing visitors with hands-on examples of what they are and how they work. Though it presents individual products, its main focus is offering integrated and holistic solutions. It consists of 19 members, including Yoga, a company which is included in the current study.

In addition to the previous five clusters, there are several clusters that are still in the cluster initiation phase, and are somewhat relevant to clean technology. All of the clusters have also received funding from the cluster programme managed by EAS. These clusters are **Electronics Cluster** and **Estonian Space Cluster**[151] (member include: Skeleton Technologies OÜ, which is included in the study, and Tallinn University of Technology and Tartu University).

Table 3.3 presents a summary of the 14 **associations,** and their web addresses in Estonia, whose activities can be considered related to clean technologies.

[148] For further reading visit www.ejkl.ee
[149] For further reading visit http://www.itl.ee/?op=body&id=16
[150] For further reading visit http://e-estonia.com/ict-demo-center
[151] For further reading visit http://ettevotluspaev.tallinn.ee/index.php?picfile=164&PHPSESSID=f8a1e0c77a0744a5f26da48bc952fc07

Table 3.3: Association in Estonia whose activities can be related to clean technologies

Association	Web
Estonian Waste Management Association (EWMA)	www.ejkl.ee
Estonian Wind Power Association	www.tuuleenergia.ee
Eesti Vee-ettevõtete Liit (Association of Estonian Water Enterprises?*)	www.evel.ee
The Federation of Estonian Chemical Industries (FECI)	www.keemia.ee
Estonian Oil Association	www.oilunion.ee
Estonian Association of Electrical Enterprises	www.eetel.ee
Estonian Association of Engineers	www.insener.ee
Federation of Estonian Engineering Industry	www.emliit.ee
Estonian Biotechnology Association	www.biotech.ee
Association of Construction Material Producers of Estonia	www.eetl.ee
Estonian Plastics Industries Federation	www.plast.ee
Estonian Association of Construction Entrepreneurs	www.eeel.ee
Estonian Association of Information Technology and Telecommunications	www.itl.ee
Estonian Forest and Wood Industries Association	www.empl.ee

1.6 Companies' feedback on policies and support organizations

The twenty companies interviewed in this study are more familiar with those government support measures in which they have participated. The general consensus was that there are no projects or programmes that are solely related to cleantech, or at least the respondents do not link them with cleantech. The support measures of Enterprise Estonia are most frequently mentioned (start-up and development grants for starting a company, for export, innovation, feasibility studies, product development, and so on). The projects of Environmental Investment Centre, Estonian Agricultural Registers and Information Board and EU Framework projects are less known, only some companies belonging to the energy technology (4) and environmental equipment (2) sub-clusters mentioned them.

The most familiar support organisation for the companies that were interviewed was Enterprise Estonia. However some other support organizations and competence centres where the companies were involved were also known, e.g. Smart House/Intelligent Building Competence Centre, The Federation of Estonian Chemical Industries, Health Board, Defence Industry Cluster, Electronics Cluster, Biomedicine Cluster, Estonian Eco Cluster, Estonian Association of Information Technology and Telecommunication, ICT Demo Centre. In general the knowledge held by companies regarding support organisations is quite limited. Many reasons were adduced for this including that the amount of support organizations was small and only a very few of them focus on cleantech. Therefore the connections with the cleantech sector are not direct and so many companies may have problems in making the link in such circumstances. Some companies are more familiar with international activities in the field of cleantech, e.g. with the activities of Cleantech Scandinavia and Cleantech Finland.

The analysis of funding from Enterprise Estonia (2004 to the beginning of 2011), of thirty six companies, twenty eight have received funding from EEF (see Table 3.4 for the comparison of EEF funding to Estonian cleantech developers in 2004-2011). In total Nordbiochem has received the biggest amount of funding (EUR 1.8 million), Crystalsol is second with EUR 1.5 million and Regio third with EUR 1.4 million (Figure 3.1). Together these top three companies account for almost half of the total funding from EEF. The highest funding allocated to the cleantech developers was in 2009 amounting to a total of slightly over EUR 3 million. The total cumulative funding (2004 – March 2011) has been about EUR 9.7 million, with the average support provided per institution EUR 0.27 million. Funds dedicated to cleantech have fluctuated between 4% (2007) and 46% (2006) of total funding budget. Most of the funding has come from European Regional Development Fund (ERDF) and European Structural Fund (ESF). The most used programme has been the programme for supporting R&D activities.

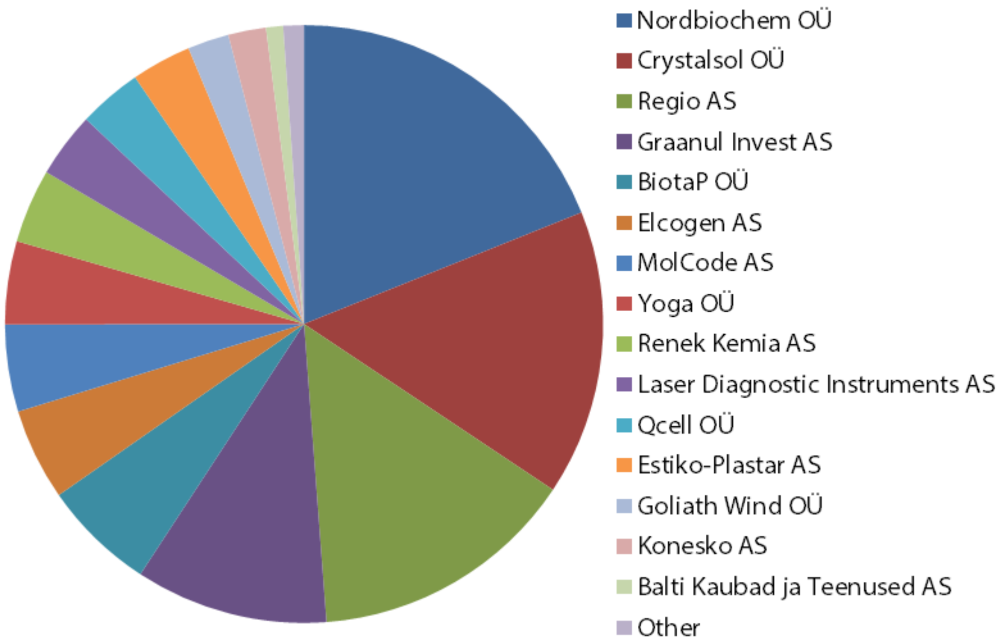

Figure 3.1: Division of Enterprise Estonia funding to the cleantech developers.
Source: Authors based on the information on supported projects from the Enterprise Estonia Foundation's online database (accessed March and May 2011)

Most of the companies seemed to have problems with applying for the grants from EEF saying that the information presentation and reporting system is too time and resource consuming but they also emphasized the positive aspects of the financial support:

> *„One additional problem for the companies is that an EEF employee defends the application in front of the EEF committee but how can EEF have so competent people to talk about so complicated technologies?" (ICT company)*

> *„A lot of companies go better to business angels or Estonian Development Fund and ask for the more expensive but wiser money. This shows the problems with asking money from the EEF." (ICT company).*

Companies also expressed opinion that EEF could better integrate different support measures, like consulting, contacts facilitation, and so on. Regarding the application and subsequent reporting system, these companies suggested more transpareny and flexibility because due to the often uncertain nature of the research it was not possible to report with a degree of predictability that reports required on the scale required.

Larger companies from the twenty cleantech companies interviewed for the current research indicated reasonable access to the EU funds allocated to cleantech from the framework programmes. Because of their high R&D competences and connections with universities, they knew about and were informed of EU support schemes. The process of preparing applications was not considered an issue or problem for them, but they added that typically the main work on this aspect was done by the consortia leader. Several micro-companies however do not have necessary contacts, human capital, knowledge and capacity to write, prepare and manage (or even participate) in large scale R&D projects.

Table 3.4: Comparison of EEF funding in Estonian cleantech enterprises in 2004-2011 (in thousand EUR)

Name of enterprise	2004	2005	2006	2007	2008	2009	2010	2011	Total
Alkranel OÜ							16.8		16.8
Balti Kaubad ja Teenused AS							89.5		89.5
Bemixe OÜ				12.5					12.5
BioGold OÜ				8.5					8.5
BiotaP OÜ				320.5		12.9	258.3		591.6
Clifton AS						2.6	3.2		5.8
Crystalsol OÜ						1 500.6			1 500.6
Elcogen AS		315.9				166.6			482.5
Energest Group OÜ							6.0		6.0
Englo OÜ	5.8					8.3			14.1
Enteh Engineering AS		2.1							2.1
Estiko-Plastar AS		9.7	10.6	101.1	48.8	3.8	140.9		315.0
Goliath Wind OÜ						200.8	16.6		217.4
Graanul Invest AS	188.5					252.7	570.9		1 012.1
Konesko AS						13.0	185.5		198.5
Laser Diagnostic Instruments AS	28.8	144.2	1.0	11.5	51.4	31.2	68.8	6.2	343.0
Mirovar OÜ		1.3			4.5			3.2	8.9
MolCode AS				12.8	430.4	14.3			457.5
Monoliit OÜ					2.7				2.7
my!Wind OÜ								6.0	6.0
Nordbiochem OÜ			588.6	51.1	1 198.6				1 838.3
Plastitehase AS			2.8						2.8
Qcell OÜ			12.7	303.2		18.1			334.0
Regio AS	389.6	84.8	200.0	30.9	497.8	129.2	26.9	45.4	1 404.7
Renek Kemia AS					38.2	335.6	15.4		389.3

Roheline Mõte OÜ							3.0		3.0
Skeleton Technologies OÜ							19.2		19.2
Yoga OÜ						340.5	96.5		437.0
Total	**612.6**	**558.1**	**815.7**	**852.1**	**2 272.4**	**3 030.1**	**1 517.6**	**60.8**	**9 719.4**
Average in 2004-2011									**270.0**

Source: Adapted from information regarding supported projects from the Enterprise Estonia Foundation online database

1.7 Innovation and firm support: Co-operation with research institutions

Patenting in the field of clean technologies by Estonian research institutions is rather limited, both generally as well as related to clean tech. For example, over the period 2007 to 2011 of the 19 patent applications submitted by Tallinn University of Technology, who was the key player, three patents are related to clean technologies. One was submitted in 2007 and two in 2009. The first patent was related to the subject of composite film and the other two applications relate to the recycling of materials.

In general the companies interviewed were familiar only with the activities of universities from which they have graduated, where their employees are studying, or with whom they have some co-operation linkages. TUT and UT are the most frequently mentioned. If there are no graduates employed at companies and no working relations, there is most often no knowledge about the activities of universities. One environmental equipment company emphasized that there were some very active research groups in Estonia but on average the co-operation remains weak.

> *„The capacity of universities is definitely higher than their performance or they could also have a problem with mediating their activities and success to the public". (ICT company)*

Relevant and most common problems mentioned by the cleantech entrepreneurs during the interviews were: Gaps between science and entrepreneurship are too wide, universities are not cooperative enough, and request extensive funds for co-operation. Some companies mentioned that quite often different departments are competing with each other and not working together. Also intellectual property (IP) terms and conditions were seen as restrictive to cooperation between universities and enterprises, event to extent where foreign universities were believed to be more pragmatic and open to co-operation. Some also claimed that the prevailing system does not facilitate cooperation between universities and entrepreneurs, the former are used only for on short-term and project basis.

> *„There are working bees and deciders in the universities, the deciders take overhead and do nothing (overhead should have a purpose, e.g. consist of rent, this would be more understandable, honest and correct). In addition a lot of people are related with the project but do nothing. Why should a company want to pay for this? (Material technology company)".*

One energy technology company emphasized a problem with the commercialization of the developed solutions. They claimed that academic personnel are conversant in conducting scientific research with external funds, and so at the end of the project they try to find additional scientific ways to develop the project further which occasions delays for the entrepreneur regarding commercialization and marketing.

Another problem is related to the fact that Estonian universities are too focused on basic research and have lack of incentives for applied research.

> *„Estonian material science has descended during the last 20 years because universities refuse to do applied research – it is better if you don't do applied research because this has a date, it can fail and people might start to ask where did you put the money?" (Material technology company).*

> *„A certain amount of basic research should go to applied research through entrepreneurs" (ICT company).*

The Estonian academic sector was much to publication-driven, existing in a so-called „Publish or Perish" environment. However, as suggested by the interviewees, the economic and social potential of the research should be also taken into account more in doing financing decisions.

Finally, the cleantech related academic community is rather small; some even argued that there are only some few enthusiastic scientists open to co-operation.

1.8 Innovation and firm support: availability of venture capital

Estonian venture capital business can be considered to be in a very early stage of development (Kauhanen 2011, 25)[152]. In 2007 the volume of venture capital investments in Estonia was EUR 36 million according to a study by the European Private Equity & Venture Capital Association (2010, 8)[153], In 2008 and 2009 the amount of investments

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[152] Kauhanen, L., Ristinen, T., Heino, M., Ojapalo, A. and Kuusisto, M. (2011) Feasibility study for Estonians Materials Technology programme. Available at: http://www.mkm.ee/public/inno_15_par.pdf

[153] European Private Equity & Venture Capital Association. (2010) Central and Eastern Europe Statistics 2009. An ECVA Speacial Paper – July 2010. Available at: http://www.estvca.ee/files/VC%20CEE2009.pdf.

made into Estonian companies decreased drastically, from EUR 15 to 5 million respectively. However, the number of companies invested in has remained almost unchanged, being in 2007 9, in 2008 and 2009 10 (ECVA 2010, 8).[154]

In the spring of 2009 under the leadership of Estonian Development Fund, the Estonian Private Equity and Venture Capital Association (EstVCA)[155] was established. EstVCA is an umbrella organization for Estonian venture capital, private equity funds, business angels and related support service providers. The central ambition of Estonian Private Equity & Venture Capital Association (EstVCA) is to develop the Estonian private equity and venture capital industry and to enhance the culture of ambitious and entrepreneurial thinking in Estonia. Currently EstVCA has 16 members, of which the following have invested in clean-technology companies, and can be connected to clean-technology.

Ambient Sound Investments (ASI)[156] was established in 2003. ASI invests in technology and knowledge-based companies which are in the seed or early-stage of the company life-cycle. The fund currently has 25 portfolio companies, among them a cleantech company Clifton (Cleantech Scandinavia 2010, 9).

The **Estonian Development Fund[157]** is a national venture capital fund that monitors development and invests in seed-stage and start-up stage Estonian companies with global growth potential. The organization's mission is to develop the Estonian venture capital market; therefore, investments are always made jointly with co-investors. Fund has invested in more than 15 projects, including cleantech companies - Goliath Wind and my!WIND, BioTap.

WNB Project[158] is an active private equity and venture capital firm. The firm invests in the early stage technology companies which have growth potential. For example, the firm has funded the Goliath Wind in co-operation with the Estonian Development Fund.[159]

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[154] European Private Equity & Venture Capital Association. (2010) Central and Eastern Europe Statistics 2009. An ECVA Speacial Paper – July 2010. Available at: http://www.estvca.ee/files/VC%20CEE2009.pdf.

[155] For further reading visit www.estvca.ee

[156] For further reading visit www.asi.ee

[157] For further reading visit www.arengufond.ee

[158] For further reading visit www.wnb.ee

[159] Lepik, J. Where can start-ups and other companies find Funding? Available at: http://www.in.ee/blog_item.php?bid=668

BaltCap[160] was established in 1995 and is a private equity and venture capital investor in the Baltic States. The company provides equity capital for growth-oriented Baltic companies. BaltCap works with a broad investment scope but has a strong interest in technology companies including cleantech (Cleantech Scandinavia 2010, 8).

Askembla Asset Management[161] was established in 1994, is a private equity firm focusing on investments in growth companies in Central and Eastern Europe. The investment activity focuses on established businesses in a cross section of industries. Though this company does not have the ordinary „venture funds“ way of working. They are more allocating money to listed companies and currently there are no cleantech companies in its portfolio.

Cresco[162] was founded in 1995 and is an independent privately owned Estonian investment banking and venture capital firm. Cresco invests in rapidly growing sectors, including technology sector.

LSVenture[163] is a venture scouting and seed management company. The company focuses on life-science and chemical industry related areas. Projects include such clean-tech company as BioTap.

MTVP[164] is a private equity partnership focusing exclusively on technology, media and telecom ('TMT') related investment opportunities in Russia, Baltic States and other Central and Eastern European countries. There are currently no clear clean-tech companies in its portfolio.

In addition to these companies, one more firm, which is not a member of EstVCA, can be identified as somewhat relevant to clean-technology. **IPC Investment Group**[165] is a private equity company, which invests in different high growth businesses. The company invests according to the IPC strategy, and is flexible with regard to different sectors, markets and investment horizons. Currently the firm has not made any investments in clean-tech companies.

In conclusion, it is clear from that the above that most of the venture capital companies invest in innovative and high growth companies. Therefore, some of the portfolios may include clean-tech companies.

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[160] For further reading visit www.baltcap.ee
[161] For further reading visit www.askembla.se
[162] For further reading visit www.cresco.ee
[163] For further reading visit www.lsventure.com
[164] For further reading visit www.mtvp.ee
[165] For further reading visit www.ipcinvestment.com

All the interviewed cleantech enterprises agreed that there are some VC firms and angel investors but in international terms there is no venture capital market in Estonia. Most of the companies have not been in contact with VC funds and therefore their awareness of the field is low. Five energy technologies, one ICT and one environmental equipment and monitoring sub-cluster company have VC investors and a few companies are looking for similar support in the future. However, most of the companies are not ready for this step. Another problem mentioned by the enterprises was that the few VCs in Estonia do not have the skills and knowledge to understand the highly technical and specific technologies regarding their investment choices and they should be in a position to understand these technologies so as to make these decisions.

> *„The venture capital industry follows trends and cleantech is one big trend. Unfortunately VC is used for funding IT projects, where you need a few guys, a lot of passion and a pizza service. That is not so easy with a power plant, where lead times are different. When it comes to commercialization, you have longer lead times, many investments and you risk with a lot of time and money before you see a result – that's why many private VCs are failing to make a real offer. It is sad, because the industry is creating jobs also in the regular sectors, apart from highly-educated ones."*
>
> ...
>
> *„VC investors want to invest in cleantech but it shall not be too big and shall not take too long. On the other hand negotiations take much time, therefore it is good to have institutions with strategic background like Estonian Development Fund" (Energy technology company).*

1.9 Firm capabilities

The majority of the twenty companies interviewed in the present study stated that there are no specific business and product development capabilities and skills for managing cleantech. There are generic skills that are needed for all high-tech areas. Common characteristics of cleantech mentioned by the entrepreneurs that are also apparent in other high-tech fields are: newness, capital intensiveness, need for extensive contacts, problems with marketing goods or services that do not have an existing market demand, transformation of enthusiasm is more complicated again because of no or limited references and to recognise successful opportunities is also very tricky.

As most of the companies are constantly doing R&D and many of them in the first two phases of the industry value chain product development capabilities are seen as very important.

> *"One big obstacle is to understand the market and the client needs – how to transform the technology into a good or service warmly welcomed in the market?" (ICT company).*

Moreover, the companies understand the problems with marketing unknown high-tech goods and therefore see marketing capabilities as the most important ones among business capabilities.

> *"A serious company has problems with marketing because cleantech is not an area that people need to consume every day (or at least they do not know it yet)" (Environmental monitoring and equipment company).*

2. Current performance in clean technologies

2.1 Enterprises in the cleantech sector and their specialization

Thirty six cleantech developers in Estonia that are active in many different fields were the subjects of analysis. Over one third are currently developing energy technologies (wind turbines, semiconductors, photovoltaics, ultracapacitors, fuel cells, electrical and power engineering, and heat exchangers), five are active in biofuels, four deal with environmental research equipment and environmental diagnostics services, five with ICT (in the fields of intelligent building, material and energy technologies and energy efficiency), four are developing cleantech services and consulting, four material technologies (environmentally friendly plastics, nanotechnology fabricating protective coatings, lactate fermentation and chemical derivatives, one deals with water protection and purification and one with waste management (Figure 3.2).

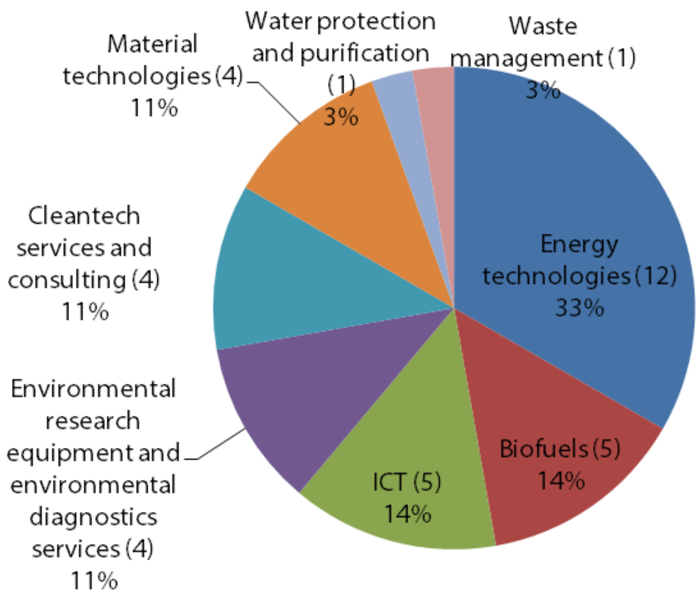

Figure 3.2: Clenatech developers in Estonia by sub-fields

Source: Compiled based on the Annual Reports of the companies

Twenty one out of the thirty six companies were founded between 2000 and 2010 (Annex 3.1, Figure 3.3). The period 2006 to 2009 has been the most active in establishing new companies developing clean technologies (13 were established) being quite similar to the number of companies founded during the 1990s (15).

Regarding the location of these companies, there are strong agglomerations which are evident in Tallinn, the capital of Estonia. Twenty three of the cleantech companies are located in the capital of Estonia (of which 3 are near Tallinn, Rae vald and Viimsi). Thirteen companies are located outside Tallinn: 8 in Tartu (about 200km from Tallinn), three in North-East Estonia (Kohtla - 150km from Tallinn, Kohlta-Järve - 155km from Tallinn and Sillamäe - 200km from Tallinn), one in South-East Estonia (Põlva, about 230km from Tallinn) and one in East-Estonia (municipality of Palamuse, about 150km from Tallinn) (Figure 3.4). In international terms, the companies are not too distant from each and could potentially belong to one national cluster.

A general tendency can be found between the year of foundation and the numbers of employees – 9 out of the 12 companies with staff over 10 employees were established in the 1990s or before. No common trend can be seen between the number of employees and the cleantech sub-field, the number of staff varies in all fields. However, all companies active in the fields of ICT and cleantech services and consulting (with some exceptions in biofuels and in energy technologies) were founded in the 2000s (Annex 1).

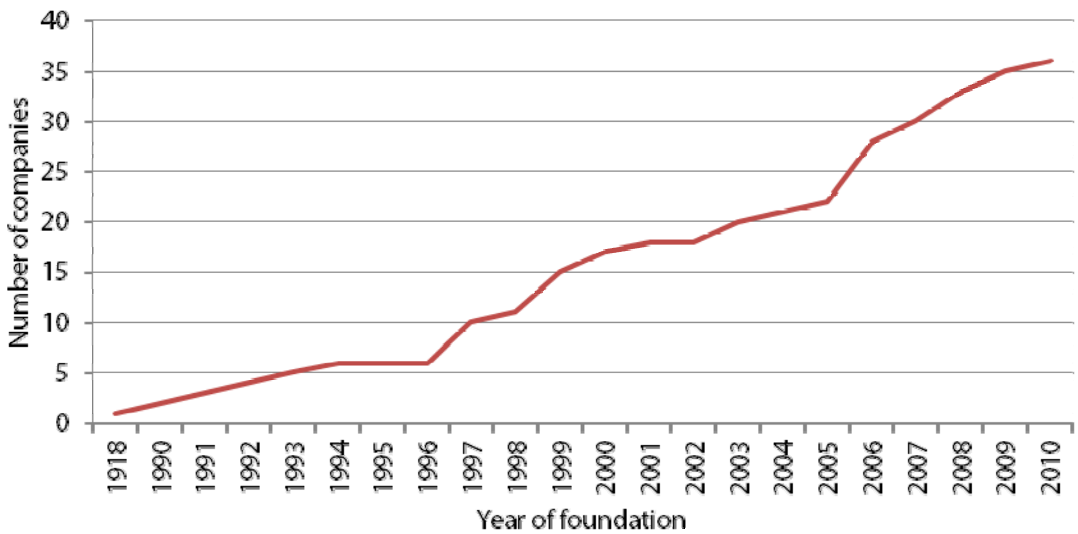

Figure 3.3 Development of the cleantech sector in Estonia from 1918 to 2010
Source: Authors based on Company Annual Reports.

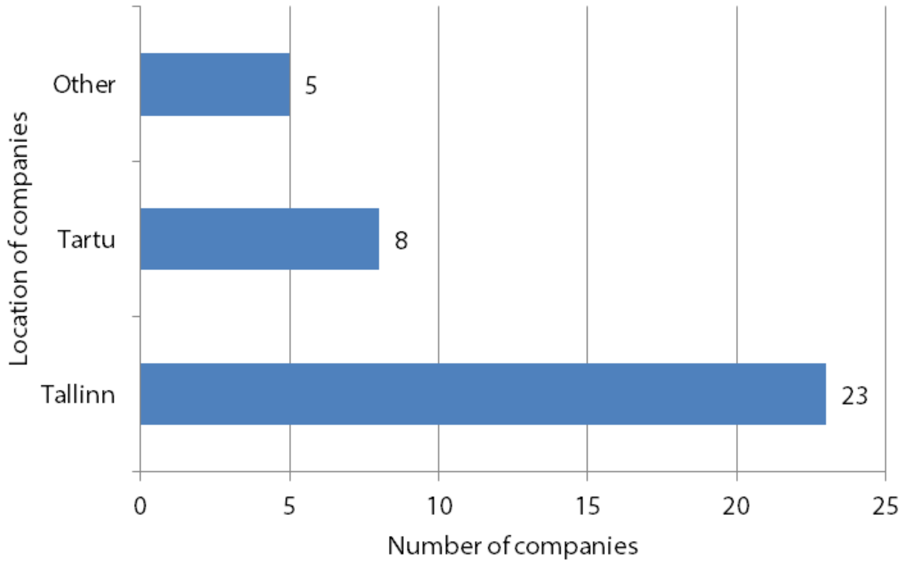

Figure 3.4 Location of cleantech developers in Estonia

Source: Authors based on Company Annual Reports.

2.2 Characteristics of the cleantech enterprises

As at 2009, most of the companies were micro enterprises, and 23 of them had less than 10 employees (Annex 3.1). Three enterprises stand out from the others (as explained further below):

- Konesko (had 312 employees and founded in 1992). Konesko's main field of operation is manufacturing of electric motors and other electric components; wind turbines are currently in the development phase and have not yet been brought to market.[166]
- Graanul Invest (with 131and founded in 2003). Graanul Invest dealt with bioenergetics and renewable energy production and was the biggest producer of pellets (sawdust granules) in the Baltics.[167]
- Estiko-Plastar (with 128 employees and founded in 1992). Estiko-Plastar is one of the leading plastic packaging manufacturers in the Baltic region, holding the status of the market leader in Estonia and an essential market share in the other

[166] For further reading visit http://www.konesko.ee/index.php?lang=en

[167] For further reading visit http://www.graanulinvest.ee/eng/page.php

Baltic countries.[168] The company was and is currently actively developing new biodegradable packaging materials.

On comparison of the three, it is evident that Graanul Invest is clearly a cleantech enterprise and Estiko-Plastar is also very active in the field. Meanwhile Konesko is only partially developing cleantech, in other words it is getting its return from other fields of operation (it should be noted, though, Konesko is using very advanced technologies in its development of wind turbines). On the other hand, Graanul Invest and Estiko-Plastar are probably currently successful as they are highly specialized, have a strong market demand for their products; and in the case of Graanul Invest the technology that employed is neither very complicated nor resource intensive. Another important aspect regarding Konesko was that at present the company was only developing wind turbines and has zero returns from cleantech. Therefore Konesko´s financial data comparisons with other companies ought to be read bearing this in mind.

An analysis of the main financial features of the companies in 2009, again Konesko, Graanul Invest and Estiko-Plastar stand out with highest net sales, labour costs, total assets and total profit (Table 3.5). Konesko´s and Graanul Invest´s share of exports ranks also amongst the top five (together with Airel, Balti Kaubad ja Teenused and Laser Diagnostic Instruments). Only Enterprise Estonia Foundation's total funding in the period of 2004-2011 is quite modest for Konesko (under the average) and slightly over the average in Estiko-Plastar, though it is over 3.5 times over the average for Graanul Invest. The three companies are among the five who have the lowest percentage of the share of labour costs compared to the net sales (11%, 13% and 6% respectively, Enteh Engineering has 8% and Renek Kemia the lowest 4%). The profile of these companies is very different from the young high-tech SMEs who usually have very high labour costs compared to sales. However it should be noted that the latter can even be absent in most cases during the R&D intensive development period in typical entrepreneurial activities. Among the companies Clifton, Goliath Wind, MolCode have the highest calculated labour cost percentage. Crystalsol, Elcogen, Nordbiochem, Bemixe and BioGold have in reality the highest percentage that cannot even be calculated as their sales are zero but labour costs are between almost 30,000 and 340,000 euros.

In 2009 the total sum of sales volume of the companies' under study was approximately EUR 124 million. The total sum for their labour costs was about EUR 15.6 million, for total assets about EUR 107 million, for total profit EUR 5.3 million, for R&D

[168] For further reading visit http://www.plastar.ee/index.php?lang_id=eng&page=99&

costs[169] in 2007-2009 about EUR 8.8 millions and for EEF funding EUR 9.7 million (Figure 3.5). The average net sales were EUR 3.6 million; 29 companies have net sales under the average (with eight companies having no sales at all). The average share of export is 28%, but 22 companies export less than that and 19 of them do not sell their production outside Estonia; while eight have no exports as they have no sales.

There is remarkably similar same trend apparent when comparing labour costs of the companies with the average of about EUR 0.5 million: 25 companies have less than the average (of which six have zero costs). The average R&D costs in 2007-2009 were EUR 0.3 million and the average EEF funding for the period of 2004-2011 EUR 0.3 million Euros; 26 and 24 companies respectively have less than the average (15 of 26 do not have any R&D costs or they do not calculate/report it and 8 of 24 have not had any funding from EEF during this period). A much more extreme situation is revealed when considering total assets and profits, only four companies (Graanul Invest, Konesko, Estiko-Plastar and Laser Diagnostic Instruments) have results over the average total assets (EUR 3.2 million) and five (the four previous plus Monoliit) have had results over the average total profit (EUR 0.2 million) while 19 companies are suffering losses.

The above analysis situation intimates toward high stratification amongst entities with very few successful companies in financial terms with the large bulk of enterprises experiencings rather lacklustre or poor financial performance. But this outcome should be treated with some caution. In many enterprises that develop new technologies such ratios are quite common in the initial periods of heavy R&D work and investment. In addition, the main activity of Konesko is not related with cleantech as explained before.

[169] R&D costs are calculated based on the company annual reports and data provided during the interviews. However, only small number of companies present R&D costs in their annual financial reports (Tables 3.5 and 3.12).

Table 3.5: Overview of the main financial features in Estonian cleantech developers (in thousands EUR)

Name of enterprise	Net sales in 2009	Share of export in 2009 (%)	Labour costs in 2009	Share of labour costs as compared to net sales in 2009 (%)	Total assets in 2009	Total profit/loss in 2009	R&D costs in the period of 2007-2009	Funding from the EEF in 2004-2011
Airel AS	130.0	0.1	57.8	0	127.2	62.6	119.8	0
Alkranel OÜ	283.6	0	155.5	0.1	192.4	18.6	13.6	16.8
Balti Kaubad ja Teenused AS	57.9	0.1	43.6	0.1	593.2	-110.6	6.1	89.5
Bemixe OÜ	0	0	25.5	0	91.7	-41.7		12.5
BioGold OÜ	0	0	50.9	0	53.8	-20.7		8.5
BiotaP OÜ	85.2	0	74.6	0.1	366.9	18.2	320.5	591.6
Clifton AS	8.2	0.1	405.7	4.9	1485.8	-619.2	792.0	5.8
Crystalsol OÜ	0	0	45.2	0	479.3	-221.4	255.4	1500.6
Dvigatel Regital OY	1030.1	0	431.2	0	896.5	67.4	6.4	0
Ecotech OÜ	2	0	0	0	1.9	-1.9		0
Elcogen AS	0	0	89.2	0	458.1	-261.6	549.6	482.5
Energest Group OÜ	0	0	0	0	2.5	-0.1		6.0
Energiatehnika OÜ	285.2	0.1	79.2	0	59.0	1.5	223.7	0
Englo OÜ	321.1	0	83.6	0	284.9	62.4		14.1
Enteh Engineering AS	1006.9	0	82.5	0	820.0	62.7		2.1
Estiko-Plastar AS	15865.2	0	2126.0	0	10044.8	644.6	1479.7	315.0
Euriko OÜ	0	0	0	0	19.1	-1.1		0
Goliath Wind OÜ	1.3	0	34.4	2.7	258.7	-151.2	226.2	217.4
Graanul Invest AS	56945.3	0.1	3207.9	0	54959.7	3954.2		1012.1
Konesko AS	34953.2	0.1	3840.4	0	20213.2	1252.7	735.0	198.5
Laser Diagnostic Instruments AS	3458.6	0.1	580.4	0	4596.5	1216.7	633.4	343.0
Mirovar OÜ	8.1	0	0	0	48.8	-13.1	70.3	8.9
MolCode AS	11.6	0	176.4	1.5	978.2	-127.8	1608.5	457.5

Name of enterprise	Net sales in 2009	Share of export in 2009 (%)	Labour costs in 2009	Share of labour costs as compared to net sales in 2009 (%)	Total assets in 2009	Total prof-it/loss in 2009	R&D costs in the period of 2007-2009	Funding from the EEF in 2004-2011
Monoliit OÜ	534.7	0	119.1	0	706.2	247.8		2.7
My!Wind OÜ	Na	na	na	na	na	na	na	6.0
Nordbiochem OÜ	0	0	341.0	0	1700.0	-466.3	1547.2	1838.3
Plastitehase AS	2656.2	0.1	621.6	0	2896.0	-667.8		2.8
Plastsys OÜ	434.7	0	195.9	0	63.4	-178.4		0
Qcell OÜ	49.6	0	56.5	0.1	184.2	-27.0		334.0
Regio AS	4005.7	0.1	2214.3	0.1	2879.5	476.5		1404.7
Renek Kemia AS	1130.6	0.1	49.4	0	886.9	13.0	151.9	389.3
Roheline Elekter AS	0	0	0	0	54.3	-0.5		0
Roheline Mõte OÜ	1.1	0	0	0	2.9	-0.7		3.0
Selefon OÜ	Na	na	na	na	na	na	na	0
Skeleton Technologies OÜ	2.8	0	1.4	0.1	34.3	-12.0	2.6	19.2
Yoga OÜ	664.1	0	424.2	0.1	555.6	72.2	95.5	437.0
TOTAL	123931.2	1.0	15613.5	10.0	106995.7	5247.8	8837.3	9719.4
Average	3645.0	0	459.2	0.3	3146.9	154.3	259.9	270.0

Source: Authors compilation based on Company Annual Reports; information on supported R&D projects from the Enterprise Estonia Foundation's online database (March 2011). Some additional data on R&D costs was obtained from the interviews with the enterprises (June-July 2011).

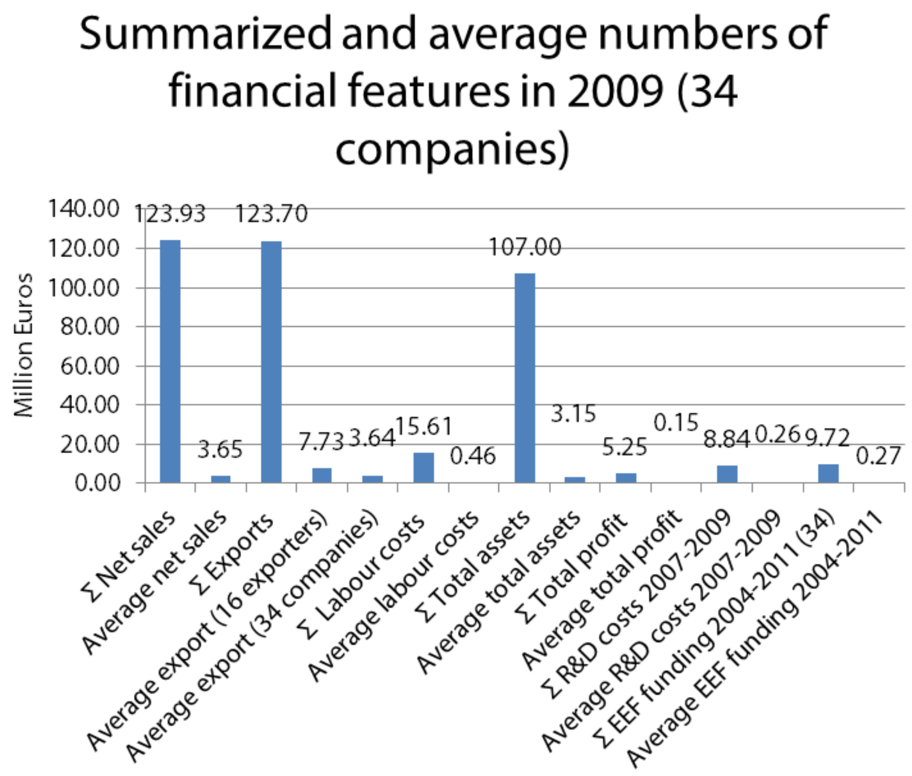

Figure 3.5: Summarized and average financial features of 34 cleantech developers in Estonia[170]

Source: Adapted based upon data from the Estonian Commercial Register on financial reports for the Estonian cleantech developers

2.3 Export orientation and problems

Graanul Invest, Konesko, Balti Kaubad ja Teenused and Airel are currently the leaders in exports. Graanul Invest exports all its production, Konesko has only a tiny part for domestic consumption and Airel has eliminated its domestic sales while Balti kaubad ja Teenused has moved toward supplying their products also to the domestic market in Estonia (Table 3.6 and Figure 3.6). Of the companies studied, it is notable that some "stars" were rising rapidly, including:- Clifton, whose share of exports grew from zero to 84% in 2009; - Laser Dignostic Instruments where the share of exports grew over 2.5 times in 2008 and 4.6 times in 2009; - MolCode for whom the share of exports grew 6.7 times in 2009; - and, Englo whose share of exports grew 3.8 times in 2009.

[170] Due to no available data my!Wind and Selefon are left out of the comparison.

Other enterpresis which are showing a more steady improvement in their exports include Estiko-Plastar, Regio, Energiatehnika, Airel (whose performance showed a rather large jump upwards in 2008 to the magnitude of 1.5 times of its exports), Renek Keemia and Plastitehas, entities that also improved their performance 1.7 times in 2009.

The economic crisis that affected the sales and also the number of employees in 2009 is less apparent for cleantech companies: 8 companies have shown mproved export features, 18 have stayed the same while 6 have seen decreases in their exports but for the latter it should be noted that the decline is not quite insignificant. In total, the average share of exports decreased slightly (from 24 to 23%) in 2008 and increased 1.2 times in 2009. Among exporters only the share of export in average terms is about half from all sales and has risen to 60% during the period under study.

