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CO-OPERATION BETWEEN FINLAND AND LITHUANIA IN THE DEVELOPMENT OF CLEAN TECHNOLOGIES

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ABSTRACT

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The objective of this thesis is, upon analysing theoretical and practical aspects of clean technologies and international co-operation as an element of internationalisation processes, to identify the need for further co-operation between Finland and Lithuania, and propose solutions for co-operation development.

In order to reach the objective, the concept and variety of clean technologies were explored. Analysis of internationalisation theories helped understanding the motives, barriers, processes and types of international co-operation. A research has been carried out to review clean technology-related legal frameworks of the European Union, Finland and Lithuania, recent policies, strategies, action plans and other legislation. To compare theory with practice, Finnish and Lithuanian clean technology sector analyses were performed to identify the size of sectors, specialisation, internationalisation level, local co-operation and centralisation level. Upon analysing theoretical and practical aspects, a list of questions was compiled and five clean technology experts from Finland and Lithuania were interviewed. After summarising and analysing the answers, and adding the findings of the before-mentioned studies, two complex analyses were carried out to identify strengths, weaknesses, opportunities and threats of Finnish and Lithuanian clean technology sectors. The latter analysis contributed to forming solutions for developing co-operation between Finland and Lithuania in the area of policymaking, science, innovations, research and development, networking, manufacturing and sales, future perspectives and brand building.

The solutions that were proposed, if applied, would help solving environmental issues, create jobs and economical welfare, increase the need for knowledge-based society and bring much more various benefits to Finland, Lithuania and the global society.

Key words

Clean technologies, cleantech, clusterisation, development, energy efficiency, environmental technologies, European Union, Finland, innovations, internationalisation, international co-operation, Lithuania, renewable energy, sector analysis, smart grid, sustainability, waste management, water treatment.

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ANOTACIJA

CENTRO OSTROBOTNIJOS TAIKOMŲJŲ MOKSLŲ UNIVERSITETAS	**Data** 2012.05.27	**Autorius** Pavel Ragozin
Studijų programa Verslo vadybos studijų programa		
Baigiamojo darbo pavadinimas BENDRADARBIAVIMAS TARP SUOMIJOS IR LIETUVOS PLĖTOJANT ŠVARIĄSIAS TECHNOLOGIJAS		
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Šio baigiamojo bakalauro darbo tikslas – išanalizavus teorinius ir praktinius švariųjų technologijų, bei tarptautinio bendradarbiavimo, kaip vieno iš internacionalizavimo procesų elementų, aspektus, nustatyti bendradarbiavimo tarp Lietuvos ir Suomijos poreikius, bei pasiūlyti bendradarbiavimo plėtojimo sprendimus.

Siekiant iškelto tikslo, buvo išnagrinėta švariųjų technologijų koncepcija ir įvairovė. Internacionalizacijos teorijų analizė padėjo geriau suprasti tarptautinio bendradarbiavimo motyvus, barjerus, procesus ir rūšis. Buvo atlikta Europos Sąjungos, Suomijos ir Lietuvos švariųjų technologijų reguliavimo politikos nuostatų ir prioritetų analizė. Siekiant palyginti teoriją ir praktiką, buvo atlikta sektorinė analizė Suomijos ir Lietuvos švariųjų technologijų sektorių dydžiui, specializacijai, internacionalizacijos lygiui, vietinio bendradarbiavimo ir centralizacijos lygiui įvertinti. Išanalizavus teorinius ir praktinius aspektus, buvo sudarytas klausimų sąrašas ir apklausti penki švariųjų technologijų ekspertai iš Suomijos ir Lietuvos. Apibendrinus ir išanalizavus ekspertų atsakymus, bei pridėjus ankstesnių tyrimų išvadas, buvo atliktos dvi kompleksinės analizės, kurių dėka buvo nustatytos Suomijos ir Lietuvos švariųjų technologijų stipriosios ir silpnosios pusės, galimybės ir grėsmės. Paskutinysis tyrimas prisidėjo prie bendradarbiavimo tarp Lietuvos ir Suomijos plėtojimo sprendimų formavimo. Bendradarbiavimo švariųjų technologijų srityje plėtojimo sprendimai apima bendradarbiavimą politinėje veikloje, mokslo, inovacijų ir tyrimų srityje, tinklaveikoje, gamybos ir pardavimų srityje, bei planuojant ateitį ir kuriant šalies savitumą.

Pasiūlytų bendradarbiavimo plėtojimo sprendimų pritaikymas galėtų padėti išspręsti aplinkos apsaugos klausimus, sukurtų naujų darbo vietų ir stimuliuotų piliečių ekonominės gerovės augimą, padidintų poreikį žinių visuomenei, bei suteiktų daug kitos naudos Suomijai, Lietuvai ir visam pasauliui.

Prasminiai žodžiai
Aplinkos apsaugos technologijos, atliekų tvarkymas, atsinaujinantys energijos šaltiniai, energijos efektyvumas, Europos Sąjunga, inovacijos, internacionalizacija, klasterizacija, klintechas, Lietuva, pažangieji tinklai, plėtra, sektorinė analizė, Suomija, švariosios technologijos, tarptautinis bendradarbiavimas, tvarumas, vandens valymas.

ABSTRACT

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1 INTRODUCTION

Industrial and technological development combined with the growing consumption in the world, negatively influences the environment and creates serious ecological problems. In addition, depleting natural resources put humankind into position where critical decisions have to be made concerning the future of generations to come. Sustainability is the key concept that nowadays is introduced to every type of activity.

The biggest challenge is to make development sustainable and at the same time satisfy the needs of the growing society using depleting natural resources. Environmental technologies were designed to minimise the negative impact of human activity, but they could solve only a minor part of the problem. Over the last decade the need for sustainability was recognised globally, and the need for change was instilled in the legislations of the majority of the world's countries. The biggest part of them had set more ambitious goals than environmental technologies could reach. Implementation of these plans was assigned to new technologies that strived to achieve zero-impact activity – clean technologies.

Clean technologies are expected to change and transform present industries into environmentally neutral. They strive to achieve zero-impact in all stages of product life circle, starting from resource extraction and manufacturing, ending with consumption and recycling. These technologies are young, but they grow in huge pace. The goal of clean technologies is to solve a global problem. This means that they have to be developed globally. No country can handle this problem alone, nor would this be effective. Strong and well planned international co-operation is needed in order to gain as much benefits from the clean technologies as possible.

Finland is globally known as one of the leaders in environmental technologies. Finnish clean technology sector grows very fast. This sector is already quite internationalised and further international co-operation could help utilising full potential of the sector. Lithuanian clean technology sector is on its early stages of development. But there are other technologies that are well advanced and they can be used to develop and improve clean technologies. Co-operation between Finland and Lithuania in the development of clean technologies could bring benefit to both countries and the world.

The object of this thesis is clean technologies in Finland and Lithuania, their development trends and legislation. Finnish and Lithuanian clean technology sectors are analysed in the studies, identifying co-operation possibilities, needs and possible outcomes.

Upon analysing theoretical aspects of clean technologies and internationalisation processes, reviewing cleantech-related legislation and its implementation, analysing clean technology sectors in Finland and Lithuania, the goal is to propose solutions for enhancing co-operation between these two countries in order to develop clean technologies.

In order to achieve the goal of this thesis, the following tasks were set:

- Explore the variety of clean technologies and identify their significance;
- Review internationalisation theories and find a theoretical base for co-operation;
- Following the theoretical studies, analyse cleantech-related policies and priorities in the European Union, Finland and Lithuania;
- Analyse clean technology sectors in Finland and Lithuania;
- Determine the needs and areas of co-operation between Finland and Lithuania;
- Identify the strengths, weaknesses, opportunities and threats of Finnish and Lithuanian clean technology sectors from the viewpoint of international co-operation;
- Form and propose solutions for enhancing co-operation between Finland and Lithuania in the development of clean technologies.

Scientific books and articles were analysed in the theoretical studies. Empirical studies employed legal acts of the United Nations, the European Union, Finland and Lithuania, statistical data from various official sources, reports, reviews and prior studies. The same methods were used in the sector analysis. The possible needs and areas of co-operation between Finland and Lithuania were identified by in-depth expert interview.

The theoretical studies in this thesis helped recognising the significance of clean technologies and understanding how to combine them with internationalisation processes. Legislation analysis explained the future trends of cleantech development, while sector analysis showed the present situation in both countries. Expert interview helped understanding the expectation of the parties and the will to co-operate. All studies contributed to forming solutions for Finnish-Lithuanian co-operation in the area of clean technologies, which, if applied, would help solving environmental issues, create jobs and economical welfare, and bring much more various benefits to both countries.

2 CURRENT TRENDS AND PRIORITIES IN CLEAN TECHNOLOGIES

With the industrial and technological development during the last century, humankind made a huge leap forward in its evolution. Unfortunately, this leap negatively answered back on the environment and created serious ecological problems. Ozone depletion, natural resource scarcity, loss of biodiversity, air and water pollution, industrial accidents – these are just a few elements of a long list of the problems caused by the industrial and technological development. These problems will worsen in the forthcoming years, influenced by rapidly growing World population. To satisfy at least basic needs of the whole population more resources will have to be used and that will generate more waste and pollution. But that will speed up ecological degradation which might turn out to be catastrophic. This is one of the biggest challenges for humankind in its history.

Humankind cannot take a step back and give up all technological achievements, but at the same time it is disastrous to continue the same harmful activity. Technological progress has to move on, but it is imperative to channel its development to the right direction. Over the last five decades an agreement has been growing, which admits that the only solution for this problem is a balance between economic and ecological variables. That was the time when environmental technologies emerged. Their main target is to decrease the harm that has been done and which is being done. Unfortunately, these technologies cannot handle such a big amount of damage that is being done by the growing consumption.

Approximately a decade ago clean technologies (cleantech) emerged. Their target is the same, but the main focus is to neutralise harmful aspect of manufacturing process. In addition, clean technologies are more ambitious – the ultimate goal is to create zero-impact manufacturing processes in all sectors of the economy, throughout the chain of supply.

Cleantech market, which includes wind energy, solar photovoltaics, biogas and biofuels, energy efficiency technologies, water treatment and waste management, smart grids, etc., grows every year with impressive pace. From 2008 to 2010 the world market for cleantech grew by 31 % per year, and in 2010 it stood at EUR 179 billion. The global cleantech market is expected to grow further, approximately by 10-15 % per year, valuing around EUR 290-360 billion in 2015. (Slot, Berg & Berkhout 2011, 14-16)

In the early 1970's the international society recognised the need for sustainable development, i.e. development which saves the environment for the future generations. This year Rio+20 Conference will be held. The conference will mainly focus on 7 issues: jobs, energy, cities, food, water, oceans, and disasters (UNCSD 2012). Cleantech is concerned with all of these issues. It is recognised by all strategies and action plans, as one of the major tools in solving the biggest challenge in human history.

The European Union has recognised the importance of sustainable development long time ago. It has over 35 years' experience of environmental policy-making. During this time, a few hundreds of legal acts concerning environmental issues have been put in place, strategies have been built and implemented. Europe 2020 is the growth strategy of the EU for the period from 2010 to 2020. Three main goals are – to become a smart, sustainable and inclusive economy (Europe 2020 targets, 2012). Environmental issues are integrated into this strategy by 20-20-20 goals. Having in mind that one of the objectives is to increase funding of R&D, it is easy to understand that a lot of attention will be paid towards developing clean technologies, as they are the only alternative, which can satisfy the growing demand and at the same time be less harmful to the environment.

All the EU member states took responsibility to contribute to global sustainable development. There are plenty of national strategies and action plans that employ cleantech to reach sustainable development goals. Over the last decade tens of programmes have been implemented in the EU to promote cleantech. On the national level, the number of such programmes reaches hundreds. The environment-related investments in manufacturing processes and environmental services, as well as the number of cleantech companies are growing throughout the EU. The increasing number of programmes, cleantech companies, cleantech-related legislation, growing investments in this sector and changing attitude of the society shows the growing demand for this kind of technologies (AmCham 2011, 3-9).

Clean technologies are the answer to a global challenge. This problem cannot and should not be solved by one or another country alone. Because of historical, economic, social, geographical and demographical reasons, each country specialises in particular technologies. Concerning the cleantech, there are leader countries, such as Denmark, Sweden, Finland, Germany, and a few others, that lead not only in production amounts, but also in innovative activities. Many other countries fall behind in the development of cleantech. However, it would be much more effective to face the problem together, by sharing achievements and collectively working on the research. Different countries with expertise in various areas can get together and bring something useful to common purpose. That is why international co-operation is very important, especially when developing clean technologies and solving global problem. (Kemp, Olsthoorn, Oosterhuis & Verbruggen 1992)

Finland is among the global leaders in clean technologies. In 2012 it was ranked as the 4th most cleantech innovative country in the world. With its strong environment oriented legislation, effective activity of research centres and institutions that promote innovations, high number of innovative cleantech companies, successful co-ordination of the cleantech sector, extensive experience and achievements in environmental technologies, and strong specialisation wind and biomass energy, water treatment, waste management, smart grids and energy efficiency, Finland is a great example for countries that try to reach excellence in cleantech. (Knowles, Henningsson, Youngman & Faulkner 2012)

Lithuanian cleantech sector is on its early stages of development. Nevertheless, the need to develop this sector is recognised and strongly supported by the government and the society. Lithuania specialises in electric and electronic engineering, laser and nanotechnologies, biotechnologies and ICT (Lithuanian Innovation Strategy 2010, LRS 2012). Part of this specialisation can be used in the development of cleantech.

There is a lot of co-operation between Finland and Lithuania in different areas. Unfortunately, there is not that much co-operation in cleantech area. Finland with its experience and achievements in clean technologies would be a good partner to Lithuania, which could offer expertise in electric and electronic engineering, laser and nanotechnologies, strong scientific base, perfect geographical location and other advantages. Co-operation between these two countries in scientific, political and economical areas, focusing on clean technologies, would be useful for both parties, as well as for the global society. If properly planned and co-ordinated, this co-operation could bring technological advancements, ecological improvements, financial benefits for companies and general improvement of living conditions of population. That is why co-operation possibilities between Finland and Lithuania have to be thoroughly studied.

3 DEVELOPMENT OF CLEAN TECHNOLOGIES IN THE CONTEXT OF INTERNATIONALISATION PROCESSES

In order to reach the goal of this thesis, clean technologies have to be clearly defined and their place among other technologies has to be identified. International co-operation is one of the internationalisation processes, so they also have to be analysed, paying attention to internationalisation theories.

3.1 The concept of environmental technologies

Some might say that technology is the engine of progress. Looking at the history of human kind, it is hard to disagree with this statement. Everyday one can hear about different kinds of technologies, see, feel and use them. A great part of those technologies became an integral part of the modern world, and are perceived as normal things that belong here. A high importance of different kinds of technologies, such as information technologies, nanotechnologies, biotechnologies, clean technologies, etc., is being stressed everyday. But before going any further, it is important to define the concept of technology, so that the path for further research would be clearer.

The definition of a word "*technology*", provided in the Encyclopedia Britannica, describes technology as an "application of scientific knowledge to the practical aims of human life or, as it is sometimes phrased, to the change and manipulation of the human environment". Technologies can be perceived as specific products that show the results of the activity of people, their groups, the society, and that are distinguished by the aim of creation and implementation, which is to improve people's way of living (Melnikas 2002, 35). Both definitions mention, that the technology is an outcome of human activity, which is being used to manipulate the environment and make it more comfortable to live. Despite the fact, that the word "technology" is being used only since the XVII century, the idea of technology emerged with the human kind, and it goes in step with the human evolution.

Technology can be divided into different groups, classes, categories, etc. Technologies are often divided into high-low levels, depending on various categorisation criteria:

- By the intensity of research and development (R&D): a classification first used by the Organisation for Economic Co-operation and Development (OECD), which looks at the expenditures on R&D. Technologies belong to a high level, if the expenditures to develop these are 3 % or more. Low technologies receive less funding.
- By the level of technological innovations: high technology (high tech) industry is the one, where the success of companies strongly depends on the ability to maintain innovative products and/or production processes. In that case, high level of innovations is crucial for high tech. Low technologies are defined other way round.
- Felsenstein and Barel classification: the level depends on a combination of three variables – technical intensity of human resources, technical intensity of capital (of the machinery used in the process of manufacturing) and technical intensity of a product. Technical intensity covers such indicators as the production of ideas and the consumption of ideas. (KTU 2004)

All the high and low technologies can also be divided into many groups and subgroups, depending on the sphere of human activity, where one or another technology is being used. Very often different technologies intersect and complement each other. This is the reason why technologies are grouped and developed in those groups, as the outcomes of such development are bigger than when developing particular subcategory.

Not all technologies are being used to utilize resources. Some of them are developed to increase the efficiency of the other technologies, and minimise the costs. While developing technologies and sophisticating industries, environmental pollution on the local, regional and global dimensions showed the necessity to include the factor of sustainability into the development processes. That led to development of technologies that were concentrating not only on production of goods in an ecological way, but also on decreasing and eliminating negative effects of the production on the environment (Kuehr 2006, 1316).

In the course of time, more attention was paid to the environmental issues. That way, the concept of environmental technologies (envirotech) or green technologies (greentech) emerged. United Nation’s (UN) action plan related to sustainable development, Agenda 21, defines *environmental technologies*, or environmentally sound technologies, as:

- the technologies that protect the environment, are less polluting, use resources in a sustainable way, recycle wastes and products, handle residual wastes in a more acceptable way than other technologies;
- the process and product technologies that generate low or do not generate any waste, prevent pollution or treat it after it has been generated (end-of-pipe technologies);
- total systems that include know-how, manufacturers, goods and services, equipment, managerial and organisational procedures. Such technologies should be compatible with national socio-economic, cultural and environmental priorities. (Agenda 21 1992)

OECD defines environmentally sound technologies as techniques and technologies that are able to reduce environmental damage via processes and materials that generate less potentially damaging substances, recover the damaging substances from the emissions before the discharge, or recycle and utilize the production waste. The assessment of such technologies has to account for their link with cultural and socioeconomic conditions under which they are implemented. (Glossary of Statistical Terms 2007, 260)

Environmental technologies can also be defined as production equipment, procedures, methods, product designs and even product delivery systems that save energy and natural resources, reduce environmental load of human activities and protect the natural environment. (Shrivastava 1995, 185)

The before-mentioned definitions are quite similar, as they stress the same features of environmental technologies: less pollution in the process, less pollution after the process, treating production waste (or even eliminating it), interaction with other technologies, sciences, and procedures.

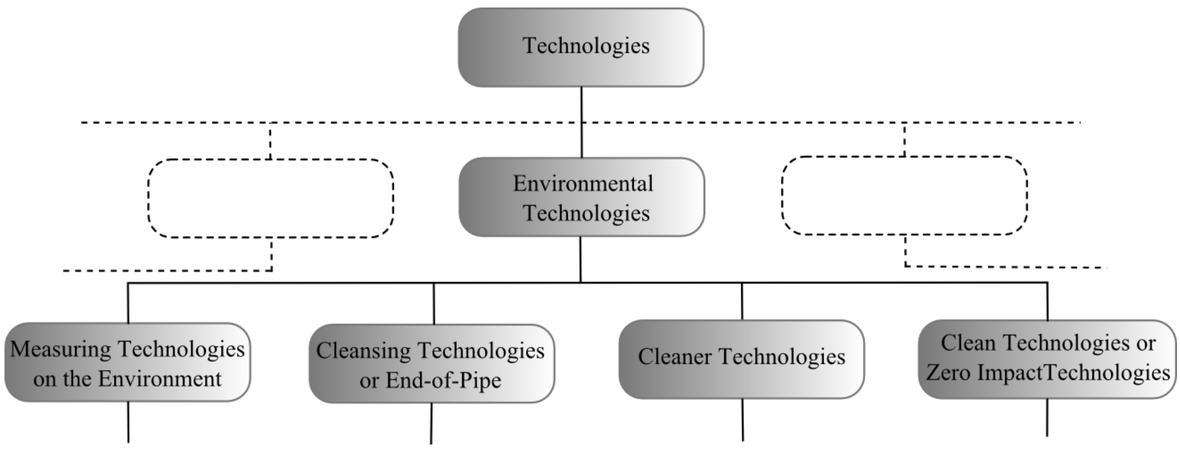
Envirotech include ‘hardware’ and operating methods, together with management orientation. Envirotech ‘hardware’ is pollution control equipment, cleaner production technologies, and ecological measurement instrumentation. Operating methods, for instance, waste management, recycling, waste exchange, conservation oriented work arrangements (car sharing), are used to save and enhance nature. As a management orientation, envirotech consolidates environmentally responsible approaches to product design and manufacturing, environmental management, choice of technology, the design of industrial systems and so on. (Shrivastava 1995, 185)

The classification of environmental technologies can be based on a range of different criteria. For instance, envirotech can be classified into five themes based on the general management orientation:

- **Design for disassembly** - rethinking the design and creating products that have maximum useful life, are easy to disassemble, reuse and recycle;
- **Manufacturing for the environment** – redesigning the production processes, using cleaner and higher-efficiency techniques, so that the negative impact on the environment would be minimised;
- **Total quality environmental management** – combines before-mentioned themes with the 'total systems' approach and seeks to ensure that all organisational inputs (i.e. energy, raw materials, labour and capital) would be used in an ecologically sound manner, the negative impact would not be shifted from one element to another, waste would be minimised by reducing total life cycle costs of a product;
- **Industrial ecosystem** – designing a network and creating linkages between companies that could use each other's wastes, and outputs (also known as waste exchange), in order to reduce the total consumption of natural resources, total amount of waste and pollution;
- **Technology assessment** – the evaluation of impact of a new or old technology on the environment, the assessment of outcomes of technology transfer from one industry, region, country, or society to another. (Shrivastava 1995, 186-189)

Another classification can be based on the use and allocation of natural resources over time. Considering this criteria, researchers suggested dividing environmental technologies into three categories: pollution prevention technologies, management systems and pollution control technologies. *Pollution prevention technologies* are concerned with physical changes to basic products and processes. These technologies minimise or eliminate harmful substances as well as negative impact on the environment in the process of manufacturing. *Management systems* affect the way manufacturing is managed. Monitoring, internal and external reporting, establishing an environmental department, training for spill prevention and waste reduction, etc., are the examples of management systems. *Pollution control systems*, in contrast to pollution prevention technologies, control harmful substances at the end of manufacturing process or even later. Such technologies are also called 'end-of-pipe' technologies. (Klassen & Whybark 1999, 602-603)

After looking at the definitions it is possible to see that environmental technologies can be divided into a few categories, considering the outcomes (see Graph 1). The first category – *measuring technologies*, is used for information purposes. These are the tools, machines and different systems that help assessing the harmful effects of other technologies, and provide necessary information for restoring a natural balance. Measuring technologies are used to understand the environment and make appropriate plans in other three categories of technologies. The second category is cleansing or *end-of-pipe technologies*. Such technologies are designed to minimise the negative effect without changing the harmful process. Quite often they are used in end-of-pipe manner, for example filters, exhaust catalysts, etc. However, such technologies would require additional recycling or reusing, manufacturing them would consume resources and energy. The third category – *cleaner technologies*, are designed to modify the processes to decrease or eliminate the harmful effects. That also can be an introduction of sophisticated control technology, change of raw materials, etc. The fourth category is *clean* or *zero impact technologies*. Such technologies do not effect the environment in a harmful way. Some might say that such technologies do not exist yet, but at least they act as a good destination point and the aim for development. However, there are some technologies that have reached zero impact on the environment in some dimensions, but still are doing harm in other parameters. (Kuehr 2006, 1319)



GRAPH 1. Categorisation of environmental technologies (adapted from Kuehr 2006, 1319)

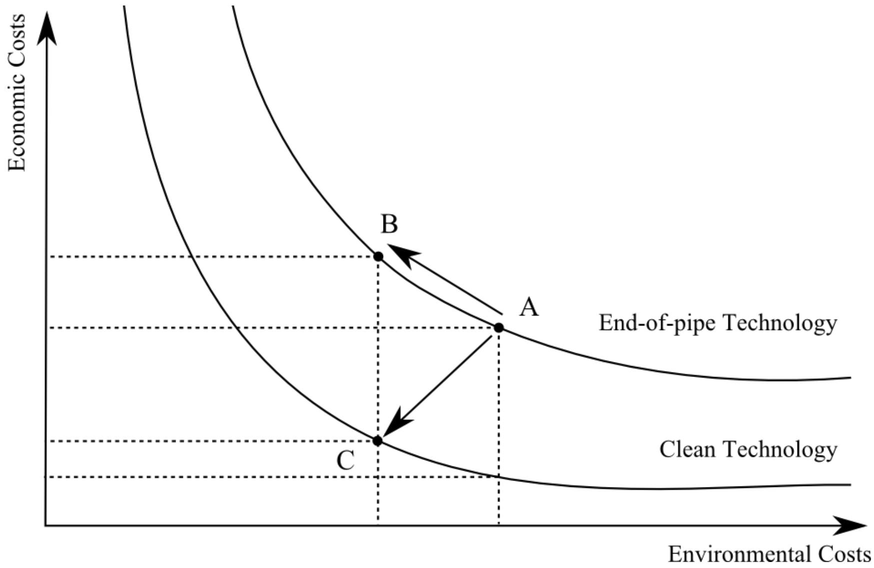
All three typologies that were mentioned before create a better picture of the concept of environmental technologies. All of them have a few things in common, for example the assessment or measuring technologies, and the change of manufacturing processes. Shrivastava’s typology looked straight at the designing, total quality environmental management and industrial ecosystems, while other typologies had those factors hidden deep in different subgroups. Kuehr's classification is preeminent, because it is based on the outcomes of a particular technique or technology, stressing the level of negative impact on the environment, the use of resources and the process of manufacturing. Although other typologies also mention decreasing level of pollution, more effective use of resources and treating waste, they do not look at renewable energy sources and zero impact technologies. Even though there are no technologies that would be harmless throughout their life cycle and supply chain, they can be harmless on a few stages, so this brings cleaner and clean technologies close to each other. The distinction between them can be made theoretically, but in practice they are mixed up (Kuehr 2006, 1319). This thesis will concentrate mainly on technologies that are defined as 'cleaner' and 'clean' technologies, so for the sake of simplicity those two groups will be called as clean technologies (*cleantech*).

3.2 The concept and classification of clean technologies

Before going any further, it is important to define the difference between cleansing (or clean-up, or end-of-pipe) technologies and clean technologies. The first deals with the pollution after the manufacturing process, while the second one – is inherently associated with less, or none environmental damage (Clift 1995, 321). Cleantech refers to products, services or processes that deliver value using limited or zero non-renewable resources and create significantly less waste than other technologies (Pernick & Wilder 2007, 2).

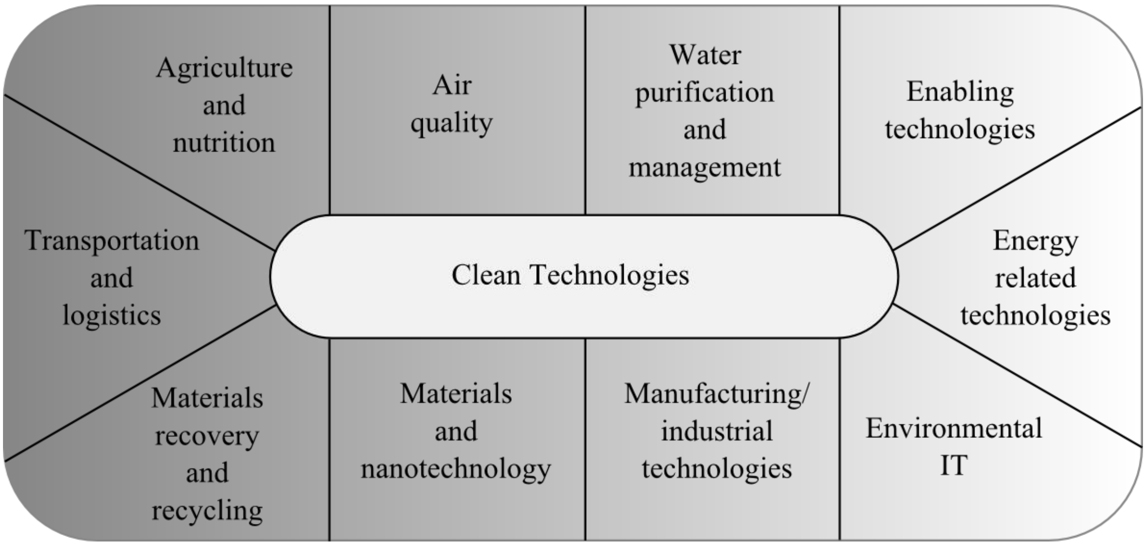
In the context of economic costs, cleantech is less demanding than out-dated end-of-pipe technologies in long-term perspective (Clift 1995, 321). A principle example is illustrated below (see Graph 2). Let us assume that an improvement in the end-of-pipe feature of a manufacturing process has been made (A → B). The environmental costs decrease, while economic costs increased. The same result (C) could be reached, if the improvement would be made using cleantech. The only difference is that in long run, the economic costs of cleantech would be much smaller. It is more effective, so with the same amount of allocations spent for end-of-pipe technology, even more could be achieved using cleantech.