Table 3.6: The share of exports in total sales revenues, 2007-2009

Name of enterprise	2007	2008	2009
Airel AS	67	98.7	100
Alkranel OÜ	0	0	0
Balti Kaubad ja Teenused	100	100	99
Bemixe OÜ	0	0	0
BioGold OÜ	0	0	0
BiotaP OÜ	na	0	0
Clifton AS	0	0	84
Crystalsol OÜ	na	0	0
Dvigatel Regital OY	0.6	1.7	0.3
Ecotech OÜ	0	0	0
Elcogen AS	0	0	0
Energest Group OÜ	na	na	0
Energiatehnika OÜ	75	74	86
Englo OÜ	28	9	33
Enteh Engineering AS	0	1.3	0.6
Estiko-Plastar AS	36	43	42
Euriko OÜ	0	0	0
Goliath Wind OÜ	na	0	0
Graanul Invest AS	100	100	100
Konesko AS	99.5	99.7	99.7
Laser Diagnostic Instruments AS	8	21	97
Mirovar OÜ	0	0	0
MolCode AS	3	3	20
Monoliit OÜ	0	0	0
Nordbiochem OÜ	0	0	0

Name of enterprise	2007	2008	2009
Plastitehase AS	44	34	57
Plastsys OÜ	16	17	7
Qcell OÜ	0	0	0
Regio AS	41	54	56
Renek Kemia AS	72	87	84
Roheline Elekter AS	0	0	0
Roheline Mõte OÜ	0	0	0
Selefon OÜ	0	0	na
Skeleton Technologies OÜ	na	na	0
Yoga OÜ	na	0	0
Average (all companies)	**24**	**23**	**28**
Average (only exporters)	**49**	**50**	**60**

Source: Compiled from Company Annual Reports.

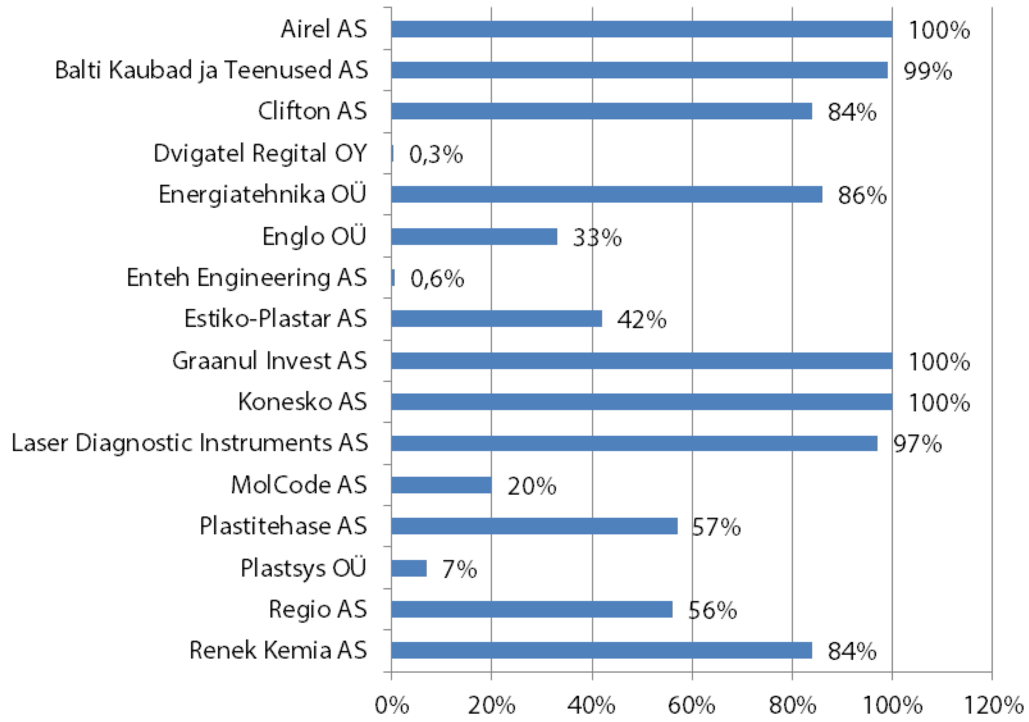

Figure 3.6: Export intensity among the exporting cleantech developers, 2009

Source: Compiled from Company Annual Reports.

In total, the biggest export revenues (2007-2009) were generated from trade with Finland (EUR 136 million), Denmark (EUR 61 million), Great Britain (EUR 25 million), Sweden (EUR 14 million), Spain (EUR 11 million), France (EUR 11 million), Russia, Latvia (EUR 7 million), Germany and Italy (Figures 3.7-3.9). In the period 2007-2009, the total export to the EU was EUR 356 million and outside the EU EUR 18 million.

Outside the EU the biggest export destinations are Russia (EUR 8 million), China (EUR 2.6 million) and Belarus (EUR 1.6 million).

The most frequent export destinations for the cleantech developers, under study, are Finland, Germany, Great Britain and Russia. Eight companies export to Finland, seven to Germany and six to Great Britain and Russia. Other quite frequent export destinations are the Netherlands (5), United States (4), France (4) and Italy (4).

Comparing the period 2007 to 2009, exports to Finland have decreased almost by half, but despite this decline it still ranks as the top export destination for Estonian products. The consistent trade partner throughout recent years has been Denmark which has remained among the top export destinations. Exports to France and Germany have decreased; meanwhile it has increased for Great Britain, Sweden, Italy and Cyprus. The comparison of export destinations and also sales in Estonia show that export to foreign countries is gaining importance while sales in Estonia have decreased only slightly from 2008 to 2009.

In Figure 3.10 export figures of big companies (Renek Kemia, Regio, Plastitehase, Konekso, Estiko-Plastar and Energiatehnika) that do not export any cleantech products or services have been excluded to show a more realistic picture of the current export destinations and cleantech sales in Estonia. According to this the overall export volumes and Estonian sales are EUR 65 million in total. Denmark and Great Britan account for almost three-fourths of all exports and sales in Estonia with a bit over EUR 44 million.

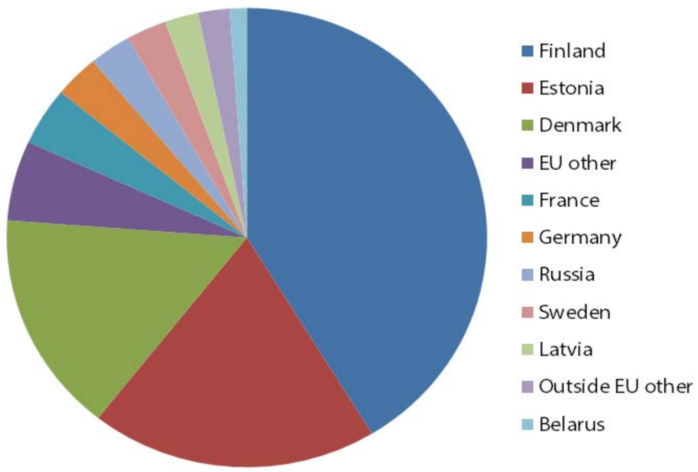

Figure 3.7: Sales in Estonia and exports of cleantechdevelopers, 2007[171]

Source: Authors derivations based on Company Annual Reports.

[171] All destinations with export volume over EUR 1 million are presented.

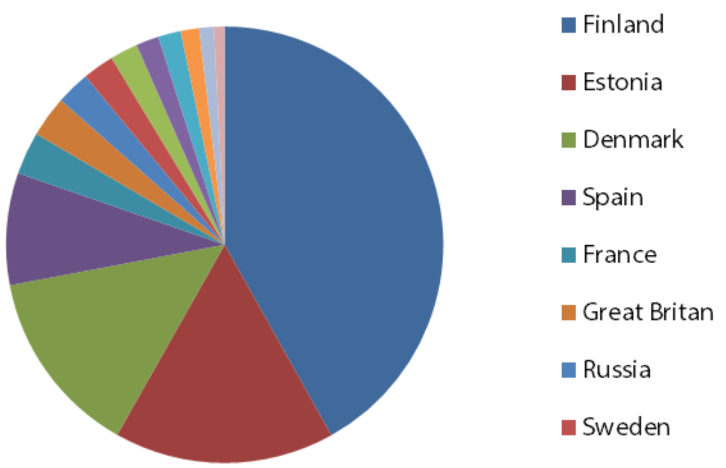

Figure 3.8: Sales in Estonia and exports of cleantechdevelopers, 2008[172]
Source: Authors based on Company Annual Reports.

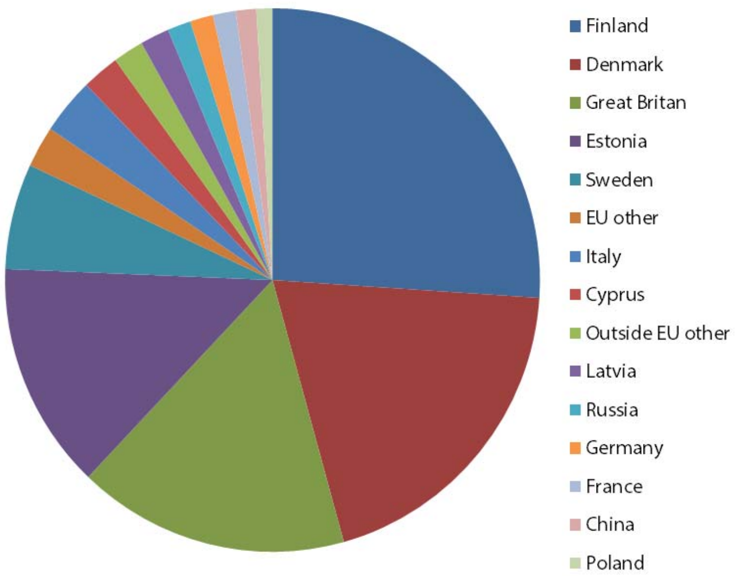

Figure 3.9: Sales in Estonia and exports of cleantech developers, 2009[173]
Source: Authors based on Company Annual Reports.

[172] All destinations with export volume over EUR 1 million are presented.
[173] All destinations with export volume over EUR 1 million are presented.

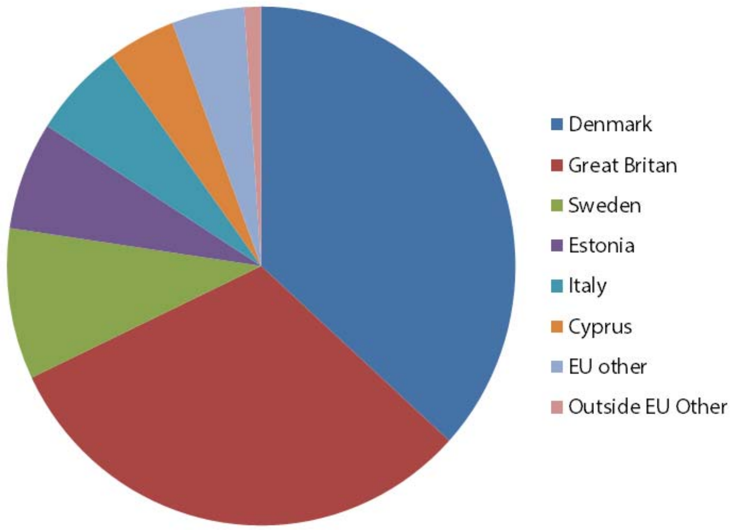

Figure 3.10: Sales in Estonia and exports of cleantech developers, 2009[174] without main big companies that do not export cleantech yet.
Source: Authors based on Company Annual Reports.

The most frequent marketing and exporting problems of the cleantech companies interviewed are related to trust and recognition issues. These may be classified as contact problems. To wit, the companies explained that trust issues are not related with a bad reputation, but with the overall perception that Estonia is a small state and was rather unknown to the rest of the world. Another related aspect is that quite often the product or service are not so unique compared to other products on the market that often have positioned themselves well as an alternative. Therefore there are huge problems with getting recognised in the market (acknowledgement) and trust in the products and services as potential clients tend to to work with what they are used to, know and what they recognize. It is therefore imperative to find good agents and representatives in export countries to deal with these contact issues as many of these products have been tested in other international markets.

Other mentioned problems include the following in respect of the the types of entities engaged in the export market or seeking to do so:

1. For energy technology, environmental equipment, ICT and CT consulting companies: A lack of information regarding opportunities in export markets and on outreach to potential clients;
2. For energy technology companies: Limited number of contacts;

[174] All destinations with export volume over EUR 1 million are presented.

3. For most of the R&D intensive entities: An approach to marketing is lacking due to the early stages of the entities progress in the market as presently mainly R&D and product development was considered important;
4. For environmental equipment companies: Some of the companies have a very limited market because of the limited interactions they engage in. Typically they interact only with universities or certain other institutions who are their clients. These companies are essentially engaged in research and operate more like research institutions with their approach to business focussed on financing their research with the attendant consequence of enjoying a very limited market for their products;
5. For cleantech consulting and energy technology companies: There are different regulations in different jurisdictions, not just in different states but also within states. e.g. in Germany each state has a different regulation regarding wind turbines. This increases the complexity of finding markets for products as specific knowledge of particular markets would be required to trade;
6. For energy technology, ICT and environmental equipment companies: Trade barriers outside the EU impose constraints on trade coupled with heavy bureaucratic and administrative burdens to pursue such access;
7. For energy technology companies: Delivery and after sales problems present challenges even where sales are made, e.g. there is often a need for a skilled person to be available locally to service and maintain the products, like wind turbine as they are immobile;
8. For ICT companies: Limited knowledge on the EU juridical system;
9. For energy technology and environmental equipment companies: Language barrier and problems with different standards in different countries; and
10. For energy technology and environmental equipment companies Price and competitiveness issues arise, as products rather expensive.

2.4 Interaction

All of the interviewed companies were cooperating with other organizations with the objective to develop clean technologies. Among science institutions the most frequently mentioned in Estonia are the Tartu of University (Institute of Technology, Institute of Ecology and Earth Sciences, Institute of Physics) and Tallinn University of Technology (Marine Systems Institute, Department of Thermal Engineering, Department of Electronics, Department of Mechatronics, Department of Chemistry), but also others like the Tallinn University (Institute of Ecology), Estonian Academy of Arts, Estonian University of life Sciences (Institute of Agricultural and Environmental Sciences), the National Institute of Chemical Physics and Biophysics. Foreign universities from the following countries were listed as co-operation partners as well: Finland (Åbo Akademia University), USA (universities from California and Florida, State University and School of Minds from Colorado), Germany (University of Potsdam, Fraunhofer Research Department), Switzerland, Spain (university from Barcelona), Sweden (Uppsala University, Umeå University) as well as partners from the Netherlands, Slovenia and Austria.

Among the government institutions referred to in the study, Enterprise Estonia was the most popular partner, but also the State Chancellery, Ministry of Economic Affairs and Communications, the Ministry of Environment, the Estonian Ministry of Defence, Estonian Development Fund, Environmental Investment Centre, Police and Border Guard Board were listed. Among the third sector institutions Food and Fermentation Technology Development Centre, the Federation of Estonian Chemical Industries, Estonian Wind Power Cluster, Health Board, Estonian Defence Industry Union, Estonian Wind Power Association and Space Enterprises NGO were mentioned.

Some of the cleantech companies were also domestically cooperating with local enterprises, but as expressed by the most high-tech ones, co-operation could only be on a limited scale. Connections and relations with international companies were regarded as more important as these relations usually provide additional value to both companies[175]. Some of the more export-oriented environmental equipment and material technology companies already have subsidiaries in foreign countries - e.g. in Luxembourg and Russia - because such a presence provides them with a better position in selling their products in these markets and also attracting local investors.

Two environmental equipment and two energy technology companies have also been partners in the EU Framework Programme R&D projects and were looking for additional involvement.

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[175] In-depth discussions on these relations were not possible during the interviews as confidential information is involved.

2.5 Innovation dynamics

The total R&D costs for the period 2007 to 2009 of 35 Estonian cleantech developers[176] were EUR 8.8 million (Table 3.12 and Figure 3.11). Figure 3.11 shows the division of the total R&D spending between the 19 cleantech developers while no data exists for the remaining 16 (the reference to Other includes Mirovar, Alkranel, Dvigatel Regital, Balti Kaubad ja Teenused and Skeleton Technologies). Notwithstanding this, these numbers must be taken with caution because the basis for the calculations was relative. This means that the costs could include direct research and development costs on testing and equipment but may also include overhead expenses for enabling these R&D activities to be conducted.

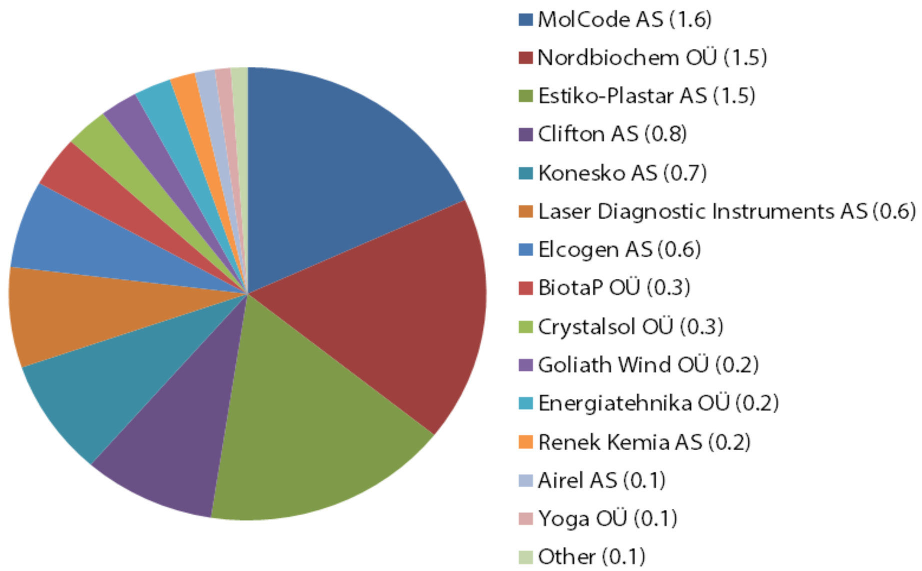

Figure 3.11: R&D costs of cleantech enterprises, 2007-2009, millions of EUR

Source: Compiled from Company Annual Reports and from conducted interviews.

The issue intellectual property rights, in particular that of patents was also addressed during the interviews. Energy technology companies were the most patent intensive of the companies studied. For example, one firm has twelve Russian patents and eight patents in application process, another has six solutions patented together with project partners. While another has two patents in application process; another one has one US and one EU patent and with 10 applications in the process. Environmental equipment companies are also active: one has six patents, another three useful models, another has oe patent and a handful of Soviet-times author certificates. Third on th pa-

[176] My!Wind is not included because it was established in 2010.

tenting score come the ICT companies: One company has three patents and licences, one company has one Estonian patent and applications pending in the EU and the US. An energy technology company explained that they usually start with the US provisional patent because it does not go public immediately as compared to the Estonian patents which go public right away.

According to the interviewees the level of technologies and knowledge intensiveness of technologies' employed was rather high in 8 companies (5 energy technologies, 1 ICT, 1 material technology, and 1 environmental equipment firm). It was high in 6 (2 energy technologies, 2 environmental equipment, one CT consulting and 1 ICT) and medium to high in 4 (1 energy technology, one CT consulter, 1 environmental equipment and 1 material technology firm) and medium in 2 (ICT and energy technologies).

Among the twenty cleantech developers interviewed one CT consulting, 1 environmental equipment, 1 material technology, 2 ICT, 6 energy technology companies have no new product revenue yet. For two environmental equipment and one material technology company it was difficult to define new products as as their products are in continuous development. In another environmental equipment firm products were developed according to clients needs with the result that every next order/product was new or had new features, making them not quite comparable to previous products so most or all sales come from new products. In one ICT firm all developed solutions are new therefore all their revenues were regarded as new services.

If industry value chain in clean technologies is envisioned as follows:

"R&D → Technology development and demonstration → Product commercialization → Market entry & volume",

then according to the interviewed companies, 8 of them were in the first and second phase (1 CT consulting, 1 environmental equipment, 1 material technology, 1 ICT, 4 energy technology companies) and their goal was that in one to two years they envision being in the last two phases – that is, to have finalized marketable products and expanded into export markets. All of these companies were very active in R&D but had problems with transforming good ideas into a product that would have a high market demand. Three energy technology companies were between the second (Technology development and demonstration) and third phase (product commercialisation), one was in the third and 8 were in the last two phases but still have problems with marketing and their future plans include investments into production and expanding to suitable export markets (3 environmental equipment, 2 ICT, 1 energy technology, 1 material technology and 1 CT consulting company).

2.6 Growth dynamics 2007-2009

Comparing the net sales for the period 2007 to 2009 in 34% of the cases (12 out of 35) the increase in sales revenues achieved in 2008 was followed by a decline in 2009 (Figure 3.12 and Table 3.7). In 6 cases the sales had increased through the period and in 7 companies there has been a continuous decline or a decline in 2008 and no changes in 2009. In 4 cases the sales have stayed zero (Crystalsol, Elcogen, Nordbiochem and BioGold – all still in R&D and/or product development phase) and only in 3 companies the decrease in 2008 was followed by an increase in 2009 (Mirovar, Laser Diagnostic Instruments, Monoliit). In total, sales increased by 18% in 2008 and decreased by 8% in 2009 and on average in the companies under the study increased by 7% in 2008 and decreased by 10% in 2009.

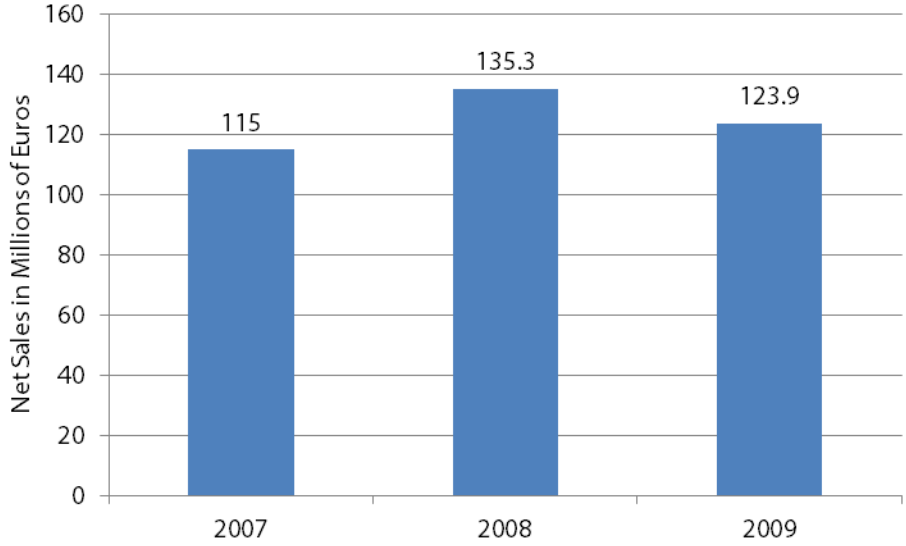

Figure 3.12: Net sales of cleantech developers, 2007-2009

Source: Authors based on Company Annual Reports.

Table 3.7: Net sales of cleantech developers, 2007-2009 (in thousand EUR)

Name of enterprise	2007	2008	2009
Airel AS	85.8	183.4	130.0
Alkranel OÜ	238.5	320.7	283.6
Balti Kaubad ja Teenused AS	1320.3	548.2	57.9
Bemixe OÜ	1.6	0	0

Name of enterprise	2007	2008	2009
BioGold OÜ	0	0	0
BiotaP OÜ	0	28.4	85.2
Clifton AS	0	0.1	8.2
Crystalsol OÜ	na	0	0
Dvigatel Regital OY	1655.7	1970.1	1030.1
Ecotech OÜ	3.0	2.6	0.2
Elcogen AS	0	0	0
Energest Group OÜ	na	na	0
Energiatehnika OÜ	135.4	287.6	285.2
Englo OÜ	263.8	313.9	321.1
Enteh Engineering AS	864.1	2189.3	1006.9
Estiko-Plastar AS	18738.1	17954.8	15865.2
Euriko OÜ	3.2	15.4	0
Goliath Wind OÜ	na	0	1.3
Graanul Invest AS	27534.0	38230.9	56945.3
Konesko AS	52357.5	61231.8	34953.2
Laser Diagnostic Instruments AS	1191.1	670.6	3458.6
Mirovar OÜ	8.3	3.5	8.1
MolCode AS	80.9	33.4	11.6
Monoliit OÜ	545.2	477.1	534.7
Nordbiochem OÜ	0	0	0
Plastitehase AS	3277.0	3808.9	2656.2
Plastsys OÜ	674.2	660.4	434.7
Qcell OÜ	4.5	94.7	49.6
Regio AS	3353.7	4581.6	4005.7
Renek Kemia AS	2643.9	1378.2	1130.6
Roheline Elekter AS	0	10.1	0
Roheline Mõte OÜ	0.6	5.1	1.1
Selefon OÜ	2.6	124.8	na
Skeleton Technologies OÜ	na	na	2754
Yoga OÜ	na	154.1	664.1
Total	**114983.1**	**135279.5**	**123931.2**
Average	**3832.8**	**4099.4**	**3645.0**

Source: Authors based on Company Annual Reports.

Comparing the number of employees in the period of 2007-2009 shows that 9 micro and smaller companies and also Graanul Invest have managed to increase the number of employees in 2009 compared to 2008 (Figure 3.13 and Table 3.8). Three have cut down the number of staff in 2009 eliminating the increase in 2008. However, this tendency is more apparent among the bigger companies (with the exception of Graanul Invest). In 5 companies the number of employees has decreased during the period and in the rest the employment numbers have stayed the same or changed only slightly. In total the number of employees has stayed roughly the same in 2007 and 2008 and decreased by some 10% in 2009. As compared to sales, the increase in staff was vastly higher in 2008 (18%) and the decrease a bit lower (8%). However the average number of employees has only decreased by 11% in 2008, and by 7% in 2009. This tendency may be contextualised in the aftermath of the global financial crisis.

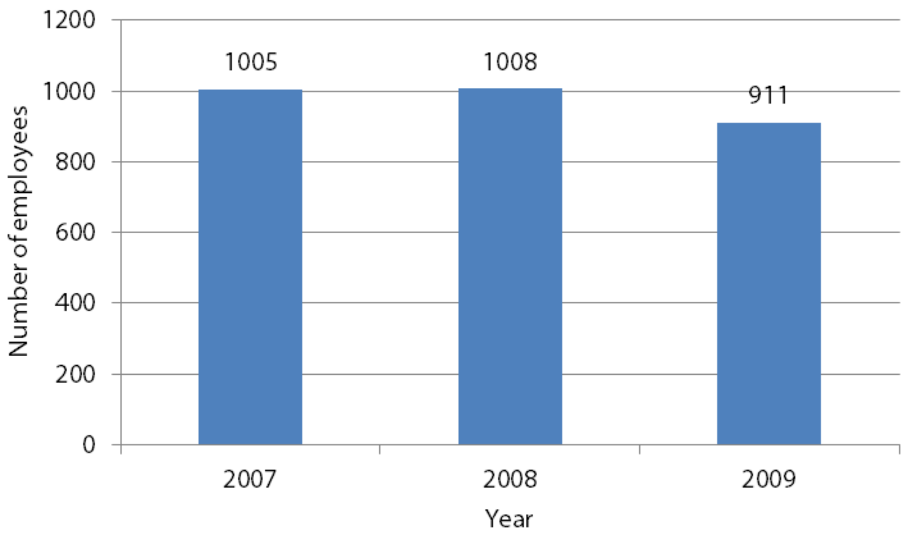

Figure 3.13 Number of employees in Estonian cleantech developers, 2007-2009
Source: Authors based on Company Annual Reports.

Table 3.8: Number of employees in cleantech developers, 2007-2009

Name of enterprise	2007	2008	2009
Airel AS	5	5	5
Alkranel OÜ	11	11	10
Balti Kaubad ja Teenused AS	5	5	5
Bemixe OÜ	0	0	0
BioGold OÜ	1	1	2
BiotaP OÜ	na	1	8
Clifton AS	26	26	22
Crystalsol OÜ	na	0	4
Dvigatel Regital OY	34	34	28
Ecotech OÜ	0	0	0
Elcogen AS	2	2	2
Energest Group OÜ	na	na	0
Energiatehnika OÜ	3	7	6
Englo OÜ	10	7	6
Enteh Engineering AS	16	16	15
Estiko-Plastar AS	181	148	128
Euriko OÜ	2	0	0
Goliath Wind OÜ	na	0	3
Graanul Invest AS	110	115	131
Konesko AS	408	414	312
Laser Diagnostic Instruments AS	24	25	25
Mirovar OÜ	0	0	0
MolCode AS	4	4	6
Monoliit OÜ	5	5	9
Nordbiochem OÜ	6	9	9
Plastitehase AS	64	70	64
Plastsys OÜ	11	11	11
Qcell OÜ	0	0	0
Regio AS	68	78	82
Renek Kemia AS	6	2	2
Roheline Elekter AS	0	0	0
Roheline Mõte OÜ	0	0	0
Selefon OÜ	3	3	na
Skeleton Technologies OÜ	na	na	2
Yoga OÜ	na	9	14
Total	**1005**	**1008**	**911**
Average	**35**	**31**	**27**

Source: Authors based on Company Annual Reports.

Labour costs increased in 2008 and this was followed by a decrease in 2009 (Figure 3.14 and Table 3.9). In 14 companies labour costs have risen steadily (MolCode, Laser Diagnostic Instruments, Nordbiochem, Enteh Engineering, Regio and Renek Kemia) and more sharply (Cristalsol, BioGold, Goliath Wind, Yoga, Graanul Invest, Monoliit, Energiatehnikad and Qcell) and in one (Selefon) there had been an increase in labour costs in 2008 but no data was available for 2009. Only in one company (Balti Kaubad ja Teenused) was the decrease in 2008 followed by an increase in 2009. In total labour costs rose by 39% in 2008 and fell by 7% in 2009. On average, the labour costs have increased by 22% in 2008 and decreased by 9% in 2009.

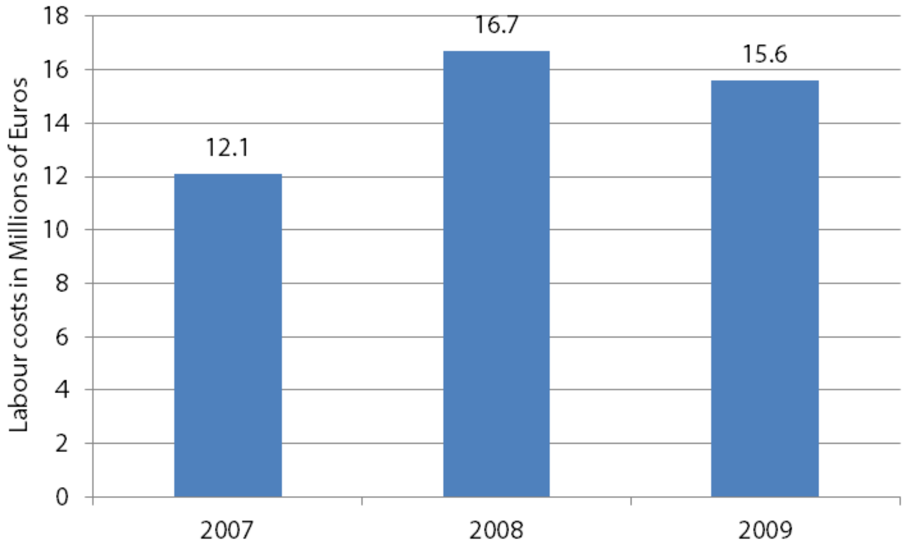

Figure 3.14: Labour costs of Estonian cleantech developers, 2007-2009
Source: Authors based on Company Annual Reports.

Table 3.9: Labour costs in cleantech enterprises in, 2007-2009 (in thousand EUR)

Name of enterprise	2007	2008	2009
Airel AS	71.8	73.9	57.8
Alkranel OÜ	107.6	161.4	155.5
Balti Kaubad ja Teenused	48.8	39.5	43.6
Bemixe OÜ	23.0	30.6	25.5
BioGold OÜ	2.8	7.2	50.9
BiotaP OÜ	na	76.8	74.6
Clifton AS	351.6	445.3	405.7
Crystalsol OÜ	na	0	45.2
Dvigatel Regital OY	465.1	626.3	431.2
Ecotech OÜ	0	0	0
Elcogen AS	61.8	100.1	89.2
Energest Group OÜ	na	na	0
Energiatehnika OÜ	49.5	50.7	79.2
Englo OÜ	72.4	86.1	83.6
Enteh Engineering AS	76.1	79.5	82.5
Estiko-Plastar AS	698.4	2208.3	2126.0
Euriko OÜ	2.2	0	0
Goliath Wind OÜ	na	0	34.4
Graanul Invest AS	1394.0	2336.6	3207.9
Konesko AS	5285.9	5914.0	3840.4
Laser Diagnostic Instruments AS	450.0	563.2	580.4
Mirovar OÜ	0	0	0
MolCode AS	159.5	169.1	176.4
Monoliit OÜ	36.6	52.5	119.1
Nordbiochem OÜ	94.2	313.0	341.0
Plastitehase AS	822.8	880.9	621.6
Plastsys OÜ	205.6	208.1	195.9
Qcell OÜ	14.2	38.6	56.5
Regio AS	1495.2	2106.5	2214.3
Renek Kemia AS	46.2	46.7	49.4
Roheline Elekter AS	0	0	0
Roheline Mõte OÜ	0	0.6	0
Selefon OÜ	15.0	11.3	na
Skeleton Technologies OÜ	na	na	1.4
Yoga OÜ	na	105.0	424.2
Total	**12050.0**	**16731.5**	**15613.5**
Average	**415.5**	**507.0**	**459.2**

Source: Authors based on Company Annual Reports.

Total assets have not changed much in the period under focus here (Figure 3.15 and Table 3.10). In 13 companies the increase in 2008 was followed by a decrease in 2009. In 13 cleantech developers' total assets had risen steadily (Clifton, Elcogen, Roheline Elekter, Regio, Englo, Graanul Invest and Qcell) while in some it has risen sharply as well (Crystalsol, Goliath Wind, Yoga, BiotaP, Monoliit). Dvigatel Regital, MolCode, Laser Diagnostic Instruments and Nordbiochem experienced a decrease in 2008 followed by an increase in 2009. In three companies (Balti Kaubad ja Teenused, Estiko-Plastar and Plastys) total assets have fallen constantly. In total there have been only slight changes: 4% increase in 2008 followed by 2% increase in 2009. The average numbers have decreased by 6% in 2008 and by 1% in 2009.

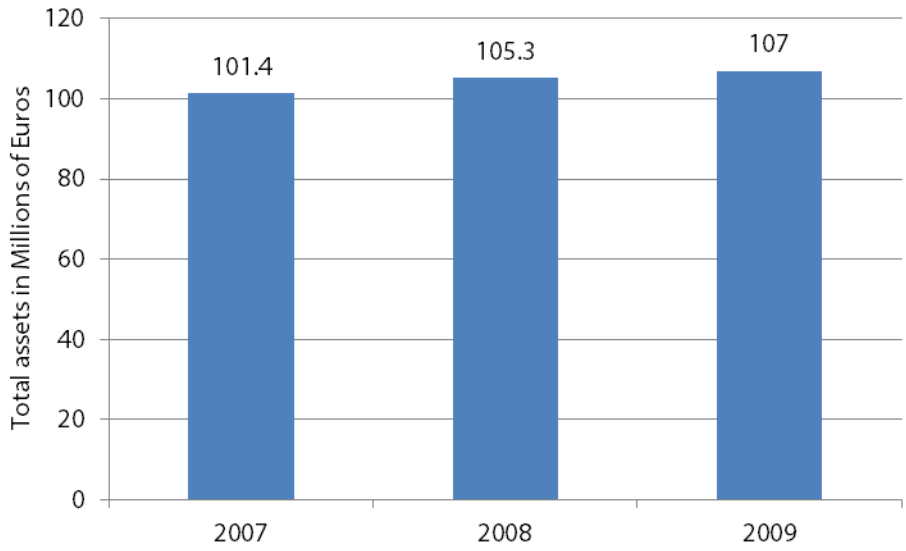

Figure 3.15: Comparison of total assets in Estonian cleantech developers
Source: Authors based on Company Annual Reports.

Table 3.10: Comparison of total assets in Estonian cleantech enterprises in 2007, 2008 and 2009 (in thousand EUR)

Name of enterprise	2007	2008	2009
Airel AS	143.5	176.9	127.2
Alkranel OÜ	146.4	198.7	192.4
Balti Kaubad ja Teenused AS	747.5	720.0	593.2
Bemixe OÜ	88.0	150.0	91.7
BioGold OÜ	50.4	68.5	53.8
BiotaP OÜ	2.6	44.4	366.9
Clifton AS	1377.6	1369.0	1485.8
Crystalsol OÜ	na	19.7	479.3
Dvigatel Regital OY	842.7	611.9	896.5
Ecotech OÜ	4.4	4.7	1.9
Elcogen AS	349.6	420.2	458.1
Energest Group OÜ	na	na	2.5
Energiatehnika OÜ	28.3	94.8	59.0
Englo OÜ	158.6	230.7	284.9
Enteh Engineering AS	459.4	845.2	820.0
Estiko-Plastar AS	12827.4	10977.3	10044.8
Euriko OÜ	5.0	20.4	19.1
Goliath Wind OÜ	na	34.8	258.7
Graanul Invest AS	48889.0	53789.5	54959.7
Konesko AS	22846.0	22951.9	20213.2
Laser Diagnostic Instruments AS	3628.7	2490.1	4596.5
Mirovar OÜ	31.2	52.6	48.8
MolCode AS	898.7	886.1	978.2
Monoliit OÜ	483.0	487.2	706.2
Nordbiochem OÜ	1076.0	1026.1	1700.0
Plastitehase AS	2670.7	3139.2	2896.0
Plastsys OÜ	273.4	237.8	63.4
Qcell OÜ	88.3	140.1	184.2
Regio AS	2141.5	2722.5	2879.5
Renek Kemia AS	741.2	919.7	886.9
Roheline Elekter AS	35.8	51.3	54.3
Roheline Mõte OÜ	1.3	3.6	2.9
Selefon OÜ	349.4	312.9	na
Skeleton Technologies OÜ	na	na	34.3
Yoga OÜ	na	126.2	555.6
Total	**101385.7**	**105324.2**	**106995.7**
Average	**3379.5**	**3191.6**	**3146.9**

Source: Authors based on Company Annual Reports.

Total profit decreased (or total loss increased) in 2008 and increased (or loss decreased) in 2009 in 11 companies (Figure 3.16 and Table 3.11). At the same time, 10 companies experienced the opposite situation. In 9 enterprises total profits have been only falling during 2007 to 2009 and in 9 profits have decreased only in 2009. Figures for the total evidence a more drastic scenario: total profits declined by 45% in 2008 and rose by 38% in 2009. This is a quite different tendency compared to the dynamics of other studied features suggesting a more profound analysis of the issue. Average profits had fallen by 52% from 2007 to 2008 and then rose to 34% in 2009.

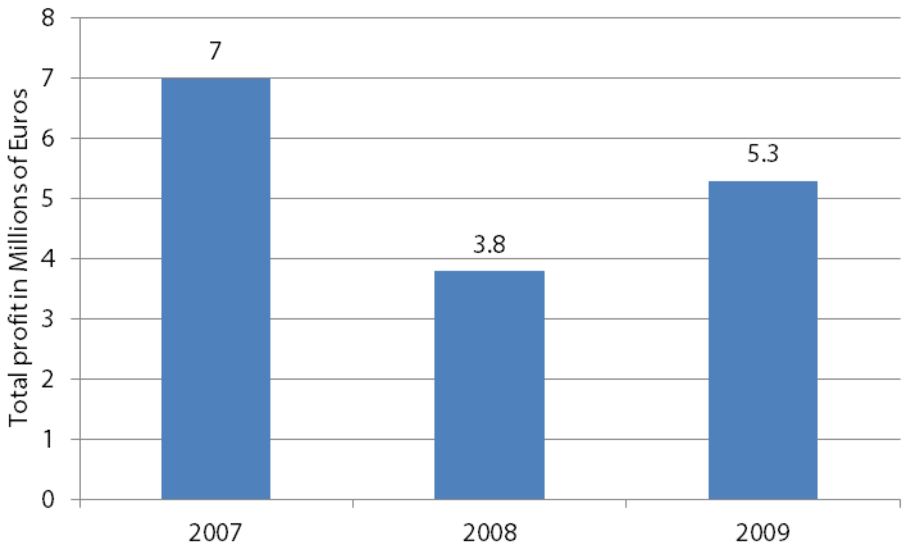

Figure 3.16: Total profits of Estonian cleantech developers, 2007-2009
Source: Authors based on Company Annual Reports.

Table 3.11: Comparison of total profit/loss in Estonian cleantech enterprises in 2007, 2008 and 2009 (in thousand EUR)

Name of enterprise	2007	2008	2009
Airel AS	35.8	87.4	62.6
Alkranel OÜ	54.8	52.5	18.6
Balti Kaubad ja Teenused AS	151.8	34.0	-110.6
Bemixe OÜ	-41.1	-46.8	-41.7
BioGold OÜ	-8.3	19.0	-20.7
BiotaP OÜ	na	-13.7	18.2
Clifton AS	-378.1	-807.4	-619.2
Crystalsol OÜ	na	-7.9	-221.4
Dvigatel Regital OY	192.5	22.7	67.4
Ecotech OÜ	2.5	0.0	-1.9
Elcogen AS	-207.1	-293.6	-261.6
Energest Group OÜ	na	na	-0.1
Energiatehnika OÜ	-11.1	20.8	1.5
Englo OÜ	47.1	79.5	62.4
Enteh Engineering AS	89.0	294.7	62.7
Estiko-Plastar AS	965.2	122.9	644.6
Euriko OÜ	0.0	15.4	-1.1
Goliath Wind OÜ	na	-2.2	-151.2
Graanul Invest AS	2092.0	1248.1	3954.2
Konesko AS	4123.3	4011.6	1252.7
Laser Diagnostic Instruments AS	78.4	-99.2	1216.7
Mirovar OÜ	2.7	0.7	-13.1
MolCode AS	-244.8	-423.4	-127.8
Monoliit OÜ	112.7	95.9	247.8
Nordbiochem OÜ	-228.6	-525.1	-466.3
Plastitehase AS	-10.4	-583.2	-667.8
Plastsys OÜ	-24.3	-19.0	-178.4
Qcell OÜ	-8.5	-17.4	-27.0
Regio AS	226.0	376.4	476.5
Renek Kemia AS	-12.1	175.4	13.0
Roheline Elekter AS	-0.1	9.6	-0.5
Roheline Mõte OÜ	-1.3	2.2	-0.7
Selefon OÜ	-38.8	29.6	na
Skeleton Technologies OÜ	na	na	-12.0
Yoga OÜ	na	-58.7	72.2
Total	**6959.6**	**3800.6**	**5247.8**
Average	**240.0**	**115.2**	**154.3**

Source: Authors based on Company Annual Reports.

For the period 2007-2009 total R&D costs were the highest in MolCode (almost EUR 1.6 million), Nordbiochem (EUR 1.6 million) and in Estico Plastar (EUR 1.5 million) (Figure 3.17 and Table 3.12). Similar costs were not calculated or not presented for 16 companies. It is interesting to note that total R&D costs increased 11% in 2008 but suffered a decrease in 2009 of 8%.

Figure 3.17: R&D costs in Estonian cleantech companies, 2007-2009
Source: Authors based on Company Annual Reports.

Table 3.12: Comparison of R&D costs in Estonian cleantech enterprises in 2007, 2008 and 2009 (in thousand EUR)

Name of enterprise	2007	2008	2009	Total
Airel AS	25.7	55.0	39.0	119.8
Alkranel OÜ	6.3	2.3	5.0	13.6
Balti Kaubad ja Teenused AS	0	3.5	2.6	6.1
Bemixe OÜ				
BioGold OÜ				
BiotaP OÜ	320.5			320.5
Clifton AS	403.1	168.5	220.4	792.0
Crystalsol OÜ	na	0	255.4	255.4
Dvigatel Regital OY				6.4
Ecotech OÜ				
Elcogen AS	134.2	204.5	210.9	549.6
Energest Group OÜ	na	na		
Energiatehnika OÜ	32.0	63.9	127.8	223.7
Englo OÜ				
Enteh Engineering AS				
Estiko-Plastar AS	402.7	687.6	389.4	1479.7
Euriko OÜ				
Goliath Wind OÜ	na	30.0	196.2	226.2
Graanul Invest AS				
Konesko AS		735.0		735.0
Laser Diagnostic Instruments AS	295.8	173.5	164.1	633.4
Mirovar OÜ	32.0	32.0	6.4	70.3
MolCode AS	695.1	454.0	459.3	1608.5
Monoliit OÜ				
Nordbiochem OÜ	463.5	391.0	692.7	1547.2
Plastitehase AS				
Plastsys OÜ				
Qcell OÜ				
Regio AS				
Renek Kemia AS		30.5	121.3	151.9
Roheline Elekter AS				
Roheline Mõte OÜ				
Selefon OÜ				
Skeleton Technologies OÜ	na	na	2.6	2.6
Yoga OÜ	na	95.0	0.5	95.5
Total	**2810.9**	**3126.5**	**2893.6**	**8837.3**
Average	**93.7**	**94.7**	**82.7**	

Source: Authors based on Company Annual Reports.

2.7 Financial needs

All the interviewed companies were asked about the fields (R&D, production, international market expansion, other) in which they planned to invest in the near future. Fourteen companies are planning to invest into R&D (one CT consulting, 2 ICT, 4 environmental equipment, 1 material technology, 7 energy technology firms), 11 into production (1 ICT, 2 environmental equipment, 2 material technology, 6 energy technology firms) and 15 into international market expansion (two CT consulting, 3 ICT, 1 environmental equipment, 2 material technology, 7 energy technology companies). This shows a clear trend that the majority of entities were focused on foreign markets and needed to have good strategies to ensure success. Two environmental equipment companies stand out from the others. They define themselves clearly as research institutions and see business and marketing as a secondary aspect useful only for financing their R&D. Therefore they were not too keen on improving their marketing behaviour.

For 10 companies R&D was the first choice (3 environmental equipment, 1 material technology, 6 energy technology firms. For 4 production was the first choice (1 ICT, 1 environmental equipment, 2 energy technology companies) and for 6 (2 CT consulting, 2 ICT, 1 material technology, 1 energy technology firms) international market expansion was mentioned first while asking about the future investment plans.

Only some companies have financed all their investments with own capital, but this tendency is normal and common to high-tech companies. One big energy technology company has had the most possibilities and resources and mainly financed wind turbine development from their own capital. Also 2 environmental equipment firms claim to have a very high own financing rate. From external capital providers EEF is the most frequent support organization. Though the amount of money in general is quite small compared to the importance of other external capital providers like owners (important for 3 ICT, 1 material technology, 4 energy technology companies), EU Framework Programmes (for 2 environmental equipment and 2 energy technology firms), Estonian Development Fund (for 1 environmental equipment, 2 energy technology enterprises), business angels (for 1 ICT and 1 material technology firm), foreign funds (for 1 material technology and 1 energy technology company – Power Fund II, LP – VNT Management OY,) and Venture Capital (for 3 energy technology companies).

> *„Compared to EEF it is easier to apply and attend in EU Framework Programme projects as there the lead partner writes the application and does most of the reporting. Though the biggest problem with international projects is that the attend-*

ing company loses intellectual property rights to the developed solution or product. We would like to develop and market the solution but in international projects the company has to be like a science institution – works out a product and afterwards production goes out of Estonia" (Environmental equipment company).

This stresses an important need for more effective state support measures to keep intellectual property rights and where appropriate local high-tech production.

"In reality the hopes of stakeholders are much higher than the bank interests. Therefore companies who do not find a good investor who gives also additional value besides just new capital should go to the bank" (Material technologies company).

"Without VC it is not possible to finance start-up R&D, EE support is limited and therefore negotiations with VC funds in Europe are necessary. Estonian VC is very limited mainly because of state smallness and history." (Energy technologies company)

For 2 energy technologies and 2 environmental equipment firms also the funding from EU Framework Programme projects has been very important in financing their R&D activities.

Four companies out of the 20 interviewed had not experienced any problems with financing (2 energy technologies, 1 ICT and 1 CT consulting company). The following problems were stated by the other 16 interviewees:

1. The main problem, stressed by the majority, was related to state support. Namely, options are limited in the beginning, but better in the growth phase and lacking in later phases, again. As high tech production generates continuous additional value in various forms, companies expected further support measures.
2. Problems with getting funding from EEF. The process was too time and resource consuming, and there was a heavy administrative burden. Also quite often the money was given later so it is very complicated for a company to follow the project especially if it does not have sufficient liquidity.
3. Better cooperation among support organizations was needed : EEF and Estonian Development Fund should strengthen their co-operation with each other and with international organizations like Cleantech Scandinavia, Cleantech Finland. They should aim at bringing foreign investors and funds to Estonian high tech companies. It was acknowledged, still, that the cooperation between these insti-

tutions had developed very quickly. It could also bethat the firms were not that well informed of the recent developments.

4. Another problem also stressed by more than one company, was location – investors want to invest into a country and culture that they know (the problem was not with reputation, i.e. a very attractive tax system, but with awareness). Estonia was far from „international money“ and local banks did not communicate with edge and venture capital funds.
5. R&D potential and intellectual property rights were not a sufficient "guarantee" for investors.
6. The financial crises has decreased opportunities to raise financing. Although stimulus packages upported green initiatives in the beginning, companies question how and whether further promises for support would be fulfilled.[177]
7. Lack of sufficient sales and own capital to secure financing from EEF. EEF's decision making commission ought to take larger risks to support SMEs who basically do R&D on their own without drawing any salary (showing a commitment) and have limited options for own funding.
8. Activities of venture capital and business angels are limited.

[177] For further reading see the Ernst & Young research about the dread that funding promises during the crises might not be fully accomplished http://www.ey.com/GL/en/Industries/Cleantech/Cleantech-matters--Green-stimulus-update--spending-to-peak-in-2011.

3. Energy technologies sub-cluster

The energy technologies is the biggest cleantech developers' sub-cluster in Estonia and therefore also has a great deal of variety in terms of operational fields. According to the cleantech companies interviewed, energy technologies (including energy efficiency) was also the sub-cluster where the best growth opportunities in the future were foreseen. The companies belonging to this sub-cluster are Clifton, Crystalsol, Elcogen, Skeleton Technologies, Goliath Wind, my!Wind, Roheline Elekter, Konesko, Dvigatel Regital, Energiatehnika, Enteh Engineering and Roheline Mõte (Table 3.13). Some of these companies could be categorised under the term energy efficiency (Clifton, Crystalsol, Elcogen, Skeleton Technologies, Roheline Mõte), some others under renewable energy and wind turbine development (Goliath Wind, my!Wind, Roheline Elekter, Konesko, Dvigatel Regital) and yet others under electrical engineering and power engineering (Energiatehnika, Enteh Engineering). Five of the companies were established in the nineties and others after the 2000s. Ten companies have less than 30 employees (seven had fewer than 10), only Konesko stands out with over 300 employees. 7 enterprises are located in Tallinn, 3 in Tartu, one in Koeru and Kohtla-Järve.

Table 3.13: Energy technologies sub-cluster companies, 2009

Name of enterprise	Cleantech sub-field	Foundation	Location	No. of employees
Clifton AS	Energy technologies (gallium arsenide semiconductor structures)	1999	Tartu	22
Crystalsol OÜ	Energy technologies (photovoltaics)	2008	Tallinn	4
Dvigatel Regital OY	Energy technologies (wind turbines)	1999	Tallinn	28
Elcogen AS	Energy technologies (fuel cells)	2001	Tallinn	2
Energiatehnika OÜ	Energy technologies (electrical engineering)	1997	Tallinn	6
Enteh Engineering AS	Energy technology (heat technology and heat power engineering)	1997	Kohtla-Järve	15
Goliath Wind OÜ	Energy technologies (wind turbines)	2008	Tallinn	3

Name of enterprise	Cleantech sub-field	Foundation	Location	No. of employees
Konesko AS	Energy technologies (wind turbines)	1992	Viimsi vald, Koeru vald	312
my!Wind OÜ	Energy technologies (small wind turbines)	2010	Tartu	na
Roheline Elekter OÜ	Energy technologies (wind turbines)	2006	Tallinn	0
Roheline Mõte OÜ	Energy technologies (heat exchangers)	2007	Tallinn	0
Skeleton Technologies OÜ	Energy technologies (energy storage condensators, ultracapacitors)	2009	Tartu	2

Source: Authors based on Company Annual Reports.

In comparing the main financial data of the 11 energy technologies developers[178] in 2009 regarding net sales, labour costs and total assets only Konesko has reslts over the average (Table 3.14). The average share of export was 25% and only Clifton, Energiatehnika and Konesko export over the average. In total only four companies sold their products or services outside Estonia while 7 had no exports (3 have no export due to no sales). Comparing total profit or loss Dvigatel Regital, Entech Engineering and Konesko have profits over the average, in the first two cases it is about six times and in the case of Konesko it is about 100 times over the average. None of these companies are active only in the field of cleantech, their main operational field is engineering and manufacturing. R&D costs were over the average in Clifton, Crystalsol, Elcogen and Goliath Wind – all active cleantech developers in the first two phases of the industry value chain (R&D development and technology development & demonstration) with the exception of Clifton (already in the third phase – product commercialization).

In 2009 the total sales volume of the energy technology cluster companies was about EUR 37 million. The same indicator for labour costs was about EUR 5 millions, for total assets EUR 25 Million, for a total profit EUR 1 Millions, for R&D costs in 2007-2009 about EUR 1.8 million and for EEF funding EUR 2.4 million. In 2009 net sales and labour costs of the energy technologies companies accounted for approximately 30% of the total figures of all the studied companies, total assets of 23%, total profit/loss of 2%, R&D costs for 2007-2009 of 26% and Enterprise Estonia funding in 2004-2011 of 25% (Table 3.5). This shows that in most cases the third of all the analysed companies (12 of 35) accounted for a fair share of 23-30% of the main financial figures. Profits are only 2% of the summarized features of all the 35 companies which indicates that they are facing serious challenges to increase their productivity. But, this

[178] My!Wind was established in 2010, therefore the company is left out of the financial data analysis exept grants from EEF where the analysed time period is 2004-2011.

is quite understandable if the majority of the enterprises are in the initial phases of R&D development and technology development & demonstration.

General barriers for all cleantech developers were also relevant for energy technologies. More specific growth obstacles mentioned by the companies belonging to this sub-cluster were first related with the availability of human resources, 5 of the companies mentioned the lack of employees with good specialist knowledge and good business and marketing knowledge. These companies have also recruited specialists from abroad. Cooperation gaps between companies and universities were also seen as a rather daunting obstacle.

> *„Better working connections between universities and enterprises would contribute to the preparation of the students – after graduating a student should be able to understand also the logic of the economy" (cleantech company).*

> *„Another problem considers the overall system of universities that is only publications based – also the economic effect, perspective, market volume and innovativeness (newness) in international terms should be taken into account" (cleantech company).*

Most common marketing and exporting problems were related to general analysis of the export markets, limited number of contacts, hindering regulations in different countries, availability of VC, delivery and after-sales problems, language problems and price negotiations.

Financial problems of the energy technologies companies were quite common to all small and young high-tech companies that were engaged in intensive R&D. This tendency was also apparent in the companies' future investment plans. Five companies emphasised the need to invest in R&D and production, two companies thought that all the three fields were important (R&D, production and international market expansion) and one company planned to invest only into R&D. In general R&D was seen as the most relevant field followed by production and international market expansion. This is in accordance with the fact that most of the companies are still in the R&D development and technology development and demonstration phase.

Like all the other cleantech developers energy technologies sub-cluster companies were also not able to finance their activities utilising their own capital. The most important external capital providers were owners (for 5), EU Framework Programme projects (2), VC (3), Estonian Development Fund (2) and foreign funds (1). Other common financing problems to this sub-cluster were related with state financing and support for potentially successful companies, getting funding from EEF, unknown culture and a faraway location, long payback time and huge investments, lack of capital for these stage companies, and missing venture capital market and angels.

Table 3.14: Financial features of energy technologies sub-cluster companies

Name of enterprise	Net sales in 2009	Share of export in 2009 (%)	Labour costs in 2009	Share of labour costs as compared to net sales in 2009 (%)	Total assets in 2009	Total profit/loss in 2009	R&D costs in the period of 2007-2009	Funding from the EEF in 2004-2011
Clifton AS	8.2	0.1	405.7	4.9	1485.8	-619.2	792.0	5.8
Crystalsol OÜ	0	0	45.2	0	479.3	-221.4	255.4	1500.6
Dvigatel Regital OY	1030.1	.0	431.2	0	896.5	67.4		0
Elcogen AS	0	0	89.2	0	458.1	-261.6	549.6	482.5
Energiatehnika OÜ	285.2	0.1	79.2	0	59.0	1.5	223.7	0
Enteh Engineering AS	1006.9	0	82.5	0	820.0	62.7		2.1
Goliath Wind OÜ	1.3	0	34.4	2.7	258.7	-151.2	226.2	217.4
Konesko AS	34953.2	0.1	3840.4	0	20213.2	1252.7		198.5
My!Wind OÜ	na	na	na	na	na	na	na	6.0
Roheline Elekter AS	0	0	0	0	54.3	-0.5		0
Roheline Mõte OÜ	1.1	0	0	0	2.9	-0.7		3.0
Skeleton Technologies OÜ	2.8	0	1.4	0.1	34.3	-12.0	2.6	19.2
TOTAL	**37288.7**	**0.3**	**5009.3**	**7.8**	**24762.1**	**117.6**	**2049.5**	**2435.0**
Average	**3389.9**	**0**	**455.4**	**0.7**	**2251.1**	**10.7**	**186.3**	**202.9**

Source: Source: Authors based on Company Annual Reports and interviews.

4. ICT sub-cluster

The ICT sub-cluster is a rather small sub-cluster but ranks second together with biofuels in Estonia. The sub-cluster is interesting because the associatin of ICT is not typically made with cleantech, this is even though it can successfully be used to reduce exploitation of the environment and create possibilities for the reduction of pollution in the environment. According to the cleantech companies interviewed information and material technologies are nowadays related to all the breakthroughs but are also on their own a sub-field with high growth potential. In addition, one of the wind turbine generator developers stated that as Estonia has a challenge around an oilshale centralized power plant grid architecture, there was a need to deal with smart-grids in order to sell unstable renewable energy – this was an opportunity for the ICT sector to enable the use of wind power to a larger extent. This statement clearly connects the two cleantech sub-clusters under study and shows the need for greater cooperation and joint efforts.

Companies belonging to the ICT sub-cluster are Yoga, Mirovar, MolCode, Euriko and Regio (Table 3.15). The first three are clearly cleantech companies, Euriko and Regio have during the last few years started partially developing clean technologies in the area of wind energy software. Some companies were very small and two have no employees. Four out of five have been established after 2004. Regio is an exception in both of the cases, it was established in 1990 and in 2009 had 82 employees. Three companies are located in Tallinn or near Tallinn and two in Tartu.

Table 3.15: ICT sub-cluster companies, 2009

Name of enterprise	Cleantech sub-field	Foundation	Location	No. of employees
Euriko OÜ	ICT (wind energy software development)	2006	Tartu	0
Mirovar OÜ	ICT (energy saving solutions for buildings)	2005	Rae vald	0
MolCode AS	ICT (material technologies, CT consulting)	2004	Tallinn	6
Regio AS	ICT (wind energy software)	1990	Tartu	82
Yoga OÜ	ICT (intelligent building system)	2008	Tallinn	14

Source: Authors based on Company Annual Reports.

As of 2009, the average net sales of the ICT sub-cluster companies are EUR 0.9 million. Only Regio has net sales over the average (about 4 times) (Table 3.16). The average share of exports is 15% (compared to the 35 companies' average of 28%). Regio and MolCode had exports over the average (56% and 20% respectively) while 3 companies out of 5 did not sell their production outside Estonia. Average labour costs of the ICT sub-clusters companies were about EUR 0. 6 millions and again only Regio exceeded the average with 4 times (Euriko and Mirovar have zero labour costs). The average figure for total assets is EUR 0.9 million, for total profit/loss EUR 0.08 million, for R&D costs also EUR 0.08 million and for EEF funding EUR 0.5 million. In the case of total assets, Regio and MolCode cross the average (MolCode with 9% and region with 3.2 times), in total profit only Regio (with almost 6 times), in R&D costs MolCode (with almost 4 times) and Yoga (with 20%) and in EEF funding again only Regio exceed the average feature 3 times. Though, MolCode and Yoga have also received EEF funding quite close to the average. It is necessary to stress that conclusions for Regio must be taken with caution as the company has only lately started to develop new wind energy software solutions in the field of cleantech.

The total sum of sales volume of the ICT sub-cluster companies was approximately EUR 4.7 million, total labour cost were EUR 2.8 million, total assets EUR 4.5 million, total profit/loss EUR 0.4 million and total R&D costs EUR 0.4 million and EEF funding EUR 2.3 million. These numbers account correspondingly for 4%, 18%, 4%, 8%, 6% and 24% from the summarized features of all the 35 companies under study (Table 5). As the ICT sub-cluster includes 5 (14%) of all the 35 companies the previously stated numbers were disproportionate in relation to the size of the cluster, only labour costs almost correspond to the size.

The main obstacles to growth mentioned by the companies belonging to the ICT sub-cluster were first related with the newness and limited recognition of their products and services. This issue concerns all the companies who offer products that have well positioned and recognized alternatives on the market. Another obstacle was the fact that usually all kinds of energy saving investments are expensive and their payback time is very long.

> *"People are still not that focused on cleaner environment but the driver is to save money" (Energy saving solutions for buildings).*

Marketing and exporting problems emphasized by the ICT cleantech companies considered trade barriers outside EU as obstacles to growth along with bureaucracy and overall administrative burden, limited knowledge of EU juridical framework, and understanding of the markets and client needs on how to transform the technology into a good or service expected by the market. Like in energy technologies, well working networks between companies and universities also seen as one big obstacle.

> *„Universities should be more cooperative with entrepreneurs or at least let the public know what they are doing so that entrepreneurs could contact the needed people (informative events). There are huge problems with information" (Intelligent building).*

Financial problems of the ICT cleantech sub-cluster companies are again quite similar as it was for energy technology companies and also common to all small and young high-tech companies that are doing intensive R&D. Differentially from the first sub-cluster in the ICT firms more investments are planned to production and international market expansion. This is understandable as most of the companies are in the third and fourth (product commercialization and market entry and volume) phase of the industry value chain.

Enterprises in the ICT sub-cluster were also not able to finance their activities with own capital. The most important external capital providers are owners (for 3) and angels (1). Main financing problems stressed by the firms were also related first with state financing and support.

> *„Estonia lacks of a compound chain to support high-tech companies with high potential. If one phase is successfully passed there is need for additional funding in the next step. Different phases should have different financing possibilities, need to*

> *map all the phases and in different phases different investor groups are needed." (Intelligent building)*

> *Better cooperation among support organization: e.g. all the potential companies should be collocated to an incubator (i.e. Technopol), EE should see who does what and can follow their activities, EE and Estonian Development Fund should cooperate with Cleantech Scandinavia, Cleantech Finland and bring foreign investors and funds to Estonian high-tech companies. (Intelligent building)*

Some of the companies seemed to have problems with applying for the grants from EEF stating that the information presention and reporting system was too time and resource consuming.

> *„One additional problem for the companies is that an EEF employee defends the application in front of the EEF committee but how can EEF have so competent people to talk about such complicated technologies?" (ICT and material technologies)*

Another barrier for the ICT companies regarded the challange of access to the EU funds allocated for the cleantech sector due to limited contacts. Companies who do not have these necessary contacts argued that they did not have the human capital, knowledge and capacity to write and manage these projects, for an SME it was hard to cut through the bureaucratic procedures.

Table 3.16: Financial features of ICT sub-cluster companies

Name of enterprise	Net sales in 2009	Share of export in 2009 (%)	Labour costs in 2009	Share of labour costs as compared to net sales in 2009 (%)	Total assets in 2009	Total profit/loss in 2009	R&D costs in the period of 2007-2009	Funding from the EEF in 2004-2011
Euriko OÜ	0	0	0	0	19.1	-1.1		0
Mirovar OÜ	8.1	0	0	0	48.8	-13.1	5.8	8.9
MolCode AS	11.6	0	176.4	1.5	978.2	-127.8	1608.5	457.5
Regio AS	4005.7	0.1	2214.3	0.1	2879.5	476.5		1404.7
Yoga OÜ	664.1	0	424.2	0.1	555.6	72.2	95.5	437.0
TOTAL	4689.5	0.1	2814.9	1.6	4481.3	406.7	1709.8	2308.2
Average	937.9	0	563.0	0.3	896.3	81.3	342.0	461.6

Source: Authors based on Company Annual Reports and interviews.

5. Conclusions

5.1 Strengths, weaknesses, opportunities and threats

Table 3.17 summarises the strengths, weaknesses, opportunities and threats that follow from the previous analysis.

Table 3.17 Estonian cleantech sector: Strengths, weaknesses, opportunities and threats

STRENGHTS	WEAKNESSES
• Universities with strong and relevant knowledge base • Participation in global innovation networks by leading companies • Companies present in variety of sub-fields, some with very high development potential • Increasing exports by the companies • Growing public awareness	• Financing issues • Lack of business development skills • Marketing and exporting problems: laws, regulations, standards • Problems with human resources • No specific government programmes and instruments • Weak domestic co-operation between academia and industry
OPPORTUNITIES	**THREATS**
• Prioritisation of energy efficiency • Commitment to increase considerably the amount of renewable energy • Possibilities to further advance interactions and networks among local stakeholders • Neighbourhood of countries with advanced cleantech use and development • Drivers of cleantech serve as windows of opportunity	• Expensive investments and long payback periods • Lack of inputs and support from the local innovation and research system

Source: Authors.

Strengths

In Estonia, a variety of cleantech sub-fields are represented, although not all of the sub-fields are developing in a uniform fashion equally. Since innovation is a complex process, this strength could also be seen as a weakness because managing many different fields creates problems while attempting to focus on the areas or fields with thee most potential. Still, the areas like energy technologies and energy efficiency (related to ICT and renewables) have the highest growth opportunities and the companies belonging to this field form also a considerable and developing cluster. These firms have their strength in their patent portfolios and because their level of innovativeness is very high. Their export potential and quality and volume of interaction are also over the average. Good cooperation with other organizations is also a strength of Estonian cleantech developers. But this is only true for the very active enterprises who deal intensively with developing new technologies and therefore need the for synergies from international and domestic (though less apparent) interaction. Lack of cooperation is also a weakness as explained in the next section.

The third strength lies in Estonian universities that have quite strong scientific and technical base (engineering, chemistry, physics, etc.) which is an essential input for cleantech and also other innovative sectors. In general the interviews with the entrepreneurs showed that they were satisfied with the average availability of general skilled workforce and that according to their belief there were enough cleantech related programmes in universities.

Public awareness of the relevance and possibilities of being green and developing clean technologies has also grown, also support measures for supporting these companies have increased.[179] Proof for this are thematic conferences, events and competitions, cluster initiatives, competence centres, the interest of community support organizations, growing actuality of green public procurement, targeted financing of cleantech related areas and the overall direction to sustainable growth. The EU contribution and financial support is very important in attracting the public attention and supporting cleantech companies. Through the local EU funds, distribution to cleantech has grown. In addition, the companies who have high R&D expenses and good links with universities and international actors are also quite familiar with all kinds of EU support schemes.

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[179] For additional reading and comparisons see "*Europeans´ attitudes towards the issue of sustainable consumption and production*" (Directorate General for Communication 2009).

Another strength of the Estonian cleantech sector is that export figures are growing in all sub-fields. Though growth has been quite modest, the list of countries where the companies are exporting has expanded considerably.

Weaknesses

The most relevant weaknesses lie in the area of finance. Most of the companies claimed to have problems with applying for the Estonian and EU funding, mainly because of administrative burden, and stressed the need for an organized, systematic and continuous funding chain – a consistent scheme how to support cleantech companies from the early R&D phase until the market entry and scaling up phases. For these schemes to work, there is also a further strengthening of the cooperation among support organizations like Enterprise Estonia and Estonian Development Fund and also international cleantech organizations, universities and other science and research institutions dealing with cleantech. Over the last few years the cooperation between these institutions has developed rather rapidly and successfully. Furthermore, location sets barriers for accessing financing possibilities because VC markets are not very interested in poorly known countries, but without which (VC) it would not possible to finance start-up R&D. In addition some enterprises mentioned that the few VCs in Estonia do not have the skills and knowledge to understand the specific technologies (their potential, advantages, etc) to inform their investment decisions. The financial crises has also decreased the opportunities to get financing. Some financial problems lie also in the companies themselves – therefore business model and business development seems sometimes even more important than developing new technologies. Finally, only a few of the companies were able to finance their investments through self-funding using their own capital. Though, this tendency is quite normal in high-tech companies in the development phase, this therefore should not only be seen as a weakness. Some companies also claimed that they use additional funding and grants because they are available but could also manage without them.

The second weakness is related to company development. Moving from the R&D phase to product commercialization and market entry and volume turns out to be a huge obstacle. The majority of the companies are young small and micro high-tech enterprises with poor financial performance, high R&D and labour costs (though not all calculate them) and no sales, and only a few export their products. As many of the companies have grown out of universities and science work it is quite understandable that most of them have more knowledge and skills in technology than in business.

The third weakness is related to the problems with marketing and exports, and are mainly related with trust and recognition, or the contact problem. Estonia is a small state and not well known to the world which creates an additional barrier aside from convincing market players that the new product or service is better than the alternatives already existing on the market. Understanding and mapping the market and gaining essential contacts is therefore very relevant.

Another weakness is linked to human resources and the education and science system. The companies emphasized the lack of specialists that also have good business and marketing education. There is a need for people who understand the technology and have good experience in marketing and exporting. There are a range of options and many possibilities to attend cleantech related programmes but most of them are not interdisciplinary, e.g. they do not have any subjects on marketing or finance.

Weak domestic cooperation and networks are also a weakness of the Estonian cleantech sector. Only some of the companies are engaged in domestic cooperation. There are also problems with cooperation with universities. The link between academia and industry is thought to be too wide. This includes information asymmetries, universities' expectations of too high financial rewards, an extensive focus on basic research (rather than applied), and the overall performance system (or incentive system) of universities is publications based.

The last weakness is related to government policies and programmes. Here there are no specific government supported cleantech programmes and support instruments in the field of cleantech.

Opportunities

The best growth opportunities are globally seen in sub-fields like energy efficiency and energy technologies (wind, solar, solar-thermo) which are also the biggest cleantech sub-clusters in Estonia. Our energy system is based on oil shale and the quest to improve energy efficiency and find alternative energy sources are prioritized at the highest levels. The match between world trends and Estonian trends could potentially enable more sustainable growth in the long term.

The commitment and goal that Estonia has set for 2020, to increase the amount of renewable energy to 25% of the whole energy usage mainly on the basis of biomass, is also an incredible opportunity. Framework conditions are favourable as well: sufficiency of wind near the coastline, high commitment to electric vehicles, funding opportunities from selling pollution quotas, the Energy Technology Program which forms the initiative and frame for supporting R&D activities in the same field, to name but a few.

Another opportunity that leverages upon the advantage of being a small state relates to: Better cooperation among support organizations and better policies and programmes to support cleantech could be deployed and attainable with less time and resources. Thus, it may well be possible to develop efficient measures that are needed to recognize and support potentially successful companies which in the long run would generate continuous additional value to the wider community, in a short time frame.

The neighbourhood of advanced cleantech countries like Sweden, Finland, and Denmark etc. is also a relevant opportunity to be exploited. This creates possibilities for learning, co-operation and networking.

Other opportunities for the cleantech sector that are the drivers of cleantech can be seen as windows of opportunity for companies. The boundaries of energy, food and clean water and the fear of pollution are the main drivers. International trends like the increase of energy prices and the decrease of electronics prices allow for the decrease in the payback time of many energy saving technologies and solutions and therefore make it possible to earn money from being green.

Threats

The highest risk for the clean technology developers is uncertainty: The goods and services developed are new. Companies that have developed such products and services have to put a lot of effort in explaining its benefits in relation to the alternatives. Also, R&D and product development works are expensive and their payback time is very long. Funding of these companies is very risky, the state lacks the resources for investments and VCs are sceptical. This again increases the price level of cleantech products making them worse of that their energy wasting alternatives, as the costs of these risks need to be internalised. Commercialization and implementation of projects especially in the energy sector is very dependent on states and government policies.

Threats more related to the Estonian cleantech sector are connected with the weaknesses mentioned above and whether policy makers and also government institutions are able to find solutions. These apply to state financing and as well as the challenge of organizing the education system so that it would produce a sufficient amount of educated specialist for these companies. At the moment the future success of these cleantech firms is determined by whether they are able to and manage to find suitable markets which they can enter with their products and start generating profits. A common mistake of these companies is that in the start-up phase they are much too focused on developing technologies that they do not prioritise simultaneously the development their business model. These problems usually appear when they start product commercialization and find themselves in a situation where they have high-tech products ready but struggle to find suitable markets or when they enjoy access to markets but are unable to produce sufficient to meet demand.

5.2 Policy Recommendations

Interviews and the analysis carried out have led to the following ideas presented in the form of policy recommendations. These are preliminary and need to be analysed (including the analysis of costs and benefits) further before being adopted as a guideline for the further development of policies in practice.

First, there is lack of integration of business courses in cleantech-related education. Namely, in order to successfully start-up and drive a cleantech company, further knowledge in business administration is needed and technology development should be much better linked to business models (i.e. how to profit from the technologies) and business development, and in the ability to communicate same.

Second, although co-operation between the industry and academia exists in Estonia, the contribution of academic and other research organizations to private sector development could be enhanced and made even stronger. It is expected that universities would offer more services to companies in addition to current product offerings of basic research and the production of high-level publications.

Third, there are only no specific government programmes and instruments available for cleantech per sè. If the development of clean technologies is prioritised, then companies expect more dedicated support measures.

Fourth, a national forum of cleantech stakeholders is largely missing. The community support organizations for managing and organizing the cleantech sector in Estonia are characterised as weak. All parties, however, would benefit from better co-operation between the companies, universities, support organizations, funding organisations, etc.

Fifth, considering the role of export destinations and their importance for local companies, better interaction among Estonian support organizations and the Northern cleantech organizations from the Nordic countries is recommended. Involvement of Cleantech Scandinavia and Cleantech Finland or similar institutions should be considered seriously.

Sixth, funding and more specifically access to venture capital is an issue according to the Estonian cleantech companies. Whether this is related to communication about business models or related to inherent weaknesses of the business models, should be studied further.

Finally, (joint) actions could be initiated in the field of public procurement for innovation. Public procurement for innovation means that a public agency places an order for a product that does not yet exist, but which could probably be developed within a reasonable period of time, based on additional or new innova-tive work. Mostly it is undertaken to solve an existing or emerging societal need, but compared to the procurement of "off-the-shelf" products, public procurement for innovation arguably has a potential to enhance providers' innovativeness and to support economic development. Since environmental issues are largely cross-border issues and as such are susceptible to joint actions which could be initiated and innovative solutions to societal needs sought.

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Annexes

Annex 3.1: Cleantech developers in Estonia: activity, year of foundation, location and number of employees (2009)

Name of enterprise	Cleantech sub-field	Foundation	Location	No. of employees
Airel AS	Environmental equipment (ambient air pollution detection)	1997	Tartu	5
Alkranel OÜ	CT consulting (water and air protection, waste management)	1999	Tartu	10
Balti Kaubad ja Teenused AS	Material technologies and chemistry ((nanotechnology fabricating protective coatings)	1993	Sillamäe	5
Bemixe OÜ	Biofuels and CT consulting	2006	Tallinn	0
BioGold OÜ	Biofuels	2006	Tallinn	2
BiotaP OÜ	Environmental diagnostics service	2007	Tallinn	8
Clifton AS	Energy technologies (gallium arsenide semiconductor structures)	1999	Tartu	22
Crystalsol OÜ	Energy technologies (photovoltaics)	2008	Tallinn	4
Dvigatel Regital OY	Energy technologies (wind turbines)	1999	Tallinn	28
Ecotech OÜ	CT services, water and ambient air protection, waste management	2000	Ida Virumaa (Kohtla vald)	0
Elcogen AS	Energy technologies (fuel cells)	2001	Tallinn	2
Energest Group OÜ	CT consulting (energy efficiency, energy audits)	2009	Tallinn	0
Energiatehnika OÜ	Energy technologies (electrical engineering)	1997	Tallinn	6
Englo OÜ	Environmental equipment (water, soil, ambient air protection, waste management)	1991	Tallinn	6
Enteh Engineering AS	Energy technology (heat technology and heat power engineering)	1997	Kohtla-Järve	15
Estiko-Plastar AS	Material technologies (plastic packages)	1918	Tartu	128
Euriko OÜ	ICT (wind energy software development)	2006	Tartu	0
Goliath Wind OÜ	Energy technologies (wind turbines)	2008	Tallinn	3
Graanul Invest AS	Biofuels (pellets)	2003	Tallinn	131
Konesko AS	Energy technologies (wind turbines)	1992	Viimsi vald, Koeru vald	312
Laser Diagnostic	Environmental equipment (pollution detec-	1998	Tallinn	25

Instruments AS[180]	tion), CT consulting			
Mirovar OÜ	ICT (energy saving solutions for buildings)	2005	Rae vald	0
MolCode AS	ICT (material technologies, CT consulting)	2004	Tallinn	6
Monoliit OÜ	Water protection and purification	2000	Tallinn	9
my!Wind OÜ	Energy technologies (small wind turbines)	2010	Tartu	Na
Nordbiochem OÜ	Material technologies and chemistry (lactate fermentation and chemical derivatevs)	1994	Põlva	9
Plastitehase AS	Waste management	1999	Tallinn	64
Plastsys OÜ	Material technologies (environmentally friendly plastics)	2003	Tallinn	11
Qcell OÜ	CT consulting and projects	2006	Rae vald	0
Regio AS	ICT (wind energy software)	1990	Tartu	82
Renek Kemia AS	Biofuels and chemistry	1997	Tallinn	2
Roheline Elekter OÜ	Energy technologies (wind turbines)	2006	Tallinn	0
Roheline Mõte OÜ	Energy technologies (heat exchangers)	2007	Tallinn	0
Selefon OÜ	Biofuels (biomass)	2006	Palamuse alevik	Na
Skeleton Technologies OÜ	Energy technologies (energy storage condensators, ultracapacitors)	2009	Tartu	2
Yoga OÜ	ICT (intelligent building system)	2008	Tallinn	14

Source: Authors based on the Company Annual Reports. The interviewed companies are underlined.

[180] Abbreviation is LDI

Chapter IV: Emergence of the Clean Technologies Sector in Latvia

Juris Vanags and Vita Brakovska

Introduction

This report reviews the development of clean technology in Latvia based on a method which has been approved by Canada's National Research Council (Arthurs *et al*, 2009). Until now, in Latvia no clean technology cluster has been officially approved. This is related to a cluster support program by the government which was planned but never launched. Regardless of that, in order to develop business activities clean technology-related enterprises have entered into a partnership, and present other indications characteristic of clusters. Due to that, and within the scope of this report, these activities can be analyzed based on cluster methodology. However, unofficially established clusters can weigh down the application of this method as the commonly performed activities by enterprises are not organized well enough and therefore will not be included in the analysis.

In this report, enterprises were defined as clean technology enterprises based on the following indicators (an enterprise was selected if it complied with the first and at least one more of the given criteria):

1. The activities are related with low-carbon or other environmental protection technologies according to the definition cited in an earlier report for this project (Report, 18 February 2011, Tallinn);
2. An enterprise manages clean technology development and these results are at least potentially valuable for other users of clean technology;
3. An enterprise works in cooperation with a scientific research group;
4. An enterprise bears research and development (R&D) expenses;
5. Advice of the following branch leaders:
    - Mr. A. Kārkliņš – Chairman of Board of the Latvian Biogas Association;
    - Mr. J. Vilgerts – Chairman of Board of the Latvian Waste Recycling Association;
    - Dr. J. Kalnacs – expert in biodiesel production field.

According to these criteria 58 cleantech enterprises were recognized in Latvia (see Annexes 4.4 and 4.5). These enterprises operate in different sub-fields of cleantech. Taking into account that the current conditions and performance of enterprises representing different directions may differ, for the purpose of analysis *the enterprises were divided in 4 cleantech groups* in this report:

1. Environmental protection;
2. Renewable energies;
3. Green service;
4. Material science.

In most cases, determining the conformity of a company's activities with clean technology criteria was not particularly problematical. However, it was not always easy to define the main cleantech sub-field of an enterprise because some companies have overlapping activities.