Historically, markets for cleansing or end-of-pipe technologies were mainly driven by compliance and regulatory concerns, instead of economic factors. Cleantech is more focused on resource efficiency, advanced materials, energy technologies, underpinned by strong economic drivers. Still, regulatory factors are important in some areas, like waste legislation and incentives for renewable energy (Forum for the Future 2007, 7). Environmental technologies are quite often associated with highly regulatory driven end-of-pipe technologies, that were popularised in the 1970's and 80's. In contrast, clean technologies are the new technologies that offer competitive returns for the stakeholders, while providing solutions for global challenges and function on the basis of sustainability. Cleantech is both a response to global climate change crisis and a great new market opportunity (Caprotti 2011, 12).



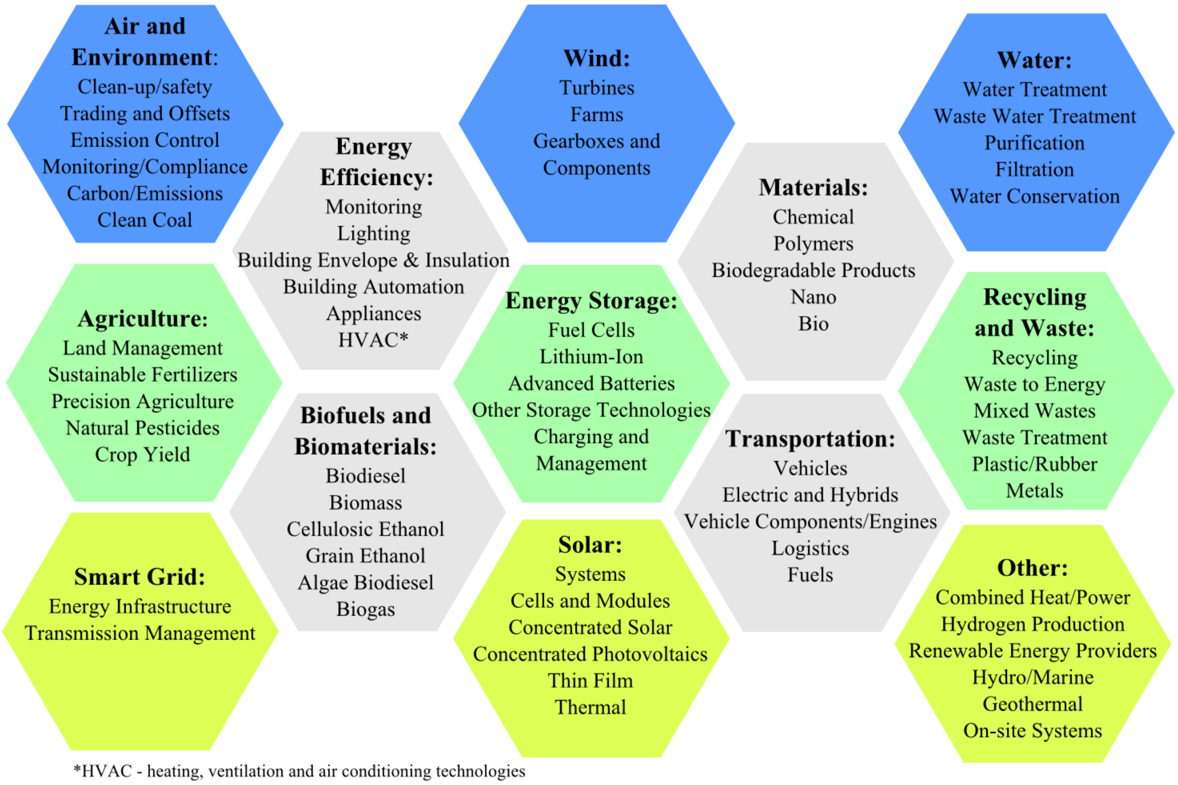
GRAPH 2. Comparison between end-of-pipe and clean technologies in the context of economic and environmental costs (adapted from Clift 1995, 321)

There have not been many attempts to classify clean technologies, because it is quite a new phenomenon. Cleantech covers four main sectors: energy, water, transportation and materials. It includes other technologies, such as solar photovoltaics, wind power, bio-based plastics, biofuels, lithium-ion batteries, tidal power, hydrogen generation, nano-technology-based materials, etc. (Pernick & Wilder 2007, 3). Ten broad cleantech sub-sectors can be identified (see Graph 3). Sometimes companies are not occupied only in one or another sub-sector, because cleantech can operate in cross-sector manner. As well, companies may not consider themselves as working in cleantech sector, but they are, if at least some of their operations are sustainable and regard the principles of cleantech.



GRAPH 3. Sub-sectors of cleantech (adapted from Forum for the Future 2007, 7)

To get a better picture of the scale of cleantech industry, it is good to look at one more classification of clean technologies, which has some different features (see Graph 4). This classification shows thirteen segments, where cleantech is used at the moment. Some of the segments were mentioned in the first classification, but the second one looks more thoroughly at them. The first classification mentioned ‘enabling technologies’, that surely have to include clean technologies. Environmental IT is a specific sub-sector, that was not mentioned in the second classification, but which nonetheless is important. Global information and communication technology (ICT) industry accounts for 2 % of global carbon dioxide emissions, so the aim of environmental IT is to decrease these emissions by optimising production, decrease the energy consumption of devices, make them last longer, etc. (Green ICT 2012). A preeminent segment mentioned in the last classification is the smart grid, which is about designing the most efficient energy network as possible, organising and managing waste exchange. This matter was discussed earlier as one of the core ideas behind environmental technologies and cleantech in particular.



GRAPH 4. Cleantech industry segments (adapted from Cleantech Group 2012)

3.3 Drivers and obstacles for clean technologies

Although, environmental technologies were developing already for decades, clean technologies emerged not that long time ago. In the market or mixed economy, clean technologies have a strong potential, as they are commercially developed, quality oriented, have lower long-run production costs comparing to existing technologies, and after all, are environmentally superior (Goodstein 2010, 368). Such potential can be characterised by the demands (see Table 1). The main factors that are driving the change from environmental and end-of-pipe technologies towards clean technologies are: the demand for efficient energy, the possibility to achieve such efficiency using advanced technologies and innovations, and the increasing concern of society about the future. The increasing demand generates the supply, so in line with those factors, there are companies that use cleantech to get into new markets and transform from out-dated to modern and innovative businesses.

TABLE 1. Cleantech drivers (adapted from Forum for the Future 2007, 8)

Cleantech drivers	
Growing demand for energy and commodities	Global demand for energy will rise 50% by the end 2030. The similar increase in food, metal and other commodities will increase the prices and create new growth markets for resource efficiency, clean production technologies and clean energy.
Volatility in supply and commodity prices	Concerns over security of supply chain are increasing price volatility for energy and commodities, making efficiency more important for domestic and industrial users.
Advances in technology	Advances in nanotechnologies, IT, biochemistry and advanced materials are being transferred to clean technologies, improving cost, performance, and reliability.
Regulatory and market pressures	An increasing global regulatory pressure, which covers a broad range of issues, such as pollution levels, climate change, permissible materials, etc.
Increasing social concern	Increasing social concerns, causing corporations and politicians to respond.
Carbon emissions	Carbon emissions control and pricing will increase investments in low carbon alternatives. This will depend on confidence in the continuous tightening of emission limits.

In line with the before-mentioned drivers, there are another six major forces that push cleantech into mainstream and ensure the rapid growth and expansion. Together they create a dynamic, profitable business and investment opportunities. A combination of these forces is abbreviated as 6 C’s:

- **Costs**: in economical terms, the most powerful force driving the cleantech growth. A decade ago clean technologies were more expensive than their counterparts. Now the trend is changing and cleantech costs are decreasing, while costs of fossil fuel energy are rising. In that case, cleantech becomes more competitive economically.
- **Capital**: increasing investments stimulate the growth of cleantech industry. Many of the same investors and entrepreneurs that have supported high tech and internet revolutions are now engaged in promoting cleantech projects. For example, in 1999 in the United States, only 1 % of total investments were made in cleantech sector, but in 2006 the same rate increased up to 9 %. This fact supports the idea, that incoming capital strongly influences the growth of clean technologies.
- **Competition**: the competition between countries in fossil fuels will gradually switch to competition in clean technologies. Being a leader in cleantech will be very profitable, because other countries will be following and learning from the leader states. Governments via standards, tax incentives, subsidies and other tools can regulate that switch of competition, which would happen sooner or later.

- **China**: growing demand for resources in China, India, other developing countries, and limited natural resources, lead these countries to choosing cleantech as an alternative. The need for cleantech generates opportunities for other countries.
- **Consumers**: there is a shift in people's interest towards cleantech. That can be explained by a growing awareness of climate change, high energy prices, and polluted ecosystems. These factors make consumers demand cleaner products that use resources efficiently and reduce costs.
- **Climate**: climate-change caused by continued dependence on carbon-intensive energy is no longer a 'question mark', but rather a certainty. Scientific researches only support this concern. Climate-change has already been taken into account when drawing up new policies that tend to decrease the level of greenhouse gases (GHG) emissions. The best alternative for these GHG emitting technologies is cleantech. (Pernick & Wilder 2007, 5-17)

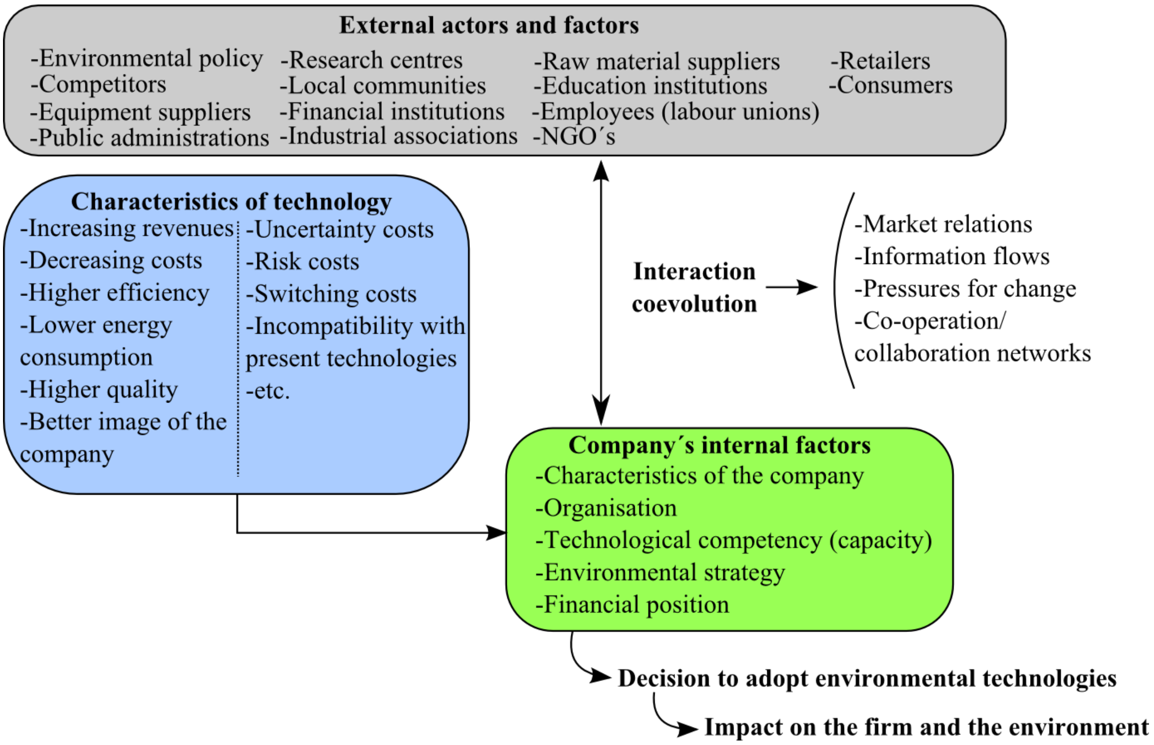
Kemp *et al.* (1992) looked at cleantech as an innovation process and innovation product. Having this approach in mind, decision to develop an innovation in cleantech may be understood in terms of the following terms:

1) Technological opportunities – to develop an innovation, certain 'older' technologies and knowledge have to be available. Usually development of innovations depends on what technological 'baggage' the company already has.
2) Market demand – development of cleantech also depends on the financial advantage it can bring to a company. This advantage comes from the higher profits that are generated by market demand or from reduced costs (by process innovation). Having in mind, that market demand for clean products and processes is getting higher, this factor is getting more important too.
3) Appropriability conditions – ability to capture higher profit after adopting innovation. This factor is usually the main force driving the R&D of a company.
4) Price and quality of the innovation – this factor is concerned with compliance costs, purchasing costs, implementing and operating costs, etc. Quality also starts to play an important role, as cleantech follows the attitude of long-lasting, high quality products and processes.
5) Knowledge and information problem – companies' and other consumers' knowledge about the availability of certain cleantech and its features, the possibilities to adopt it, how to obtain technical and financial support, etc. Small

firms often face knowledge and information gathering problems, are unaware of the environmental damage of products or processes they use and of the existence of cleaner alternatives. In addition, they always seek for an independent advice about innovative technologies.

6) Risk and uncertainty – when adopting an innovation some amount of risk is present. A big part of companies do not apply cleantech to their activities because of possible technical and economic risk. (Kemp *et al*. 1992, 617-622)

On micro-economic level, every company that considers engaging in clean technologies or adopting cleantech innovations, is influenced by three sets of factors (see Graph 5). This triangular model suggests that the decision is influenced by: company's internal factors, external actors and factors, and characteristics of the technology.