In order to analyze Latvian cleantech activities the following methods of gathering information were used in this report:

1. Officially available information from corresponding web sites;
2. Requesting information from the government structures;
3. Interviews with the representatives of cleantech enterprises (questionnaires, phone interviews, personal meetings);
4. Analyzing company surveys.

Officially available information was obtained on all 58 recognized cleantech companies. Questionnaires were sent to all 58 cleantech companies. Besides questionnaires, phone interviews and personal meetings were also used. In this way, using these 3 types of interviews helped to collect additional information from 28 companies.

1. Current conditions in clean technologies

1.1 Human resources

There are 7 higher education institutions in Latvia having study programs related to cleantech:

- University of Latvia
- Liepaja University
- Daugavpils University
- Mechanics and Technology College of Olaine
- Rezekne Higher Education Institution
- Riga Technical University
- Latvia University of Agriculture.

Following is a short description of these higher educational institutions or faculties having cleantech programs. These data were received from the institutions' offices.

University of Latvia

As an institution of higher education and science the University of Latvia (UL) encouraged scientific research work, facilitated spreading science among people and prepared highly qualified experts in accordance with national requirements. In the course of time, new teaching staff and generation of scientists grew up and UL became a part of science community on an international scale.

Faculty of Geography and Earth Sciences at the University of Latvia provides academic studies in geography, geology and environmental science. The faculty offers higher academic education at 3 level studies – bachelor's, master's and doctoral study programs, as well as professional training in teachers study program of geography and nature sciences, and professional higher education master's study program of spatial development planning.

Liepāja University

Liepāja University (LiepU) is the biggest higher educational establishment in Kurzeme, it implements study programs in six fields of study out of the eight areas defined in Latvia (about 50 study programs in total).

Study work at LiepU is organized by:

- Faculty of Humanities
- Faculty of Educational Sciences
- Faculty of Natural and Social Sciences

Faculty of Natural and Social Sciences is the newest from among LiepU faculties; it was established on the basis of the Department of Natural and Social Sciences in 2003 (it started its work as an independent structural unit in September 1999). One of the study programs in this faculty is Environmental Management.

Daugavpils University

Daugavpils University (DU) is situated in the Southeastern part of Latvia. It was founded in 1921 and today is the biggest regional state university and the only university in Eastern Latvia. DU has five faculties: the Faculty of Humanities, the Faculty of Social Sciences, the Faculty of Natural Sciences and Mathematics, the Faculty of Music and Art and the Faculty of Education and Management.

Study program - Environmental science:

The goal of the study program is to ensure integration of different branches of environmental science, ecology and geography, as well as of the theory and practice in the study process, to provide the opportunity to acquire the practical skills in working with modern latest scientific equipment and environment-oriented information technologies. The program introduces students to the environment and connections among its basic components, the diversity and evolution of these components. Regularities, systems and facts about environmental science are studied, as well as the territorial organization of human society, inhabitants, economy and tendencies of its development. A part of the program is also devoted to actual global and local problems of environmental science.

Mechanics and Technology College of Olaine

The study programs on environment protection, food quality control and biotechnology. It is a college in Eastern and Central Europe, where the biotechnology study program is provided.

Rezekne Higher Educational Institution

Rezekne Higher Educational Institution (RHEI) was established on the basis of the branches of the University of Latvia and Riga Technical University in 1993. The aim of RHEI is to provide academic and professional higher education in compliance with the science development level and cultural traditions of Latvia which is competitive in the European education space; to develop culture, science and education in Latgale region and thus in the whole Latvia.

Natural Sciences Department was established in 1995. Its initial function was to ensure natural sciences and engineering sciences study courses in the study programs at the Faculty of Engineering, and mathematics, physics, chemistry, general and special engineering courses – at other faculties of RHEI. After implementation of the study programs "Bachelor of Natural Sciences" and "Environmental Engineer Eco-technologist" in 1996, the main goal of the department was to create teaching-methodological, material and technical and informative basis for these study programs, as well as to organize teaching-methodological and scientific work in the sphere of environment protection. The department simultaneously implements long-term development of study courses related to environmental sciences to students of other RHEI faculties. Currently the department is implementing a higher professional education Bachelor study program "Environmental Engineer".

Riga Technical University

Today the RTU has 8 faculties: Architecture and Urban Planning, Building and Civil Engineering, Computer Science and Information Technology, Electronics and Telecommunications, Power and Electrical Engineering, Engineering Economics, Materials Science and Applied Chemistry, and Transport and Mechanical Engineering. There are also part-time and distance learning departments. The RTU has affiliations in the largest towns of Latvia – Daugavpils, Liepaja, and Ventspils.

Faculty of Materials Science and Applied Chemistry (FMSAC)
FMSAC incorporates:

- Institute of Biomaterials and Biomechanics;
- Institute of Applied Chemistry;
- Institute of Polymer Materials;
- Institute of Silicate Materials;
- Institute of Technical Physics;
- Institute of Technology and Design of Textile Materials;
- Institute of Technology of Organic Chemistry;
- Institute of General Chemical Engineering.

FMSAC students study the theoretical basis of composition of different materials, chemical synthesis and analysis: forms of biologically active substances, chemistry and technology of biologically active compounds, fundamentals of medical substances and production of their finished forms, fundamentals of composition of human tissues and biomaterials, technology of obtaining biomaterials, technology of polymer and composite materials, technology of silicate and high-temperature materials chemistry and technology. The Faculty is modeling and developing new, environmentally friendly chemical technology processes and is engaged in the design of production facilities.

Latvia University of Agriculture

Latvia University of Agriculture is the only higher educational establishment in Latvia related to agriculture and it aims at: promoting intellectual potential for rural development in agriculture; encouraging young people to acquire higher academic and professional education; developing research; contributing to the cultural development; studying, maintaining and perfecting the gained experience from the Latvian people and passing it over to the future generations. Faculty:

Environmental and water sciences play a very important role in the life of every human being, since it is hard to imagine our daily life without pure water and air, without forests and a research maintained infrastructure. Environmental engineering science deals with the theory of environment, humans and nature-friendly technology – eco technology, methods and practice of the realization of its main processes. It analyses conformity of technology principles with the development rules of nature ecosystems, raw materials and energy output, as well as the complex and rational use of physical-chemical processes. Students acquire knowledge about water supply, sewage treatment, land amelioration, waste management, and rational use of natural resources, construction of countryside roads, water management and hydrology. Environmental engineers mostly work in the field of water management and sewage treatment.

Faculty of Rural Engineering is the second biggest faculty of the University, where new engineers - construction, environment and water management specialists, land surveyors, as well as landscape designers and planners are educated. There are four scientific laboratories at the faculty two of which are located in modern premises. Students at the Faculty work with up-to-date equipment, thus having an opportunity to comprehend causalities existing in the nature and to apply them when dealing with a particular task in their future work.

Source: Compiled by the author

Table 4.1: Cleantech programs in Latvia higher education institutions

Nr	University, High school, College	City, Region	Study program	Graduate							
				2007/2008		2008/2009		2009/2010		2010/2011	
				Bachelor	Master	Bachelor	Master	Bachelor	Master	Bachelor	Master
1	University of Latvia	Riga	Environmental science	36	14	45	11	43	9	55	18
2	Liepaja University	Kurzeme	Environmental management	42	0	14	0	30	0	10	0
3	Daugavpils University	Latgale	Environmental science	21	0	23	0	24	0	30	0
			Environmental planning	0	15	0	16	0	11	0	19
4	Mechanics and Technology College of Olaine	Vidzeme	Technology of environmental protection	7	0	7	0	7	0	10	0
5	Rezekne Higher Education Institution	Latgale	Environmental engineering	19	0	17	0	26	0	28	0
			Environmental design	2	0	5	0	9	0	4	0
			Environmental protection	0	0	0	0	0	1	0	5
6	Riga Technical University	Riga	Environmental science	17	0	17	0	17	0	18	0
			Environmental engineering	0	3	0	3	0	3	0	3

			Biofuel (sub-program of chemical technology)	0	3	0	4	1	4	2	4
			Material science	9	5	4	12	10	10	6	18
			Waste water treatment	0	2	0	4	0	5	0	5
7	Latvia University of Agriculture	Zemgale	Environmental and water supply	17	0	22	0	17	0	20	0
			Environmental engineering	0	5	0	2	0	3	0	5
			Biogas (sub-program of agricultural energetic)	0	0	0	2	2	1	2	2
			Environmental science	0	0	0	0	0	2	0	4

These data are received from the high school administration offices. There are data about bachelor and master programs. No information about doctoral study programs was available.

Analysis of the bachelor and master program statistical data

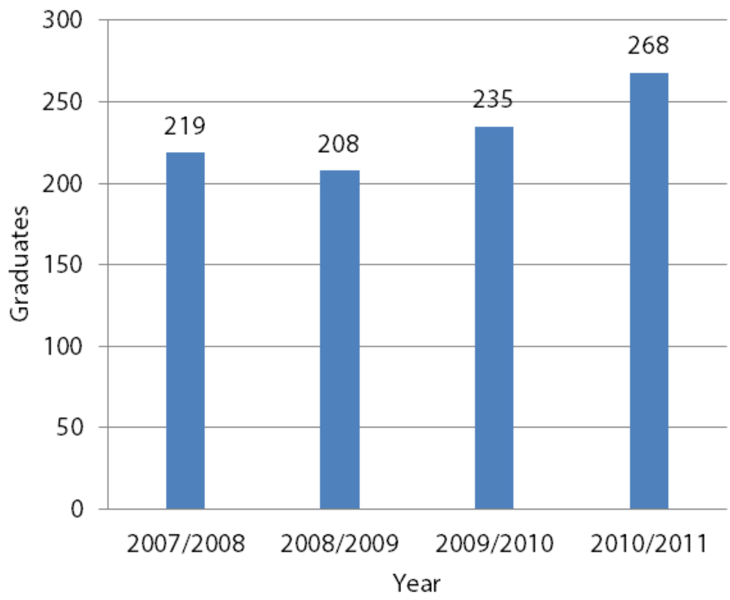

Figure 4.1: The number of clean technology related graduates in different study years

Source: Author based on the data received from the high school administration offices

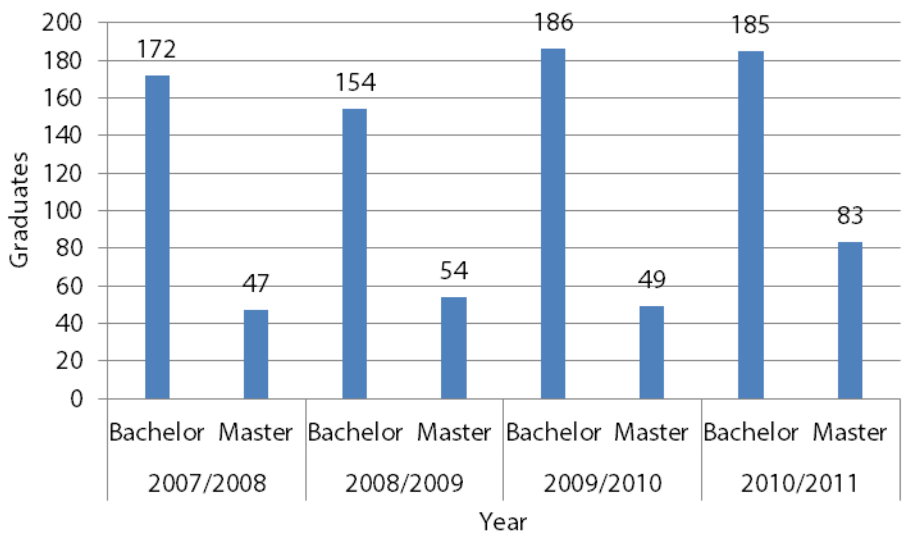

Figure 4.2: The number of clean technology related graduates (bachelor, master) in different study years

Source: Author used the data received from the high school administration offices

In Figure 4.1 and Figure 4.2 the dynamics of the number of graduates related to clean technologies in Latvian high schools is explained. It can be seen that the growth of graduates increased starting from 2009/2010. Analogically, the increase of the number of Masters starting from 2010/2011 can be explained. It reflects the increase of request for clean technologies after joining the EU (the graduates of 2009/2010 started the studies in 2004-2006 depending on the program).

In Figure 4.3 the amount of students in 3 clean technology groups are indicated separately, e.g., environment protection, renewable energies and material science. The amount of students is essentially higher in environment protection. However in renewable energy and material science the growth of the number of graduates gradually increases. In environment protection the number of graduates grew only in 2010/2011.

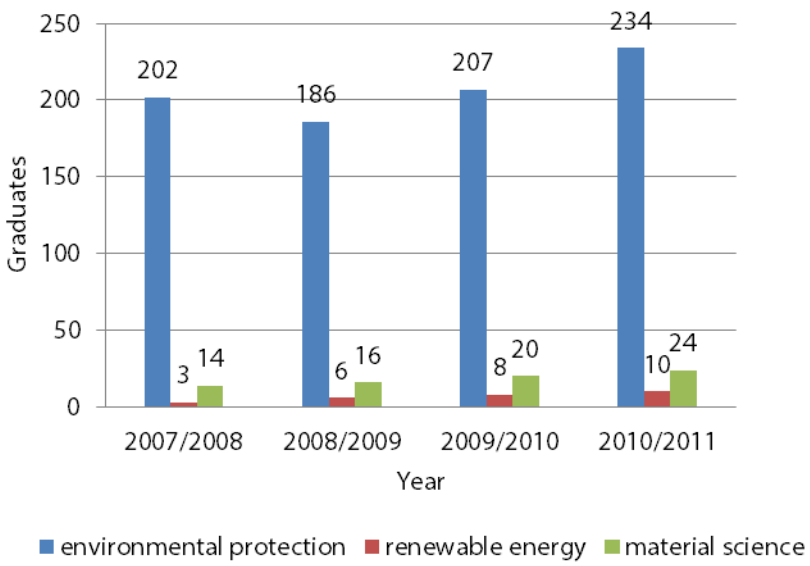

Figure 4.3: The number of graduates in 3 cleantech sub-fields in different study years

Source: Author used the data received from the high school administration offices

In Figure 4.4 the number of students in different regions in Latvia is provided. There are study programs related to cleantech in all regions in Latvia. Basically the number of clean technology related graduates is distributed rather evenly in Latvia taking into account the population in the regions. Only in Kurzeme the relative number of clean technology graduates in the last study years decreases.

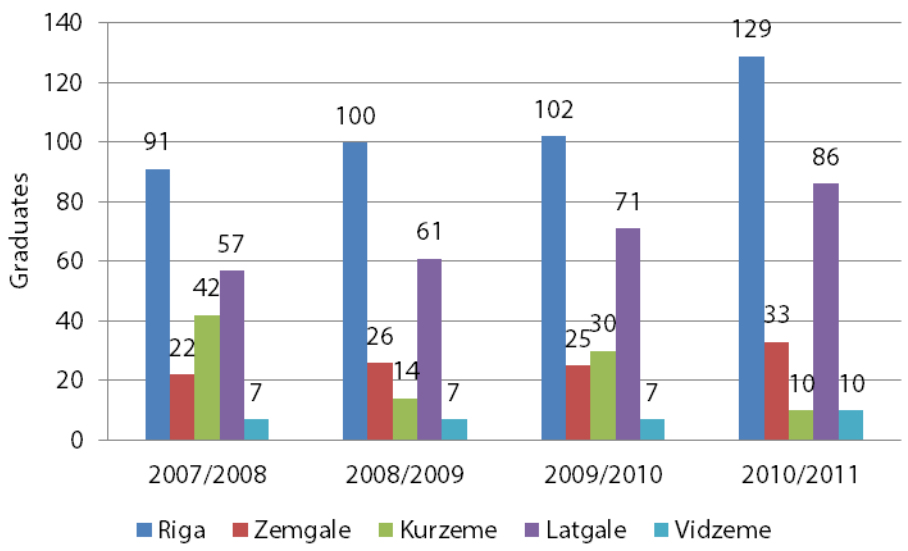

Figure 4.4: The number of cleantech related graduates in different regions in Latvia
Source: Compiled by the author

The opinion of respondents on availability of specialists in cleantech field

The opinion of respondents demonstrated the satisfaction with compliance of graduates

Satisfied	18
Unsatisfied	6

Mostly, respondents were generally satisfied with availability of specialists in cleantech fields. However, the representatives of the green service group (e.g., Biohumuss2010, Green reality) informed, that specialists of their specifics are not educated in high schools in Latvia. They adapt the graduates from the University of Latvia (Faculty of Biology) and Latvia University of Agriculture (Faculty of Agriculture). A part of relatively recently founded companies (e.g. advanced technologies, M-zelts) were unsatisfied with the availability of the respective specialists. Usually new companies are oriented to specific directions and due to this they require a higher flexibility from graduates.

1.2 Community support

Government policies and support

Between 2007 and 2011, in particular the following policies of the Latvian government are **relevant for companies in the cleantech sector:** National reform programme of Latvia for implementation of the “Europe 2020”strategy, Sustainable Development Strategy of Latvia until 2030, Renewable Energy Guidelines 2006 – 2013, Energy Development Guidelines 2007 – 2016, Environmental Policy Strategy 2009 – 2015, Entrepreneurship Competitiveness and Innovation Promotion Program for 2007-2013 and Latvian National Development plan 2007-2013.

Most of the national policy planning documents do not include specific support measures for the cleantech industry and cluster development, still they are **highlighting a high potential for development and commercialization** of this industry, taking into account global trends and the national commitments on environmental protection, such as renewable resources for energy production. “Eco innovation” is mentioned as the perspective direction; still the formulation is too global to define specific support measures.

A number of cleantech key policy planning documents **lacks the action program** that would allow in short or medium term to plan specific support measures for cleantech industry or clusters.

Sectorial policy planning documents **do not emphasize enough the need to promote collaboration between the cleantech companies and research or education institutions**, as well as public sector institutions (institutional support), which set the preconditions for cleantech industry or cluster development.

Planning documents **lack of data analysis on the merits**, which is needed to define an economically justified projections and determine the perspective directions of economic development.

Planning documents **do not reflect planned measures for cross-ministerial collaboration** – there are no common initiatives by Ministry of Environmental Protection and Regional Development and Ministry of Economy that are main policy making institutions on cleantech industry development.

The main documents for cleantech policy planning in Latvia are:

* Latvian National Development Plan 2007-2013 [181]
* The National Environmental Policy Plan, 2004–2008 [182]

The first Latvian Environmental Protection Policy Plan approved by the Cabinet of Ministers in 1995 was replaced by a new National Environmental Policy Plan. The National Environmental Policy Plan complies with the EU legislation and policy documents (including the 6th EU Environment Action Program "Environment 2010: Our Future, Our Choice"), as well as binding commitments to the United Nations (the UN) and other international conventions.

* Environmental Policy Strategy 2009–2015 [183]

The Strategy describes the existing situation, defines the goals and challenges of the environmental policy and explains its main principles and actions.

The Ministry of Environmental Protection and Regional Development offers also a training program *"Cleaner Production in Latvian Industries"* [184]

Since the beginning of 2007, the responsibility for sustainable development was shifted from the Ministry of Environment to the Ministry of Local Governments and Regional Development (MLGRD), which was also responsible for the development of the National Development Plan 2007-2013. At the same time a new national planning framework was adopted by the government. This framework places a sustainable development strategy at the top of the national planning structure. After receiving the government mandate, in the mid 2007 the MLGRD started developing Latvia Sustainable Development Strategy until 2030.

Opinion of respondents regarding government policies

The results of interviews indicate different opinions of enterprises regarding the government policies. Mostly there were no clear positive or negative evaluations.

181 www.nap.lv
182 http://www.varam.gov.lv
183 http://www.varam.gov.lv
184 http://www.varam.gov.lv

There were the following options of answers regarding the government policies and support:

No.	Possible answers	Yes	No
1.	There are enough government cleantech projects, in which enterprises can participate under tender conditions	12	4
2.	The conditions of participation in the government projects are not transparent enough	6	10
3.	The government regulations regarding cleantech promoting are not consequent enough	8	3
4.	To promote the development of renewable energies the subsidy policy must be improved	4	0

Source: data composed by the author based on company interviews

The representatives of waste water treatment and waste water management emphasized the topicality of the government organized tenders for cleantech projects. Regarding the government regulation norms the interest was mostly showed by the representatives of environmental protection, but regarding the subsidy policy the representatives of renewable energies were more active. The development and application of renewable energies to a great extent depend on the government regulations. According to the opinion of the contributors of interviews the subsidy policy is an important instrument.

There are government programs regarding cleantech application, where enterprises participate under tender principles. For example, in the different cities there are waste management and waste water treatment projects supported by the Environmental Ministry.

However, in this report more attention is devoted to activities related to cleantech development in enterprises. Due to this support programs promoting cleantech development in enterprises will be analyzed.

Investment and Development Agency of Latvia (IDAL)

The government support of enterprises in Latvia mostly is realized by the Investment and Development Agency of Latvia (IDAL).

General description of IDAL

The objective of the IDAL is to promote business development by facilitating more foreign investment, in parallel increasing the competitiveness of Latvian entrepreneurs in both domestic and foreign markets[185].

After Latvia's accession to the EU, the Agency needed to adopt new methods and tools, including the effective utilization of resources from the EU funds. Today IDAL offers an integrated solution – it supports companies in Latvia trading internationally, as well as overseas businesses seeking partners or locations in Latvia; administrates state support programs for entrepreneurs, co-financed from the EU funds.

Support can be provided in the following fields:

- human resources and employment development - individually and in partnership organized training of employees, to attract highly qualified employees,
- scientific innovation and development - to promote research commercialization and technology transfer, promoting new products and technologies, practical oriented research, science and technology parks and the formation, access to finance - in order to promote the attraction of strategic investors,
- the promotion of entrepreneurship - in order to facilitate acquisition of external markets and the international competitiveness of industries, incentives for innovation and business creation,
- encourage investment in small and medium business development activities especially in the territories; improve the business infrastructure, clustering and business incubators, to promote investments in companies that manufacture high value-added, high-quality living environment and economic activity.

IDAL adopts and evaluates project applications for support, decides on the project application whether it is accepted or rejected, monitors project implementation, verifies payment requests and makes payments.

Trade missions on specific themes are also organized by IDAL, for instance:

185 http://www.liaa.gov.lv/eng/home/about_us/about_us/

Cleantech companies' visits to:

- Georgia in October 2010[186],
- Azerbaijan in June 2011[187],
- Austria in September 2011[188].

The main IDAL cleantech related programs and projects

There are following corresponding IDAL support programs, in the framework of which innovation in the development of clean technologies can be supported.

1. New products and technologies - supporting new products and technologies in production 2008-2011.
2. „Centers of competence" 2011-2016.

186 http://www.liaa.gov.lv/lv/sakumlapa/pasakumu_arhivs/2010_gads/oktobris/tm_gruzija/
187 http://www.liaa.gov.lv/lv/sakumlapa/pasakumi/junijs/baku/
188 http://www.liaa.gov.lv/lv/sakumlapa/pasakumi/septembris/austrija/

Table 4.2: the projects supported through IDAL program „The development of new products and technologies"

No.	Enterprise	Coordinates	Project	Cleantech sub-field	Financing volume, Euro
1.	EF & EM, Ltd	Peldu street 7, Jelgava, LV-3002	Effective operation of biological waste water treatment plant building and operating test	Environment protection	98 200
2.	Nordic Metalplast, Ltd	Aviacijas street 18, Jelgava, LV-3001 Ph.: +371 63094220 Fax: +371 63094219 info.nordic@inbox.lv	Polymer residue processing technology development, research on rubber residue recycling methods and material properties of different treatment processes.	Environment friendly materials	125 368
3.	Plastic Technologies, Ltd	Elizabetes street 41/43, 425. room, Riga, LV-1010 Ph.: +371 67505592 www.plastictech.eu	Study of wear-resistant natural fiber composite stock acquisition. The project will result in a durable natural fiber composite composition and technology, as well as improved knowledge of the natural fiber composite structure, properties and application areas.	Environment friendly materials	84 401
4.	Eko Osta, Ltd	Tvaika street 39, Riga, LV-1034 Ph.: +371 67393860 ekoosta@ekoosta.lv www.ekoosta.lv	Environmentally friendly Technologies using biotech methods (fermentation)	Environment protection	590 370
5.	Baltic biopolymers plastic recycling, Ltd	"Kalnaji", Belavas parish, Gulbenes distr.,	Introduction of new technology, production of the	Environment friendly materials	340 423

		LV-4410	new products proposed by project - plastic construction profiles.		

The source of information is the website of the IDAL [189]

It follows from Table 4.2 that 2 projects in environment protection and 3 projects in environment friendly materials sub-fields are supported by this program. There are no renewable energies and green services projects supported. The projects regarding biofuel, bioethanol and biogas are supported by Latvian Rural Support Service through subsidizing and other support instruments. Information on these projects is available from the secondary information data. No projects in the sub-field of green services are supported either. This is a new direction and projects are expected in the next calls.

The program "Centres of Competence"

The general principles of Competence Center program

Under the program "Competence Center" of 2011, the Competence Center for Environment Protection, Bioenergy and Biotechnology (CCEBB) was built. In this competence center the following clean technology-related projects will be supported: See Annex 4.1. *This information was received from the management of the CCEBB.*

Under this program, projects in the sub-fields of environment protection and renewable energies are supported, because these directions correspond to the activities of the given competence center.

The competence center support program in Latvia started in April 2011. A total of thirteen proposals were submitted and support was approved for six competence centers. Clean technology activities are included in the projects for one of the competence centers accepted that of the Competence Centre for Environment Protection, Bioenergy and Biotechnology (CCEBB). The competence center program will remain in force until 2015, and the financial value of the support for all competence centers is 54 million EUR, or 9 million EUR for each center.

189 http://www.liaa.gov.lv/lv/es_fondi/es_fondi/noslegtie_ligumi_20072013plano/

Any founders of a competence center have to consist of at least three enterprises and one research institution. The industrial research contract is entered into between the competence center and the IDAL. The competence centers have similar contracts with enterprises which carry out the projects. It is not necessary that these enterprises be the founders of the respective competence center. They must represent the corresponding branch and their project has to be related to industrial research or experimental development. The project is financed by the enterprise itself, otherwise known as the project holder, and the IDAL is responsible for the payment of financial support after the project has been concluded. This support is divided so that 70% is for industrial research and 50% is for experimental development.

The Competence Centre for Environmental Protection, Bioenergy and Biotechnology includes seventeen enterprises and four scientific research organizations as its founders. The other two enterprises participate just as project financers. A total of 38 projects have been started at this competence center, and 18 of those are related to clean technologies (see Annex 4.1).

The goal of Competence Center program and its potential benefit for cleantech sector in Latvia

The goal of each competence center is to promote the activities of enterprises by developing industrial research and experimental development. The enterprises at each competence center carry out their own research and also order further research from scientific research organizations. These research organizations are not obliged to be members of a competence center. They can also be from other countries. The only condition is that each proposal complies with the conditions of the procurement procedure.

The enterprises will be involved in research and this will promote an increase of high value added products and services. As a result the competitiveness of companies will improve and this will promote the increase of exports.

It is too early to discuss the returns that will be gained from this program because it has been started too recently and none of the projects have been completed. This competence center program is similar to programs in Austria, Estonia and Sweden.

A reasonable prognosis in the case of Latvia is an increase in the scientific research application in industry itself. There is a sufficient amount of research (based on the number of available publications and patents) in Latvia, but until now the content of this research has not been enough oriented towards industrial needs. Under this program, the scientific research organizations will be urged to adapt their research to the requirements of companies.

The opinion of respondents regarding the government support program

Many enterprises showed interest about the new product and technology development support programs. Mostly, the enterprises confirmed a possibility to receive support, but they had objections regarding the following aspects of the support programs:

Nr.	Objection	Confirm.
1.	Complicated administration of the supported project, many additional “paperwork”	12
2.	Long money payback period (in most programs the first investment is ensured by the enterprises, and only when a project is finished successfully the invested funds are paid from the government support)	6
3.	The restrictions of using the obtained results in business	10

Source: information compiled by the author based on company interviews

Community support organizations

The following community support organizations are identified as useful or potentially useful for clean technology sector in Latvia.

The Enterprise Europe Network Latvian Office, member of network of contact points providing information and advice to the EU companies on EU matters, in particular small and medium enterprises (SMEs), provides support in business cooperation[190].

190 http://www.een.lv/

Latvian Technological Center (LTC) [191] is an innovation and technology-oriented business support structure - business acceleration center, which stimulates establishment and growth of knowledge-based SMEs by creating relationships between research and industry as well as encouraging SMEs for transnational cooperation. LTC has co-operation agreements with 25-30 local companies (tenant companies) every year, on the basis of which the advisory services on international cooperation, marketing issues, how to access financial resources etc. are provided. For partner companies LTC organizes brokerage and matchmaking events, stands in international exhibitions, targeted study tours to different countries. If necessary, LTC assists them in negotiations with potential co-operation partners. LTC requirements for tenants allow also making agreements with cleantech companies.

The government support of enterprises in Latvia mostly is realized by **Investment and Development Agency of Latvia (IDAL)**[192]. The objective of the IDAL is to promote business development by facilitating more foreign investment, while increasing the competitiveness of Latvian entrepreneurs in both domestic and foreign markets. After Latvia's accession to the EU, the Agency needed to adopt new methods and tools, including the effective utilization of resources from the EU funds. Today IDAL offers an integrated solution – it supports companies in Latvia trading internationally, as well as overseas businesses seeking partners or locations in Latvia; administrates state support programs for entrepreneurs, co-financed from the EU funds.

The Latvian Council of Science[193] (LCS) was founded according to a decision of the Council of Ministers, Republic of Latvia in July, 1990. In accordance with the Law on Scientific Activity, the Latvian Council of Science is a collegiate institution of the scientists with the rights of a legal entity. The Council's tasks include advancement, evaluation, financing and coordination of scientific research in Latvia. The Latvian Council of Science prepares, jointly with the Ministry of Education and Research of Latvia, the draft of the state's science budget for the next year, elaborates draft decisions and drafts of laws aimed at the development and organization of science in Latvia. The Latvian Council of Science distributes funding earmarked for projects among the branch commissions of different fields of science.

191 http://www.innovation.lv/ltc/
192 http://liaa.gov.lv
193 http://www.lzp.lv

The Rural Support Service[194] is a state administration institution. It was established on 1 January 2000, and operates under the supervision of the Ministry of Agriculture in accordance with the Law on Rural Support Service. The Rural Support Service is responsible for implementation of a unified state and European Union (EU) support policy in the sector of agriculture, forestry, fisheries and rural development; it supervises compliance of the sector with the laws and regulations and fulfils other functions connected with agriculture and implementation of rural support policy. In the framework of its competence, the Rural Support Service administers the EU and state support for rural areas, agriculture, forestry and fisheries: Accepts and assesses project applications; Makes decisions on allocation or rejecting of financing; Keeps records of the granted financing and controls the use of it. The Rural Support Service consists of the central office located in Riga and the territorial structural units – nine regional agricultural departments. The high standards of professional activities provide for successful implementation of its mission – high quality and integrity in task fulfilment in order to promote growth of agriculture in the whole territory of Latvia in accordance with its competence and providing practical assistance for rural entrepreneurs.

Construction, Energy and Housing State Agency of Latvia[195] is a state institution supervised by the Ministry of Economics of Latvia. Enhancing the housing quality, the availability and the opportunities of choice for Latvian citizens is the principal mission of the Agency. The target of the Construction, Energy and Housing State Agency of Latvia is to realize a long-term corporate policy in the housing sphere and integration of Latvian housing policy in the European Union in accordance with the EU normative acts in housing.

The agency's main functions are:

1. To manage state support programs, regional, national and cross-border development projects on housing;
2. To manage methodologically municipalities and other owners in housing maintenance;
3. To ensure housing monitoring and communication with target audience;
4. To improve housing legislative basis and housing quality of Latvian residential stock;

194 http://www.lad.gov.lv

195 http://www.managenergy.net/actors/1855

The agency has been active in the housing energy efficiency field since 2003 and has experience of: co-financing and management of energy audits, developing a suitable calculation system and form. It has developed energy efficiency calculation tools which are helpful in local conditions, methodologies and a prototype of energy certificate.

Clean technology activities are included in the projects for **Competence Centre for Environment Protection, Bioenergy and Biotechnology** (CCEBB). The competence center program will remain in force until 2015, and the financial value of the support for all competence centers is 54 million EUR, or 9 million EUR for each center. The goal of each competence center is to promote the activities of enterprises by developing industrial research and experimental development. The enterprises at each competence center carry out their own research and also order further research from scientific research organizations. These research organizations are not obliged to be members of a competence center. They may also be from other countries. The single condition is that each proposal complies with the regulations of the procurement procedure. The Competence Centre for Environmental Protection, Bioenergy and Biotechnology includes seventeen enterprises and four scientific research organizations as its founders. The remaining two enterprises participate as project financers.

The following **Associations** of professional branches supporting clean technology related activities were recognized (based on interviews and analyzing the association web-sites):

No.	Name of association	Web-site
1.	Latvian Association of Waste Management companies	http://www.lasua.lv
2.	Waste Management Association of Latvia	http://www.lasa.lv
3.	Latvian Biogas Association	http://latvijasbiogaze.lv
4.	Latvian Biotechnology Association	http://www.latbiotech.lv
5.	Latvian Biofuel and Bioenergetics Association	
6.	Latvian Biohumus and California Red Hybrid-earthworm Production Association	www.biohumuss.com
7.	Latvian Energy Efficiency Association	www.latea.lv
8.	Latvia District Heating Association	www.lsua.lv
9.	Latvian Biomass Association "Latbionrg"	www.latbionrg.lv
10.	Small Hydropower Plant Association	http://mhea.lv
11.	Latvian Association for Environmental Management	www.lvpa.lv

Source: Compiled by the author

The EU funds allocated to cleantech sector.

The study examined **26 public funding support tools** (EU funds and programs), where guidelines include support for environmentally friendly activities, networking events, new product development and commercialization as well as for research activities.

Results of the study show that in Latvia there is **a good financial basis to build a combined financial tool for Clean Tech industry**, including both public and private investments.

According to the survey the green technology companies and clusters are relatively **considerable target** of public funding for their development (see below) – network and capacity building, research, marketing, education, new product development, human resources and infrastructure development or new equipment purchase.

Dominating part of the support instruments are focused on networking, marketing and research, still **considerable share of the programs provides support for investment in infrastructure and new product development.** However, the national specifics requires that there should be conditions created for increasing trust between partners so, support for network building is essential part, just as support for educational activities, which are closely related to increasing the administrative and strategic capacity of cluster initiatives.

Nr.	Forms of support	Number of support tools
1.	Networking	17
2.	Research	15
3.	Marketing/ promotion	10
4.	Education	10
5.	New product development	9
6.	Infrastructure/ purchase of equipment	6

Most public funding programs that support environmentally friendly technologies or business interests of the cluster, have been **open also to private applicants (entrepreneurs)** – the number of these programs is higher than the number of programs, where applicants can be non-governmental organizations or research institutions.

Nr.	Status of applicant	Number of support tools
1.	Private company	17
2.	Non-profit organization	15
3.	Research institution	13

Taking into account that the current programming period ends in 2013 and from 2014 will start the new programming period of financial aid programs and foundations, the study on Clean Tech industry **support tools should be updated after 2013.**

According to the interviews with risk capital investment ex- and existing managers, it is evident that **investors are looking for the business projects that have payback period ~7 years** (and not 15 years long as often offered by the companies looking for private investments).

Since the growth potential is directly related to the value of the intellectual property, the companies are not able to satisfy the basic requirements of private investors concerning the **business return** – **in most cases it is not maximized** but just kept regular as for usual business models, not relevant to risk capital investments. For example, instead of development and utilizing of new technologies (basic requirement by investors), the companies are using technology transfer approach and implement already tested and invented technologies by purchasing them from abroad which does not provide additional competitive advantages in the global market. Another challenge is to use the byproducts that are produced but not used to enlarge the income flow (e.g. heating and energy).

The 7th Framework Program projects were analyzed, where at least one participant was from Latvia. 7 projects related to cleantech were recognized.

Table 4.4: the projects of the 7th Framework Program with the participation of Latvian institutions and companies related to clean technologies

No	Project Name	Latvian participants	Coordinator	Duration	Cleantech sub-field
1	Forest Resource Sustainability through Bio-Based-Composite Development FORBIO-PLAST	1. Latvian State Institution of Wood Chemistry, Ugis Cabulis 2. Ritols Ltd, Peteris Tukums	University of Pisa (Italy)	01.07.2008-30.06.2012	Environmental friendly materials
2	Smart fire-retardant coatings based on intumescent nano-composites HEF-EST	LET-COMM, Ltd Olegs Grjazevs	CIDEMCO Centro Tecnologico (Spain)	01.11.2008-31.10.2010	Environmental friendly materials
3	Bio waste and Algae Knowledge for the Production of 2nd Generation Biofuels BIOWALK4BIOFUELS	Riga Technical University	Scandinavian GTS AB (Sweden)	01.04.2010-31.03.2014	Biofuel
4	High-reliability, nanochemical disinfestation system of fruits and vegetables CLEANFRUIT	AS Pures Darzkopibas izmeginajumu stacija Janis Leps	Feltalaloi es Kutato Kozpont Szolgaltato Kft (Hungary)	01.10.2008-30.09.2010	Waste management
5	CLEANSITE: Novel electrochemical oxidation for landfill leachate treatment	Integritum, Ltd Tomas Kauders	CleanSite Finmekanisk Vaerksted I/S (Denmark)		Waste treatment
6	Development of an innovative sanitation and wastewater treatment system for remote located tourist facilities	Norplast, Ltd Maija Maris	SAN-BOX Jets Standard As (Norway)		Waste water treatment
7	OXIdation of hazardous gases and ashes in rotating plasma ZONE	Panzer, Ltd Jevgenijs Kanonirs	OXIZONE ATON-HT S.A. (Poland)		Ambient air purification

Source of information: www.zinatne.lv *and the IDAL Project Development Department* www.liaa.gov.lv

Latvian companies and Universities take part in 7 cleantech related projects of the 7th Framework Program. They represented all sub-fields of cleantech, green service including. In the 6th Framework program there was no data on projects with Latvian participants regarding cleantech applications.

The benefit of enterprises and their opinion about the Framework programs

Regarding Latvian cleantech companies' participation in FP7th and due to accessibility to the EU funds, Latvian entrepreneurs noted that participation offered a wider experience with international partners as well as opportunities to gain knowledge about innovative materials and appliances, which can be further continued in export –potential products. It is important to note that participation of Latvian cleantech companies in the Framework Program is not sufficient. During the interviews companies expressed their opinion that Latvian government support programs are available and they don't have enough staff to simultaneously carry out national and international projects. Some companies were not sure about the management and technological qualification for participation in the Framework Program.

1.3 Innovation and firm support

Contribution of academic and other research organizations

Many of the interviewed companies confirmed cooperation with academic or other research organizations (21).

Table 4.5: Cooperation identified between cleantech enterprises and research organizations

No.	Cleantech enterprise	Research organization
1.	Eko Osta, Ltd	University of Latvia
2.	BAO, JSC	University of Latvia, Riga Technical University
3.	Getlini Eko, Ltd	University of Latvia, Latvia University of Agriculture
4.	Hidro-Standarts, Ltd	University of Latvia, Riga Technical University, Latvia University of Agriculture
5.	Biotehniskais centers, JSC	Riga Technical University
6.	Liepājas RAS, Ltd	Liepaja University
7.	Ziemeļvidzemes atkritumu apsaimniekošanas organizācija	Institute of Physical Energetics
8.	Virsma, Ltd	Institute of Physical Energetics
9.	PET Baltija, Ltd	Riga Technical University
10.	Zala josta, Ltd	University of Latvia
11.	Biohumuss 2010, Ltd	Latvia University of Agriculture
12.	Daga, SIA	University of Latvia
13.	Primekss, Ltd	Riga Technical University, University of Latvia
14.	Bio-venta, Ltd	Riga Technical University, University of Latvia
15.	Jaunpagasts plus, Ltd	University of Latvia
16.	Latraps	Riga Technical University
17.	Biogas, Ltd	Institute of Solid State Physic (University of Latvia)
18.	Advanced Technologies, Ltd	Institute of Physical Energetics
19.	Zaļās Tehnoloģijas, Ltd	Latvia University of Agriculture
20.	Vekover, Ltd	Riga Technical University
21.	Flexoplastic Ecological, Ltd	Riga Technical University

Source: the author's compilation based on company interviews.