GRAPH 5. Triangular model of cleantech adoption (adapted from González 2005, 24-28)

Company's internal factors are mainly concerned with company's structure and attitude towards cleantech, its environmental strategy, ability and competency to adopt technological innovations, the financial capability and availability of other resources needed to adopt innovation, the size of a company, etc. Cleantech may involve substantial change in production process, so internal factors are quite important. *External environment factors* are worth considering, because every company keeps contact with stakeholders, such as consumers, retailers, suppliers, associations, NGO's, banks, public administrations, competitors, etc. The decisions that are made inside the company, including the questions about adopting cleantech innovations, are influenced by these factors. *Characteristics of technology* involve benefits and costs from adoption. In case of cleantech, adoption may lead to increasing revenues, decreasing costs, increasing efficiency by decreasing energy consumption and recycling or reusing wastes, higher quality of a product, better image of the company, staff motivation, etc. As well there are significant barriers that are mainly concerned with uncertainty and risk costs, switching costs, long-term profit versus short-term costs, incompatibility with present technologies, etc. (González 2005, 24-28)

Despite a potential success of cleantech, there are some obstacles for development. One of the major market obstacles is the lack of substantial profit advantage. There are too little incentives for companies to undertake necessary effort to overcome market barriers: poor information, poor access to capital, thin resale markets and high discount rates. Another obstacle is subsidy policies favouring dirty technologies. Such subsidies can range from R&D funding to price supports and tax credits. In addition, market prices for the dirty technologies do not reflect externality costs (Goodstein 2010, 369). On the micro-economic level, cleantech innovation process may be obstructed by management and engineering resistance, lack of technical expertise and skills, insufficient financial resources. Risk is often a strong development barrier. It can be associated with uncertainty about the technical success of such project, the costs of adopting cleantech, future consumer needs and government regulations, etc. (Kemp *et al.* 1992, 617-618).

3.4 The concept of internationalisation and its processes

The modern world can be characterised by a few specific attributes that make globalisation, international exchange and internationalisation processes the most prioritised in the political, social, economical and technological development. The modern world is perceived as a highly intensive system of international co-operation and international relations, which is oriented to the creation and development of common cultural, informative, economical and technological environment. (Melnikas 2002, 57)

Internationalisation was evolving gradually over time in line with globalisation. Even though the term of globalisation emerged not long time ago, a global interplay was started already in the ancient times. For instance, Amber Road and the Silk Road linked various regions of the world. These trade routes were implying international trade, culture and civilisation linkages (Adekola & Sergi 2007, 8).

Internationalisation and globalisation processes are interrelated. While the concept of globalisation is being used in almost all spheres of life, internationalisation is usually concerned with the economical and institutional (organisational) side of the globalisation.

Internationalisation, according to Johanson and Mattson, is the process of adapting company's operations (structure, strategy, resources, etc.) to international environments (Ruzzier , Hisrich & Antoncic 2006, 479). Other definition says that internationalisation is a cumulative process, during which relationships are being established, maintained, developed and dissolved in order to achieve the company's objectives (Johanson & Vahlne 1990). Nordic researchers, U. Lehtinen and H. Penttinen, stated that "internationalisation concerns the relationships between the firm and its international environment, derives its origin from the development of the personnel's cognitive and attitudinal readiness and is concretely manifested in the development and utilization process of different international activities, primarily inward, outward and co-operative operations" (Ruzzier *et al*. 2006, 479). A Finnish researcher Ahokangas suggested another definition of internationalisation, in which it is defined as a process of mobilising, accumulating and developing resource supply for international activities (Ruzzier *et al*. 2006, 479).

Some of the before-mentioned definitions are different. For instance, Johanson-Mattson's and Ahokangas' definitions concentrate mainly on the process of internationalisation, company's activities and resources. Johanson's and Vahlne's (1990) definition mentioned another important feature of internationalisation – relationships. A broader version of this definition was provided by Lehtinen and Penttinen, who defined the link between internationalisation, relations, company's operations and international environment. Each definition shows that there can be a different approach to internationalisation. In order to understand the best the process of internationalisation, it has to be approached from different viewpoints.

Internationalisation is viewed as the process of increasing involvement in international markets (Buckley & Ghauri 1999, 45). That process can be divided into inward and outward activities. *Inward* internationalisation processes (e.g. importing, licensing, franchising) have received relatively little attention, despite the fact that many companies start their first internationalisation practices on the inward side. *Outward* processes that are associated with exporting, franchising, licensing and foreign direct investments (FDI) attracted much more attention in the previous studies (Susman 2007, 281). Some researchers add a third type of internationalisation – *co-operation*. It is a combination inward and outward processes (Ruzzier *et al*. 2006, 480). It is important to adopt a broader concept of internationalisation, as both ways of this process are closely linked in the dynamics of international trade (Buckley & Ghauri 1999, 84).

3.5 The key theories and models of internationalisation

Basically, theories of internationalisation explain why and how companies get involved in international activities. Another function of theoretical models is to predict actions of companies concerning internationalisation in the future. As internationalisation has been studied for more than half a century, there are plenty of different theories that explain different aspects of this process. The process of internationalisation can be viewed from a few different viewpoints: economical, evolutionary and network approaches. Each kind of approaches contains a few theories that usually complement each other. None of the approaches is more right than another. All of them describe the process from various sides.

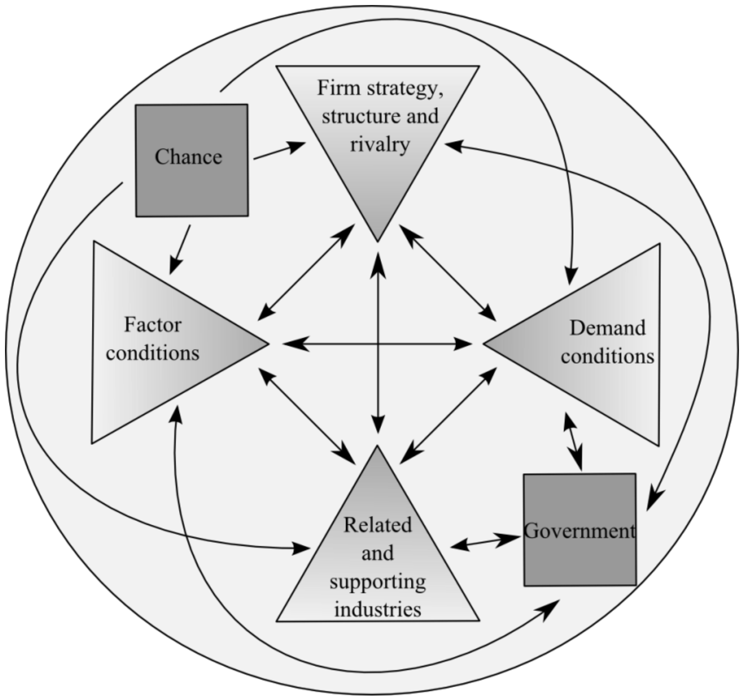
The first theories dedicated to international trade were **absolute cost advantage** (by A. Smith) and **comparative cost advantage** (by D. Ricardo) theories. The first claimed that the country should specialise in and export goods in which it has an absolute advantage, i.e. can produce it using less resources than another country (Ingham 2004, 12). Ricardo’s theory opposes Smith’s theory by stating, that even a comparative difference in costs between countries can serve as reason to start trading (Ingham 2004, 27). Of course it is impossible to say which theory is right, because both of them are correct in different occasions. Both theories stress that country should export goods that it can produce using less resources, and import goods that require more resources for production.

The next theory that was built upon comparative cost advantage theory is **Hecksher-Ohlin** theorem (abbreviated as H-O theory, or HOT). This theory states that a country exports those commodities whose production is intensive in the state's relatively abundant resources and imports goods that are intensive in resources which are relatively scarce (Blaug 1992, 185). For example, if a country is abundant with labour force and scarce with capital, it will get more advantage from trade with a country which is abundant with capital and scarce with labour. But, this theory fails to explain the process of internationalisation, if demand in a country is mainly for abundant resources. In that case there should be no trade. That is the reason, why researchers kept looking for other theories.

Empirical studies that were carried out later to test H-O theory revealed that this theory does not always work. Calculations showed that the USA exported relatively labour intensive goods, while importing capital intensive commodities. These results contradicted H-O theory, because the US economy was regarded as the most capital abundant country in the world (in the mid-50's). This study is known as **Leontief's paradox**. The reason for this paradox is the imperfection of H-O theory, which did not take such factors into account, as: natural resources (in addition to labour and capital), skill intensive exports (different kinds of labour), trade policies, etc. (Ingham 2004, 24)

The Porter diamond theory generally looks at competitive advantage and serves for generating better understanding of company's environment. The Porter diamond comprises of six factors that influence company's activities, as well as the intention to get involved into international operations (see Graph 6). *Factor conditions* concern different kinds of resources (human, physical, knowledge, capital) and infrastructure. Specialised resources are often specific in different industries and are important, as they create competitiveness. *Demand conditions* are the forces that influence companies and change their operations. *Related and supporting industries* are engaged in producing inputs that are important for internationalisation, innovation, or any other kind of shift in company's operations. *Firm strategy, structure and rivalry* are highly important and can make a big difference when making a decision on going international. *Government* plays a big role when talking about competitiveness and internationalisation. It can regulate the relations between companies, influence market and affect each one of the before-mentioned factors (Traill & Pitts 1998, 18-19). All five factors that were mentioned before can influence each other. This interdependence shows how dynamic the competitiveness is. The sixth factor – *chance*, cannot be affected, but it can make a huge impact on other factors.

Even though Porter diamond theory explains competitiveness, this theory also can be used to explain the internationalisation processes, as companies could get involved into international activities for the reason of strengthening their competitive advantage. Porter's theory can be used on a preparatory stage of internationalisation, to evaluate the prospects and build up the strategy.



GRAPH 6. The Porter diamond (adapted from Traill & Pitts 1998, 19)

The before-mentioned theories have an economic approach. In order to get a better and full understanding of internationalisation, it is important to look at other approaches as well. For example, evolutionary approach which looks at the stages of development of a company and its products. One of such theories is Vernon's **product life cycle theory**. It is based on the example of the US multinational corporations (MNC). The idea behind this theory is that the life cycle of a product (in the context of internationalisation) contains of six stages (see Appendix 1):

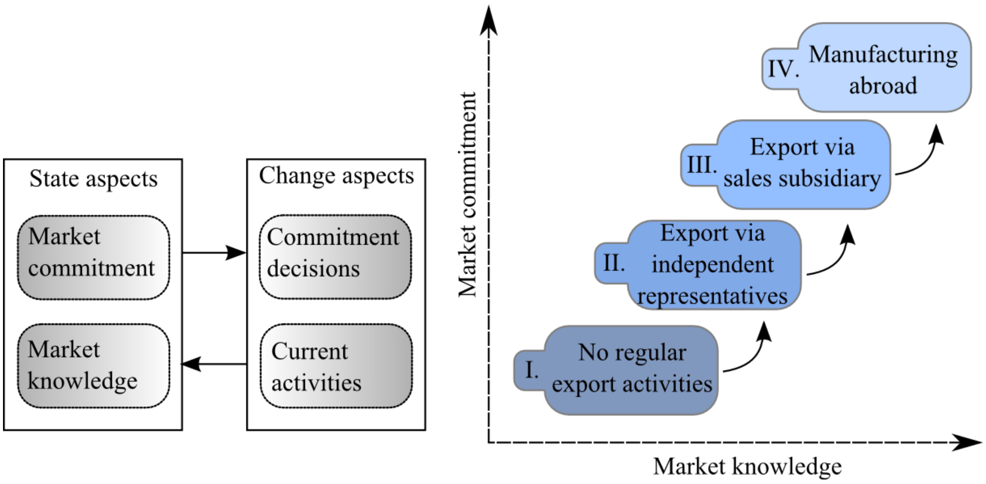
1. The new product is introduced, so it is still unknown for the consumers. Buyers' price sensitivity is high. Product is being developed in 'home' country.
2. The product and the consumer are being matured.
3. Demand for the product in other countries grows and this growth compensates the decreasing 'home' demand.
4. Export.
5. Production abroad.

6. Import. (Radzevičienė 2011)

Even though, this theory was developed in 1966, its main principles are still working. In consequence of globalisation, the period of time between all six stages becomes smaller, so the life cycle of products becomes shorter. Anyway, the switch of manufacturing of standardised products to less developed countries is obvious in a modern world. High income countries in the beginning act as the innovation centres, where new products are developed and tested, and later on the mass production switches to less economically developed countries. The principles of this theory can be applied in Finnish cleantech sector, because at the moment Finland is developing and maturing new cleantech products, while many other countries are only identifying the demand for such products, and have not started the production at such level as Finland has.

In the late 70's, influenced by the behavioural theory of the firm and theory of knowledge, Nordic researchers Johanson and Vahlne, after studying four Swedish companies, developed **Uppsala internationalisation model (**U-model**)** (Ruzzier *et al.* 2006, 482). It is also based on evolutionary approach. This theory sees internationalisation as a process in which the company gradually increases its international involvement. This process evolves in the liaison between the increasing commitment of resources to foreign markets and the development of knowledge about foreign markets. Two aspects are being separated in this theory: state and change aspects of internationalisation. The state aspects are market commitment and market knowledge (see Graph 7). The change aspects are current business activities and commitment decisions. Market knowledge and commitment affect decisions regarding commitment of resources to foreign markets and the performance of current activities. In turn, current activities and commitment decisions influence market knowledge and commitment (Johanson & Vahlne 1990, 11).

Uppsala model proposes that companies learn and their internationalisation depends on their experience. Internationalisation progresses in four stages: 1) no regular export activities are performed; 2) export takes place through independent representatives; 3) export goes on through sales subsidiaries; 4) manufacturing moves to the target state. At each stage company learns more about the target foreign market, sets up information channels. This knowledge and experience enables it to move on to the next level of internationalisation. The same knowledge and experience can be used in other markets with a low psychic distance, i.e. in such countries where the exchange of information would be the least disturbed by such factors as language, culture, political systems, etc. (Johanson & Vahlne 1990, 13)



GRAPH 7. Internationalisation process by Uppsala model (adapted from Johanson & Vahlne 1990, 12-13)

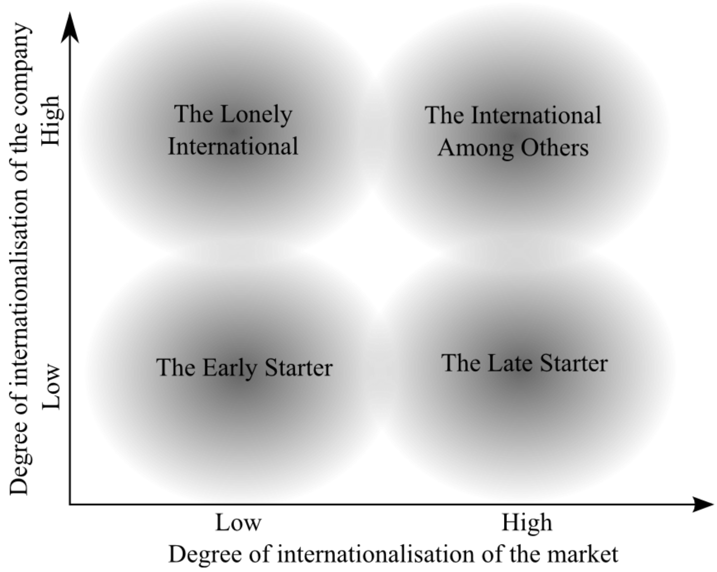
Uppsala internationalisation model was supported and opposed by the other researchers. Some critics argue that this model can be applied only during the early stages of internationalisation, when a company does not have any information or experience of operating internationally. After going through a few stages in one country, the company would not go through the same stages in another country, as it would have some essential experience. So the internationalisation process there would start from another stage. Other critics say that this model will be less valid in the future, as the lack of market knowledge becomes a weaker factor that would limit the pace of internationalisation. Another factor, which becomes weaker, because of globalisation and intensive exchange of information between nations, is psychical distance. Other researchers criticise the model, because it is based on reactive perspective, instead of proactive perspective of experiential learning, which is more future-oriented and focuses more on the search for new solutions rather than knowledge about already identified solutions (Johanson & Vahlne 1990, 14-15). Another challenge for this model today is that many companies do not follow traditional steps of the stage theory. Some companies are international from the start of their activities (Ruzzier *et al*. 2006, 483). The critics of Uppsala model show that this theory is not perfect and many things can be changed or improved. Nowadays, it is still possible to see internationalisation processes progressing as it is described in the model, but more often companies internationalise in different way, so possibly, this model is becoming less up-to-date. For that reason researchers continue studies of internationalisation processes, in order to build up a model which would explain on-going processes.

There are a few more stage internationalisation theories, as called **innovation-related models**, or I-models. These models consider each stage of company's internationalisation as an innovation for a firm. They focus exceptionally on the export development process. Various I-models have many ideas in common and usually differ only by the number of sequential stages. Nevertheless, three common stages were identified: the pre-export stage, the initial export stage and the advanced export stage. All such models treat individual learning and the learning of top managers as highly important aspects in understanding company's international behaviour. The main problem of I-models, as well as before-mentioned U-models, is that there are vague criteria for distinguishing between different stages. Determining the differences between stages with reference to activities seems to be more a matter of subjective opinion than objective evaluation and identification of real distinction. (Ruzzier *et al.* 2006, 483-484)

Another way to analyse company's internationalisation processes is to use the **network approach**. Every company maintains relations with other market subjects and this way the interaction between firms is developed. Usually all companies are engaged in a network comprising of various companies – customers, competitors, suppliers, supplementary suppliers, distributors, consultants, agents, regulatory and public agencies. In different countries additional specific networks can be distinguished. Business relationships and industrial networks cannot be easily observed and analysed by an outsider, for instance a potential entrant. All members within the network are tied to each other through a range of various bonds: technical, administrative, social, economic, cognitive, legal, etc. (Johanson & Vahlne 1990, 18-19). The activities within the network allow companies to gain access to different kinds of resources and markets (Chetty & Blankenburg Holm 2000, 80).

Relationships are seen as a network, so one company may internationalise if other members of the network do. The reason behind this is that within the industrial system, companies often depend on each other due to specialisation (Ruzzier *et al.* 2006, 484). Networks within a country may also be extended beyond the border. Internationalisation of a company is more expected if national networks are internationally extended. Involvement in such network can be achieved: 1) through *international extension*, i.e. by establishing relationships in country networks that are new to the company; 2) *penetration*, i.e. by developing relationships in those networks; 3) *international integration*, i.e. by co-ordinating positions in different national networks (Johanson & Vahlne 1990, 19-20).

Johanson and Mattson identified four categories of companies, concerning the situations they operate in: the Early Starter, the Lonely International, the Late Starter, the International Among Others (see Graph 8). The *Early Starter* is a company which operates in a network with low internationalisation level. The company itself has little or no knowledge of foreign market and networks, and cannot get this knowledge from domestic network. In order to enter foreign market, at the same time reducing costs and uncertainty, it has to use services of an agent or distributor, who might have knowledge and experience in foreign markets. The *Lonely International* is a company of high internationalisation level in a domestically focused network (market). Such company would have capabilities to promote internationalisation of the whole market. The *Late Starter* is a type of business which is not highly internationalised, but operates in an internationally focused market. Such company would have indirect international relationships, mainly via suppliers, customers and competitors. Such relationships and market condition drive the company to increase internationalisation level. The *International Among Others* is a highly internationalised company operating in an internationally focused market. Such companies have enough knowledge needed for further internationalisation and can set up sales subsidiaries and move production from one network to another quickly, co-ordinate activities in different markets, and make use of all advantages of internationalisation (Chetty & Blankenburg Holm 2000, 80-81).



GRAPH 8. The network model (adapted from Chetty & Blankenburg Holm 2000, 79)

As this model shows, the company itself can be highly internationalised, but the market may stop any further expansion. There must be a balance between internationalisation level of a company and market, as they influence one another, and the balance tries to reach equilibrium. Of course high level of company's internationalisation will stimulate the growth of market's internationalisation level, and the other way round. High level of market's internationalisation definitely creates a more attractive environment for companies' internationalisation, because, regarding U-model and other learning theories, companies would have an easier access to information sources, they would not have to create an international network, as it would be established already, there would be other companies, whose examples could be followed.

One of the ways to go international through inter-organisational networking is building a strategic alliance with other companies. A strategic alliance is a formation of two or more independent companies that co-operate on a specific project, which is bounding in terms of activity, geography, product process and time. They share common benefits, risks, intellectual property, markets, technology, resources, in order to gain a competitive advantage in the market (Slowinski & Sagal 2003, 4). Forming an alliance would help companies gain bigger weight on the market, in some cases decrease costs, reach more markets, etc. Alliances can be formed on the basis of various functions: production alliance; selling and distribution alliance; technological alliance; standards alliance (to set a particular level of standards on the market) (Radzevičienė 2011). When building alliance, mutual trust, which is gained through years of relationships, is needed. That is why building alliance is a gradual process (see Table 2).

TABLE 2. Evolution of strategic alliance (adapted from Radzevičienė 2011)

Vendor	→	Preferred Supplier	→	Alliance	→	Strategic Alliance
• "Closed Book" • Little differentiation in product/service • Minimum contract life • Contract drive • Focus on lowest price		• Longer term relationship • Trust earned • Some differentiation in products/services • Quality programs implemented • Price and quality considered • Begins to focus on total value		• Long term relationship • "Open Book" • High level of trust • Win/Win – mutual advantage • Top Management interchange • Continuous exchange of ideas • Business process reengineering • Focus on significant value-added		• Mutual dependency • Strategic framework in place • High level of commitment • Increased capabilities and/or capacities • Enhanced business opportunities • Improving shareowner value

Building an alliance requires very close communication between alliance members. It may not always be perfect, and sometimes it is a fragile place of an alliance, so it can act as a guarantee of success or as a barrier. There are more factors that can make alliance's activity more complicated, such as, cultural barriers, different management strategies and practices, and similar. Decision making and common actions on behalf of alliance has to be made on top level, because in other case, interests of partner companies may not be considered. In addition, conflicts between partners can arise on a basis of different approaches to one or another problem, different priorities. Other points that can be hard to agree on can be the advantage that each member would get from a decision, share of risk, setting the requirements and rules. Some members may not hold on to their commitments (Radzevičienė 2011). All the barriers that are mentioned above can take place on any level of alliance, but they are more likely to appear on early stages, because later, on the level of strategic alliance, absolute trust is needed and it is established over years, during which the relationships are tested by some of those barriers.

3.6 The research methodology for investigating the development of clean technologies

After clarifying theoretical aspects of clean technology and internationalisation processes, the further research will be conducted in this thesis. As it was discussed before, there are not many theories concerning the clean technologies, because this matter has not been studied enough and many studies are continuing now. In the case of internationalisation processes, this matter is being researched for decades already. Even though the new theories and models are being invented as an outcome of different researches, a perfect model that would be suitable to explain all the internationalisation processes and predict future actions still does not exist. For this reason, there will be a few researches carried out in this thesis, with the purpose of getting deeper into this problem, understanding and investigating the legal, technological and social environment in which cleantech companies operate in Finland and Lithuania, finding out the co-operation demands and possibilities between two countries and finally coming up with the solutions of expanding co-operation between them.

It is believed that multiple realities exist and multiple interpretations are available from different people and all of them are equally valid. The way how one problem is researched can differ from another way and the results, of course, will be different but valid (Jha 2008, 6). For this reason, a few kinds of research methods will be employed.

Mainly all researches that will be carried out in this thesis will be of a qualitative nature. Qualitative research includes case studies, field studies, document studies, naturalistic inquiry, observational studies, descriptive studies and interview studies (Jha 2008, 13). In order to get a bigger picture of the problem which is being investigated in this thesis, more attention will be paid towards qualitative methods, because quantitative research cannot be implemented on a large scale and a lack of representative sample will decrease the trustfulness of this kind of research.

Upon analysing theoretical aspects of cleantech and internationalisation processes, **legal frameworks** will be analysed. As the development of technologies highly depends on the regulatory systems, initiatives, strategies and actions by the officials, it is very important to investigate how Finnish and Lithuanian governments regulate, promote and create the environment for clean technologies, how they utilise possibilities of internationalisation. As Finland and Lithuania are members of the EU, it is not enough to look only at the national systems, because they are highly dependent on higher common institutions. For this reason, the EU's legal framework concerning cleantech will be reviewed, putting more stress on Nordic-Baltic (NB) region. This legal framework analysis will be useful in identifying the environment for development of co-operation between Finland and Lithuania in promoting cleantech. The main sources for this research are national and international legal documents, strategies, directives, regulations and various reviews.

After analysing legal systems, strategies and priorities, **sector analysis** will be performed. The sectorial research will look deeper into the situation in cleantech sector in Finland and Lithuania: how many companies are engaged in manufacturing, researching or using clean technologies; what type of cleantech they are engaged in; how they are organised together, if they are at all, and so on. The aim of this analysis is to show not the theoretical, but actual situation in this industry. The information for this research will be collected from different industry reviews, development reports from authorities and NGO's, different information publications both from Finland and Lithuania.

The next research will take form of an **in-depth interview** with five experts that have enough experience in economical work and work in cleantech sector. The experts represent three Finnish (Elozo Oy, Beneq Oy, Watrec Oy) and two Lithuanian (UAB FinEco and

UAB Ineco) companies. On experts' request, the names will not be mentioned. Instead, the names of the company will be mentioned when talking about one or another expert. The possibilities of bilateral co-operation will be discussed and the results of this research will be used when constructing the solutions for promoting co-operation between Finland and Lithuania. All five experts will be interviewed separately by phone and e-mails. A description of the experts will be presented in successive parts of thesis. In order to get more detailed information, the experts will be asked to answer a few major open questions that might start further discussions. The questions are as follows:

1. *What is your company's internationalisation level?*
2. *Do you co-operate with foreign countries? If yes, what are your major partners?*
3. *In what areas do you co-operate, or plan to co-operate with Lithuanian (Finnish) companies?*
4. *What areas of co-operation between Finland and Lithuania should be further developed (concerning cleantech)?*
5. *What are or could be the barriers for co-operation with Lithuania (Finland)?*
6. *What is Finland's (Lithuania's) strongest side in cleantech?*
7. *Should Finnish cleantech concentrate on foreign or domestic markets?*
8. *Is clusterisation the most effective tool to develop cleantech sector?*

In the third question Finnish experts will be asked about co-operation with Lithuania, while Lithuanian expert about co-operation win Finland. In the sixth question Finnish experts will asked about the strengths of Finnish cleantech sector, while Lithuania experts about Lithuanian cleantech sector. The seventh question is dedicated to Finnish experts only.

The last section of the practical part of this thesis will be purely analytical analysis, a summary of all findings in a form of **two SWOT analyses**. Each one of them will overview the strengths, weaknesses, opportunities and threats of the Finnish and Lithuanian cleantech sectors. SWOT analyses will be focused mainly on international aspect. This means that strengths, weaknesses, opportunities and threats will be analysed from the viewpoint of international co-operation, or its absence. The significance of these SWOT analyses is not only in describing Finnish and Lithuanian cleantech sectors. They will also be necessary when identifying the most beneficial co-operation opportunities between Lithuania and Finland. Finnish weaknesses that can be minimised, and opportunities that can be brought to life, could find solution in the strengths of Lithuanian cleantech sector.

4 EXPLORATION OF CO-OPERATION POSSIBILITIES IN THE DEVELOPMENT OF CLEAN TECHNOLOGIES

After analysing theoretical aspects of cleantech and internationalisation processes, practical aspects have to be explored. Empirical part of this thesis will concern cleantech-related legal aspects on international and national levels, will look at Finnish and Lithuanian cleantech sectors. It is important to get up-to-date knowledge and evaluation of cleantech sectors, so that is why an expert interview will be employed and analysed. Only after summarising all findings of empirical studies, the solutions can be formed and proposed.

4.1 The analysis of clean technology policies and priorities on the international level

Over the last decade there has been increasing interest in a new approach to environmental protection. Instead of focusing on control or cleanup of waste, the new approach emphasises redisigning industrial products and processes to reduce and eliminate hazards at their source, reduce quantities of waste, energy consumption, other costs. This approach is driven by the „pull“ of demand and „push“ of technology. Environmental policies have made significant advances over the last 30 years, controlling emissions from large industrial facilities to key durable goods. (Lempert, Norling, Pernin, Resetar & Mahkovski 2003, 1-3)

When analysing the legal environment of cleantech it is important to investigate situation on different scales – from regional to national, and from national to international levels. On a small scale, legal environment for cleantech in Finland and Lithuania has to be researched. These two states are members of the EU, so environment within them is strongly influenced by common rules of the Union. On a larger scale, there are international organisations, such as the UN, that set general development goals.