The research organizations receive the government support through grants. 9 current grants related to cleantech were indicated.

Table 4.6: Clean technology related research grants, supported by the Latvian Science Council

No.	Name of the grant	Institution	Cleantech sub-field
1.	The research and development of environment friendly lignocelluloses functional products	Latvian State Institute of Wood Chemistry	Environment friendly materials
2.	The research of wood biodegradation mechanisms in early stage and development of protection materials and modification techniques for improving the durability	Latvian State Institute of Wood Chemistry	Environment protection
3.	Nanostructured materials from environment friendly technologies and renewable energy	Riga Technical University	Renewable energies
4.	New multi-functional polymer products from lignocelluloses, polyols, and lignin, the acquisition, modification of the nanoparticles and improving their properties	Latvian State Institute of Wood Chemistry	Material science
5.	Renewable energy sources combined heating and energy-saving technologies in increasing the agricultural energy efficiency	Latvia University of Agriculture	Renewable energies
6.	Water management system development for sustainable exploitation	Latvia University of Agriculture	Water management
7.	The research of biofuels and biomass receiving technologies	Latvia University of Agriculture	Renewable energies
8.	The components of forest ecosystems and water resources	Latvian State Forest Research Institute "Silava"	Environment protection
9.	Conifer yield, resistance, genetic diversity, propagation to the preservation and enhancement solutions for global climate change conditions	Latvian State Forest Research Institute "Silava"	Environment protection

Source: the Latvian Council of Science, www.lzp.lv

Besides the grants, the research organizations carry out projects under different programs announced by special calls of ministries (Ministry of Science and Education, Ministry of Defense), the EU founded projects and commercial orders of companies. With the support of the Latvian Science Council the scientific publications of Latvian scientists were systematized in the last 5 years. The number of publications is 62, many of which are citied. The list of research publications is provided in Annex 4.2. *Source: Scopus database (www.scopus.lv).*

The quantitative and qualitative analysis of scientific publications

The above mentioned information does not sufficiently characterize the contribution of the academic research. Below follows ***an evaluation of the contribution of the academic research*** by quantitative and qualitative analysis of the scientific publications.

Scientific publications acknowledge the potential opportunity for enterprises to acquire competence in certain technological solutions in cooperation with research organizations. Of course, this is not the situation in all cases. Some clean technology research is a continuation of previous work, disregarding the fact that they are not currently demanded by local enterprises. Other research is carried out in cooperation with foreign colleagues, and the areas of this research are actually being adapted to the application requirements of the enterprises in those other countries. Some research has a very precise and determined direction which means that enterprises do not have any practical interest in them. However, the majority of clean technology research publications are actually related to particular applications or to an intention to make them so in the very near future. This is confirmed by the correspondence of the titles of publications with actual applications. The degree of application was also determined by consulting with the leaders in the field mentioned above (p. 3).

From the collected publications (see Annex 4.2), the following publications can be considered as being potentially applicable (shown by issue number): 1-8, 15, 18-21, 23, 26-28, 37, 42-49, 51, 54-57, 60, and 62). It can be seen that 34 publications (52% of the total) represent a particular real interest for enterprises to apply the results. Some of the publications, for which no particular interest is shown in applications, are related to modern renewable energy topics (including fuel cells, hydrogen fuel cells, and energy extraction from air and water).

As shown in Figure 4.5, traditionally most studies are in environmental protection group, which is proven by the number of scientific publications during the recent 5 years.

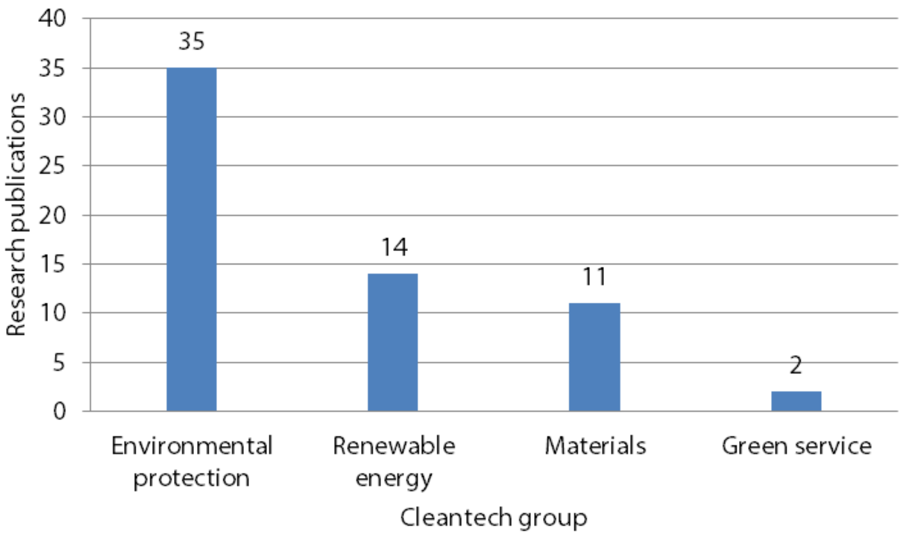

Figure 4.5: The distribution of publication between the sub-fields of cleantech
Source: Compiled by the author

These topics may appear to be interesting for a new innovative enterprise which is going to engage in the business of alternative energy generation plants. A proportion of the publications are devoted to general environmental and ecosystem issues that may be interesting to local government authorities and public authorities. And they, in turn, can carry out activities on the basis of this information in order to engage enterprises in projects solving particular issues of environmental protection.

The opinion of respondents regarding cooperation with the scientific research organizations

The enterprises have cooperation with scientific research organizations according to one of the following contracting principles:

Nr.	Cooperation principle	Confirm.
1.	Direct contract to solve a specific problem defined in the application	8
2.	Partnering is some government supported program	12
3.	Partnering is the 7^{th} Framework or other EU program	2
4.	The initiative from the side of a research organization to approve research results in cleantech applications	2

Source: information collected by the author based on company interviews

Same enterprises noted (4): this type of cooperation in cleantech is crucial to learn better the application of new technologies and to increase the competitiveness.

Patenting

The results of interviews show that cleantech are not active by announcing patents. Only 8 companies have patents or are in the process of preparing them. One of the typical arguments is that Latvian patent does not play an important role, whereas the European and world patent require essential costs and procedures are long.

The patent research found 35 Latvian patents related to cleantech applications. Mostly patents were announced by research organizations or individuals (see Annex 4.3 *Source of information: patent access database (*http://ep.espacenet.com*)*. Altogether, there are 35 patents by Latvian participants in cleantech related subfields.

Such a situation has arisen because of the existing national legislation, which allows scientists using the scientific infrastructure in universities, to register intellectual property rights in their own name.

Taking into account that patents were applied not only from research organizations, but also from companies and private persons, the analysis of patenting (including the opinion of respondents) is provided in Chapter 1.2.5 "Innovation dynamics" of this report.

Availability of Venture Capital

General description of Venture Capital

There are the following main financial support opportunities for SMEs:

1. Banking sector;
2. European and state support programs;

3. Venture capitals;
4. Business angels.

It must be noted that the business angel movement in Latvia is underdeveloped. The European and state support programs are discussed later in this review. Venture capital foundations as a financial instrument in Latvia will be studied more closely.

Being a member of the EU, Latvia is committed to the Lisbon Strategy, which aims at the EU becoming the 'most competitive and dynamic knowledge based economy in the world'. A critical factor for the success of this strategy is capital mobilization to support entrepreneurship and innovation. This is true for the EU as a whole and in particular for Latvia. In Latvia the overwhelming majority of enterprises are private companies meeting their capital needs either internally or in the form of bank loans. However, for fast growing or innovative companies these sources of finance may not be proper. In such cases a special type of financing, namely venture capital (VC), is often appropriate. Venture capital is a small but emerging sector of the Latvian capital market and the aim of this survey is to describe and evaluate the current situation of the venture capital market in Latvia (Dijokas *et al*, 2004).

In 2005, in close co-operation with the Ministry of Economy and the Investment and Development Agency of Latvia, a 'fund-of-funds' was established at the Latvian Guarantee Agency. Instead of establishing a publicly managed fund, the Latvian government assigned the launch of new venture capital funds to private professional institutions because it is believed that they would offer a more effective and efficient implementation of the program. Accordingly, three venture capital funds into which the fund-of-funds would invest have been established with a total capital of €31.5 million: *Eko investors, TechVentures Fondu Vadibas Kompanija and Zalas gaismas investicijas (ZGI).* By November 2007, the three fund management companies had approved 15 investments. Approximately 40% of these investments are made in the so called new sectors (information and communication technologies, electronics) with the average project size being €1 million. Public funds contribute a maximum of 70% of the total funds, the rest coming from private sources.

Investments of Venture Capital in Latvia cleantech

These venture capital funds have also invested in cleantech oriented projects:

1. „ Eko Kurzeme, Ltd" by Eko investors in 2008 (for the projects of waste management);
2. „Eko Riga, Ltd" by Eko investors in 2008 (for the projects of waste management);
3. "Pet Baltija, JSC" by Eko investors in 2008 (for recycling PET using green technologies);
4. "Tukuma Ainava, Ltd" by Eko investors in 2008 (for the projects of waste management);
5. "Re Cikls, Ltd" by ZGI in 2008 (for developing a technology of biofuel producing from animals fats).

Opinion of respondents regarding availability of Venture Capital

After the first investments, the venture capital foundation program was not continued. According to the opinion of respondents, the local investors are oriented towards more rapid profit bringing branches; at the same time foreign investors have taken the wait-and-see position. Overall there is a skeptical attitude towards the availability of venture capital for Latvian cleantech enterprises.

1.4 Firm capabilities

Business development capabilities

Practically all the companies interviewed expressed their interest in expanding business activities. The companies see the following as the first step of getting this done:

1. Development of manufacturing and business structure;
2. Development of applied technologies by teaming up with research institutes or by developing their own R&D;
3. Marketing research to expand the existing business in Latvia;
4. Marketing research to expand Latvian businesses in other countries;

5. Marketing research to find new variations of company business activities.

Only five companies applied at least three factors together (1, 2, 3 or 4). Only four companies applied Factor 5. Factors 1 and 2 were more popular than the rest of the five.

The companies' opinion indicated to an idea that if the levels of advancement in manufacturing, business, and technology were appropriate, then the competence factor for export activities would be achieved as expected. However, many companies use support programs of the Investment and Development Agency of Latvia for developing their marketing activities.

Product development capabilities

The respondents have indicated the following three main factors as being the most critical for product development in the clean technology business:

1. A proper combination of technological and engineering competence.
2. Development laboratories and other elements of infrastructure fully equipped with modern technology and instrumentation.
3. Flexible contract relations with research organizations and other subcontractors who are able to develop elements of new products and new technologies.

The right combination of technological and engineering knowledge was recognized as being the most important factor. Some respondents were of the opinion that if one has knowledge he/she will always be able to organize technical facilities and corresponding subcontractors. However, quite a few respondents noted the last two factors as being the most important.

Programs have been initiated in Latvia that will promote development of industrial research, for example, a program involving competence centers. These programs will help to create the infrastructure and other conditions necessary for flexible product and technology development.

2. Current performance in clean technologies

2.1 Enterprises in the cleantech sector and their specialization

Overview of the current performance of clean technologies in Latvia begins with a general description of the situation in different clean technology sub-fields. This description will better help to understand the characteristics of clean technology enterprises.

58 clean technology enterprises were recognized in Latvia according to the principles described in the introduction of this report.

Initially the companies were grouped according to cleantech sub-fields. Since the number of such sub-fields is comparatively large, the companies were divided into cleantech groups. The following groups of cleantech were developed:

1. Environmental protection
   This group includes the following sub-fields:
   - Environmental service
   - Waste management
2. Renewable energy
   This group includes the following sub-fields:
   - Biofuel
   - Biogas and biomass
3. Green service
4. Materials
   This group includes the following sub-fields:
   - Energy saving technologies
   - Environment friendly materials

Groups were selected on the basis of significant differences in trends in cleantech sub-fields. Activities of some companies overlapped with 2 cleantech groups. Each company was added to the group that composes the biggest share of the company's turnover.

The financial and statistical analysis was performed on the basis of the data available from all 58 companies.

28 companies were interviewed to obtain additional information.

Data about turnover, profit/loss statements, and number of employees, location and foundation year of these companies in the last 3 years were obtained from the Register of Enterprises of the Republic of Latvia (www.ur.gov.lv*)* and the Databases of Enterprises (www.lursoft.lv *). See Annex 4.4 and Annex 4.5.*

In Annex 4.5 data about the foundation year, location, number of employees, export volume and R&D expenses of cleantech enterprises were provided. The data about export volume and R&D expenses were obtained based of questionnaires. These data mostly were indicated as approximate.

It can be seen from Annex 4.4 that founding new enterprises became more active since 2003. It may be explained by joining the EU and accessibility of new financial support in environment protection and other fields of clean technology. However, increase of activities of the already established enterprises was more pronounced.

There are enterprises in all Latvian regions. However, in Latgale and Kurzeme the number of clean technology enterprises is smaller compared to other regions of Latvia.

The breakdown of companies in cleantech groups and sub-fields is conditional. In most cases the assignment of the company to a group is comparatively easy to define. Some companies cannot unambiguously answer to the question "In which cleantech sub-field your company would be placed? ", as their basic activities involve different cleantech sub-fields or even groups. E.g., Primekss Ltd manufactures environment friendly materials for selling structures as green service. The companies sharing different cleantech sub-fields in their operation are capable of the best assessment of the best growth opportunities of their own company in different directions of cleantech sub-fields.

It should be noted that in most cases the companies evaluate the cleantech development trends through their own specifics of operation. E.g., companies involved in waste management see opportunities of biogas production, because today it appears as an efficient way of waste disposal. Some waste management companies see opportunities for waste utilization by manufacturing environment friendly materials.

The majority of companies see the main development trend and drivers in the increased demand for environment protection activities.

Technological development and willingness of companies to learn new technological methods for increasing their competitiveness is another important driver.

Some companies see the main risk in unclear government policy in developing the regulatory basis of environment protection. However, important issues for biofuel and bioethanol sub-field companies concern the regulations declared by the government on the mandatory bio-additive to gas and the subsidy policy.

2.2. Characteristics of the regional cleantech enterprises

Size of firms

As can be seen in Figure 4.6, the cleantech field in Latvia is predominated by micro-enterprises and small enterprises. According to the number of employees, only 5 of the enterprises are medium sized enterprises, and there are no big enterprises at all in the field.

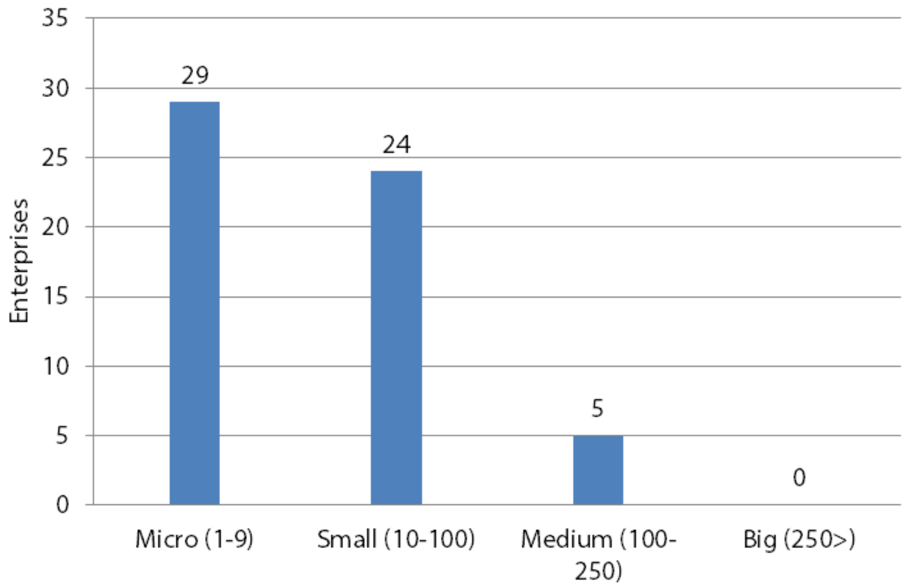

Figure 4.6: The distribution of clean technology enterprises in different size groups
Source: The Register of Enterprises of the Republic of Latvia (www.ur.gov.lv *) and the Databases of Enterprises* (www.lursoft.lv*)*

Micro-enterprises can be found in all cleantech groups the majority being in the green service group (60%). It is partly related to the fact that the majority of the green service enterprises are founded over the last 2 years. It should be noted though that the average number of employees in the green service field is smaller (13) than in other cleantech groups. It is due to the specific green service activity focusing on a specific type of production units with the number of employees needed being small.

Comparatively many micro-enterprises are operating in the renewable energy group, although there are also relatively big enterprises in this group (*k/s Latraps, Bio-Venta, Jaunpagasts Plus*). When the process of production and sale of fuel have been developed successfully, such an enterprise can become a medium sized enterprise because producers of biofuel are mostly exporting their products. The reason for the comparatively high number of micro-enterprises and small enterprises in this group is the fact that innovative enterprises developing new approach in the fields of renewable energy have been founded comparatively recently and have not stabilized their manufacturing process and gained their market share yet.

In the field of environmental service, the structure of the number of employees is various because the nature of their activities may vary in a wide range. Some enterprises provide environmental services (e.g., waste management) where the number of employees required is comparatively big. At the same time, there is a sufficient number of enterprises operating in this direction, providing specific services under the environmental niche (e.g., environmental analysis) and manufacturing specific devices (e.g., filters).

Net sales (turnover)

In 2009, the total turnover of 58 cleantech enterprises accounted for EUR 211.88 million. The turnover distribution by cleantech sub-fields is represented in Annex 4.4 declares that the renewable energy group has the highest turnover (EUR 157.19 million). Nevertheless, 90% of the group turnover is made by 3 producers of biofuel (B*io-Venta, Jaunpagasts plus, Latraps*) which have stabilized their production and sales in the export markets. The turnover breakdown by enterprises is more even in other groups. It is difficult to evaluate the green service group turnover in 2009 because in that year only 4 enterprises launched their activity and 95% of the group turnover was made by *Primeks Ltd*. 6 green service enterprises started their activity in 2010. A comparatively even turnover can be observed in the material group, although only 3 enterprises operated in the group in 2009 (currently, there are 4 enterprises in the group).

In 2009, the turnover in the environmental protection group is largely related with the nature of service provided by an enterprise. Some enterprises provide special environmental purification service, and one enterprise is completely sufficient for such type of service in a country as small as Latvia. For example, *BAO JSC* is running the business of utilization of environmentally hazardous, medical and other types of specific pollution. Thus the firm's turnover of EUR1.96 million largely depends on demand of such specific pollution assessment in Latvia. Analogically, *Eko Osta Ltd*, with its turnover accounting for EUR 2.47 million, runs the business of elimination of specific environmentally harmful factors (soil pollution). Sometimes competition between both firms emerges. This happens in case when elimination of a type of pollution falls within the specific competence of both firms.

Firms engaged in waste management have a comparatively big turnover. Usually such firms are servicing a particular area which mainly defines their turnover. For these firms, the turnover also depends on the scale of other activities related to environmental adjustment. For example the turnover of *Ventspils labiekārtošanas kombināts* accounts for EUR 5.8 million, *Liepājas RAS* – EUR 1.36 million, and *ZAOO* – EUR 3.4 million.

Total profit / loss

In 2009, the highest profit/loss was experienced by the fields of environmental protection (EUR 3.64 million) and renewable energy (EUR 4.015 million). The profits in both directions are comparatively similar, although the turnover in the renewable energy group is almost 6 times higher.

The second biggest group enterprise (*Bio-Venta*) suffering loss in the amount of EUR 1.2 million had a negative impact on the overall situation in the renewable energy field. At the same time, the profit of the two other enterprises of the group, namely *Jaunpagasts plus Ltd* and *k/s Latraps*, was considerable (EUR 3.7 million and 2.3 million, accordingly). Losses were rather high in the green service field due to the biggest enterprise of the group suffering a loss of EUR 1.43 million.

2 out of 3 material group enterprises suffered significant losses; consequently the comparative losses of the group are big.

70% enterprises in the environmental service group in 2009 operated with profit. Only 2 out of 28 enterprises suffered rather big losses.

Losses in the renewable service, green service and material groups are largely related with the consequences of the national subsidy policy. More detailed information could not be obtained because the enterprises are reluctant to talk about the reasons.

The distribution of wages in waste recycling and treatment branches in the regions of Latvia

The sole officially available data base from which the information about wages in cleantech related sector was possible to receive is Latvian Statistical Department. Information in the direction of environmental protection fields, e.g. waste management and waste water treatment was available. It was not possible to obtain this information with the help of questionnaires.

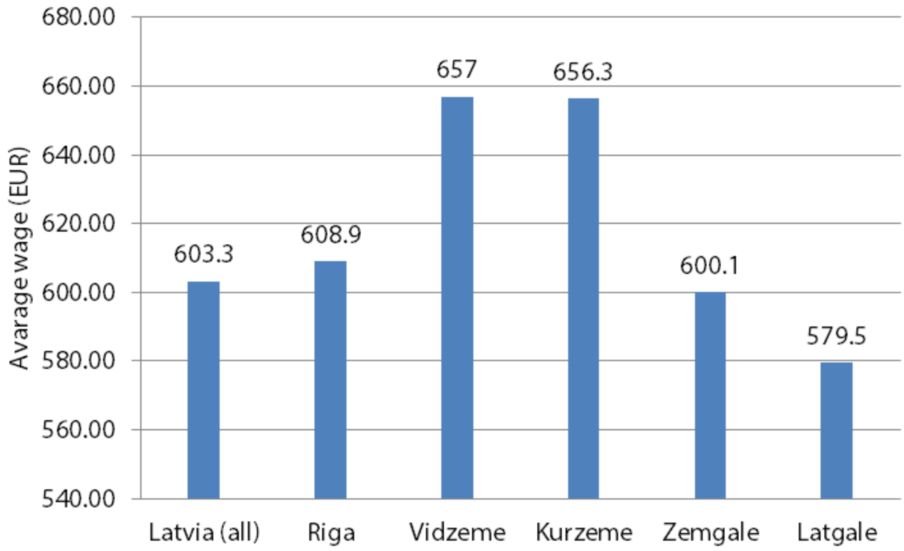

Figure 4.7: Distribution of average wages in waste water treatment field in different regions of Latvia (in 2009)

Source: the Register of Enterprises of the Republic of Latvia (www.ur.gov.lv) *and the Databases of Enterprises, Ltd* (www.lursoft.lv)

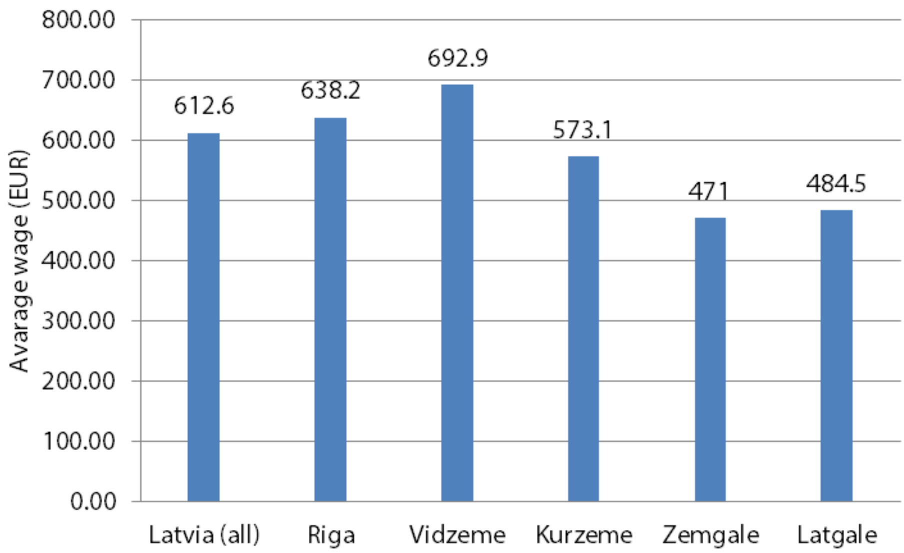

Figure 4.8 Distribution of average wages in waste management field in different regions of Latvia (in 2009)

Source: the Register of Enterprises of the Republic of Latvia (www.ur.gov.lv) *and the Databases of Enterprises, Ltd* (www.lursoft.lv)

As can be seen in Figure 4.7 and Figure 4.8, the average wage in waste management is about 2% higher than in the waste water treatment field. However, in Kurzeme, Zemgale and Latgale this relation is opposite. In both directions wages in Zemgale and Latgale are about 10-20% lower than in other regions.

The lowest average salaries in Zemgale and Latgale in the given cleantech subfields are explained by the lowest average salaries generally in these regions. In the given cleantech directions in Vidzeme the salaries are higher than in Riga, regardless of the fact that the overall average salaries in Riga are higher than in Vidzeme.

2.3. Export orientation and problems with marketing and exporting cleantech products and services

General trends based on export share of companies in 2009

Figure 4.9 presents the relative export share of cleantech group companies. The export share in % was obtained by counting up the total export and turnover of the group companies (Annexes 4.4 and 4.5), and creating a proportion of these figures (i.e., 100*export/turnover).

Information about export was collected from companies by means of interviews. Most companies could inform only about export in 2009. Due to this fact, the export dynamics is not available and analysis is done based on information about the year 2009.

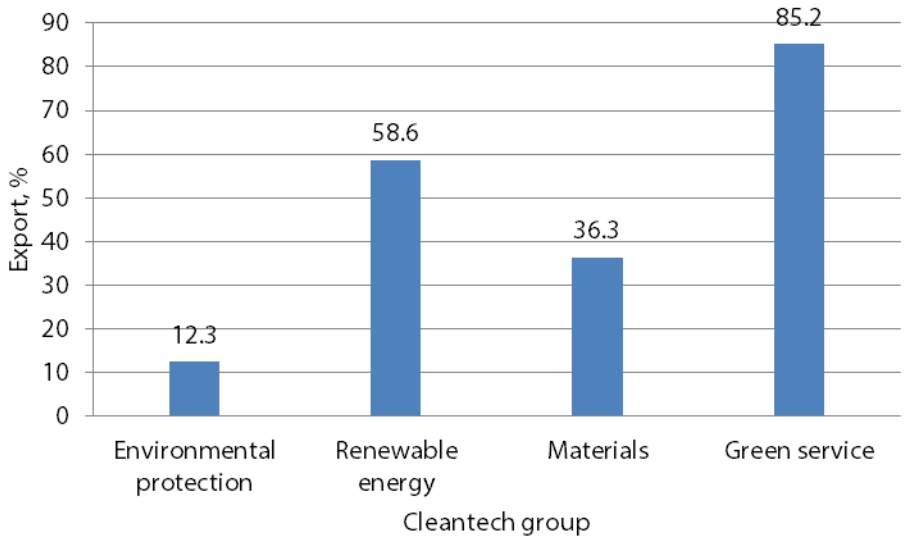

Figure 4.9: Export share of cleantech enterprise export in different cleantech groups
Source: information compiled by the author based on company interviews

According to the given Figure 4.9, the renewable energy (58.6) and green service (85.2) directions have export above 50%. It is even higher for the renewable energy group companies producing biofuel (~60%) and bioethanol (~80%), but for the companies producing biogas and biomass the export share is up to 20%; since the turnover of companies producing biofuel and bioethanol is higher, their effect is significant on the average rates of the group. The relatively large export percentage of the green service was largely determined by a significant export proportion and turnover of Primekss Ltd. Almost all green service companies have a tendency towards activities advancing an increase in export. Usually the European Union countries are the export region countries for renewable energies and green service companies. Export proportion of environmental protection direction companies is comparatively insignificant (12.3%). It is related with the fact that performance of the local environment protection tasks is the primary task for such companies. However, the number of companies in this group having initiated export tends to grow. Russia, Belarus, Georgia, the Baltic States and some Eastern European countries are the fundamental export market for the companies in this group. Some companies collaborate with Nordic companies by participating in joint projects.

The motivation of the necessity to perform a qualitative analysis of export

The above performed information presented an overview of general export trends for all groups of enterprises in the clean technology field. Disregarding the fact that this information is unbiased and measurable, it does not provide a complete insight into the clean technology export trends and problems. Unfortunately, no information is available in regard to the export levels of individual enterprises to various markets. Information about the reference amount of exports (the percentage and net sales ratio) for the enterprises, as well as the main export markets of these enterprises, has been obtained via interviews. ***Therefore the author will try to understand the general clean technology export trends and problem by expanding on export experience of some enterprises.***

Analysis of export trends in the sub-field of environmental protection

When analyzing export trends in the environmental protection group in detail, the following export trends were found:

1. Enterprises providing for traditional waste management services have minimal exports or do not have any at all (*Ventspils labiekārtošanas kombināts, Liepājas RAS, ZAOO*). Enterprises of such a type are not considering exporting for the time being because the provision of their particular clean technology service requires a specific infrastructure which would be inconvenient to implement in another country due to various considerations.
2. Exports for enterprises providing specialized environmental purification services (such as *BAO* or *Eko Osta*) account for approximately 10-20% of total exports. Currently these enterprises are exporting their services to other Baltic States and to Scandinavia. This is achieved in cooperation with analogous enterprises in the respective countries. Even so, companies such as *BAO* are looking for business prospects in Russia, Belarus and Azerbaijan. They see business perspectives in these countries due to demand for recycling environmentally hazardous waste in these countries, and local firms have not mastered the required technologies yet. For the purpose of taking advantage of this business opportunity, finding a partner firm that could help to accomplish specific waste recycling technologies is essential. In this

respect, knowledge of the national legislation regarding the issues of intellectual property and the area of environmental protection is essential for starting a business.

3. For the majority of the enterprises engaged in waste water treatment and potable water supplies, export volumes are rather small as, for the time being, these enterprises are focusing on local projects (such as *Lakalme*). The enterprises still realize that waste water treatment and water supply projects in the Latvian cities implemented within the framework of the EU support project will be completed soon. Therefore, enterprises of such a type are looking for new market opportunities in other countries. In this respect their interest is mainly focused on the markets of the following countries: Russia, Ukraine, Serbia, Macedonia and Montenegro. There is a demand for modernization of treatment plants in these countries. Having said this, there is an enterprise operating in the water treatment business mainly focusing on markets in other countries (*Karme Filtrs*). *Karme Filtrs Ltd* is engaged in both manufacturing mobile water treatment facilities and application of treatment technologies. The firm's export volumes account for 80% of its business. At present, its export markets are Russia, Ukraine, Azerbaijan and Belarus. The firm is searching for export opportunities in Uzbekistan and Kazakhstan.
4. Some environmental protection firms are exporting design and technological consultations (such as *Venteko* and *Akorda*). The export markets for *Akorda Ltd* are Russia, Georgia, Azerbaijan and Ukraine, while those of *Venteko* are Russia, Iran and Israel.

To sum up, it can be assumed that at present the group enterprises see their business opportunities in countries in which environmental technologies have not yet been introduced sufficiently, and the conditions for their mastering are ripe. This refers to the former Soviet Republics in which the political and economic situation is stabilizing, as well as to some former Yugoslavian republics. For this purpose, enterprises are willing to participate in different trade missions in the given countries, most of them being organized by the Investment and Development Agency of Latvia (IDAL) according to requests received from the enterprises.

Analysis of export trends in other sub-fields

Export conditions similar to those in the environmental protection area also exist in the green services. The only difference is that the green service enterprises are focusing the majority of their activities on exports because bio humus and other technologies are comparatively new, and there is a demand both in Russia and the EU countries. When worrying about exports, this type of enterprise must also focus on a particular service activity, which means that they cannot look at exporting worldwide. Material direction enterprises are focusing mainly on production, which means that they are able to export to other regions. Renewable energy enterprises are mainly exporting biodiesel or bioethanol. They export mainly to the EU countries. For example, *Latraps* is selling its products via an exchange, which means that the enterprise is not always aware of the final destination of its products.

Export opportunities and problems of Latvian cleantech enterprises in other EU countries

Certainly, the majority of interviewed enterprises are considering export opportunities in other EU countries.

The enterprises are aware that the following preconditions must be accomplished in order to acquire these markets:

1. The level of innovation of the existing products and services must be increased, because the required environmental services are already being provided at a high level by local firms in almost every EU country;
2. They must search for partnership opportunities with local environmental firms with a similar profile. For this reason, some enterprises are looking for opportunities to participate in various EU programs. Nevertheless, the majority of the enterprises have first decided to carry out a research cycle within the framework of programs available in Latvia (such as the programs being offered by competence centers) in order to raise their competence and their level of innovation. In this way, conditions for equal partnership are prepared.

2.4. Interaction with other organizations

General trends of interaction with other organizations

There is information about cooperation between cleantech enterprises and research organizations obtained from interviews (*Table 4.5 Cooperation identified between enterprises and research organizations).*

Enterprises were interview about interaction with the government and other organizations. The enterprises indicated their interaction with the government organizations related to participation in the government support programs:

Name of organization	Confirmation
Investment and Development Agency of Latvia	16
Ministry of Environmental protection and Regional Development	7
Ministry of Education and Science	2
Rural Support Service	3
Competence Centers	6

Source: Compiled by the author

It is known that many clean tech enterprises take part in industry associations. The following industry associations were recognized:

No.	Name of association	Web-site
1.	Latvian Association of Waste Management Companies	http://www.lasua.lv
2.	Waste Management Association of Latvia	http://www.lasa.lv
3.	Latvian Biogas Association	http://latvijasbiogaze.lv
4.	Latvian Biotechnology Association	http://www.latbiotech.lv
5.	Latvian Biofuel and Bioenergetics Association	
6.	Latvian Bio humus and California Red Hybrid-earthworm Production Association	www.biohumuss.com

Source: Compiled by the author

The number of cleantech enterprises in these associations is not precisely known, because not always full updated lists of members are available.

As for interaction activities among companies, they are looking for every opportunity to cooperate. At the same time, the companies are not directed towards using the adequate business models corresponding to challenges of building the XXI century partnership – basically there are used traditional business principles and methods of collaboration.

To compensate the lack of this information an example of interaction between 6 environmental protection companies is analyzed.

Example of interaction between environmental protection companies

Companies like Eko Osta, Ltd and BAO, JSC are involved in collection and disposal of pollution. Each of them also operates in its specific field, i.e., Eko Osta, Ltd - in treatment of soil contaminated with oil and other substances, BAO, JSC – in utilization of medical, agricultural and household waste. Both companies collaborate in a way that one company collects and utilizes the source of pollution, while the other company prevents the effect of the pollution of soil. BAO, JSC collaborates with Zaļā josta, Ltd to recycle different types of waste, e.g., it produces environment friendly construction materials. Eko Osta, Ltd collaborates with Biotehniskais centers, JSC for using fermentation technologies for treatment of oil contaminated soil. Eko Osta, Ltd and BAO, JSC collaborate with Virsma, Ltd to carry out the chemical analyses of pollution. Both companies also collaborate with LaKalme, Ltd for using their technologies in waste water treatment systems. LaKalme, Ltd collaborates with Biotehniskais centers, JSC in automation of these procedures and with Virsma, Ltd in quantitative assessment of the treatment process. A part of the mentioned companies participate in the IDAL innovation programs (Ekoosta, BAO, Zala josta, Biotehniskais Centers). The companies are also members of industry associations. Ekoosta, BAO, Zala josta and Virsma are members of Waste Management Association of Latvia, but Biotehniskais Centers is a member of the Latvian Biotechnology Association.

2.5. Innovation dynamics

General trend based on analysis of R&D expenses

The data about R&D of enterprises were collected by means of interviews (Annex 4.5). In Latvia this information is not available from the Register of Enterprises of the Republic of Latvia or other official information sources.

According to Figure 4.10, the green service cleantech group has the largest corporate contribution in research.

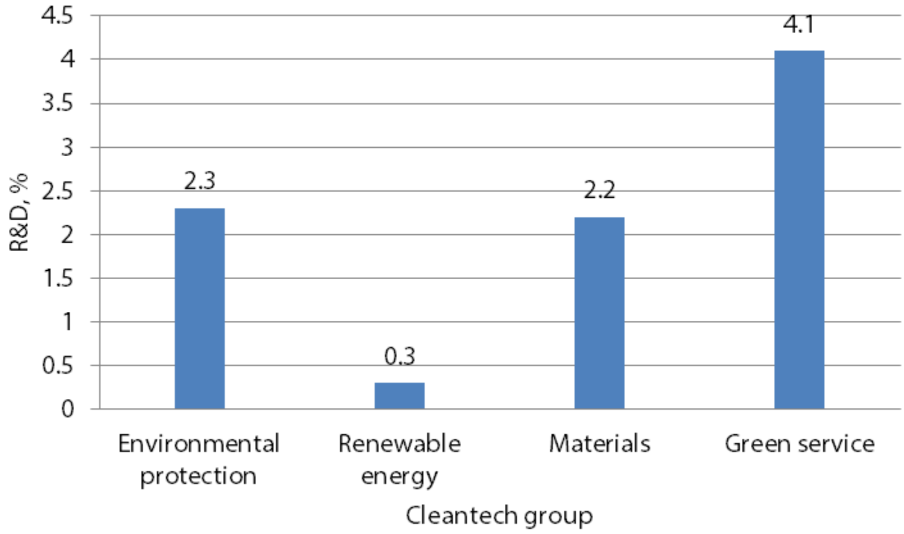

Figure 4.10: The relative amount of cleantech enterprise R&D expenses in different cleantech groups

Source: the Register of Enterprises of the Republic of Latvia (www.ur.gov.lv *) and the Databases of Enterprises, Ltd* (www.lursoft.lv*)*

It is explained by the fact that this direction is relatively new and in order to improve their competitiveness the companies are interested in performing studies for better acquisition of technologies. The renewable energy group has the lowest contribution in research. It can be explained partially by a significant turnover of biofuel and bioethanol, which is ensured by production (resulting in the fact that the contribution to research is smaller than that of the directions more related with service). However, the largest enterprises of the renewable energy use rather traditional technologies based on crops and research activities by developing transformation of other substrates (not competing with the needs of food) are hardly promoted.

The analysis of clean technology related Latvian patents

The quantitative information about R&D expenses does not completely provide the characteristics of the innovation dynamics. The Latvian patents in the last 5 years from the Patent Office of the Republic of Latvian data were obtained and analyzed to expand the view about the innovation dynamics in Latvia clean technology sector (see Annex 4.3).

The number of patents in the directions of renewable energy and material science is almost equal to the environmental protection group (see Figure 4.11).

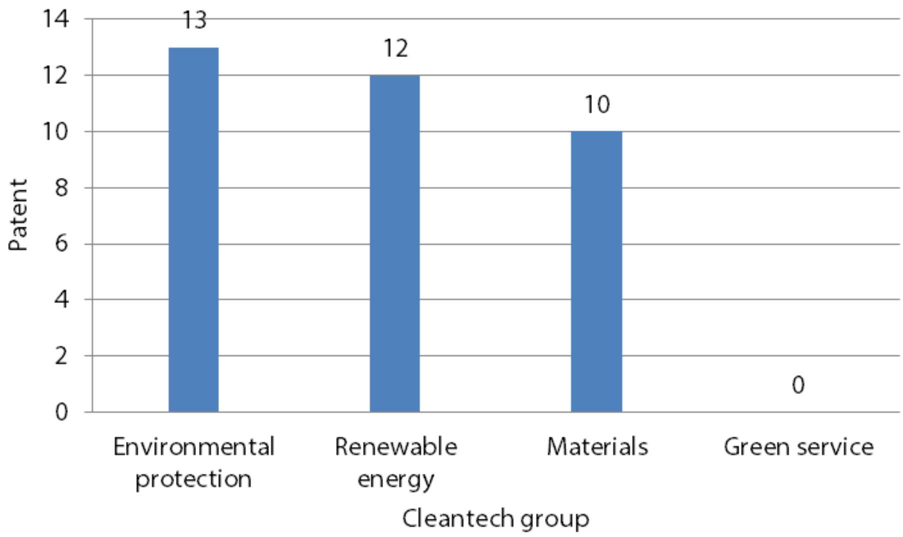

Figure 4.11: Distribution of patents between the sub-fields of cleantech

Source: Compiled by the author

This fact shows that new specific niches are provided for renewable energy and environment friendly materials directions. Based on that, one may forecast an increase in the number of applications in these directions.

The analysis of patents (see Annex 4.3) by the type of submitter (i.e., an enterprise, public research body, private individual), shows the following situation:

1.	Enterprise	5
2.	Public research body	15
3.	Natural person	14
4.	Enterprise and public research body	1

It follows that the biggest part of the number of patents (fourteen) has been submitted by private individuals. It is difficult to find an unbiased explanation for this due to the fact that arranging interviews with individuals working alone in this field is not easy. In some cases it is clear that the submitter is the owner of a company who is using the patent within the scope of that business (e.g., No 10).

Patents created in universities can be divided in the following three groups according to their application potential:

1. During a research, a patentable solution has been found. At the moment of registering the patent there was no particular interested party;
2. A patent has been developed intentionally by forwarding a research in order to find a solution for particular enterprises or applications;
3. A patent has been developed by creating a solution for a topical subject of a worldwide importance, nevertheless no potential demand from a local enterprise has been found.

Within the context of this report, only the patents pertaining to the second group could be of interest. First, representatives of the public research bodies were interviewed in order to identify the group within which an enterprise falls, and secondly, if it falls in the second group, what would the situation of the given patent be in terms of its introduction. It should be noted that replies were not unequivocal, and in most cases they could not be catalogued easily.

Opinion of cleantech enterprises regarding patenting related problems

It can be seen from the answers of applicants that the approach used regarding the implementation of patents by research organizations and enterprises is very different. The main reason for enterprises to register a patent is when they already know the potential way of using the product. Sometimes a product can be used in its early stages even before the findings related to it can be published. However, having a patent does not always ensure success in business. The potential problem can be that a patented product or service is realized only in the domestic market and marketing activities for its promotion in the markets of other countries are not developed well enough.

Usually Latvian clean technology enterprises do not register the European or worldwide patents. According to interviews, it has the following reasons:

Nr.	The reason of failing to register patents	Confirm.
1.	Enterprises would like to start with the Latvian market and then, depending on results, take the appropriate next step. Such next steps are usually uncertain and their continuation does not always come into existence.	6
2.	Registering of the European and worldwide patents seems to be too expensive for most enterprises and for this reason they are far from assured that their investment in such a patent will deliver the expected return.	5
3.	Enterprises develop a product or service and simultaneously carry out a marketing research on it. During this period they do not register a Latvian patent for it because the rights for Latvian patents to be announced as the European or worldwide patent remain set at one year. Sometimes a situation may emerge when a market position is found only after a product or service has been created, in the result of which a patent is not registered at all.	4

Source: Compiled by the author based on company interviews

Research organizations usually see the need for patents to be applied for in a well-founded enterprise. However, from the side of enterprises there is often little interest in applying for a patent. From another point of view, it is not always easy for two cooperation partners involved in a product development to agree on the rights of the intellectual property. Due to this research organizations do not always study the needs of enterprises deeply enough.

The uncertainties mentioned above are reflected in the amount of patents that have been applied for by Latvian clean technology enterprises. According to the results of interviews, three or more patents are held by two different enterprises, two patents are held by three different enterprises, and one patent is held by a total of seven enterprises. Two enterprises have started the registration process to get a European patent.

The discussion about innovation in Latvia cleantech based on interviews

In Latvia, the following scale for the evaluation of innovativeness is applied. This can also be translated as a relatively innovative spirit for the enterprises involved.

1. The application is new for enterprises.
2. The application is new in Latvia.
3. The application is new worldwide.

The enterprises were interviewed regarding innovation in Latvia and worldwide. The trend of worldwide innovation manifested itself in three enterprises, Jaunpagasts Plus Ltd, Primekss Ltd and Biotehniskais centers JSC. Eighteen enterprises have handled innovation in Latvia.

To characterize the feedback of innovation, the best option would be to evaluate the revenue earned from new products and services. It was not possible to obtain this information even by interviews because such information is not available even to the enterprises themselves.

Some examples might be able to explain the qualitative characteristics of benefits and the chain of industry value with regard to particular innovations.

Primekss Ltd. develops, produces, and exports industrial concrete and epoxy floors. They have captured a sizeable share of the market in the Baltics and Scandinavian countries. These floors are environmentally friendly; they improve the level of cleanliness in the work and recreational space. As a result, due to application of these floors, the manufacturing and service conditions of other enterprises become more environmentally friendly, thus the clean technology expanding in other applications.

The next example with regards to Jaunpagasts Plus Ltd is production of bio-ethanol. Essentially innovation by these companies is grounded on bio-ethanol manufacturing technology based on environment friendly and economic principles. The production emissions are returned back to the process and used as an energy source. Waste products are recycled in other products, such as cattle feed thus minimizing the environment pollution. The green manufacturing increased the competitiveness of the enterprise. Production costs were decreased and the production process was more oriented towards low carbon emission technologies. This aspect was also reflected in the end-product, with some of its qualitative parameters being improved.

It follows from this analysis that there are two main factors slowing down the process of patenting new products in Latvia. These are uncertainty of export markets and lack of government programs supporting the patenting process.

2.6 Growth dynamics

According to Figure 4.12 the number of employees grows every year in the last 3 years. However, according to Figure 4.13 the growth of employees is principally due to only two cleantech sub-fields, e.g. renewable energy and materials (environmental friendly and energy saving).

The total turnover (Figure 4.14) of cleantech enterprises increased in 2008 compared to 2007, but decreased in 2009 relative to 2008. It is obviously related to the economic crisis. However, in the fields of renewable energy and material the turnover showed an increasing trend every year (Figure 4.15).

The drop of profit in 2008 and 2009 is more expressed than the decrease of total turnover (Figure 4.16). However, these curves reflect the influence of subsidy policy of the government in 2008 regarding the renewable energies (Figure 4.17). Due to this the losses in the sub-field of renewable energies makes about 15% of the turnover of the companies of this direction.

The turnover dynamics in the group of environmental protection shows a decreasing trend from 2007 till 2009. To a great extent it is related with economic crisis. Compared to 2007, the profit decreased two times in 2008, but in 2009 it even slightly increased. It is important to note that in every case the total profit of environmental protection enterprises remained positive in 2008 and 2009. At the same time, compared to 2007, the number of employees in 2008 increased, but in 2009 it slightly decreased. The data that, at first sight, may look conflicting can be explained by the fact that service costs in environmental protection sector were raised in 2007, whereas beginning from 2008 the salaries decreased.

Compared to 2008, the turnover of the green service enterprises decreased essentially in 2009. This applies also to the profit/loss.

It is difficult to evaluate the green service group turnover in 2009 as only 4 enterprises had launched their activity and 95% of the group turnover was made by *Primeks Ltd*. 6 green service enterprises started their activity in 2010.

The negative trend of the financial data can be partly explained by the consequences of the national subsidy policy. On the other hand, there are relatively many recently established enterprises in this group and due to this fact improvement of the financial parameters is expected in this sub-cluster.

The total turnover of the renewable energy sub-field did not show a tendency of decrease even during the economic crisis. However, in 2008 this group suffered relatively large losses arising from the political uncertainty of the government regarding subsidy.

After systematizing these regulations, the profit in 2009 returned, and even exceeded the level of 2007.

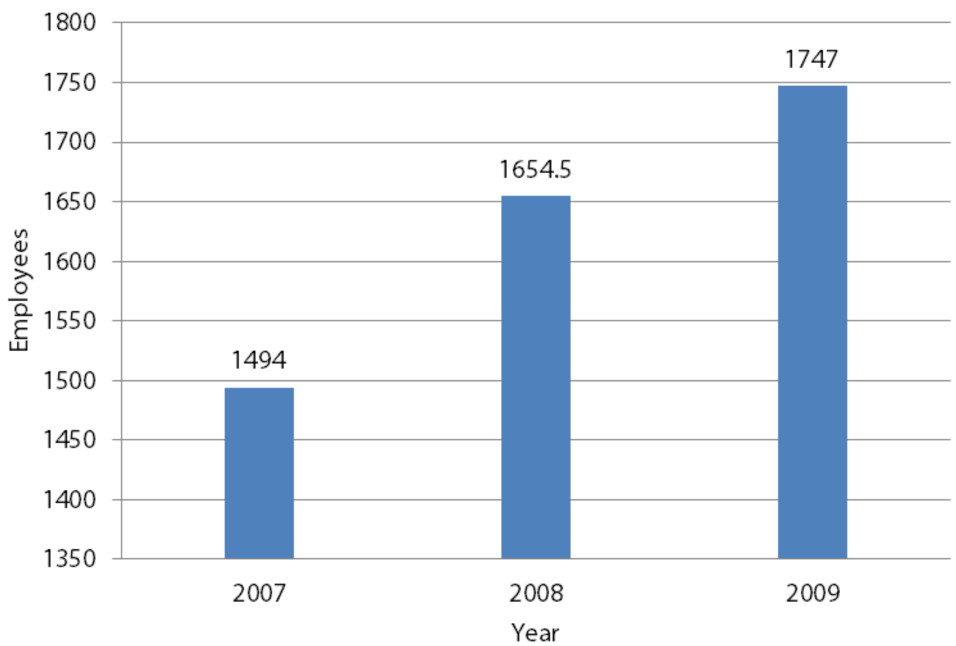

Figure 4.12: Number of employees in clean technology enterprises of Latvia
Source: the Register of Enterprises of the Republic of Latvia (www.ur.gov.lv *) and the Databases of Enterprises, Ltd* (www.lursoft.lv*).*

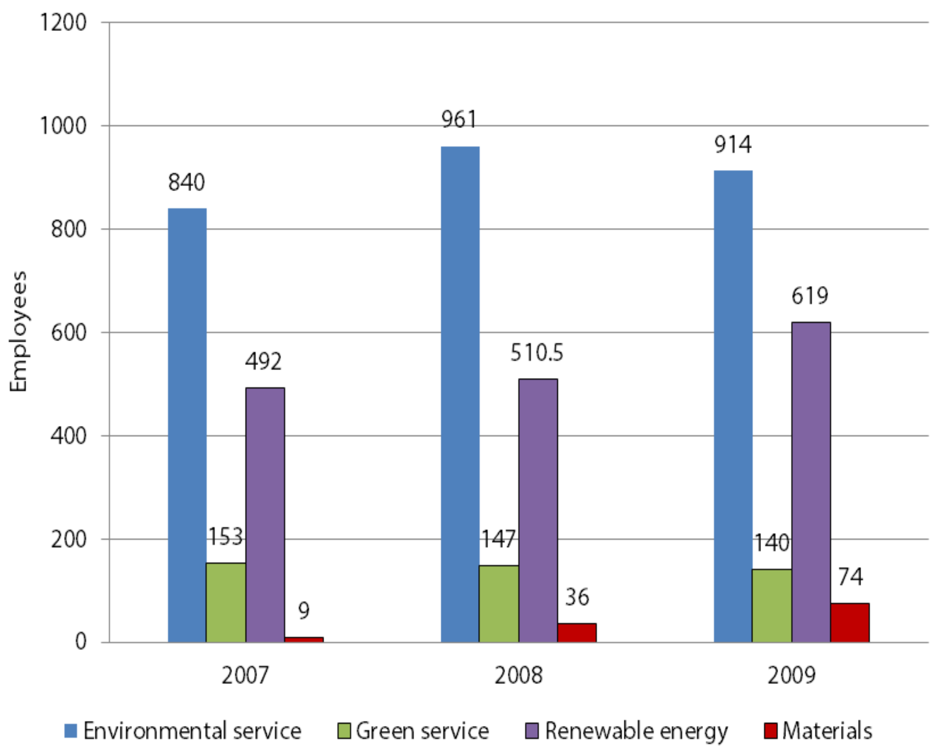

Figure 4.13: Breakdown of the number of employees in Latvian clean technology enterprises by sub-field

Source: Compiled by the author

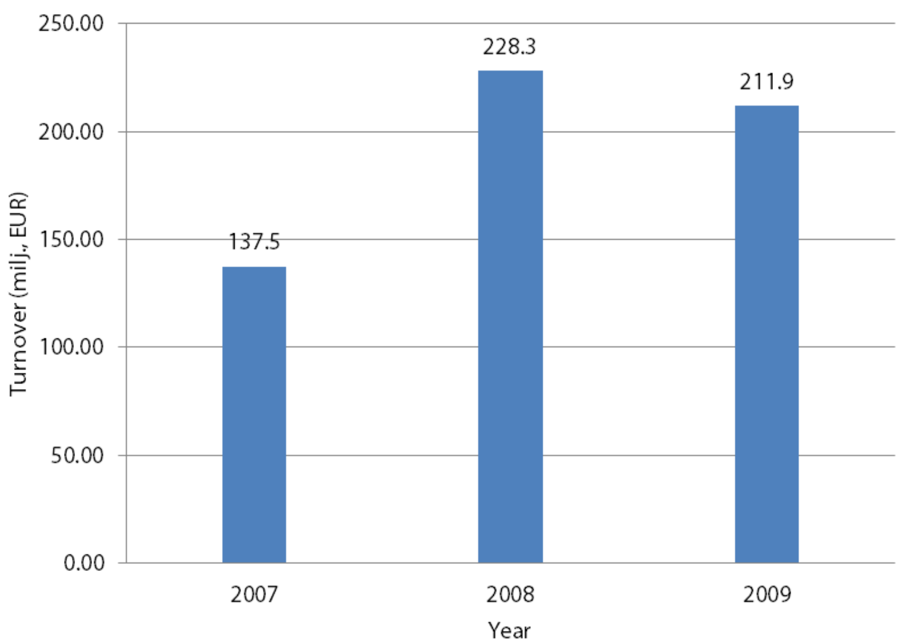

Figure 4.14: Total turnover of Latvia clean technology enterprises.

Source: the Register of Enterprises of the Republic of Latvia (www.ur.gov.lv) *and the Databases of Enterprises, Ltd* (www.lursoft.lv)

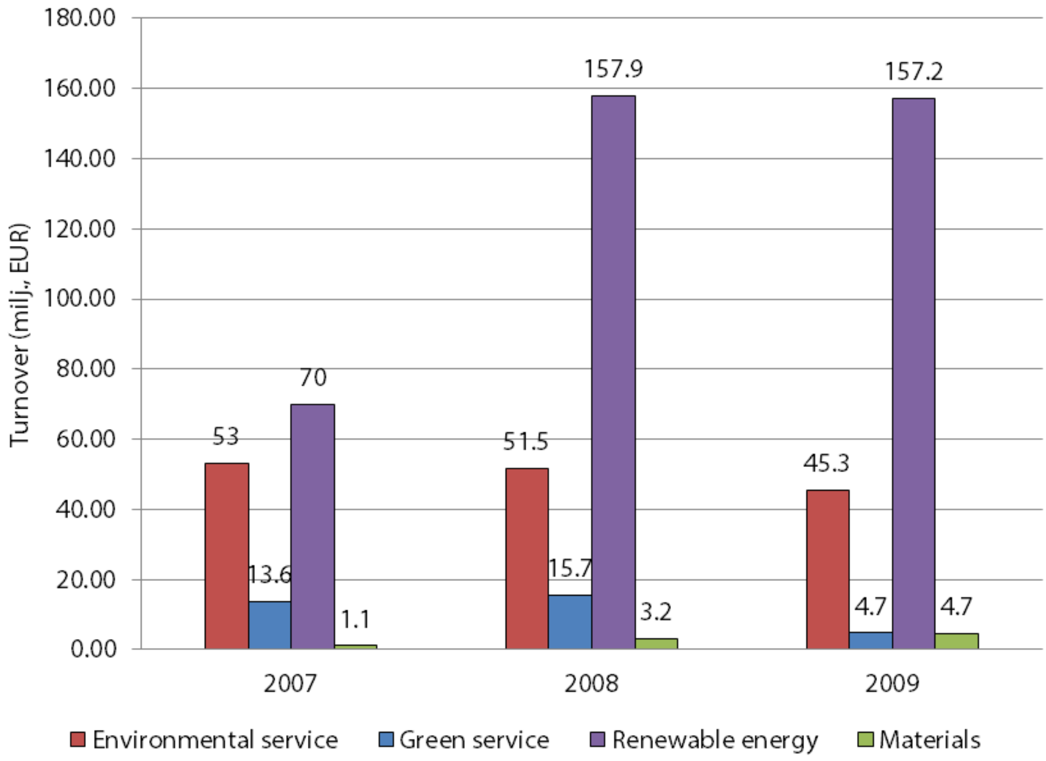

Figure 4.15: Breakdown of the Latvian clean technology enterprise turnover by sub-field

Source: Compiled by the author

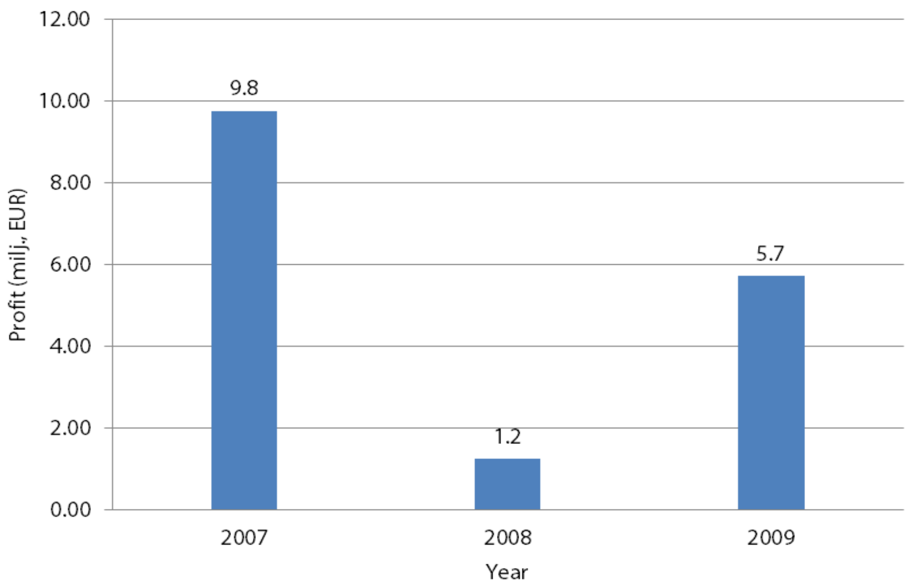

Figure 4.16: Total profit of Latvian clean technology enterprises

Source: the Register of Enterprises of the Republic of Latvia (www.ur.gov.lv) *and the Databases of Enterprises, Ltd* (www.lursoft.lv)

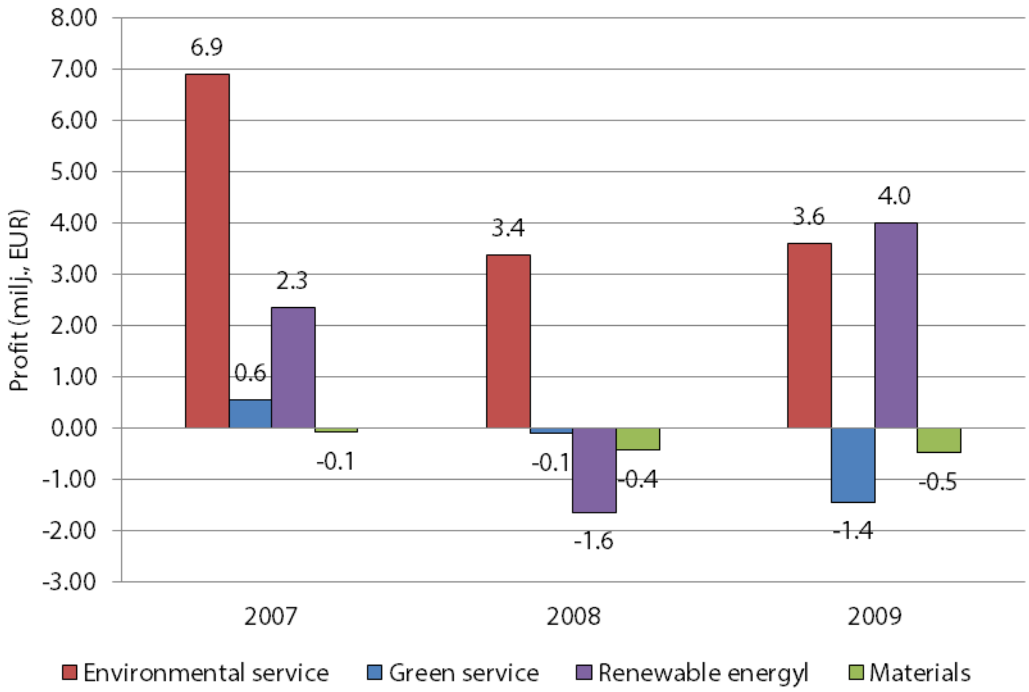

Figure 4.17: Profit breakdown of Latvian clean technology enterprises by sub-field.
Source: Compiled by the author

2.7 Financial needs

Companies were interviewed regarding investment plans for business development. The following answers were compiled:

Investment need area	Answers	No. of companies
R&D	Yes	18
	No	10
Manufacturing	Yes	24
	No	4
Marketing	Yes	14
	No	14

Source: Author based on company interviews

According to these data, the dominating investment field planned by the companies was manufacturing. The following trend can be observed for some companies. Firstly, manufacturing is developed, followed by improving technology based on R&D. Only when manufacturing is established and the product/ service design is developed, the marketing research is launched. However, 11 companies provide the three activities simultaneously.

The next question of the interview was related to using external financial sources for project realization and other cleantech business activities.

Financial source	Yes	No
Bank	5	23
Venture capital	1	27
Public organization	18	10
Customers	15	13
Shareholder	20	8
Other	5	23

Source: Author based on company interviews

As can be seen, the companies are mostly oriented at their own capital or support from public organizations (mostly through the programs of IDAL). Using bank and venture capital financing is not widespread. After the economic crisis, the politics of banks is extremely vigilant providing strict conditions of crediting often not acceptable to companies. A venture capital foundation program with government support was launched in 2008, but later these activities were not promoted.

Favorable conditions for a more rapid development of the cleantech have not been provided intensively enough, which is to a great extent related to low availability of investments as local investors are oriented towards branches yielding profit more rapidly, and foreign investors have taken the wait-and-see position.

3. Sub-clusters

3.1. Sub-cluster of environmental protection

In the sub-cluster of environmental protection, enterprises operating in different cleantech sub-fields are included (see Annex 4.5). Altogether, there are 29 enterprises in this sub-cluster. Taking into account the fact that the sub-fields of waste management and waste water treatment have the biggest contribution in terms of turnover and number of employees the general overview of the two sub-fields is provided.

General overview

Waste management

About 750 000 tons of municipal waste are produced in Latvia annually. Approximately one half of the quantity can be regarded as biodegradable municipal waste. Management of municipal waste within administrative territories is the responsibility of municipalities. The majority of the collected municipal waste and other types of waste are buried in dump sites without pre-treatment. About 40 % of the waste collected is buried at the Getliņi Eko landfill site ("Waste management").

About 97 000 tons of hazardous waste is produced in Latvia annually. The majority of hazardous waste (60 %) is arises from metal production. At present, the hazardous waste is temporarily stored at the premises of business companies and special waste storage sites.

Legislative framework on waste management in Latvia provides that tenants are responsible for organizing waste management in their property. Usually they are signing an agreement directly with a waste managing company on waste management. However, there are also some municipalities that have undertaken the responsibility of managing waste in their territory. In this case, tenants are co-operating directly with the municipality on waste management.

According to the Waste Management Plan, 10 to12 regional landfill sites will be developed and the existing dumping grounds will be closed and recovered as follows:

- Until 2010 – construction of the regional landfills according to requirements of Directive 1993/31/EK
- Until 2010 – closing of the existing dumping grounds and complete recovering until 2013
- Waste collecting and sorting and processing equipment incorporated in the new landfill projects

Latvia is divided in 11 waste management regions. For each region a separate waste management plan has to be developed and approved by the Cabinet of Ministers of Latvia. Currently 7 regional landfills are in operation and in two of them (landfill "Getlini" and landfill "Kivites") landfill gas is collected and used for heat and electricity production. In landfill "Daibe", a gas collection project is in the stage of development.

Waste water treatment

Due to pollution, water, air and "surface of the ground" are crucial problems in Latvia. In order to solve it, the government should implement investment programs, take control over standards of environment quality and natural resources as well as their implementation and, of course, invite qualified environment experts. Also, people should have more access to information about the environment, its changes and problems. Traditional methods of environmental conservation, for example economical, technological and regulatory incentives should be initiated. These measures should be applied as soon as possible as the ultimate efficiency of these activities is determined by economic processes and they are not directly related to environment protection. In Latvia, high amounts of pollutants and extensive utilization of resources are mostly caused by using out-of-date technologies. Therefore, technological measures should be most efficient. In order to diminish emissions of harmful substances and use resources more efficiently introduction of modern technologies and equipment should be encouraged in the country.

It is important to note that environmental services started to progress after joining the EU in 2004. It was partly related to stricter environment protection rules by the EU, as well as to availability of different EU financed waste management and environmental services programs. It has promoted development of clean technologies. Mostly no new companies were established, but the existing ones started to manage technology development parallel to their operation.

Financial analysis

The turnover in the environmental protection group is largely related with the nature of service provided by an enterprise. Some enterprises provide special environmental purification service, and one enterprise is completely sufficient for such type of service in a country as small as Latvia. For example, *BAO JSC* is running the business of utilization of environmentally hazardous, medical and other types of specific pollution. Thus the firm's turnover of EUR1.96 million largely depends on demand of such specific pollution assessment in Latvia. Analogically, *Eko Osta Ltd*, with its turnover accounting for EUR 2.47 million, runs the business of elimination of specific environmentally harmful factors (soil pollution). Sometimes competition between both firms emerges. This happens in case when elimination of a type of pollution falls within the specific competence of both firms.

Firms engaged in waste management have a comparatively big turnover. Usually such firms are servicing a particular area which mainly defines their turnover. For these firms, the turnover also depends on the scale of other activities related to environmental adjustment. For example the turnover of *Ventspils labiekārtošanas kombināts* accounts for EUR 5.8 million, *Liepājas RAS* – EUR 1.36 million, and *ZAOO* – EUR 3.4 million.

70% of enterprises in the environmental service group operated with profit in 2009. Only 2 out of 28 enterprises suffered considerable losses.

The turnover dynamics in the group of environmental protection shows a decreasing trend from 2007 till 2009. To a great extent it is related with economic crisis. Compared to 2007, the profit decreased two times in 2008, but in 2009 it even slightly increased. It is important to note that in every case the total profit of environmental protection enterprises remained positive in 2008 and 2009. At the same time, compared to 2007, the number of employees in 2008 increased, but in 2009 it slightly decreased. The data that, at first sight, may look conflicting can be explained by the fact that service costs in environmental protection sector were raised in 2007, whereas beginning from 2008 the salaries decreased.

Barriers for growth and financial needs

The barriers to environmental services companies are mainly associated with the needs to stabilize and expand the business activities. The main stability factor is providing environmental services according to the needs of the Republic of Latvia. Taking into account that the trends of the "green" politics in Latvia always improve, the demand for environmental services is steadily growing. Due to that, it is important for companies to be involved in different programs promoting development of innovative services. Regarding expansion of the market share the environmental protection companies start their activities mainly in the former republics of the Soviet Union and Yugoslavia. The EU market needs more developed innovation aspects to be competitive in these markets. Some companies are beginning to operate in the EU markets by participating in joint projects together with partners of other EU countries.

Opportunities to develop new technologies, entering new markets and improving manufacturing facilities determine the financial needs. However, not all companies believe that investment in technology development must be made before investing in manufacturing.

3.2 Sub-cluster of green service

General overview

The period of 2009-2011 can be characterized by an increasing number of companies offering green services like biohumuss and sapropel. 10 companies are currently involved in this sub-cluster.

Shortly about both products:

Biohumuss is a result of organic waste treatment using "California Red" earthworms. This is all organic process, where the "California Red" worms produce high-quality assistance biohumuss having no analogue in the world. Biohumuss has a good influence on soil micro flora acquiring 12-25% more plant germination. By using bio humus, the yields are obtained 2-3 weeks earlier. Sapropel is freshwater mud sediment consisting of organic chemical and minerals and can be found mainly in lakes. Sapropel is a long-acting fertilizer with a positive impact on environment. Adding sapropel to soil results in 40-50% faster crop growth.

In 2009, there were 4 companies offering biohumuss, in 2011, there are more than 15 companies the biggest being Biohumuss producers association www.biohumuss.com with 360 members in Latvia.

In 2009, there was only one company using sapropel as an ingredient in cosmetic production. Now there are more than 10 companies offering sapropel from Latvian lakes for further use in agriculture as fertilizer, in cosmetic industry and medicine.

In 2011 another company launched its operation offering a highly effective fertilizer obtained by processing chicken and other poultry feces.

Financial analysis

Compared to 2008, the turnover of the green service enterprises substantially decreased in 2009. It refers also to the profit/loss.

It is difficult to evaluate the green service group turnover in 2009 as only 4 enterprises launched their activity in that year and 95% of the group turnover was made by *Primeks Ltd*. 6 green service enterprises launched their activity in 2010.

Barriers for growth and financial needs

The negative trend of the financial data can be partly explained by the consequences of the national subsidy policy. On the other hand, there are relatively many recently established enterprises in this group and due to this fact improvement of the financial parameters is expected in this sub-cluster.

The activities of green service companies involve applying approaches relatively new on international scale. The program shows a growing demand, because it is based on sustainable development of soil and environment. Due to that, it is important for companies to be involved in different programs promoting development of innovative services. Regarding increase of the market share the green service companies should expand their marketing activities by participating in exhibitions and trade missions.

Opportunities to develop new technologies, entering new markets and improving manufacturing facilities determine the financial needs. Doing all these activities parallel to each other is a challenge to the green service companies.

3.3 Sub-cluster of renewable energies

The cluster involves 15 companies representing different sub-fields of renewable energies. Taking into account that according to quantitative data the largest contributors are enterprises of biodiesel, bioethanol and biogas production, a general background is provided on these sub-fields.

General background

Biogas production

By the end of 2010, there were 11 biogas cogeneration plants operating in Latvia. Their total installed electricity production capacity was 13.46 MWel.

Latvia has a good infrastructure and framework for waste collection however the waste is not separated, and mostly ends up in landfill sites. The EU standards of waste collection and handling have been largely adopted; however, there are only some pilot programs for waste separation and recycling. In order to implement biogas waste treatment and energy production facilities, collection, sorting and recycling economy must be brought up to a standard that the efforts make sense from the economic perspective.

Important areas of biogas production, based on biomass potential, as well as the main types of resources that could be used for biogas generation, could be completed with details related to land fragmentation and crop diversity, ownership structure and livestock peculiarities.

The number of comparatively small farms is considerable in Latvia and this might have a negative impact on the development of effective potential sites. On the one side, small-size biogas production units could be a solution to the high fragmentation of farming. On the other side, more diverse farms (including farm types, size, production capacity and crop heterogeneity) means better diversity in opportunities for different anaerobic digestion patterns.

One of the most significant environmental impacts resulting from growing energy crops for biogas production is changing the use of land. Since almost 40 % of the available agricultural land in Latvia is still not used for agricultural production, each activity promoting usage of agricultural land including biogas production will give a positive impact on farmers' income and the general rural development. Biogas production could contribute to a more intense usage of the available agricultural land allowing for an increase of the farmers' living standard.

Exploitation of locally produced renewable energy resource like biogas would allow for reducing dependency on the imported fossil fuels and for strengthening the national and regional economy in Latvia. In order to achieve it and to be able to compete with fossil fuels, strong incentives or subsidies are required. Yet, a new power tariff system for biogas electricity is introduced in Latvia; still the efficiency of the new system is not proved by real projects.

The current renewable energy support instruments in Latvia are as follows:
Legal instruments:

- National regulations (No 592) for power tariffs of renewable energy suppliers;
- Specific regulations (No 221) for electricity produced in central heating plant (the net heat power that must be delivered to public heat grid).

Financial instruments:

- Rural Development Support Program (Reg. No 696) for agriculture type RES energy plants (up to 40% from investment);
- National climate financing instrument (up to 50% from investment).

The biogas production increased considerably some years after joining the EU. It is related with the EU regulations and policy regarding renewable energy sources, as well as access to the financial support instruments. For example, in 2007 there were 3 biogas plants of 7,5 MWel power, but in 2010, 11 biogas plants of 13,46 MWel power.

Another important aspect worth mentioning is that companies are involved in technology development using the European Regional Development Fund (ERDF) program support by the IDAL. In this way, companies started manufacturing and using clean technologies.

Biodiesel and Bioethanol producing

Since Latvia regained its independence in 1991, the institution developing the energy policy, especially regarding the energy sector, is the Ministry of Economics (Department of Energy) supported by the Government and the Parliament. However, since 2005 issues concerning renewable energy sources are also addressed by the Ministry of Environment (Climate and Renewable Energy Department), yet the main role and decision-making power belong to the Ministry of Economy. Two other executive institutions, the Investment and Development Agency of Latvia (IDAL) and the Public Utilities Commission (Regulator), have minor influence at the political level; the last one is in charge of setting the network tariffs and default supply tariffs.

Since Latvia lacks fossil resources it has a high level of import dependency with oil and gas imported mainly from Russia. Hydro energy and gas provide nearly all domestic supply of electricity, with wind and biomass added in recent years and contributing less than 1% from all energy produced from renewable energy sources. There are two bioethanol production plants, five biodiesel plants and seven rapeseed oil production plants operating in Latvia. Regarding the information given by the Latvian Ministry of Agriculture over the next few years at least six new biofuel production plants will be developed. In 2009, the total annual capacity of biodiesel plants was around 251,000 t, while bioethanol production units had a capacity of 35,000 t. In 2008, 71 % of the biodiesel and 93 % of the

(100 %) bioethanol produced in Latvia was exported to other EU Member States. 100 % biodiesel can currently be purchased at 14 filling stations.

Biodiesel producer capacity in Latvia covers 5 % mix with fossil fuel. Businesses are ready to produce biodiesel and bioethanol, but the following factors cause problems:

- The local demand for the production is small;
- The lack of promoting policies to stimulate the end-users;
- Weak financial support from the state;
- Strong lobbying by fossil fuel retail traders.

Financial analysis

The turnover distribution by cleantech sub-fields is provided in Annex 4.4 suggests that the highest turnover of EUR 157.19 million was shown by the renewable energy group. Nevertheless, 90% of the group turnover is composed by 3 producers of biofuel (B*io-Venta, Jaunpagasts plus, Latraps*) which have stabilized their production and sales in the export markets. The turnover breakdown by enterprises is more even in other groups.

The second biggest group enterprise (*Bio-Venta*) having suffered a loss in the amount of EUR 1.2 million had a negative impact on the overall situation in the renewable energy field. At the same time, the profit of the two other enterprises in the group, namely *Jaunpagasts plus Ltd* and *k/s Latraps*, was considerably big (EUR 3.7 and 2.3 million respectively). The comparative losses were rather high in the green service sector due to the losses of EUR 1.43 million by the biggest enterprise of the group.

The total turnover of the renewable energy sub-field did not show a tendency of decrease even during the economic crisis. However, in 2008 this group suffered relatively large losses arising from the political uncertainty of the government regarding subsidy.

After systematizing these regulations, the profit in 2009 returned, and even exceeded the level of 2007.

Barriers for growth and financial needs

The financial data of this sub-cluster are better compared to other cleantech clusters, and indicators show a necessity to correct the applied manufacturing technologies in the future. Due to that, it is important for companies to be involved in different programs promoting development of innovative services. The market expanding aspects of the renewable energy companies is not crucial as the biofuel and bioethanol manufacturers are already export oriented in the early stage, but biogas manufacturers are the local service providers. However, the biogas manufacturers' perspective is to manage the technology transfer to other regions. Due to that, it is important for these companies to develop innovative approaches and international cooperation.

Opportunities to develop new technologies, entering new markets and improving manufacturing facilities determine the financial needs.

3.4. Sub-cluster of materials

This sub-cluster is represented by companies offering energy saving technologies and environment friendly materials.

General background

Increasingly more attention is paid to energy saving technologies and design of new environment friendly materials.

The last 2-3 years are characterized by appearing of new companies offering innovative and environment friendly decisions. These companies are expected to be the new business incubators tenants; Kuldiga business incubator[196] and Valmiera business incubator[197] can be mentioned.

196 www.kbi.lv
197 www.vbii.lv

Other companies have successfully used grants from the EU programs to develop ecofriendly construction materials as well as polymer residue processing technologies.

Another successful trend of the new companies is research on rubber residue recycling methods and material properties of different treatment processes.

A bright example is ecological and environment friendly heat insulation material – ecowool Vekover as a solution to sound isolation and absorption, offered by JTS Ltd. The company is the only wood wool cement board (WWCB) producer in the Baltics with over 45 years of expertise in the domestic and international markets.

Vekover ecowool is a high-quality, heat insulating building material made from wastepaper. It is used for heat insulation of both dwelling and industrial buildings.

There are also the newest technologies in packaging materials manufacture offered such as Bio bags made from bio polymer of natural components (corn or potato starch). These bags comply with all European norms of bio packaging (EN13432).

Financial analysis

According to Annex 4.4 and Figure 4.15 the turnover in this sub-cluster from 2007 till 2009 has a growing trend. However, 2 out of 3 material group enterprises suffered significant losses; consequently the comparative losses of the group are big.

Losses are largely related with the consequences of the national subsidy policy. More detailed information could not be obtained because the enterprises are reluctant to talk about the reasons of losses.

Barriers for growth and financial needs

The activities of materials companies are related with two important aspects, i.e. energy saving and environment friendly living conditions. Both trends to a great extent are related with the government support programs. In Latvia, there is a building heat insulation program.

Taking into account that similar programs are in other EU countries a serious barrier is export expanding as Latvia is a relatively small country and demand for these materials will be insufficient to ensure rentable manufacturing.

4. Conclusions

4.1. SWOT analysis of the Latvian cleantech cluster

Strengths	**Weaknesses**
Cleantech related graduates of master and bachelor study programs are available. Many cleantech enterprises cooperate with scientific research organizations. The growth trends (turnover, profit, number of personnel) of clean-tech companies after the economic crisis have returned. The sub-field of renewable energies posts the most significant growth. Export is significant in sub-fields of renewable energies and green services. Self-organized interaction among the companies based on everyday business needs.	There are no cleantech related clusters in Latvia Lack of qualified personnel with Dr. Sc. degree in clean technologies. Patenting activities by clean technology enterprises are not sufficient. Contribution of academic and other research organizations exists, but the research should be more industrial oriented. The network of cleantech community support organizations is underdeveloped and weakly coordinated. Minimal interaction among the cleantech companies not overlapping their short-term business activities, i.e. among different cleantech directions. Relatively low average export in the direction of environmental protection. Lack of new business models corresponding to XXI Century challenges
Opportunities	**Threats**
State support for research and introduction of new technologies is available for cleantech companies, and they also collaborate with the scientific research insti-	Availability of venture capital and other financial instruments is limited. Lack of government programs supporting

tutes. A support program for competence centers is initiated. There are documents for cleantech planning in Latvia. The world-wide trends of green policies promote cleantech development in Latvia. Opportunities to participate in the EU supported projects of clean technologies throughout the recent years have improved. Export expansion opportunities for environmental protection companies in Russia and the republic of the former Yugoslavia. A cluster support program is planned to be launched in 2012.	patenting. The government program of cluster development is temporarily stopped. The budget consolidation of the government can induce a decrease of the support programs. Potential difficulties to create a cluster due to an insufficient interaction among enterprises of different cleantech directions. The global economic crisis.

4.2. Policy recommendations (guidelines for developing suitable regional cluster policies)

The SWOT analysis, informal discussions with cleantech enterprises as well as evaluation of national policy planning documents revealed issues about clean technology policy making in Latvia.