Cleantech is strongly associated with sustainable development, as it is one of the tools that would help reaching sustainable development goals. Sustainable development is one of the UN priorities. By making international agreements, drawing up conventions, protocols, organising meeting, summits and forums, UN seeks to promote cooperation between member states, and their responsibility towards each other. Looking at those protocols and international agreements other organisations and countries form their own plans how to achieve the aims proposed in the agreement. That is why it is important to look at the actions by the UN pointed towards sustainable development and cleantech in particular, as these actions influence the environment on a smaller scale.

Before 1970's green issues were not mainstream. Only in 1972 Stockholm Conference (also known as UN Conference on Human Environment) took place. This conference set start for all further international dialogues about the environment and sustainable development. Later in 1980 International Union for Conservation of Nature (IUCN) with finance provided by UN Environment Programme (UNEP) and World Wildlife Fund (WWF) prepared The World Conservation Strategy. This was the dawn of sustainable development. This strategy was further developed in Our Common Future (1987), Caring for the Earth (1991), Agenda 21 (1992), Earth Summit (2002). (Adams 2009, 59)

The first steps to make sustainable development mainstream were taken in 1992, when UN Conference on Environment and Development took place in Rio de Janeiro (also known as the Rio Conference). It was attended by 172 states and 116 heads of state or government. The main achievements of the Rio Conference were: creation of the Rio Declaration, listing 27 principles for sustainable development; creation of Agenda 21, which promotes sustainability; conventions on Biological Diversity and Climate Change were signed. Mainly all these principles and activities stated in declaration and Agenda 21 are vital, but not mandatory. In other words, this framework included 'soft law'. (Adams 2009, 86-105)

Agenda 21 is worth mentioning because it has become an icon of sustainable development. In more than 600 pages it covered issues from water quality and biodiversity to different roles in delivering sustainable development. As an integral part of this plan the environmental technologies are mentioned and their significance is stressed. As it was described in theoretical part of this thesis, cleantech is a part of envirotech, so this means that Agenda 21 concern cleantech as well. It is an international and even global action plan, which covers: 1) social and economic dimensions; 2) conservation and management of resources for development; 3) strengthening the role of major groups; 4) means of implementation. (Adams 2009, 93; Agenda 21 1992)

Twenty years after Rio Conference, the Rio+20 Conference will be held in 2012. Progress will be reviewed and further development goals will be set. The conference will mainly focus on 7 issues: jobs, energy, cities, food, water, oceans, and disasters (UNCSD 2012). Cleantech is concerned with some of the issues, especially energy, cities, water and jobs.

Nowadays nearly all programmes and offices within UN, especially the ones reporting directly to General Assembly, fully or partly address environmental issues. Many of them prioritise clean energy sources, the need to increase efficiency, treatment of waste, reforming as many processes as possible in order to make them less harmful, and so on. All these questions are directly concerned with cleantech. Different institutions, such as UNEP, UN Development Programme (UNDP), UN Commission on Sustainable Development (UNCSD), UN Framework Convention on Climate Change (UNFCCC), were created to support and co-ordinate the development of advanced and emerging economies in more sustainable way, through a range of studies, international agreements, reports, forums, etc. (UN 2012).

Agreements and decisions that are made on international level are further transferred onto ‘less global’ international, national and regional levels. The EU has recognised the importance of sustainable development long time ago. It has over 35 years’ experience of environmental policy-making. During this time, a few hundreds of legal acts concerning environmental issues have been put in place, strategies have been built and implemented. Policy, which initially focused on standard regulation, gradually shifted to wider range of instruments (EEA 2011a). The 6th Environmental Action Programme (6EAP), which is now in its final year (2002-2012), combines legal requirements, technology transfer, market-based instruments, environmental liability provisions, research, voluntary schemes and green public procurement. 6EAP created a strong legal basis for further environmental legislation and its principles are integrated into Europe 2020 strategy. (EC 2012)

Europe 2020 is the growth strategy of the EU for the period from 2010 to 2020. Three main goals are – to become a smart, sustainable and inclusive economy. As well, in this strategy the EU sets five objectives to be reached by 2020: employment, R&D, climate change and energy, education, poverty and social exclusion (see Appendix 2). Each member state concerning its situation and circumstances sets its own objectives. All the objectives are interrelated and mutually reinforcing. For instance, educational improvements reinforce R&D and innovations that promote cleaner technologies, which create more business and job opportunities by decreasing unemployment, stimulating economy growth and decreasing poverty (Europe 2020 targets, 2012). It is easy to notice that environmental issues are integrated into this strategy by 20-20-20 goals. Having in mind that another objective is to increase funding of R&D, it is easy to understand that a lot of attention will be paid towards developing clean technologies, as they are the only alternative, which can satisfy the growing demand and at the same time be less harmful to the environment.

The EU Sustainable Development Strategy emphasises the synergy between economic, social and environmental aims (EEA 2011a). In addition to these three aims one more factor should be added – technology, including R&D, innovations, eco-friendliness, etc. The importance of environmental factor in technology was fully recognised in the Lisbon Strategy (2000-2010), the EU Sustainable Development Strategy (2006-2010), the 6EAP (2002-2012) and Europe 2020 Strategy (2010-2020). (EEA 2011b)

The environmental goals that have been set in Europe 2020 Strategy can be reached by decreasing production, which is not possible taking into account the growing demand and consumption, or by modernising production systems, i.e. adopting lower, or zero-emission techniques, that are specific feature of clean technologies. This need was acknowledged in January 2004 by adopting the Environmental Technologies Action Plan (ETAP). This action plan complements the European Commission's (EC) regulatory approaches, encompasses a range of actions to promote eco-innovation and the development of environmental technologies (EEA 2011b). ETAP mainly focuses on the following areas:

- Getting from research to market – improving the innovation process and promoting inventions, so that they would be utilised in the market;
- Improving market conditions – setting performance targets, leveraging investment, creating incentives and removing economic barriers, building support for environmental technologies in civil society;
- Acting globally – promoting foreign investment and supporting envirotech in developing countries. (ETAP 2004)

The solutions that are proposed by ETAP have to be implemented in the whole EU. Still, majority of the measures have to be taken on national levels, taking into consideration present economical, social, political and technological situation of a particular Member State, present level of development of envirotech and cleantech, and other specific factors. This is the reason why each of the Member States, based on ETAP, have developed formal national ETAP implementation plans, also known as National Roadmaps. They described plans, actions and targets on national level (EEA 2011b). More detailed review of Finnish and Lithuanian Roadmaps will be presented in further sections.

Based on ETAP and Europe 2020 strategy, the Eco-innovation Action Plan (Eco-AP) was launched in the end of 2011. It expands focus from environmental technologies to broader area of eco-innovations, and seeks to bring the advantages of cleantech to all other sectors. Through Eco-AP the values of cleantech (i.e. productivity, resource efficiency, competitiveness, etc.) are transferred to other industries. Eco-AP identifies barriers and drivers for eco-innovations in SMEs. The biggest barriers are limited knowledge and certainty of the markets, return on investments, harmful incentives and subsidies, rigid economic structures, infrastructure and behavioural lock-ins. Main drivers are high energy and material prices, new regulations and standards, and access to knowledge. Based on the barrier and driver analysis, Eco-AP suggests seven targeted actions on the EU level:

1. Use environmental policy and legislation as a driver to promote eco-innovation;
2. Support demonstration projects and bring promising, smart and ambitious operational technologies to the market that have been suffering from low uptake;
3. Develop new standards to enhance eco-innovation;
4. Mobilise financial instruments and support services for SMEs;
5. Promote international co-operation;
6. Support the development of skill, jobs and related training programmes to match labour market needs;
7. Promote eco-innovation through the European Innovation Partnerships foreseen under Innovation Union. (Eco-AP 2011)

Every action described in Eco-AP is followed up by a few milestones – more detailed plans of performing each action. Based on the ETAP experience, Eco-AP will be followed by national roadmaps of every member state, where every state will identify the most efficient policies, and draw up a plan of implementation of Eco-AP. The roadmaps will build on the existing initiatives regarding environmental technologies but with sharper focus on eco-innovation, both in private and public sectors (Eco-AP 2011, 15).

Programmes and strategies are only one of the tools to influence the development of cleantech in member countries and throughout the EU. More powerful tools of the Union are regulations, decisions and directives. As it was described in previous chapter, cleantech sector involves zero-emission technologies from different areas: air and environment, agriculture, energy, biofuels, smart grid, renewable energy sources, transportation, waste treatment, and others (see Graph 4). This wide range of different sectors involved in cleantech means that the area covered by regulations and directives will also be quite wide. A summary of the main acts of the EU, Finland and Lithuania in various areas is showed among appendices (see Appendix 3).

Upon analysing the legislation summary, the first thing that draws attention is that there are no acts directly and solely concerned with cleantech. As it was described earlier, cleantech can be perceived as a part of a wider group – environmental technologies. Regarding envirotech, only ETAP looks at it as single entity. Despite the fact that cleantech sector is not regulated as an entity, there are many acts about separate segments of this sector:

- Air and environment: acts on reducing GHG and industrial emissions, assessing environmental impacts, defining environmental liabilities, establishing programmes, etc. Majority of the acts mention cleantech as a mean of implementation and the target of development.
- Agriculture: cleantech is one of priorities when financing common agricultural policy (CAP).
- Energy efficiency: energy-efficient technologies are perceived as highly important in majority of acts on energy. The most recent acts mention concepts, such as energy performance, eco-design and eco-innovation.
- Renewable energy: in line with the Strategy 2020, there are many acts promoting the use of renewable energy sources – wind, solar, geothermal, biomass, biofuels, etc. This topic is of high importance, but unlike other topics, such as cutting industrial emissions, can be implemented only on a voluntary basis.
- Transportation: acts are mainly concerned with cutting emissions, promoting the transport that uses renewable energy sources and is highly energy-effective. Once again, cleantech plays a big role achieving those aims.
- Water: mainly concerned with keeping water clean from pollution caused by agricultural, industrial and other activities.
- Recycling and waste treatment: more attention is paid to treating radioactive waste. There are not many acts on recycling and waste treatment, even though this topic is included in 6EAP.
- Smart grid: recent acts on energy acknowledge the importance of smart grids, as a tool to enhance the energy-efficiency. At the moment there are not many acts

concerned with building smarter energy networks, but most likely this topic will draw more attention in the nearest future, with the development of alternative energy sources.

- Technologies, R&D, innovations, and other segments: the need to develop new, sustainable and enabling technologies is recognised in the EU legislation. As well, the funding is allocated for various eco-innovation programmes, emerging and environmental technologies. (Summaries of EU legislation 2012)

There are as well many Communications by the Commission that are concerned with the implementation of strategies and the ways of reaching goals. These Communications are not obligatory, so they act as a message to the Commission about a present problem and the ways of solving it. The Communications are worth looking at, because they might serve as basis for future legislation. In addition, it takes a long time to enact a regulation or a directive, but Communications are declared more frequently, so they reflect the present situation more precisely and with expedition.

All the strategies are implemented through plans that are specialised on a more specific area. Plans are implemented through regulations, directives, recommendations and a range of programmes (e.g. 7^{th} Framework Programme, Marco Polo II, Competitiveness and Innovation Framework Programme, etc.), schemes (e.g. GHG emission allowance trading scheme, Eco-management and Audit Scheme (EMAS)), initiatives (e.g. Clean Sky Joint Technology Initiative). In order to inform the public about environmental legislation and gather the most precise and up-to-date information about situation concerning the environment, European Environmental Agency was established in 1990 (EEA 2011a).

Within the EU, there is a range of public and private funds and facilities to finance cleantech innovations and technology transfer. For example, SMEs involved in eco-innovation can apply for support through the *Competitiveness and Innovation Framework Programme* and *High Growth and Innovation Facility*. *LIFE+* fund was established to co-finance projects that contribute the implementation of environmental policy, development of innovative policy approaches, methods, instruments and technologies. *The Seventh Research and Technological Development Framework Programme* (for 2007-2013) is directly referred to ETAP. It largely supports the development of environmental technologies through technological platforms and Joint Technological Initiatives (JTI). The *European Renewable Energy Fund I* finances mainly wind power and some other cleantech projects, especially PV. Support is dedicated generally to the Central and Eastern Europe region. *The Intelligent Energy Europe Programme* was established to support cleantech projects, especially energy efficiency, all over EU, Croatia, Norway, Iceland and Liechtenstein. All EU member states can get support for cleantech from *Structural and Cohesion Funds* that promote eco-innovations (ETAP Funding 2012). One of the biggest European private funds dedicated to clean technologies is Zouk Cleantech Europe II. This fund supports innovative cleantech companies engaged in alternative and renewable energy development, resource efficiency and cleantech services (Zouk Cleantech 2012).

To sum up this section, it is necessary to notice that after looking at the wide range of legislation, strategies and programmes, the importance of cleantech becomes clearer. Cleantech, as a part of environmental technologies, is perceived as a mean for the implementation of sustainable development. It is recognised globally and on the EU policy making level. A big part of the EU legislation regarding cleantech was enacted over the last decade, so some areas of this industry are not yet covered. So far mainly emission, waste and pollution-related acts are binding. The majority of other legal acts, concerning renewable energy sources, energy efficiency, smart grid, waste management, etc. are voluntary, so all the MS are on different levels of development in these areas, because of the differences in national legislation. Having in mind the trend of environment and cleantech-related policy emergence over the last decade and obvious climate change, it is possible that new policies will emerge in the nearest future, and they will bear more binding character. Upon analysing the legal environment of cleantech in the EU, it is important to look at the same aspect on the national level, because that is the executive level, where common Union’s decisions are being brought to life.

4.2 The analysis of clean technology policies and priorities in Finland

Similar to the EU legislation, a big part of Finnish laws and legal acts are concerned with environmental issues. There is no single comprehensive act that would incorporate all regulations of the same topic, but instead there are many acts covering different sides of the environmental issues. Some acts, especially concerned with pollution prevention, emission trading and environmental impact assessment, were strongly influenced by the EU legislation (AmCham 2011, 24). However, the adoption of some environment-related acts, especially concerned with oil pollution and waste treatment, dates back to the 80's and early 90's, when Finland was not yet a member of the EU (see Appendix 3). This fact shows a big concern about the topic already in the early stages of the 'green movement'.

The majority of environment-related acts are concerned with one of the 3 areas: air and environment (Nature Conservation Act, Act on Compensation for Environmental Damage, Environmental Protection Act), water (Act on Water Resources Management, Decree on Urban Waste Water Treatment, etc.) or recycling and waste treatment (Waste Act, Waste Decree, Decree on Waste Electrical and Electronic Equipment, Decree on End-of-Life Vehicles, etc.) (FINLEX 2012). This shows that a lot of attention is being paid towards these issues. By no accident a big part of Finnish cleantech companies are engaged in one of these areas, especially focusing on recycling and reusing activities. Regularly national legislation is being amended taking into account adoption of different EU acts.

Some environmental policies are implemented through strict requirements, assessments of environmental impact, permit grants and liability appointments. All the significant projects in Finland have to go through an environmental impact assessment, after which they may, or may not get a permit to perform a particular activity. (AmCham 2011, 24)

As an EU member, Finland has to take responsibility of implementing common acts and agreements. For example, the Europe 2020 goals: for the moment Finland has reached a few EU headline targets for 2020 (e.g. in R&D, renewable energy, tertiary education, early school leaving), so it had set more ambitious targets (see Appendix 2). In order to reach these targets, Finland runs different programmes to support growth in R&D and eco-development, especially focusing on cleantech industry.

Cleantech sector in Finland is not yet regulated as a single entity (AmCham 2011, 8). Instead, there are plenty of acts related to different sides of this industry (see Appendix 3). One of the first legal acts partly concerned with cleantech was Finnish National roadmap for the implementation of ETAP, designed by the former Ministry of Trade and Industry, and Ministry of Environment. All the member states were obliged to draw up a National implementation plan of ETAP. Finnish national roadmap was drawn up in 2005, when Finland was already actively taking part in the development of environmentally sound technologies. The roadmap mainly describes the importance of envirotech, the role of business, research institutes and government in the development of these technologies. The roadmap is comprised of the following topics:

- National innovation system in Finland – R&D industry is described with the main players (research centres, institutes, universities, agencies, etc.) that contribute to the development of cleantech and other environment-related technologies.
- Getting technologies from research to markets – description of a few programmes and technology platforms with a strong technological-environmental focus that helped envirotech to be adopted by a wider range of users. As well the challenges for those programmes are discussed. The development of financial instruments for supporting envirotech is described, with export promotion, eco-networking, etc.
- Public instruments – policy measures to create a market for eco-innovation, for instance through public procurement.
- Awareness raising and training – the need to share best experiences between the member states is identified. Awareness raising is also perceived as an important factor when developing envirotech. It would not only help to create market, but would also encourage people to take part in the development of such technologies.
- International co-operation – Finland pays a lot of attention towards co-operation with the developing countries and technology transfer to developing regions. As well, there is a lot of co-operation between Finland and neighbouring states. (Finnish National Roadmap 2005)

The before-mentioned roadmap is more like a situation analysis, the description of previous programmes and the ones that were running at the moment of designing the roadmap. For an action plan, this roadmap lacks clear goals and the description of the way of achieving them. However, its strong side is the definition of main stakeholders in the development process, their present and future responsibilities. The mentioned stakeholders will be discussed in the next section of this thesis.

Some of the goals that were missed in the before-mentioned roadmap can be found in through other strategies and acts. For example, the Long-term Climate and Energy strategy analyses the current situation, describes the goals along with the means of reaching them. It focuses on the period until year 2020, creates a vision of year 2050, and sets clear and concrete goals for particular indicators (Long-term Climate and Energy Strategy 2008). Based on this strategy Government Decision on Energy Efficiency Measures (2010) was issued. The implementation programme for period from 2010 till 2020 is described. This programme is divided into activities (basis research, development of research and innovations, public sector, communication, advisory services and education) and sectors (community structure, buildings, transport, household and agriculture, industry and services). For every point of the programme the executive institution is appointed (Government Decision on Energy Efficiency Measures 2010).

It is expected that in the nearest future Finnish government will draw up national programmes for material efficiency, sustainable use of natural resources and other eco-related topics. Cleantech and its activities will be prioritised in order to implement the programmes. It is likely, that for this purpose environmental business programmes will be launched in order to promote growth of cleantech sector and innovations. (Finnish National Environmental Innovation Panel 2011, 2)

Another strategic act, alongside the ETAP implementation roadmap, directly regards cleantech industry. The plan identifies the potential of cleantech sector, its positive environmental, technological, economical and social impacts. As well, it portrays Finland as a country with strong environmental image, which is top-ranked in the world. Nowadays many Finnish SMEs are engaged in cleantech industry, but there is still a lot of unrealised potential. Clustering is on the early stage and there is a lack of co-operation between small and large companies. In order to make Finland the leading cleantech country by the end of 2012, four strategic projects were proposed (see Appendix 4). The projects are supposed to be implemented from year 2007 until 2012, or even extended. For every suggested action the key responsible parties are identified. This action plan makes a good basis for further action planning in the suggested institutions. (Cleantech Finland 2007)

By looking at the projects and recommendations, a few key goals can be identified: branding of Finnish expertise, promoting national environmental companies, building a centralised system to enhance three sided (i.e. state-business-science) co-operation, and strengthening international networking. The strong side of this plan are the recommendations and mentioning the responsible parties. It is clear that responsibility is divided between state institutions, private businesses and research institutions. For this plan to be implemented, state institutions have to act as co-ordinators and development promoters. When talking about the division of responsibility for cleantech development, three parties are often identified in many legal acts – state, business and science institutions. Even though science and research institutions are sometimes financed by the government, they are treated as a separate stakeholder.

According to the analysed Finnish laws, national action plans and strategies, the one of the key players in creation and implementation of Finnish cleantech policy is the State with its legislative and executive branches. Other key players - financing and research institutes, are founded by the government (see Appendix 5): Tekes, the Academy of Finland, Sitra, the Finnish Environmental Cluster Research Programme, VTT, SYKE, OSKE, SHOK.

4.3 The analysis of clean technology policies and priorities in Lithuania

Lithuania, as one of the member states of the EU, builds its national policies, taking into account common EU policies. It is also must implement EU strategies on a national level. For example, as it was mentioned earlier, each EU member state had to set their national goals for Europe 2020 strategy (see Appendix 2). In some aspects, Lithuania’s goals are much lower than common EU targets, especially goals for employment rate, R&D, CO_2 emissions. Still, 2020 targets are very ambitious: increase employment by 8.4 % and increase expenditures for R&D 2.4 times, increase renewable energy production by 6 %. This means that resources will be redistributed and more funding will go to innovative sectors. At the moment Lithuania has a big potential for boosting innovations, as its early school leaving and tertiary education indicators are already better than the EU targets.

Lithuania regained its independence and started building its legal system in the early 90’s, at the same time when environmental issues started being taken into account by policymakers all over the world. The most important acts regarding the environmental issues are concerned with the protection of water, air and soil, setting pollution and emissions limits, treating waste, saving energy, etc. (see Appendix 3). All of them mention such priorities, as cutting emissions, decreasing pollution, increasing recycling rate, promoting energy efficiency and energy generated using renewable sources, etc. (LRS 2012). Having in mind that the goals of cleantech are the same, it is appropriate to conclude that many environment-related acts indirectly promote cleantech.

All the before-mentioned environmental areas are mentioned in the Lithuanian Sustainable Development Strategy. One of the main goals of this strategy is to reach the EU average (for year 2003) level of economic and social development, and resource efficiency by 2020. In order to achieve this goal, modern and less harmful technologies have to be adopted widely (Lithuanian Sustainable Development Strategy 2009, 2). This statement shows the importance of cleantech and envirotech in sustainable development of the state.

Despite the fact that a range of Lithuanian legal acts acknowledge the importance of cleantech in the future development, there are no acts that would promote particularly cleantech in Lithuania. The closest act, which is concerned with the promotion of environmental technologies, is Lithuanian National Roadmap on implementation of ETAP. The Roadmap gives a definition of environmental technologies and mainly describes the present situation in Lithuanian envirotech industry. A list of main acts that promote innovation and R&D is given, alongside the available financial instruments and implemented public awareness raising programmes. The Roadmap also appoints responsible institutions for each action mentioned in ETAP. It is acknowledged that envirotech (not talking about cleantech in particular) is indirectly mentioned in majority of innovation-related acts and is perceived as an innovation goal. Envirotech is promoted indirectly by many institutions, but the development of this kind of technology is not prioritised. Envirotech and particularly cleantech, have to be separated as distinctive development directions with high priority (Lithuanian National Roadmap 2007).

Despite the fact, that Lithuanian National Roadmap was enacted two years after its Finnish equivalent, the difference between two acts is enormous. Both Roadmaps were more like situation analysis. However, Finnish Roadmap had a better insight in environmental technologies and their place in state's R&D and innovation system. Lithuanian Roadmap hardly identifies the place of envirotech in Lithuanian R&D and innovation system. Because of that further plans on development of cleantech are rather obscure.

When talking about the development and promotion of clean technologies and envirotech in general, innovation strategies, plans and programmes have to be reviewed, because, as it was mentioned before, they might partly and indirectly regulate these industries. Lithuanian Innovation Strategy for the year 2010-2020 evaluates the present situation in Lithuanian R&D and innovations through SWOT analysis, and determines the areas of high importance for the future development. These areas are: promotion of innovation in SMEs, promotion of business-science-studies co-operation, strengthening information society and educating its creative and innovative skills. Since a country cannot lead in all technologies, the Innovation Strategy gives highest priority to traditional industry (food, wood, textiles) and the following advanced technologies: 1) biotechnologies;

2) mechatronics; 3) laser technologies; 4) electricity and optic equipment; 5) electronics and nanotechnologies; 6) ICT. (Lithuanian Innovation Strategy 2010, 7-8)

Lithuania is already quite advanced in these areas. Having in mind the innovation strategy, it becomes clear that national technology policy focuses on sectors where Lithuania has already achieved a great success. Unfortunately, for the moment cleantech is outside this group of technologies. However, cleantech alongside future energetic, creative industry, welfare and wellness areas (such as pharmacy, medical equipment, ecological food, etc.) is perceived as a new promising economy area, which could determine the country’s welfare in the future (Lithuanian Innovation Strategy 2010, 8). Nevertheless, the implementation plan of Innovation Strategy for the period of 2010-2013 does not mention cleantech as a development goal. Moreover, cleantech and envirotech are not mentioned at all.

Despite the fact, that cleantech is not being addressed in any acts as a single piece, different parts of it are regulated by various laws. For example, Renewable Energy Act defines renewable energy sources, and renewable energetics sector, divides responsibilities among government, ministries and municipalities, promotes energy production using renewable sources, promotes smart grids and use of renewable energy in transport sector, describes the funding of R&D, and sets development goals (Renewable Energy Act 2011). Even though cleantech is not mentioned in this law, an indirect support can be noticed.

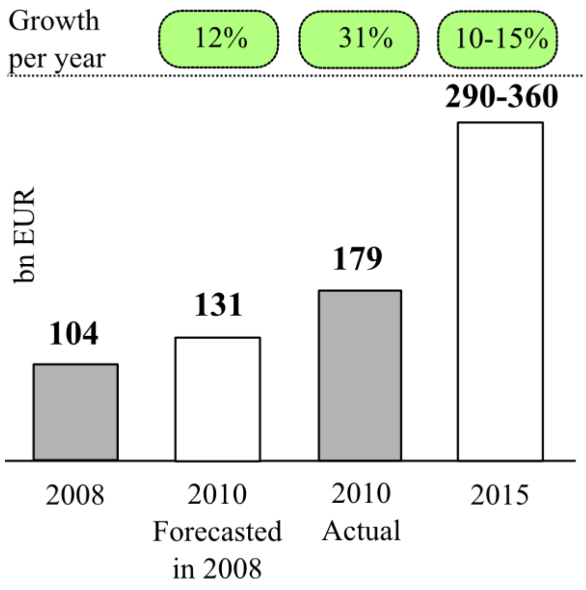
When it comes it implementation of different strategies and plans, the government, as well, as ministries, governmental councils, agencies and other institutions take a big part of responsibility. Ministries usually build policies and later on co-ordinate the implementation of by delegating activities to research and innovation institutes. Key institutions that are occupied in promotion of R&D and innovations, and possibly cleantech in the future are (see Appendix 6): the Research Council of Lithuania, Lithuanian Innovation Centre, Agency for Science, Innovations and Technology, Lithuanian Business Support Agency, Agency for Environmental Projects Management, Integrated Science, Studies and Business Centres (Valleys), INVEGA.

Finally, summarising this section, it is worth mentioning that Lithuanian legal system is not as well prepared for cleantech as its Finnish analogue is. The need to adopt more efficient and less harmful technologies is acknowledged, but the main focus of state’s R&D is concentrated on other technologies, where Lithuania has already reached good results. National cleantech strategy is absent and co-ordination of cleantech-related projects, innovations and other activities is decentralised and rather poor. More precise legislation concerning cleantech definition, goals, responsibilities and support is something to be desired. However, looking at the EU legislation trends and prevailing values of sustainable development, which are the same as cleantech values, it is very likely that Lithuanian legal system will pay much more attention to eco-friendly and highly efficient technologies in the nearest future. The same trend is observable all over the EU.

4.4 Finnish clean technology sector analysis

As it was mentioned before, environmental and clean technologies have attracted a lot of attention from the Finnish authorities and society. Cleantech is understood as one of the greatest aims for the development (Finnish National Roadmap 2005; Cleantech Finland 2007). The relation between Finnish businesses and clean technologies has been strong for many years now. Especially, this relation is specific for Finnish small start-up companies with a strong engineering background and main focus on R&D. The emergence and activity of such start-ups is sustained by private equity financing (AmCham 2011, 8-9).