1. Developing tighter interaction among enterprises of **different clean technology sub-fields** to create the conditions for establishing a cleantech cluster. It is important to organize events and other activities which can help to improve the communication. Successful initiatives are always the result of fruitful coordination of the public and private sector. It is important for

policy makers to take into consideration all **relevant agents** and promote co-operation.

2. Promoting international co-operation to learn the experience of co-operation and creating clusters. Co-operation at the international level helps the national policy makers to follow directives that **incorporate the expertise of multiple national constituencies and have been tested.**
3. Expanding of clean technology related programs with doctoral study programs. In the case of lack of local teaching competence, looking for opportunities **to delegate students for doctoral study abroad.**
4. Promoting programs which would activate **the patenting activities** of enterprises.
5. Further development of **interaction between enterprises and research organizations** to promote industrialization of the scientific research. It is necessary for policy makers to take into consideration the factors disturbing the execution of the existing corresponding programs effectively.
6. Improving the **availability of venture capital and other financial instruments** for cleantech oriented enterprises. The policy makers should take into consideration both the opinion of enterprises and financers.
7. During the designing of the Latvian National Development Plan for the 2014 - 2020 there should be environmentally friendly technology industry defined as **one of the most perspective economic development directions.**
8. Policy makers during the planning the allocation of EU Structural Funds for 2014 - 2020 programming period, should **include specific support measures** for promotion of environmentally friendly technologies.
9. The Ministry of Environmental Protection and Regional Development during the monitoring of regional development plan elaboration process (regional and local authorities as implementing bodies) should keep the requirement **to integrate on renewable energy sources focused energy plans** in regional development policy documents.
10. The local and regional spatial planning documents must define location of **potential wind parks** and the regulations for use of land and construction of buildings must include **requirements for renewable energy (solar, biomass, geothermal).** It is necessary to develop a state policy to promote the use of renewable energy resources supported by **tax reductions and special green investment schemes**.
11. In the process of updating existing short-term and medium-term policy planning documents that directly affect the environment-friendly technologies industry and companies, they should **include the action programs,**

specific support instruments, responsible bodies and the timing for implementation the support measures.

12. The action plan should include concrete measures in these areas aiming to provide favourable conditions for the cleantech sector that are needed in order to deliver world class solutions to a sustainable future. Furthermore, the action plan should highlight the importance of an **effective structure (range of particular partners)** for the Latvian cleantech sector, which may be achieved through an action-oriented, national unit coordinating the efforts of different bodies.
13. **To strengthen the targeted message of state aid policy for cleantech**, policy planning documents should clearly define areas of cleantech industry and certain economic activities according to NACE classification (2nd version).
14. Planning documents must integrate **effective models of collaboration between private and research/ education sector** (key structures - liaison offices/ technology transfer offices, excellence centers, cluster initiatives, professional associations etc.), as well as cooperation with public institutions (particular department of coordination unit on cleantech issues).
15. **The state institutional support to cleantech industry** should be defined in order to decrease possible administrative barriers and to foster political and economic achievements in cleantech industry (e.g. Advisory Council on cleantech issues). Main responsible structures - Ministry of Environmental Protection and Regional Development, Ministry of Economy and Investment and Development Agency of Latvia.
16. Policy makers have to take into account the local and global environmental challenges in the near future (5-7 years) and **define more precisely the most perspective areas** for cleantech companies and clusters, thus pointing out the industry's role in implementation of sustainable state policy. The key areas could be the following: use of renewable energy resources, storage and logistics of materials, development of new, cleantech materials, cross-sector products and collaboration.
17. Policy planning documents should include more precise **list of responsibilities of corresponding institutional bodies and potential social partners** that play a particular role in establishment and development of cleantech industry and cluster initiatives. The list should definately include such structures representing state, research and private sector as: Ministry of Environmental Protection and Regional Development, Ministry of Economy, Investment and Development Agency of Latvia, Latvian Guar-

antee Agency, Latvian Academy of Sciences, Competence Centre for Environment Protection, Biotechnology and Bioenergy, The Enterprise Europe Network Office in Latvia, Latvian Technological Center and the professional industry associations.

18. The following gaps should be fixed in policy planning documents in the context of support for the cleantech industry development:
    - **Environmental Policy Strategy for the 2009 – 2015** - the **strategic objective** should be clarified, including support for the cleantech sector;
    - **National Development Plan 2007 – 2013** – should be supplemented with **the list of the responsible authorities** for the implementation of tasks related to cleantech industry;
    - **Entrepreneurship Competitiveness and Innovation Promotion Program for 2007 - 2013** –the need for corrections for **vision, strategic objectives, action programs** and **listing of responsible institutions** should be evaluated.
19. The position of the government should be formulated on what is the most acceptable **model of combining both private (risk capital) and public (state budget and EU structural funds) investments** for supporting cleantech industry (taking into accounts administrative barriers related to the 'de minimis' and other EU directives conditions adapted by Latvia).
20. Planning documents have to be based on **data analysis on the merits**, to define more precisely an economically justified projections and determine the perspective directions of economic development in Latvia.
21. The national **legislation of intellectual property protection and administration issues** has to be review in order to enable universities to commercialize more effectively their inventions.

4.3. Recommendations on enhancing private investments

Since additional early stage support tools have appeared in Latvia, the companies are more capable to meet investors' requirements, still the **challenges on payback period and lack of significant growth potential** appears during the preparation of investment readiness.

The following recommendations for enhancing private investments are offered:

1. The position of the government and the rules should be formulated on **how to create the new funding framework including both private (risk capital) and public (state budget and EU structural funds) investments** and what are the basic financial and managerial requirements from all involved parts – state, investor and entrepreneur. In particular, it concerns to 'de minimis' and other EU directives conditions adapted by Latvia.
2. The companies looking for investment have **to re-design the business model to provide payback period no longer than 7 years** which is acceptable time period for risk capital investor. The government has to provide specific business competences to the investment subjects for elaboration the business models of shorted payback period.
3. **More intensive collaboration between private and research sector** has to be promoted, in particularly this role should be in charge of the state institutions responsible for development of knowledge economy. This will help to create new intellectual property rights used also in Clean Tech industry and making the Clean Tech business projects more attractive to risk capital investors since there will be used new technologies and not the adapted ones.
4. The Clean Tech companies have to regularly use the following basic tools **to increase the value of their intellectual property rights:** services of liaison offices (technology transfer offices in the universities), participation in projects implemented by Excellence centers, being involved in activities initiated by professional organizations (Latvian Biotechnology Association, Association of Latvian Chemical and Pharmaceutical Industry etc.) and cluster initiatives, contract research done by the universities and research institutions.
5. The responsible public authorities (Ministry of Environmental Protection and Regional Development, Ministry of Economy, Ministry of Finance as well as Investment and Development Agency of Latvia, etc.) in close collaboration with Latvian Venture Capital Association should create **particular coordination unit** responsible for enhancing the private investments in Clean Tech industry by decreasing administrative barriers, setting priority support for market identification, attracting business competence and promoting cross-sector collaboration as well as decreasing economic risks by setting strict conditions for investment protection and tax policy.

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“Renewable Energy in Latvia”,
http://www.exim.lv/uploaded_files/catalogue_files/Renewable%20Energy.pdf

“Waste management, air pollution, energy from renewable resources in Latvia”, http://eng.atlants.lv/essays/waste-management-air-pollution-energy-from-renewab-/587702/

Annexes

Annex 4.1: Supported cleantech related projects under program of competence centre

No.	Project title	Enterprise	Cleantech sub-field
1.	Biological treatment of water containing pharmaceutical and petroleum compounds	Grindeks, JSC	Waste water treatment
2.	Research of fermentation process control and other interaction factors in laboratory and pilot scale	Biotehniskais centrs, JSC	Environment protection
3.	Biomass conversion in steam explosion to improve fodder, extract fodder additives and derived products	Zalie Lielkalni, Ltd	Waste management
4.	Isolation of methan-forming bacteria in Latvia' s biogas reactors and research of its biotechnological indicators	Biogas, Ltd	Biogas
5.	Research of new biogas formation enhancing bioactive substances and their indicators	Biogas, Ltd	Biogas
6.	Ozone exploitation technology development for raising efficiency in poultry	Balticovo, JSC	Environmental protection
7.	Varnish and paint industry wastewater treatment with chemical and biological methods	Biolar, Ltd	Waste water treatment
8.	Inorganic sulfur removal from biofuel production residual feasibility study	SPD Energo, Ltd	Biofuel
9.	Research of impact of new substrate processing technologies on the anaerobic digestion and biogas production	SPD Energo, Ltd	Biofuel
10.	Improvement of biomass recycling processes and their parameters using physical methods	Advanced Technologies, Ltd	Renewable energies
11.	Development of pig farming by-products' processing technology	Advanced Technologies, Ltd	Waste management
12.	Research of wastewater sludge and other organic substances anaerobic co-fermentation technologies and their optimization opportunities, research of digestate efficient exploitation technologies	Zalas Tehnologijas, Ltd	Waste water treatment
13.	Municipal and industrial wastewater sludge environment friendly depositioning and production of energy with high efficiency coefficient	Advanced Technologies, Ltd	Waste water treatment

14.	Hazardous industrial waste recycling for raw materials and energy production	BAO, JSC	Waste recycling
15.	Innovative, environment-friendly solutions for the modernization of chlorine-containing technological processes	BAO, JSC	Environment protection
16.	Innovative microbiological, chemical and physical methods, processes and technologies of waste treatment, destruction and processing	Eko Osta, JSc	Waste recycling
17.	Synthesis and biodegradation studies of vegetable oil-based surfactant substances	Auravia Latvia, Ltd	Waste recycling
18.	Landfill gas cleaning concept development according to internal combustion engine and gas turbine technical requirements	Getlini Eko, Ltd	Waste recycling
19.	Quality improvement of landfill gas	Getlini Eko, Ltd	Waste recycling
20.	Assessment of landfill surface coating emissions	Getlini Eko, Ltd	Waste recycling
21.	Study of trigeneretion installation options in landfill energy-units	Getlini Eko, Ltd	Waste recycling
22.	Research and development of concept of waste separation in order to acquire recycled materials as well as RDF	Getlini Eko, Ltd	Waste recycling
23.	Development of waste storage fill and life expectancy detection methods	Getlini Eko, Ltd	Waste recycling
24.	Landfill leachate formation, composition, collection and treatment model development	Getlini Eko, Ltd	Waste recycling

Source: Management of the Competence Centre for Environment Protection, Bioenergy and Biotechnology

Annex 4.2: Research publications of Latvian scientific institutions in cited international journals (during the 5 last years)

No	Publication, including authors, name, journal data, citation index	Cleantech cub-field
1.	Tihomirova, K., Rubulis, J., Juhna, T. Changes of NOM fractions during conventional drinking water treatment process in Riga, Latvia. (2010) Water Science and Technology: Water Supply, 10 (2), pp. 157-163	Water purification
2.	Mezule, L., Tsyfansky, S., Yakushevich, V., Juhna, T. A simple technique for water disinfection with hydrodynamic cavitation: Effect on survival of Escherichia coli. (2009) Desalination, 248 (1-3), pp. 152-159	Water purification
3.	Sire, J., Klavins, M., Kreismanis, J., Jansone, S. Impact of the process of isolating humic acids from peat on their properties. (2009) Canadian	Water purification

	Journal of Civil Engineering, 36 (2), pp. 345-355	
4.	Juhna, T., Birzniece, D., Larsson, S., Zulenkovs, D., Sharipo, A., Azevedo, N.F., Ménard-Szczebara, F., Castagnet, S., Féliers, C., Keevil, C.W. Detection of Escherichia coli in biofilms from pipe samples and coupons in drinking water distribution networks. (2007) Applied and Environmental Microbiology, 73 (22), pp. 7456-7464. Cited 16 times	Water purification
5.	Juhna, T., Birzniece, D., Rubulis, J. Effect of phosphorus on survival of Escherichia coli in drinking water biofilms. (2007) Applied and Environmental Microbiology, 73 (11), pp. 3755-3758. Cited 8 times	Water purification
6.	Klavins, M., Eglite, L., Zicmanis, A. Immobilized humic substances as sorbents. (2006) Chemosphere, 62 (9), pp. 1500-1506. Cited 4 times	Water purification
7.	Klavins, M., Purmalis, O. Humic substances as surfactants. (2010) Environmental Chemistry Letters, 8 (4), pp. 349-354	Waste water treatment
8.	Klavins, M., Kokorite, I., Springe, G., Skuja, A., Parele, E., Rodinov, V., Druvietis, I., Strake, S., Urtans, A. Water quality in cutaway peatland lakes in Seda mire, Latvia. (2010) Ecohydrology and Hydrobiology, 10 (1), pp. 61-70	Waste water treatment
9.	Grinberga, L. Environmental factors influencing the species diversity of macrophytes in middle-sized streams in Latvia. (2010) Hydrobiologia, 656 (1), pp. 233-241	Waste water treatment
10.	Kokorite, L., Klavins, M., Rodinov, V. Impact of catchment properties on aquatic chemistry in the rivers of Latvia. (2010) Hydrology Research, 41 (3-4), pp. 320-329	Waste water treatment
11.	Springe, G., Grinberga, L., Briede, A. Role of hydrological and hydromorphological factors in ecological quality of medium-sized lowland streams. (2010) Hydrology Research, 41 (3-4), pp. 330-337	Waste water treatment
12.	Cooper, W.J., Song, W., Gonsior, M., Kalnina, D., Peake, B.M., Mezyk, S.P. Recent advances in structure and reactivity of dissolved organic matter in natural waters. (2008) Water Science and Technology: Water Supply, 8 (6), pp. 615-623. Cited 1 time	Waste water treatment
13.	Terauda, E., Nikodemus, O. Sulphate and nitrate in precipitation and soil water in pine forests in Latvia. (2007) Water, Air, and Soil Pollution: Focus, 7 (1-3), pp. 77-84. Cited 3 times	Waste water treatment
14.	Stolte, W., Balode, M., Carlsson, P., Grzebyk, D., Janson, S., Lips, I., Panosso, R., Ward, C.J., Granéli, E. Stimulation of nitrogen-fixing cyanobacteria in a Baltic Sea plankton community by land-derived organic matter or iron addition. (2006) Marine Ecology Progress Series, 327, pp. 71-82. Cited 11 times	Waste water treatment
15.	Balcers, O., Teteris, J. Luminescence study of detergent optical brighteners in the context of developing optical environmental sensors for water quality control. (2006) Journal of Environmental Engineering and Landscape Management, 14 (3), pp. 121-125	Waste water treatment
16.	Springe, G., Sandin, L., Briede, A., Skuja, A. Biological quality metrics: Their variability and appropriate scale for assessing streams. (2006) Hydrobiologia, 566 (1), pp. 153-172. Cited 21 times	Waste water treatment
17.	Humborg, C., Pastuszak, M., Aigars, J., Siegmund, H., Mörth, C.-M., Ittekkot, V. Decreased silica land-sea fluxes through damming in the Baltic Sea catchment - Significance of particle trapping and hydrological	Waste water treatment

	alterations. (2006) Biogeochemistry, 77 (2), pp. 265-281. Cited 34 times	
18.	Viksne, A., Berzina, R., Andersone, I., Belkova, L. Study of plastic compounds containing polypropylene and wood derived fillers from waste of different origin. (2010) Journal of Applied Polymer Science, 117 (1), pp. 368-377. Cited 1 time	Waste management
19.	Gravitis, J., Aboliņš, J., Tupčiauskas, R., Veveris, A. Lignin from steam-exploded wood as binder in wood composites. (2010) Journal of Environmental Engineering and Landscape Management, 18 (2), pp. 75-84	Waste management
20.	Kuplais, G., Blumberga, D., Dace, E. System analysis for integration of landfill energy production in regional energy supply. (2010) WIT Transactions on Ecology and the Environment, 140, pp. 21-30	Waste management
21.	Malers, L., Plesuma, R., Locmele, L. A composite material based on recycled tires. (2009) Mechanics of Composite Materials, 45 (1), pp. 105-108	Waste management
22.	Gravitis, J., Abolins, J., Kokorevics, A. Integration of biorefinery clusters towards zero emissions. (2008) Environmental Engineering and Management Journal, 7 (5), pp. 569-577. Cited 4 times	Waste management
23.	Bakradze, G.G., Kajaks, J.A., Reihmane, S.A., Lejnieks, J.E. Correlation between the mechanical properties and the amount of desorbed water for composites based on a recycled low-density polyethylene and linen yarn production waste. (2007) Mechanics of Composite Materials, 43 (5), pp. 427-432. Cited 1 time	Waste management
24.	Grube, M., Lin, J.G., Lee, P.H., Kokorevicha, S. Evaluation of sewage sludge-based compost by FT-IR spectroscopy. (2006) Geoderma, 130 (3-4), pp. 324-333. Cited 38 times	Waste management
25.	Rozenstrauha, I., Bajare, D., Cimdins, R., Berzina, L., Bossert, J., Boccaccini, A.R. The influence of various additions on a glass-ceramic matrix composition based on industrial waste. (2006) Ceramics International, 32 (2), pp. 115-119. Cited 6 times	Waste management
26.	Belousova, R.G., Schwartz, E.M., Zarina, I.E., Valdniece, D.J. Low-toxicity boron-containing fire-retardant additives for polymeric coatings. (2010) Russian Journal of Applied Chemistry, 83 (2), pp. 328-331	Environment friendly material
27.	Shulga, G., Betkers, T., Brovkina, J., Neiberte, B., Verovkins, A., Belous, O., Ambrazaitene, D., Zukauskaite, A. New lignin-based polymers for ecological rehabilitation. (2008) Molecular Crystals and Liquid Crystals, 486, pp. 291/[1333]-305/[1347]. Cited 1	Environment friendly material
28.	Gravitis, J. Zero techniques and systems - ZETS strength and weakness. (2007) Journal of Cleaner Production, 15 (13-14), pp. 1190-1197. Cited 5 times	Environment friendly material
29.	Parra, V., Rei Vilar, M., Battaglini, N., Ferraria, A.M., Do Rego, A.M.B., Boufi, S., Rodríguez-Méndez, M.L., Fonavs, E., Muzikante, I., Bouvet, M. New hybrid films based on cellulose and hydroxygallium phthalocyanine. Synergetic effects in the structure and properties. (2007) Langmuir, 23 (7), pp. 3712-3722. Cited 6 times	Environment friendly material
30.	Gravitis, J. Nano level stuctures in wood cell wall composites.(2006) Cellulose Chemistry and Technology, 40 (5), pp. 291-298. Cited 4 times	Environment friendly material
31.	Michna, J., Bednarz, L., Elek, L., Ekmanis, J., Frormann, D., Mantorski, Z., Manoilova, T., Miskinis, V., Molochko, F., Ney, R., Prakhovnik, A., Rousek, J., Rudi, Ü., Rugina, V., Sieminowicz, J., Zeltins, N., Kaleta, P.	Environment protection

	Risk management on energy and environmental conservation in CEE countries. (2010) International Journal of Global Energy Issues, 34 (1-4), pp. 139-225	
32.	Dimante, D., Atstaja, D. The economies of the Baltic Sea Region in relation to green economics, with particular focus on Latvia: Environmental sustainability and well-being. (2010) International Journal of Green Economics, 4 (3), pp. 292-305	Environment protection
33.	Österblom, H., Gårdmark, A., Bergström, L., Müller-Karulis, B., Folke, C., Lindegren, M., Casini, M., Olsson, P., Diekmann, R., Blenckner, T., Humborg, C., Möllmann, C. Making the ecosystem approach operational-Can regime shifts in ecological- and governance systems facilitate the transition? (2010) Marine Policy, 34 (6), pp. 1290-1299. Cited 2 times	Environment protection
34.	Jankovska, I., Straupe, I., Panagopoulos, T. Professionals awareness in promotion of conservation and management of urban forests as green infrastructure of Riga, Latvia. (2010) WSEAS Transactions on Environment and Development, 6 (8), pp. 614-623	Environment protection
35.	Klavins, M., Potapovics, O., Rodinov, V. Heavy metals in fish from lakes in Latvia: Concentrations and trends of changes. (2009) Bulletin of Environmental Contamination and Toxicology, 82 (1), pp. 96-100. Cited 1 time	Environment protection
36.	Sliaupiene, R., Sliaupa, S., Shogenova, A., Shogenov, K., Vaher, R., Zabele, A. Industrial Carbon Dioxide emissions and potential geological sinks in the Baltic States. (2008) Oil Shale, 25 (4), pp. 465-484. Cited 4 times	Environment protection
37.	Ganeev, A.A., Ivanenko, N.B., Ivanenko, A.A., Kuz'Menkov, M.A., Skudra, A., Slyadnev, M.N., Yakovleva, E.M., Nosova, E.B. Direct and rapid determination of elements in the ambient air and in human exhalation using the electrostatic precipitation of aerosols in the graphite atomizer of a Zeeman spectrometer. (2006) Journal of Analytical Chemistry, 61 (1), pp. 84-91	Ambient air protection
38.	Purvins, A., Krievs, O., Steiks, I., Ribickis, L. Influence of the current ripple on the hydrogen fuel cell powered inverter system efficiency. (2009) 2009 13th European Conference on Power Electronics and Applications, EPE '09, art. no. 5279001, . Cited 1 time	Renewable energies
39.	Hodakovska, J., Kleperis, J., Grinberga, L., Vaivars, G. Conductivity measurement of different polymer membranes for fuel cells. (2009) Russian Journal of Electrochemistry, 45 (6), pp. 657-661. Cited 2 times	Renewable energies
40.	Viba, J., Shtals, L., Eiduks, M. Eenergy extraction from air or water by vibrations. (2009) Latvian Journal of Physics and Technical Sciences, 46 (2), pp. 3-12	Renewable energies
41.	Barmina, I., Desnickis, A., Zake, M. The effect of combustion dynamics on the formation of pollutant emissions by co-firing the wood biomass with gaseous fuel. (2008) Heat Transfer Research, 39 (5), pp. 379-389. Cited 1 time	Renewable energies
42.	Grinberga, L., Kleperis, J., Vaivars, G., Nechaev, A., Poulsen, F.W., Pedersen, A.S. Investigations of the influence of different additives to the lanthanum rich mischmetal. (2007) NATO Security through Science Series A: Chemistry and Biology, pp. 279-286	Renewable energies
43.	Luo, H., Vaivars, G., Mathe, M. Covalent-ionically cross-linked polyeth-	Biofuel

	eretherketone proton exchange membrane for direct methanol fuel cell. (2010) Journal of Power Sources, 195 (16), pp. 5197-5200	
44.	Markova, D., Bazbauers, G., Valters, K., Alhucema Arias, R., Weuffen, C., Rochlitz, L. Optimization of bio-ethanol autothermal reforming and carbon monoxide removal processes. (2009) Journal of Power Sources, 193 (1), pp. 9-16. Cited 3 times	Biofuel
45.	Djomo, S.N., Humbert, S., Dagnija Blumberga. Life cycle assessment of hydrogen produced from potato steam peels. (2008) International Journal of Hydrogen Energy, 33 (12), pp. 3067-3072. Cited 2 times	Biofuel
46.	Miskinis, V., Slihta, G., Rudi, Y. Bio-energy in the Baltic States: Current policy and future development. (2006) Energy Policy, 34 (18), pp. 3953-3964	Biofuel
47.	Muter, O., Versilovskis, A., Scherbaka, R., Grube, M., Zarina, D. Effect of plant extract on the degradation of nitroaromatic compounds by soil microorganisms. (2008) Journal of Industrial Microbiology and Biotechnology, 35 (11), pp. 1539-1543. Cited 2 times	Environment protection
48.	Bikovens, O., Telysheva, G., Iiyama, K. Comparative studies of grass compost lignin and the lignin component of compost humic substances. (2010) Chemistry and Ecology, 26 (SUPPL. 2), pp. 67-75	Green service
49.	Chirkova, J., Irbe, I., Andersone, I., Andersons, B. Study of the sorption-desorption properties of pine wood at the initial stage of decay by wood-rot fungi. (2009) Holzforschung, 63 (6), pp. 761-766. Cited 1 time	Environment protection
50.	Morozovs, A., Buksans, E. Fire performance characteristics of acetylated ash (Fraxinus excelsior L.) wood. (2009) Wood Material Science and Engineering, 4 (1-2), pp. 76-79	Environment friendly materials
51.	Kajaks, J.A., Bakradze, G.G., Viksne, A.V., Reihmane, S.A., Kalnins, M.M., Krutohvostov, R. The use of polyolefins-based hot melts for wood bonding. (2009) Mechanics of Composite Materials, 45 (6), pp. 643-650	Environment friendly materials
52.	Chirkova, J., Andersons, B., Andersone, I. Study of the structure of wood-related biopolymers by sorption methods. (2009) BioResources, 4 (3), pp. 1044-1057	Environment friendly materials
53.	Zandersons, J., Dobele, G., Jurkjane, V., Tardenaka, A., Spince, B., Rizhikovs, J., Zhurinsh, A. Pyrolysis and smoke formation of grey alder wood depending on the storage time and the content of extractives. (2009) Journal of Analytical and Applied Pyrolysis, 85 (1-2), pp. 163-170	Green service
54.	Locs, J., Berzina-Cimdina, L., Zhurinsh, A., Loca, D. Optimized vacuum/pressure sol impregnation processing of wood for the synthesis of porous, biomorphic SiC ceramics. (2009) Journal of the European Ceramic Society, 29 (8), pp. 1513-1519. Cited 4 times	Environment friendly materials
55.	Telysheva, G., Dizhbite, T., Evtuguin, D., Mironova-Ulmane, N., Lebedeva, G., Andersone, A., Bikovens, O., Chirkova, J., Belkova, L. Design of siliceous lignins - Novel organic/inorganic hybrid sorbent materials. (2009) Scripta Materialia, 60 (8), pp. 687-690. Cited 3 times	Environment friendly materials
56.	Yakushin, V., Stirna, U., Sevastyanova, I., Deme, L., Zeltiņš, V. Properties of sprayed polyurethane and polyisocyanurate foams obtained from vegetable oil polyols. (2008) Medziagotyra, 14 (4), pp. 333-336	Environment friendly materials
57.	Shulga, G., Betkers, T., Brovkina, J., Aniskevicha, O., Ozolinš, J. Relationship between composition of the lignin-based interpolymer complex and	Environment friendly materials

	its structuring ability (2008) Environmental Engineering and Management Journal, 7 (4), pp. 397-400. Cited 3 times	
58.	Popescu, C.-M., Dobele, G., Rossinskaja, G., Dizhbite, T., Vasile, C. Degradation of lime wood painting supports. Evaluation of changes in the structure of aged lime wood by different physico-chemical methods. (2007) Journal of Analytical and Applied Pyrolysis, 79 (1-2 SPEC. ISS.), pp. 71-77. Cited 7 times	Environment friendly materials
59.	Jakobsons, E., Laka, M., Chernyavskaya, S. Rheological properties of microcrystalline chitosan gels. (2007) Mechanics of Composite Materials, 43 (3), pp. 259-268. Cited 1 time	Environment friendly materials
60.	Telysheva, G., Dizhbite, T., Jashina, L., Andersone, A., Volperts, A., Ponomarenko, J., Mironova-Ulmane, N. Synthesis of lignin-based inorganic/organic hybrid materials favorable for detoxification of ecosystem components. (2009) BioResources, 4 (4), pp. 1276-1284	Environment friendly materials
61.	Viksne, A., Bledzki, A.K., Rence, L., Berzina, R. Water uptake and mechanical characteristics of wood fiber-polypropylene composites. (2006) Mechanics of Composite Materials, 42 (1), pp. 73-82. Cited 3 times	Environment friendly materials
62.	Laugale, V., Daugavietis, M. Effect of coniferous needle products on strawberry plant development, productivity and spreading of pests and diseases. (2009) Acta Horticulturae, 842, pp. 239-242	Environment protection

Source: Scopus database (www.scopus.lv)

Annex 4.3: The patents of Latvian citizens in the field of cleantech (during last 5 years)

Nr.	Patent name	Patent number	Priority date	Invertor	Applicant	Clean tech subfield
1	Laboratory apparatus for studying biomass fermentation process	LV14158(B)	2010-03-23	Jemeljanovs Aleksandrs [LV] Osmane Baiba [LV] Cirulis Andris [LV]	Agency of Latvian Agrucul-tural Academy Research Insti-tute of Biotechnology and Veterinary Medicine Sigra	Waste recycling
2	Installation for processing of auto-mobile tyre covers and other wastes containing rubber	LV13724(B)	2008-04-04	Kirilovskis Aleksandrs [LV] Skripnicenko Vladimirs	Kirilovskis Aleksandrs [LV] Skripnicenko Vladimirs	Waste recycling
3	Composition and method for man-ufacturing of glass-ceramic prod-ucts from industrial waste, glass and clay	LV14118(B)	2010-01-14	Rozenstrauha Ineta [LV] Krage Linda [LV]	Riga Technical university [LV]	Waste recycling
4	Pyrolysing device of cogeneration type for processing rubber wastes	LV14086(B)	2009-12-15	Petrovs Aleksandrs [lv] Flegontovs Aleksandrs [lv] Kocanovs Nikita [lv] Bertulsons Gunars [lv] Landrats Juris [lv]	Pyrotex SIA [LV]	Waste recycling
5	Device and method for recycling of rubber wastes and the product obtained	LV13892(B)	2008-12-15	Kaza Eriks [lv] Bartulis Eriks [lv] Liseyko Grigory [lv]	Rimo wood sia [lv]	Waste recycling
6	Filtering element for wastewater purification plants' filtration dams	LV14102(B)	2009-11-30	Faitelsons Viktors [lv]	Faitelsons Viktors [lv]	Wastewater treat-ment
7	Filtering element for oil and petrol containing drain treatment	LV13795(B)	2008-04-14	Faitelsons Viktors [lv]	Faitelsons Viktors [lv]	Wastewater treat-ment

8	Quasi-invariant control method of wastewater aeration process	LV13998(B)	2008-02-28	Sniders Andris [lv] Greivulis Janis [lv] Laizans Aigars [lv]	Sniders Andris [lv]	Wastewater treatment
9	Magnetic device for treatment of liquids	LV13934(B)	2009-04-09	Ivanovs Aleksejs [lv] Bure Aleksejs [lv]	Ivanovs Aleksejs [lv] Bure Aleksejs [lv]	Wastewater treatment
10	Device for biological treatment of water	LV13734(B)	2008-03-26	Tracuks Sergejs [lv]	Tracuks Sergejs [lv]	Water purification
11	Water treatment installation for boiler scale liquidation	LV13990(B)	2008-02-01	Pugacevs Vladislavs [lv] Grikis Egils [lv] Grike Sanita [lv]	Institute of Physical Energetics [lv] Vidtech sia [lv]	Water purification
12	Method and device for biological treatment of household and industrial sewage	LV13868(B)	2008-12-23	Issak Erika [lv] Radcenko Jurijs [lv]	Issak Erika [lv] Radcenko Jurijs [lv]	Environmental protection
13	Device for pumping acid tar	LV13596(B)	2007-03-15	Polakova Evelina [lv] Jurcenko Andrejs [lv] Polakovs Aleksandrs [lv]	Polakova Evelina [lv] Jurcenko Andrejs [lv] Polakovs Aleksandrs [lv]	Environmental protection
14	Compositions of recycled polycarbonates for manufacture of packing and method for production thereof	LV14203(B)	2010-05-12	Usilonoks Aleksandrs [lv]	Gammaplasts sia [lv]	Environmental friendly materials
15	Ecological reusable bag and process of its manufacturing	LV14018(B)	2009-09-03	Fonarjovs Levs [lv]	Flexoplastic ecological sia [lv]	Environmental friendly materials
16	Method for conversion of external source thermal energy into other energy modes	LV13878(B)	2008-12-12	Tonkoskurs Aleksandrs [lv] Domanich Viktor [ru]	Tonkoskurs Aleksandrs [lv]	Energy technologies
17	Alternative electric power statin	LV13799(B)	2007-03-23	Jakimovs Pjotrs [lv]	Jakimovs Pjotrs [lv]	Energy technologies
18	Burner of solid fuel with definite zones for pyrolysis, reduction and	LV13994(B)	2009-03-27	Muiznieks Aigars [lv]	Muiznieks Aigars [lv]	Energy technologies

	oxidation					
19	Thermally and mechanically resistent ceramics	LV14238(B)	2010-09-02	Sedmale Gaida [lv] Hmelovs Aleksejs [lv] Sperberga Ingunda [lv]	Riga Technical university [LV]	Energy saving materials
20	Heat accumulating concrete and technology of casting the structures in formwork	LV14216(B)	2010-08-31	Lapsa Videvuds-Arijs [lv] Krasnikovs Andrejs [lv] Strauts Karlis [lv] Macanovskis Arturs [lv] Vagele Angelina [lv]	Riga Technical university [LV]	Energy saving materials
21	Ceramic filter	LV14078(B)	2009-06-16	Svinka Visvaldis [lv] Svinka Ruta [lv] Butlers Andris [lv] Zake Ieva [lv]	Riga Technical university [LV]	Energy saving materials
22	Ceramic crucible and method for producing thereof	LV13991(B)	2009-06-04	Bidermanis Laimonis [lv] Svinka Visvaldis [lv] Svinka Ruta [lv] Lagzdina Silvija [lv] Cimmers Andris [lv]	Riga Technical university [LV]	Energy saving materials
23	Porous ceramics	LV13933(B)	2009-03-03	Sedmale Gaida [lv] Sperberga Ingunda [lv] Hmelovs Aleksejs [lv] Sedmalis Uldis [lv]	Riga Technical university [LV]	Energy saving materials
24	Composition and method for producing porous ceramic products	LV13932(B)	2009-02-05	Bajare Diana [lv] Korjakins Aleksandrs [lv]	Riga Technical university [LV]	Energy saving materials

25	Thermal shock resistant ceramic material and method for processing thereof.	LV13904(B)	2007-10-04	Bidermanis Laimonis [lv] Svinka Visvaldis [lv] Svinka Ruta [lv] Lagzdina Silvija [lv] Cimmers Andris [lv] Bula Gerda [lv]	Riga Technical university [LV]	Energy saving materials
26	Silicate ceramic and method for producing thereof	LV13723(B)	2006-12-19	Svinka Ruta [lv] Svinka Visvaldis [lv] Bidermanis Laimonis [lv] Butlers Andris [lv]	Riga Technical university [LV]	Energy saving materials
27	Method for production solid fuel from wastes	LV13849(B)	2007-06-29	Dobrodusins Mihails [lv]	Dobrodusins Mihails [lv]	Renewable energies
28	The method of glyceric acid selective preparation and catalysts for its realization	LV14079(B)	2009-12-10	Cornaja Svetlana [lv] Kulikova Lidija [lv] Serga Vera [lv] Kampars Valdis [lv] Dubencovs Konstantins [lv] Zizkuna Svetlana [lv] Muravjova Olga [lv]	Riga Technical university [LV]	Biofuel
29	The method of glyceric acid preparation and catalyst for its realization	LV13956(B)	2009-04-17	Cornaja Svetlana [lv] Kampars Valdis [lv] Grabis Janis [lv] Jankovica Dzidra [lv] Muravjova Olga [lv] Zizkuna Svetlana [lv] Kampare Ruta [lv] Dubencovs Konstantins [lv]	Riga Technical university [LV]	Biofuel

30	Process for isolation phenols from lignocelluloses fast-pyrolysis oils	LV13847(B)	2008-12-04	Kampars Valdis [lv] Kreicberga Jana [lv] Dobele Galina [lv] Urbanovics Igors [lv]	Riga Technical university [LV]	Biofuel
31	Method for increasing stability of biodiesel against their oxidation during storage	LV13870(B)	2008-12-04	Kampars Valdis [lv] Kampare Ruta [lv] Kreicberga Jana [lv]	Riga Technical university [LV]	Biofuel
32	Mobile unit for production of bio-diesel	LV13501(B)	2006-07-25	Avotins Juris [lv]	Avotins Juris [lv]	Biofuel
33	Combined, the molecular sieve-alcohol salt distillations, bioethanol dehydratation method	LV13691(B)	2007-11-20	Bremers Gunars [lv] Blija Anita [lv] Skele Arnolds [lv] Birzietis Gints [lv] Gulbis Vilnis [lv] Danilevics Aleksejs [lv] Bosenko Anatolij [by] Taukacs Agris [lv] Sargautis Darius [lt]	Latvia University of Agricul-ture [LV] Latvian Environmental Pro-tection Fund [LV] Jaunpagasts plus SIA [LV]	Bioethanol
34	Lump fuel element	LV14218(B)	2010-05-11	Petersons Gints [lv]	Petersons Gints [lv]	Biogas
35	Cogeneration power station equipped with a biogas generator	LV14160(B)	2010-03-15	Deksnis Gatis [lv]	BB Biogaze sia [lv]	Biogas

*Source: Patent Access database (*http://ep.espacenet.com*)*

Annex 4.4: The turnover and profit/loses of cleantech enterprises in 2007, 2008 and 2009

Cleantech group	Company name	Foundation	Profit, EUR			Turnover, EUR			Employers		
			2007	2008	2009	2007	2008	2009	2007	2008	2009
Environmental protection	VentEko, SIA	17-04-1997	530374.0	582428.4	59978.3	3567281.9	3483706.7	2157561.7	56	58	47
Environmental protection	Ekoservis Lat, SIA	16-03-2004	-56472.4	-40174.8	-21492.5	152641.4	93400.2	120629.6	5	4	4
Environmental protection	LaKalme, SIA	13-02-1998	576379.8	840400.7	620901.4	3157092.2	2930067.3	3952153.1	40	32	31
Environmental protection	Bioinvest, SIA	14-03-2003	4816.4	346198.9	7797.3	165514.1	84794.6	0.0	2	2	2
Environmental protection	Eko Osta	28-01-1999	0.0	214045.5	265591.8	0.0	3586109.4	2470945.0	0	73	67
Environmental protection	BAO, AS	05-12-1996	477744.9	20947.5	6623.5	2610817.5	2.3	1960328.9	82	81	69
Environmental protection	Getlini Eko	21-11-1997	1677841.9	2819517.2	2029965.7	7192753.6	9598171.0	9067299.0	95	93	92
Environmental protection	Akorda	21-06-2004	21637.6	190424.4	43056.1	223452.1	663081.0	483153.2	9	11	9
Environmental protection	Karme filtrs, SIA	15-11-1994	83138.4	163287.3	127440.9	4051946.2	4268808.9	2137002.6	49	51	50
Environmental protection	Rešetilovs un CO, IK	18-04-1991	1776454.0	0.0	0.0	6392385.4	0.0	0.0	0	0	0
Environmental protection	"Biowater", SIA	24-02-2004	35684.2	22995.0	-40448.0	212370.7	186477.3	41452.5	6	4	2
Environmental protection	Vateris, SIA	10-01-2007	-853.7	-37.0	6237.9	0.0	0.0	551428.3	0	0	12

Environmental protection	Vides tehnoloģijas, SIA	16-06-2005	0.0	-22283.6	-7458.7	0.0	72106.9	51943.4	0	8	6
Environmental protection	SIA Filtri	16-04-2004	63835.7	67296.1	14127.7	370236.9	475324.6	342455.4	10	12	9
Environmental protection	HORUS LABORA-TORY	08-03-2007	48.4	684.4	2017.6	3229.9	36471.1	201081.7	1	1	4
Environmental protection	Watex, SIA	25-11-2004	299181.6	292704.7	402271.5	986397.3	1172469.1	1363992.0	16	18	23
Environmental protection	EKOSTANDARTS TEHNOLOĢIJAS, SIA	15-10-2003	220785.6	196823.0	150152.8	867377.0	605141.7	252995.1	14	14	11
Environmental protection	HIDRO-STANDARTS, SIA	23-09-1994	64739.2	40839.3	-37162.6	679037.1	711374.7	406558.6	22	21	20
Environmental protection	Biotehniskais centrs, AS	22-01-1996	67546.6	5194.9	9338.3	402247.3	424462.6	729470.8	10	11	10
Environmental protection	Ventspils la-biekārtošanas kombināts	08-06-1994	63622.3	11936.5	-418711.3	8352695.8	8370057.7	5828202.5	249	248	234
Environmental protection	Liepājas RAS, SIA	24-02-2000	255465.3	172153.3	13138.8	1037852.4	1431171.4	1367433.9	0	43	45
Environmental protection	Vides konsultācijas birojs	08-02-1996	17270.8	32650.6	93541.0	1304700.9	1350920.0	1199024.2	20	22	21
Environmental protection	ZIEMEĻVIDZEMES ATKRITUMU AP-SAIMNIEKOŠANAS ORGANIZĀCIJA	20-11-1998	567.7	-19758.0	452616.9	3509136.3	4165154.2	3417748.0	106	112	100
Environmental protection	Virsma Ltd	08-08-1991	2067.4	-1878.2	-6824.1	26701.6	29729.5	20103.8	4	0	6
Environmental	PET Baltija	02-01-2003	-277021.8	-3022063.1	-671283.9	1929636.1	208403.8	3507581.1	0	0	0

protection											
Environmental protection	LAUTUS	02-10-1997	55684.1	141664.0	131047.9	567028.6	610902.9	527674.9	13	0	15
Environmental protection	SIA "Zaļā josta"	15-08-2002	846553.2	391992.6	365661.0	4242797.4	4018857.3	2878758.5	14	26	14
Environmental protection	LET-COMM, SIA	10-11-1994	37008.9	5835.2	-7554.0	184222.1	134393.1	53354.8	5	5	4
Environmental protection	MELDERI V, SIA	21-01-1994	67848.2	-58435.9	13356.5	782828.5	499621.5	199869.4	12	11	7
Green service	BIOHUMUSS 2010, SIA	04-10-2010	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0
Green service	Bioorganic Earthworm Compost SIA	10-12-2010	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0
Green service	Mežu zelts, SIA	16-11-2009	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0
Green service	SIA "DAGA"	22-10-1992	0.0	3692.4	3719.4	0.0	262038.9	246559.5	0	0	31
Green service	Sapratix	11-03-2010	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0
Green service	SIA "Baltbiogran"	29-12-2009	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0
Green service	Novotech	02-02-2009	0.0	0.0	786.8	0.0	0.0	68161.3	0	0	1
Green service	CAO Alliance	30-09-2009	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0
Green service	Primekss, SIA	14-02-1997	565506.2	-98676.2	-1437365.2	13544691.0	15306542.1	4390222.6	148	142	103
Green service	LATEUS, SIA	07-11-2005	-4965.8	1319.0	1236.5	84481.6	78590.9	35089.4	5	5	5
Renewable energy	Biodegviela, SIA	07-12-2004	128.1	6377.3	-471872.7	2845.7	123122.5	2173603.2	0	1.5	37
Renewable energy	Bio-venta	05-10-2004	-889310.5	-634028.8	-1205227.9	0.0	20959711.4	51413675.8	26	50	61
Renewable energy	Delta Riga	21-03-2001	224825.1	-32333.3	110994.0	2895778.9	3464923.4	2388419.8	17	17	170
Renewable energy	Mežrozīte	06-05-1991	646834.7	-535809.4	445293.4	2617240.4	5147980.1	3151268.3	21	23	21
Renewable energy	Mamas D	29-12-1994	86001.2	-1081146.4	-330139.0	5668956.1	2517616.6	2226438.7	175	94	0
Renewable energy	Oniors	10-10-1997	27203.9	136319.7	-188688.5	859840.0	2523992.5	1718029.5	0	39	39

Renewable energy	SIA "JAUNPAGASTS PLUS"	03-09-1997	1736011.7	1040467.9	3739644.3	13446712.0	19537707.5	13614377.6	180	198	196
Renewable energy	Latraps	09-05-2000	526291.8	-531156.6	2327099.7	42238802.0	101634700.4	80350686.7	68	84	86
Renewable energy	Conatus BIOenergy	11-11-2008	0.0	0.0	12.8	0.0	0.0	0.0	0	0	0
Renewable energy	Bioenerģija 08	06-11-2008	0.0	-16852.5	-428470.8	0.0	0.0	0.0	0	2	2
Renewable energy	SIA UPB Energy	13-05-2002	11784.2	4906.1	223.4	1557245.0	74024.9	76618.8	0	1	1
Renewable energy	SIA Biogas	19-10-2009	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0
Renewable energy	ADVANCED TECHNOLOGIES	09-05-2008	0.0	-4601.6	9183.2	0.0	0.0	7801.6	0	0	1
Renewable energy	SIA BB Biogāze	14-11-2008	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0
Renewable energy	SIA Zaļās Technoloģijas	03-05-1991	-19960.0	16217.9	7349.1	521516.7	1958800.7	71412.5	5	1	5
Materials	SIA "VEKOVER"	09-08-2004	-126489.0	-19748.0	45529.1	315001.1	863744.4	811460.9	6	10	10
Materials	JELGAVAS BŪVNIECĪBAS SISTĒMAS, SIA	23-05-2003	0.0	-406894.4	-210727.3	0.0	502517.1	228376.6	0	23	21
Materials	FLEXOPLASTIC ECOLOGICAL, SIA	21-06-2004	67848.2	932.0	-309578.5	782828.5	1861967.2	3616900.3	3	3	43
Materials	GREEN REALITY, SIA	06-07-2010	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0

Source: Latvian Business Register (www.ur.gov.lv) and Lursoft, Ltd (www.lursoft.lv)

Annex 4.5: Sub-field, foundation year, employees, export (2009) and R&D (2009) expenses of cleantech enterprise

Cleantech group	Cleantech sub-field	Company name	Foundation	Location	Employ-ees	R&D expenses, EUR	Export expenses, %
Environmental protection	Environmental service	VentEko, SIA	17-04-1997	Babites district	50	28000	20
Environmental protection	Environmental service (waste water treatment)	Ekoservis Lat, SIA	16-03-2004	Riga	4	4200	0
Environmental protection	Environmental service (waste water treatment)	LaKalme, SIA	13-02-1998	Riga	10	28000	0
Environmental protection	Environmental service (waste water treatment and disposal)	Bioinvest, SIA	14-03-2003	Riga	178	9500	20
Environmental protection	Environmental service (soil protection technologies)	Eko Osta	28-01-1999	Riga	60	27000	15
Environmental protection	Environmental service (utilization)	BAO, AS	05-12-1996	Olaine	79	285000	25
Environmental protection	Environmental service (utilization)	Getlini Eko	21-11-1997	Stopinu district	25	n/d	n/d
Environmental protection	Environmental service	Akorda	21-06-2004	Riga	10	20000	20
Environmental protection	Environmental service (water treat-ment)	Karme filtrs, SIA	15-11-1994	Riga	43	28500	80
Environmental protection	Environmental service (equipment for waste water treatment)	Rešetilovs un CO, IK	18-04-1991	Jelgavas district	35	n/d	n/d

Environmental protection	Environmental service (Waste water management)	"Biowater", SIA	24-02-2004	Limbazi	9	7000	15
Environmental protection	Environmental service	Vateris, SIA	10-01-2007	Riga	12	8500	10
Environmental protection	Environmental service (waste water treatment)	Vides tehnoloģijas, SIA	16-06-2005	Riga district	6	0	0
Environmental protection	Environmental service (air purification)	SIA Filtri	16-04-2004	Riga	9	n/d	10
Environmental protection	Environmental service	HORUS LABORATORY	08-03-2007	Riga	23	30000	30
Environmental protection	Environmental service (Waste water management)	Watex, SIA	25-11-2004	Riga	15	0	0
Environmental protection	Environmental service (biological waste water treatment)	EKOSTANDARTS TEHNOLOĢIJAS, SIA	15-10-2003	Riga	35	0	10
Environmental protection	Environmental service (Fermentation and process control equipment)	HIDRO-STANDARTS, SIA	23-09-1994	Riga	1	0	0
Environmental protection	Environmental service	Biotehniskais centrs, AS	22-01-1996	Riga	11	103000	50
Environmental protection	Waste management	Ventspils labiekārtošanas kombināts	08-06-1994	Ventspils	234	35000	0
Environmental protection	Waste management	Liepājas RAS, SIA	24-02-2000	Grobinas district	43	15000	0
Environmental protection	Waste management	Vides konsultācijas birojs	08-02-1996	Riga	25	28000	20
Environmental protection	Waste management	ZIEMEĻVIDZEMES ATKRITUMU APSAIMNIEKOŠANAS ORGANIZĀCIJA	20-11-1998	Valmiera	105	50000	0
Environmental protection	Waste management	Virsma Ltd	08-08-1991	Riga	6	7000	0

Environmental protection	Waste management (PET bottle)	PET Baltija	02-01-2003	Jelgava	78	40000	40
Environmental protection	Waste management (health care)	LAUTUS	02-10-1997	Riga	15	4500	0
Environmental protection	Waste management (building materi-als)	SIA "Zaļā josta"	15-08-2002	Riga	14	82000	10
Environmental protection	Waste management	LET-COMM, SIA	10-11-1994	Riga	4	0	0
Environmental protection	Waste management	MELDERI V, SIA	21-01-1994	Riga	7	0	0
Green service	Green service	BIOHUMUSS 2010, SIA	04-10-2010	Keguma district	12	0	0
Green service	Green service	Bioorganic Earthworm Compost SIA	10-12-2010	Engures district	15	0	90
Green service	Green service	Mežu zelts, SIA	16-11-2009	Riga	14	7114	20
Green service	Green service	SIA "DAGA"	22-10-1992	Ventspils	8	14000	30
Green service	Green service	Sapratix	11-03-2010	Jekabpils	9	4268	0
Green service	Green service	SIA "Baltbiogran"	29-12-2009	Ogre	3	0	0
Green service	Green service	Novotech	02-02-2009	Daugav-pils district	3	0	20
Green service	Green service	CAO Alliance	30-09-2009	Ogre	3	0	0
Green service	Green service	Primekss, SIA	14-02-1997	Riga	55	180000	90
Green service	Green service	LATEUS, SIA	07-11-2005	Riga	5	0	0
Renewable energy	Biofuel (Bioethanol)	Biodegviela, SIA	07-12-2004	Riga	69	140000	70
Renewable energy	Biofuel (Biodiesel)	Bio-venta	05-10-2004	Ventspils	61	35000	83
Renewable energy	Biofuel (Biodiesel)	Delta Riga	21-03-2001	Valmieras district	17	n/d	35
Renewable energy	Biofuel (Biodiesel)	Mežrozīte	06-05-1991	Jelgavas	21	n/d	30

				district			
Renewable energy	Biofuel	Mamas D	29-12-1994	Daugav-pils	32	n/d	40
Renewable energy	Biofuel	Oniors	10-10-1997	Daugav-pils	36	n/d	30
Renewable energy	Biofuel (Bioethanol)	SIA "JAUNPAGASTS PLUS"	03-09-1997	Talsu district	210	250000	85
Renewable energy	Biofuel	Latraps	09-05-2000	Jelgavas district	86	72000	40
Renewable energy	Biogas and biomass (Electrical and heating energy)	Conatus BIOenergy	11-11-2008	Ergli dis-trict	0	0	0
Renewable energy	Biogas and biomass (Electrical and heating energy)	Bioenerģija 08	06-11-2008	Madonas district	5	n/d	0
Renewable energy	Biogas and biomass (Cogenerations units)	SIA UPB Energy	13-05-2002	Liepaja	3	n/d	80
Renewable energy	Biogas and biomass (Innovative bio-gas production)	SIA Biogas	19-10-2009	Madona	1	n/d	0
Renewable energy	Biogas and biomass	ADVANCED TECHNOL-OGIES	09-05-2008	Riga	1	0	10
Renewable energy	Biogas and biomass (Innovative bio-gas production)	SIA BB Biogāze	14-11-2008	Gulbene	1	n/d	0
Renewable energy	Biogas and biomass (Innovative bio-gas production)	SIA Zaļās Technoloģijas	03-05-1991	Jurmala	5	15000	0
Materials	Energy saving technologies	SIA "VEKOVER"	09-08-2004	Valmiera	3	24000	30
Materials	Energy saving technologies	JELGAVAS BŪVNIECĪBAS SIS-TĒMAS, SIA	23-05-2003	Riga	21	n/d	0

Materials	Environmently friendly materials	FLEXOPLASTIC ECO-LOGICAL, SIA	21-06-2004	Riga district	83	80000	40
Materials	Environmently friendly materials	GREEN REALITY, SIA	06-07-2010	Liepaja	1	0	0

Source: Latvian Business Register (www.ur.gov.lv) and Lursoft, Ltd (www.lursoft.lv)

Chapter V: Clean Technology Developers and Policies in Sweden, Estonia and Latvia - Conclusions

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1. Innovation environments in Sweden, Estonia and Latvia

In depth analysis of clean technology related developments in the regions covered shows that the regions are very different. This is also reflected by the Innovation Union's performance scoreboard for research and innovation (2011) according to which:

- **Sweden** is one of the innovation leaders with an above average EU27 performance. It has strengths in human resources, R&D system, and national support system.

- **Estonia** is one of the innovation followers with a close to average (EU27) performance. Its relative strengths are in human resources, firm investments and linkages, and entrepreneurship. Relative weaknesses are related to R&D system, and to intellectual assets and outputs.

- **Latvia** is one of the modest innovators with a below average EU27 performance. Its relative strengths are in human resources and in support measures, while weaknesses are related to R&D system and to linkages and entrepreneurship.

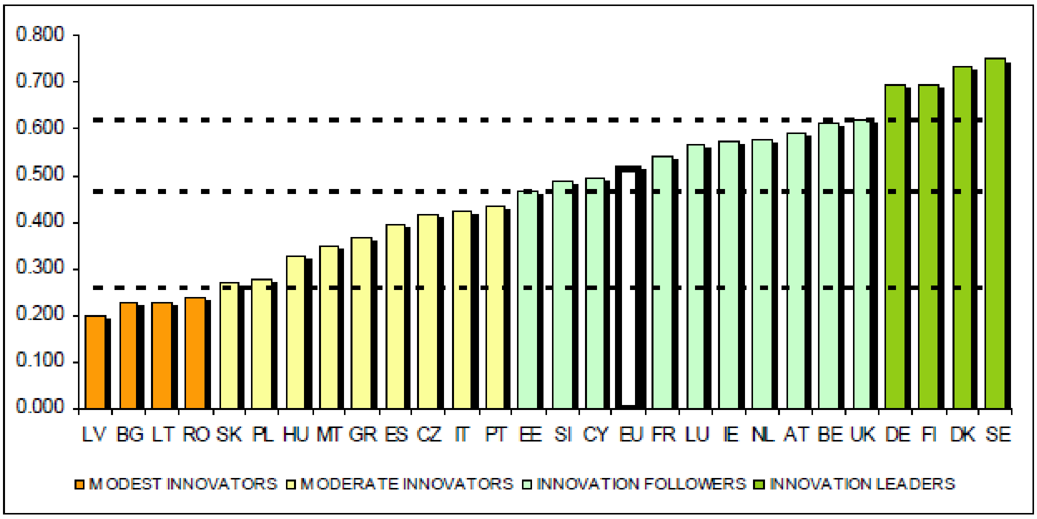

Figure 5.1: EU Member States' Innovation Perfomance

Source: Innovation Union Scoreboard 2011, 4.

In the following we take a closer look at the clean technology sectors and clean technology developers and developments in the regions covered as well as conclude on policy recommendations.

2. Clean technology sectors in Sweden, Estonia and Latvia

There are 6,530 clean technology companies active in **Sweden** according to the Swentec database (2009). More than 40% of these companies are related to the sub-field waste management and recycling. About 15% are developing, producing and/or selling technologies for sustainable building and energy efficiency. Other main technology sub-fields engaged in by these companies includes consulting services (15%), water treatment (7%) and bioenergy and biofuels (7%).

For the current research, clean technology developers from seven Swedish counties covered by the project were identified. Fifty percent of the clean technology developers identified are located in Stockholm County, other main locations are Östergötland County as well as the counties of Södermanland and Gävleborg. The companies analysed from Sweden altogether employed 13,860 persons in 2009, corresponding to 33% of all persons employed by Swedish clean technology companies.

Compared to Sweden, the clean technology sector in **Estonia** was much smaller. The number of companies that could be related with environmental technologies was approximately 200 to 300, according to some studies. These companies were active in sub-fields like energy technologies, biofuels, material technologies, waste management, water and ambient air protection, green construction, clean technology consulting, environmental research equipment as well as information and communication technologies (ICT).

However, the majority of these companies comprised resellers or representatives of foreign clean technology enterprises or technology users. For the purposes of the current study, 36 clean technology developers were identified. These were the companies in Estonia that were relatively active in the development of new environmentally friendly solutions in the field of clean technologies. Over one third are developing energy technologies (wind turbines, semiconductors, photovoltaics, ultracapacitors, fuel cells, electrical and power engineering, and heat exchangers); the other larger segments are biofuels and clean technology related ICTs. The 36 clean technology developers that were analysed from Estonia employed altogether 911 persons in 2009.

The **Latvian** clean technologies sector was more comparable to Estonia rather than of Sweden. 58 clean technology enterprises were identified for purposes of the current study, although this figure may be susceptible to possible overestimation as the count may include more than just technology developers. The 58 companies analysed from Latvia employed a total of 1,240 persons in 2009.

Five **clean technology clusters** were found in the Swedish regions covered by the study. The map below (Figure 5.2) illustrates clean technology clusters in the fields of 1) waste management and recycling, 2) bioenergy and biofuels, 3) sustainable building, 4) air purification, and 5) solar energy.

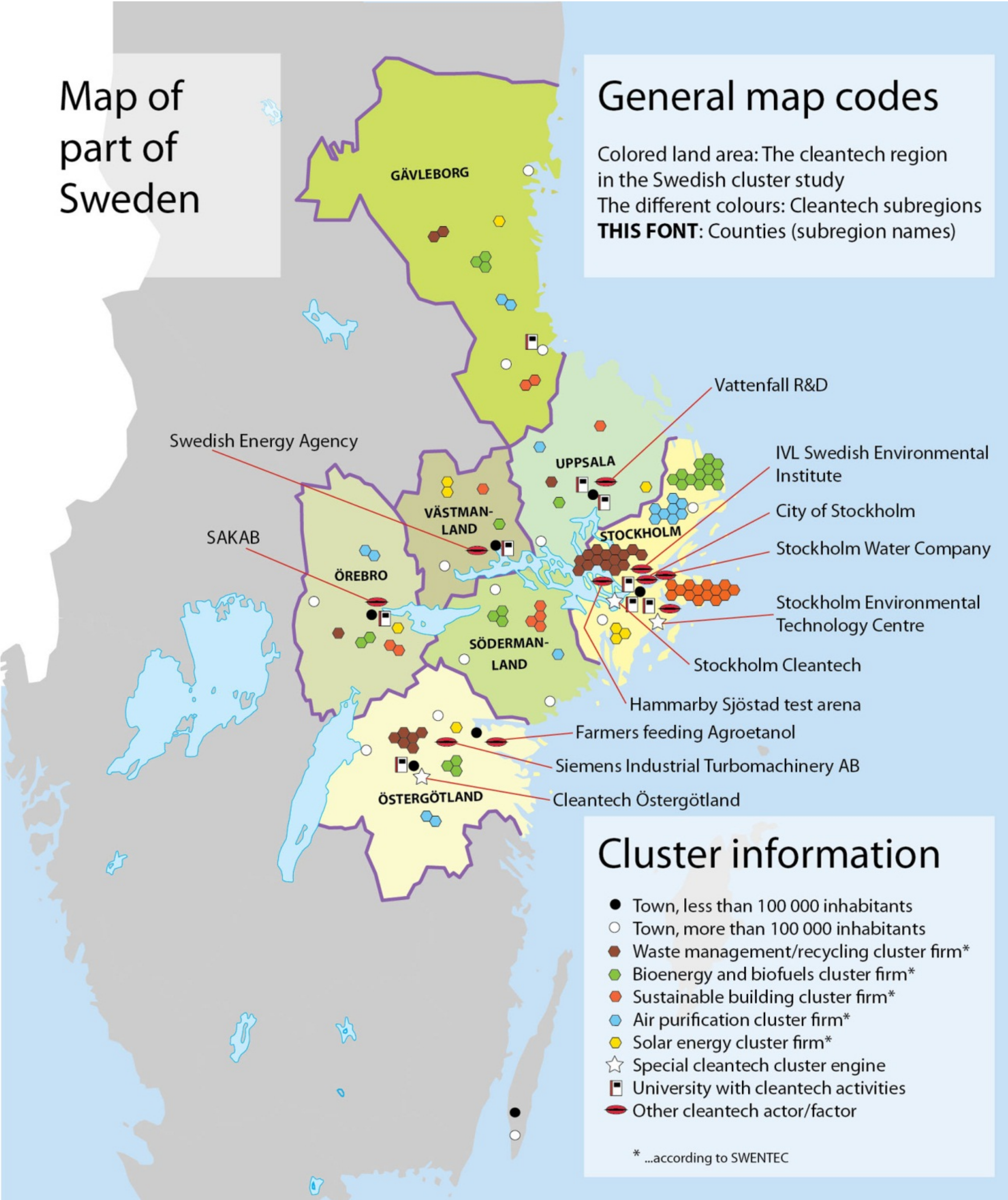

Figure 5.2: Clean technology cluster and sub-clusters in the region included
Source: Authors.

In Estonia, the majority of clean technology companies develop energy technologies, clean technology related ICTs and biofuels. In Latvia the emerging clusters were in the fields of environmental protection, green services and renewable energies.

3. Clean technology developers in Sweden, Estonia and Latvia

Clean technology developers tended to be rather **young companies**. Nearly 60% of the Swedish regional companies analysed were founded in or after 1990. Of the 36 Estonian clean technology developers, 21 companies were founded between 2000 and 2010. Also in Latvia, the founding of new enterprises as well as the activities of the already established enterprises became more active following 2003.

In all three countries, the majority of the clean technology companies were **micro companies**, i.e. employed up to ten employees. Clean technology developers with the largest number of employees in the regions analysed were found in Sweden: YIT Sverige AB (4,578 employees [2009] in Sweden) and Munters AB (4,087 employees, both Stockholm County), as well as Systemair AB in Västmanland County (2,013 employees), but also Camfil Svenska AB in Södermanland County (316 employees), Econova AB in Östergötland (256 employees) and BooForssjö AB in Södermanland (210 employees).

Even the largest clean technology related companies from Estonia – Konesko (312 employees in 2009), Graanul Invest (131 employees) and Estiko-Plastar (128 employees) were rather small in international terms, and of the 36 companies analysed 23 had less than 10 employees. This was also true for Latvia where the field was dominated by micro- and small-enterprises. Only five of the enterprises in Latvia were medium sized enterprises.

The financial results of companies in Estonia and Latvia, in particular, revealed a high degree of **stratification**. In other words, there were some successful companies according to financial results but a majority of enterprises evidenced rather poor financial performance. But this should be treated with some caution as these firms were mostly, at that point, in the technology development stages.

In Sweden, one in four clean technology companies **exported** its products or services to other countries in 2009. Total exports of clean technologies reached SEK 38.9 billion (EUR 3.6 billion), an increase of SEK 18.8 billion (EUR 1.8 billion) or 94% since 2003 showing the increased competitiveness of Swedish companies in the international market. The sub-fields waste management and recycling had the highest total export value between 2007 and 2009 for Sweden. This accounted for nearly one fourth of the national clean technology exports in 2009. However, as this sub-field also consists of the largest number of clean technology companies (2,764 companies) the high share of clean technology exports was not surprising. In contrast, exports have in recent years also reached a relatively high level for two smaller sub-fields in terms of enterprises engaged, namely sustainable building and energy efficiency (956 companies), and solar, wind and water energy (504 companies). For both clean technology sub-fields, a steady increase of exports had been noted since 2007. Companies with a business related to solar, wind and/or water energy increased their exports by 60% between 2007 and 2009, while the number of employees increased during these years from 2,327 to 2,766.

In Estonia, total exports amounted to EUR 124 million (2009) and this trade was dominated by few companies. Out of the 36 companies analysed 16 companies exported their products. Graanul Invest, Konesko, Balti Kaubad ja Teenused and Airel were the export leaders, although Konesko was in the process of developing its wind turbines and as yet had not exported any cleantech products. Graanul Invest exported all its production while Konesko had only a tiny part for domestic consumption. This indicates that export markets were very important for the Estonian clean technology companies.

In Latvia, total exports amounted to EUR 192.4 million (2009). Exports were highest in green services and renewable energies (Figure 9). The relatively large export percentage of the green services segment was due to the activities of one company, Primekss Ltd.

The major export destinations of the Swedish clean technology companies are European countries, but also China and the USA. European export destinations that were among the top ten export markets together amounted for 50% (SEK 19.6 billion, or EUR 1.8 billion) of the total clean technology export in 2009. Germany was by far the largest export market for Sweden with regard to clean technologies. In addition, all three Nordic countries sharing a border with Sweden (namely Norway, Denmark, and Finland) were important export destinations accounting for nearly 20% of the total clean technology exports.

For the Estonian clean technology developers, the biggest export revenues were from Finland (EUR 136 million in total; 2007–2009), Denmark (EUR 61 million), Great Britain (EUR 25 million), Sweden (EUR 14 million), Spain (EUR 11 million), France (EUR 11 million), Russia, and Latvia (EUR 7 million). In the period 2007–2009, the exports to the EU totalled EUR 356 million and outside the EU

EUR 18 million. Outside the EU the biggest export destinations were Russia (EUR 8 million), China (EUR 2.6 million) and Belarus (EUR 1.6 million). For Latvia also, the European Union countries were largely the major export destination.

Co-operation between industry and academia was most developed in Sweden. There are regional centres of excellence in the field of clean technologies, e.g. “Svenskt VattenkraftCentrum”, Centre for Molecular Devices and the Centre for Renewable Electric Energy Conversion. A majority of the companies interviewed had cooperated with research institutions with the objective of developing clean technologies. A majority of the interviewed companies claimed a moderate or significant contribution of academic and other research organizations in the development of clean technologies. The perception of several companies was that academic participation in clean technology related projects was high. Universities were seen as excellent in various specialized research fields and companies found it important to develop personal contacts with researchers engaged in projects. Interaction with individual researchers was seen as critical. Moreover, company representatives requested a larger focus on knowledge about commercialization of technological products.

For Estonia, the companies’ representatives interviewed were familiar mainly with the activities of universities from which they had graduated, where their employees were studying, or with whom they have had some co-operation linkages. A few very active science groups at the leading universities in the field of clean technologies (photo voltages, fuel cells, passive houses) that also work closely together with certain companies exist.

The most common and relevant problems mentioned by the clean technology entrepreneurs during the interviews were that the gaps between the science (undertaken at universities) and entrepreneurship were too wide, universities were not sufficiently cooperative and also frequently made extensive requests for funds in lieu of co-operation. Some companies mentioned that quite often different departments within universities competed with each other and were not working together. Additionally the intellectual property (IP) terms and conditions were seen as restrictive and impeded co-operation between universities and enterprises, even to the extent where foreign universities were believed to be more pragmatic and open to co-operation. Some companies also claimed that the prevailing system did not facilitate co-operation between universities and entrepreneurs, the former were used only for on short-term and project basis.

Approximately half of the company representatives in Latvia confirmed that the collaboration with academic or other research institutions often used state support through grant programmes. At the present, nine grants were related to the clean technology industry. In addition, research institutions carried out projects under various national programmes launched by ministries, EU funded projects and contract research for private companies.

Co-operation amongst companies with the goal of developing clean technologies was more evident in Sweden than in Estonia and Latvia. In Sweden more than two thirds of the companies were involved in such co-operation at the national level. Most companies have enjoyed extensive interaction with other players in the clean technology field. Moreover the interactions were not limited only to companies in their interactions, around half of the interviewed companies also had links with universities and research organisations.

Such interactions were increasingly evident in Estonia as well. All of the interviewed companies were cooperating with other organizations with an objective to develop clean technologies, but only the very active clean technology developers were related to international networks. However, there were limits to domestic co-operation as competencies sought were sometimes not available within the local R&D and innovation system.

Over half of the cleantech companies in Latvia indicated interactions with government organizations. Most of the clean technology companies were also members of respective professional associations. Partnership between companies was perceived positively and industry players did attempt co-operation. At the same time, partnerships were typically based on short-term contracts and may not in the long run provide substantial benefits to businesses to strengthen their competitiveness.

4. Clean technology policies and instruments in Sweden, Estonia and Latvia

Government support to clean technologies was most visible in **Sweden**. A Research Strategy for Environmental Technology was approved by the Government in 2007. The strategy highlights research and development of environmental technologies in six research areas, namely sustainable planning, sustainable transport, environmental protection technology, biological resources, ease and advanced materials, and energy.

Furthermore, there exists an action plan for the Swedish clean technology sector (2010) which was prepared by Swentec on behalf of the state. The Action Plan indicates a focus on five strategic areas: political management, skills for sustainable development, commercialization, business models and partnerships. The action plan includes 82 concrete measures in these areas.

Swedish efforts include the government's national initiative providing SEK 560 million (EUR 52.6 million) for support measures between 2007 and 2010 in the field of clean technologies. For the period 2011–2014, an additional SEK 400 million (EUR 37.6 million) was allocated for the promotion of development and export of environmental technologies.

There are numerous national initiatives and funding programs, e.g. "SymbioCity", "DemoEnvironment", and "ProEnviro". In addition to governmental initiatives, the regional clean technology sectors are supported in Sweden by a number of private cluster organizations and networks, including the network "Sustainable Business Mälardalen", Stockholm Environmental Technology Centre (SMTC), and Cleantech Östergötland .

In **Estonia**, two strategic documents relate to clean technologies on the general level – Estonian National Strategy on Sustainable Development "Sustainable Estonia 21" – and the Estonian Environmental Strategy. The most important document guiding R&D and innovation is the Estonian R&D and Innovation Strategy 2007–2013 "Knowledge-based Estonia". The strategy identifies three key technologies for Estonia: 1) information and communication technology, 2) biotechnology and 3) material technology. Although some clean technology related prioritization can be found in those strategies, there were no extensive and specific support instruments dedicated to the development of clean technologies in Estonia. While R&D and innovation support organisations were well established in Estonia, there are not specific measures dedicated to clean technologies. However, over the last few years a number of associations and umbrella organisations related to various sub-fields of clean technologies have emerged.

For **Latvia**, the key policy documents were the National Development Plan 2007–2013 and the National Environmental Policy Plan 2004–2008. Similar to Estonia, there existed no specific support instruments for the development of clean technologies. The government support for enterprises in Latvia was mostly implemented through the Investment and Development Agency of Latvia (IDAL). In the provision of support to new products and technologies and support to the centres of competence and excellence, there were some support measures, similar to those found in Estonia, for clean technologies in Latvia. Another similarity with Estonia was the existence of a number of professional associations in the field of clean technology.

5. Perceived development problems

All of the interviewed companies from the three countries emphasized the importance of specific competencies (namely **technical, marketing and business competence**) for success in the clean technologies market. According to them it was essential to develop an appropriate mix of these three competencies to achieve good market performance. Furthermore, experiential and practical competence was seen as valuable but also formal education in specific technical areas. In Sweden, more than the half of the companies interviewed claimed that these capabilities were apparent in their companies. A smaller share stated that these capabilities were partly manifested. Such competences were less present in the Estonian and Latvia companies.

In all of the countries concerned, interviewees pointed out the most crucial **barriers to exports** of their products and services related to customer relations, laws and regulations (in destination countries), and customer contact problems. Deeper discussion of these issues revealed, however, the need for further strengthening of strategic business competences in the companies interviewed. Business competences might be as hard to build up as technical competences.

In Sweden quite many companies pointed at problems with “customer value” as one of the top three problems. That can be interpreted that some companies lacked state of the art product offerings. Many companies pointed at “contact problems” and on “customer relations”. It is obvious from this study that relationship management is crucial for exporting clean technology.

Regarding the problems identified concerning laws and regulations as a main challenge to international expansion, it was not possible to reveal, whether the problem concerned laws and regulation per sè or the companies' ability to access and use information about such laws and regulations.

For the Estonian companies the issue of trust and recognition came up as well since Estonia was a small state and rather unknown to the world.

The majority of the clean technology companies interviewed planned **major investments** in R&D, production and market expansion. In Sweden and Estonia many companies claimed that they already had made significant investments in R&D and were currently planning and taking measures for development of production as well as market expansion. This also shows that the majority of the companies interviewed were focused on foreign markets and thus needed to have good strategies for success in these ventures. However, and this is common to all regions, the companies were generally not able to finance such strategic investments by means of their own capital.

The venture capital market in Sweden was considered well developed and some of the best practice cases showed how public support measures could enhance private investments in the clean technology sector.

The circumstances regarding financing prevailing in Sweden was once again quite different from Estonian and Latvian situation. The Estonian venture capital sector was considered to be in formative stages of development. In 2007 the overall volume of venture capital investments in Estonia was EUR 36 million. In 2008 and 2009 the amount of investments invested into Estonian companies decreased drastically, from EUR 15 to 5 million, respectively. The Estonian Private Equity and Venture Capital Association (EstVCA) currently had 16 members who have also invested into clean technology companies. The most active investor in clean technologies was the Estonian Development Fund.

In Latvia, venture capital company Eko investors has been most active in the field of clean technologies. Currently two venture capital funds – BaltCap Management and Imprimatur Capital Baltics – are operating investment programmes.

In Sweden the companies did not state that there was lack of capital on the venture-capital market or other capital markets. However, they argued that it was very difficult and time-consuming to attract capital investments. The main problems, according to the companies, were not the products, technologies or business models in the companies. Rather the problems were related to communicating information about the products, technologies and not least the business models, and the need for the right contacts. The availability of capital generally, and venture capital more specifically, was much more limited in Estonia and Latvia. Further in these two countries the business model development and its communication remained an issue.

6. Clean technologies related strenghts and weaknesses in Sweden, Estonia and Latvia

Strengths

The particular strengths of the Swedish clean technology sector related to human resources and community support.

There were well functioning **higher education institutions** in the relevant regions in Sweden that addressed the sector's future demand for qualified personnel. A range of courses and studies that were demanded by clean technology companies were on offer. Examples of Master's programmes specific to clean technology specific includes "Environmental Science" (Stockholm University), "Sustainable Technology" (Royal Institute of Technology), and "Energy and Environmental Engineering" (Linköping University). More than half of the companies interviewed claimed to have had sufficient access to qualified personnel. However further research is needed as the same companies indicated the need for personnel with more business knowledge and the above educational programs mostly were technology-oriented.

One of the strengths regarding clean technology in Estonia and Latvia lay also in local universities that have strong technical, engineering, chemistry, physics, etc. base which was essential for clean technology development. The relevant companies were satisfied with the overall availability of skilled workforce and held the opinion that there were enough clean technology related programmes at universities.

One of the strengths of the Swedish clean technology sector was related to the comprehensive **community support system.** Examples here include the Swedish government's national initiative providing SEK 560 million (EUR 52.6 million) for support measures between 2007 and 2010 in the field of clean technologies. For the period 2011–2014, an additional SEK 400 million (EUR 37.6 million) was allocated for the promotion of development and export of environmental technologies. Examples of government programmes supporting clean technology companies include "Green Nano", which promotes research on nanotechnologies for a better environment, and "DemoEnvironment" which promotes the testing of new environmental technologies. Moreover, special initiatives were conducted in order to promote the export of Swedish clean technology to Asia (i.e. India and China). An example of this was the establishment of the Centre for Environmental Technology (CENTEC) in China. On a regional level, five community support organizations were of particular importance for the clean technology sector's development. Here examples were the Stockholm Environmental Technology Centre (SMTC), Cleantech Östergötland and the network "Sustainable Business Mälardalen".

Again, the Swedish experience was rather different from Estonia and Latvia where such large-scale and clean technology specific support programmes and instruments were lacking. Still, public awareness about the relevance and possibilities of "being green" and developing clean technologies had been increasing in Estonia over the last years as indicated by the thematic conferences that have been organized, cluster initiatives which have been started, community support organizations that were in the process of being established, green public procurement was increasingly discussed, etc. Such developments were largely directed by EU policies and guidelines, as well as co-funded by the Cohesion Fund measures.

One of the overall strengths was that **various clean technology sub-fields** were developing in the regions covered. Sweden was the most advanced with the following existing clusters which were being developed further: waste management and recycling, bioenergy and biofuels, sustainable building, air purification and solar energy. In Estonia, a variety of clean technology sub-fields were represented and were being developed and the largest sub-fields were energy technologies and clean technology related ICTs. For Latvia renewable energies posted the most significant growth. Especially in these specific fields there was also co-operation at national level (including between the academic and industrial sectors) and internationally, expressed both by the exports of the companies as well as their participation in global innovation networks.

Weaknesses

One of the weaknesses regarding the clean technologies sector in all countries was related to **lack of integration of business courses** in clean technology related education. That is, in order to successfully start and drive a clean technology company, specific knowledge about both business administration as well as business development were needed. It was thus seen as a weakness that business-related topics such as marketing were not a major part of studies in the clean technology field. Although a lot of technology development goes on in the companies, this could be much better integrated to business models (i.e., how to profit from the technologies) and business development, and also in communicating these.

Companies in all regions experienced problems with the **acquisition of funds**. This was expressed by the companies interviewed and was regarded as the most serious issue for Estonia. Problems were related to heavy administrative burden, lack of support schemes for some stages of R&D and product development, and the limited presence of the (clean technology specific) venture capital, although this partially could be related to lack of skills in linking the technology to the firm's business model.

Although co-operation between the industry and academia existed in all the countries, the **contribution of academic and other research organizations** to private sector development could be enhanced significantly. In Sweden it was desirable that those academic organisations became more active in commercialization of knowledge as well in patenting activity in the field of clean technologies. In Estonia and Latvia there was also the expectation that universities would offer more services to companies instead of basic research and the production of high-level publications.

In all the regions covered clean technology companies perceived considerable **barriers to exporting and marketing** their products and services. Companies in Sweden, Estonia and Latvia experienced difficulties in finding and contacting customers and building up a long-term relationships with them. In addition, laws and regulations in export markets were seen as a major export and marketing barrier. A more specific aspect related to Estonia was the issue of trust and recognition. The country is small and relatively unknown and this makes successful entrance to other markets even more difficult.

7. Policy recommendations

The interviews and analysis carried out have led to some of the following ideas about the improvement of policies and undertaking joint actions. These are preliminary policy recommendations and need further analysis and interrogation before being used as a guideline in practice.

Firstly, there was lack of integration of business courses into the clean technology related education curriculum. That is, in order to successfully start and drive a clean technology company, **more knowledge in business administration and development** was needed. Technology development should be located much more substantively to business models (i.e., how to profit from the technologies) and business development, and in communicating it. One option could be joint master's programme driven by a consortium consisting of carefully selected actors in the Baltic Sea region. The primary target group would potentially be the managers in clean technology companies. The pedagogy of such a course ought largely to be employ practical cases with ready application in practice. The intended outcomes would be both a higher level of competence among the participants with a view to enhancing business success.

Second, the forum of clean technology stakeholders from the all regions involved was largely missing. **Better interaction of the support organizations** from Sweden, Estonia and Latvia, and involvement of the other clean technology organizations from the other Nordic countries, is also recommended. One of the actions undertaken could be related to better information exchange and further co-operation between the clean technology companies from Sweden, Estonia and Latvia. This could take the form of match-making events. In a similar vein, many clean technology companies were currently too small to invest enough in export projects on their own. To address this need policy-makers should consider funding allocations towards organizing co-operative trade fair operations, wherein clean technology companies work together. For example this could include integration of their marketing budgets to attend trade-fairs.

Thirdly, joint actions could be initiated in the field of **public procurement for innovation**. Public procurement for innovation means that a public agency places an order for a product that does not yet exist, but which could probably be developed within a reasonable period of time, based on additional or new innovative work. Mostly it is undertaken to solve an existing or emerging societal need, but compared to the procurement of "off-the-shelf" products, public procurement for innovation arguably has a potential to enhance providers' innovativeness and to support economic development. Many governments around the world are currently re-discovering policies that would put public procurement – usually worth 10–20% of countries GDP – explicitly into the service of technology and innovation policies. Since environmental issues are largely cross-border issues and as such are susceptible to joint actions which could be initiated and innovative solutions to societal needs sought. The possibilities are good considering that Sweden has extensive experience in carrying out public procurement for innovation especially since both Estonian and Latvian stakeholders have shown increasing interest in this as well.