According to studies that were conducted by the World Wide Fund for Nature (WWF) and Roland Berger in 2009 and 2011, the market for cleantech grew by 31 % per year between 2008 and 2010 and it stands at approximately EUR 179 billion. Actual cleantech market growth exceeded the forecasted growth by almost a third (see Graph 9). The largest segment of 30% of the cleantech market is wind energy. The demand for wind turbines is growing across the globe. There are many companies active in this segment, such as GE, Vestas, Suzlon, Dongfang, and others. Solar photovoltaics (PV) segment has grown by 100 % and is now the fastest growing segment of cleantech with the sales standing at EUR 45 billion in 2010 (i.e. 24 % of the market). Such companies as Suntech Power, Yingli, LDK Solar, Applied Materials, Centrotherm and many others contributed a lot to enhancing the growth of this segment. The third largest segment (22 % of the market) is biogas and biofuels. Here the United States and Brazil are the main suppliers of bioethanol, while European countries have a strong position in biogas. The global cleantech market is expected to grow further, approximately by 10-15 % per year, valuing around EUR 290-360 billion in 2015. (Slot *et al.* 2011, 14-16)



GRAPH 9. Global cleantech market size (adapted from Slot *et al.* 2011, 14)

It is hard to measure Finnish cleantech market because of the wide concept of clean technologies. As it was mentioned before, a big share of companies might apply cleantech in their operations, but at the same time they might state that they operate in other sector that cleantech. In some cases companies operate mainly in one sector, e.g. construction, or logistics, and at the same time apply cleantech in all, or in a part of their daily operations. In such case it would not be proper to see this company as a cleantech business. In addition, it would be hard to calculate revenues generated by cleantech that was applied.

According to different sources, as for the year 2012, there are around 1300 companies operating in Finnish cleantech industry. All together they generate total revenues of around EUR 4.5 bn. Half of the revenues were generated from exports (Helsinki Business Hub 2012, Tilastokeskus 2012). This figure proves that at the moment, Finnish cleantech industry is too big for domestic market. Exports - good step in realising sector's potential.

According to Finnish Statistics authority (Tilastokeskus), in 2010 there were 777 companies that operated in envirotech sector (see Table 3). All in all, 6630 people were employed in this sector. Turnover stood at EUR 2.5 bn. Even though this data is only two years old, according to other sources, the number of cleantech-related businesses was growing really fast in the last couple of years. Also, the statistical data provided by Tilastokeskus covers only a part of cleantech sector. Such segments, as smart grids and energy transmission, energy efficiency, energy storage, environmental IT, etc., are missing. If reckoned in, they would increase sector's total turnover, exports and personnel numbers.

TABLE 3. Finnish environmental technology sector in 2010 (adapted from Tilastokeskus 2012)

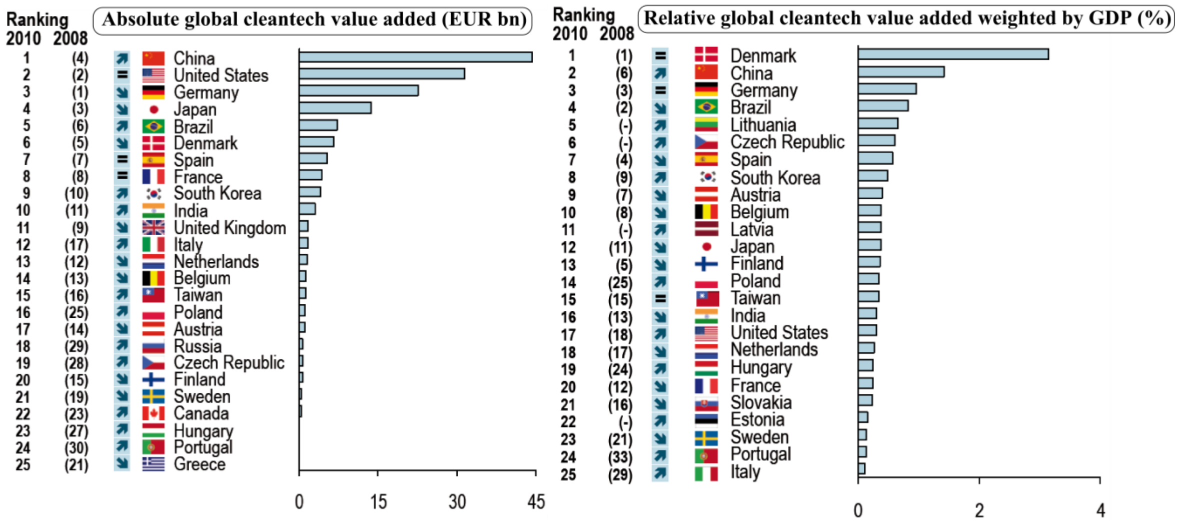
Industry (TOL2008)	Companies (number)	Personnel	Turnover (EUR million)	Exports (EUR million)	Investments in environmental business (EUR mln.)
Wind and water energy	75	473	642	4	136
Sewage and waste water management	150	379	93	0	17
Waste collection, treatment and disposal	398	4 189	885	4	81
Recycling of materials	107	217 1	745	456	22
Remediation and other waste management services	47	372	60	4	3
Total:	777	6 630	2 425	469	259

According to Cleantech Finland survey, Finland's 100 major cleantech companies in 2010 accounted for EUR 17.9 bn. in turnover. Domestic cleantech market grew by 5.6 % in 2010, and was expected to grow by 9.6 % in 2011. At the moment, energy efficiency contributes almost half of the turnover of cleantech companies in Finland. Renewable energy production, transmission and distribution are believed to be the fastest growing segments, in line with water management, waste management and waste water treatment (Invest in Finland 2011).

Talking about energetic segment of cleantech – renewables, over the last decade, the share of energy generated using renewable sources in the total energy supply grew from 24.6 % (in 2010) to 27.7 % (in 2011). The share started expanding rapidly only in 2007. 14.6 % of energy supply in 2011 was generated using hydro power. Wind energy's share is smaller – 0.6 %. This index is one of the lowest in the EU. Anyway, since 2010 the share doubled. In addition, Finland pays a lot of attention to enhancing wind power segment. For example, a new 19 turbines (50 MW) Myllykangas Wind Park should be operational in the first quarter of 2013. Such project will definitely increase the share of this segment. 44.4 % of energy is produced using fossil fuels. (Tilastokeskus 2012)

So far, Europe forms the biggest market for Finnish cleantech companies, alongside China, which is the most significant single market. The growing Chinese consumption and investments into clean and efficient technologies, energy, waste and water treatment offer a good opportunity for Finnish R&D. The second most significant single market is Germany, which is expected to be taken over by Russia in the nearest future. Importance of India, Brazil, North America, and Africa, as a target market is growing. (Invest in Finland 2011)

Finland is famous for its commitment to environmental practices in technological area, political, scientific and even societal area. The same study by WWF and Roland Berger that was conducted in 2011, ranked the countries by economic value added from manufacturing cleantech products (see Graph 10).



GRAPH 10. Country ranking by absolute and relative cleantech value added (adapted from Slot 2011, 18)

Finland ranks as the 20th country with the highest absolute cleantech value added and the 13th with the highest relative cleantech value added comparing to GDP. Absolute leaders are China, the US, Germany, Japan and Brazil, while relative – Denmark, China, Germany, Brazil and Lithuania. Finland lost its position held in 2008, while some countries improved their positions, for instance China, Lithuania, Poland, and Hungary (Slot *et al.* 2011, 18). This ranking is based on manufacturing clean energy technologies. Growing markets, such as China, Brazil or Germany, face the growing demand for energy. Cleantech is one of the alternatives to meet this demand. That explains why these three countries are among the leaders in cleantech production. Meanwhile, Finland, which has relatively small market, loses its position in cleantech production.

However, having in mind that Finland has an extensive experience in manufacturing environmental and clean technologies, it is possible that the development direction was switched from quantity to quality. A lot of attention is nowadays being paid to innovations and R&D. From this perspective, Finland is ranked by the WWF and the Cleantech Group as the 4th country in the world with the highest cleantech innovation index (see Table 4). Cleantech innovation index is an average of six other indexes that evaluate the cleantech and innovation environment in a country. Finland ranks second in general innovation drivers (general environment for creation of cleantech start-ups, policies, etc.) and cleantech-specific innovation drivers, e.g. public cleantech R&D budget of 0.07 % of Finland's GDP. Despite good R&D environment and sufficient funding, Finland is doing relatively worse in scaling up companies and commercialising innovations. Small domestic market is an obstacle for company growth (Knowles *et al.* 2012, 14-34).

TABLE 4. Country ranking by cleantech innovation index (adapted from Knowles *et al.* 2012, 15)

Rank	Country	Cleantech Innovation Index	Inputs to Innov.	Outputs of Innov.	General Innov. Drivers	CT-Specific Innovation Drivers	Evidence of Emerging CT Innov.	Evidence of Commercialised CT Innov.
1	Denmark	4,7	3,5	6,0	2,9	4,1	6,2	5,7
2	Israel	4,1	2,5	5,7	2,9	2,2	8,6	2,7
3	Sweden	4,1	3,3	4,8	3,5	3,2	6,2	3,4
4	Finland	4,0	3,6	4,5	3,5	3,7	5,7	3,2
5	USA	3,8	3,3	4,3	3,5	3,1	6,0	2,6
6	Germany	3,6	3,1	4,1	2,7	3,6	4,9	3,2
7	Canada	3,4	2,8	4,1	3,5	2,1	4,8	3,5
8	S. Korea	3,3	3,2	3,5	2,8	3,5	5,0	2,0
9	Ireland	3,2	2,9	3,6	3,5	2,3	3,5	3,7
10	UK	3,2	3,2	3,2	3,3	3,2	4,2	2,3

However, without having big domestic market, Finland concentrates more on R&D and innovations. This makes Finland one of the world's leading innovation centres. Better commercialisation of Finnish cleantech innovations would make Finland number one innovator. Because of lack of big domestic market, commercialisation has to be international and mainly pointed towards big markets, such as China, India, Russia, or smaller markets that are not advanced in cleantech.

Strong Finnish position in cleantech sector is ensured by efficient co-operation between authorities, business, science and general support by the society. Multilateral co-operation and support programmes are implemented by various Finnish institutions (see Table 5). The programmes are usually aimed at specific segment, e.g. renewable energy, biomass, smart grids, energy efficiency, etc. Some of them focus more on R&D, while others promote co-operation. Research oriented Cluster for Energy and Environment – CLEEN, brings together over 45 companies and 15 research institutes. Currently this cluster focuses on four cleantech-oriented programmes. At the moment, energy and resource efficiency topics dominate in the agenda. CLEEN has 44 shareholders: 28 companies (ABB, Fortum, Helsingin Energia, Kuusakoski, Lassila & Tikanoja, Metso, Neste Oil, Outokumpu, The

Switch, Wärtsilä Finland, and 18 other) and 16 research institutions (Helsinki University, University of Oulu, Tampere University of Technology, SYKE, VTT, and 11 more).

TABLE 5. Cleantech-related programmes in Finland (launched in 2002 or later)

Programme	Period	Institution	Volume (mln. EUR)	Focus technology area
KETJU	2006-2013	Academy of Finland	8	Sustainable Production and Products. Research of chemical industries, process and productions engineering
Kestävä yhdyskunta	2007-2012	Tekes	100	Sustainable development in real estate and construction clusters
BioRefine	2007-2012	Tekes	200	New, biomass-related products
Polttokennot	2007-2013	Tekes	144	Products and services based on fuel cell technology
Sustainable Energy (SusEn)	2008-2012	Academy of Finland	9	New technologies for energy production, effective energy system and energy use efficiency
FCEP	2010-2013	CLEEN	36	Future Combustion Engine Power Plant. Improve energy efficiency and environmental impact of combustion engine power plants
Uusiutuva energia-Groove	2010-2014	Tekes	95	Renewable energy
MMEA	2010-2014	CLEEN	50	Measurement, Monitoring and Environmental Efficiency Assessment. New technologies, methods, tools and services for environmental observation systems
SGEM	2010-2014	CLEEN	36	Smart Grids and Energy Markets. Develop international smart grid solutions
CCSP	2011-2015	CLEEN	15	Carbon Capture and Storage. Know-how, development and commercialization of CCS
Green Growth	2011-2015	Tekes	79	Climate change and market change
Green Mining	2011-2016	Tekes	60	Developing sustainable mineral industry
EFEU	2012-2016	CLEEN	12	Efficient Energy Use

Finnish Cleantech Cluster is a great example of specifically cleantech oriented business-research-study co-operation. The cluster and four centres of expertise come under OSKE. Cleantech Cluster covers around 60 % of Finnish cleantech businesses and 80 % of cleantech research: over 400 enterprises and Finland's leading universities and research institutes. The cluster promotes internationalisation of Finnish cleantech businesses, especially towards big markets, such as Russia, China, the US, India, Japan. Cluster's target is to enhance cleantech business in Finland through: creating 1500 new jobs between 2007 and 2013; using EUR 170 mln. R&D&I venture portfolio; helping to establish 80 new cleantech companies; attracting up to 15 % of all venture capital investments to cleantech sector; creating 20 new leading companies to international markets. The cluster comprises of four Centres of Expertise:

- Lahti Science and Business Park – Lahti Region Centre of Expertise. Co-ordinates the activity of the whole cluster. Focuses mainly on developing cleantech business by co-ordinating internationalisation programmes and venture capital investments.
- Kuopio Innovation – Kuopio Region Centre of Expertise. Focuses on technologies related to climate, air quality, health and environmental ICT.
- Business Oulu – Oulu Region Centre of Expertise. Main focus is catalytic air purification and water purification.
- Culminatum Innovation/Green Net Finland – Helsinki Region Centre of Expertise. Main project are related to urban energy efficiency and environmental monitoring. (Cleantech Cluster 2012)

The concept of cleantech involves wide range of techniques and technologies. For one country it is nearly impossible to lead in all segments of this sector. Still, each country, depending on geographical and economical reasons, is doing better and specialises in particular segments (see Table 6). The specialisation was identified by analysing patent applications in selected countries. Relative technological advantage (RTA) index was used to measure the ratio of each segment of cleantech. RTA index value higher than 1 indicates that country has relatively has more patent applications in this special area. Finland's specialisation has changed over the last two decades. Now Finland specialises in waste management, water treatment, biomass, ocean and wind energy (Palmberg & Nikulainen 2010, 19). Among the clean technologies energy efficiency and smart grids are not mentioned, though Finland specialises in these two segments as well.

TABLE 6. Cleantech specialisation of selected countries (adapted from Palmberg & Nikulainen 2010, 19)

Technology	FI-90's	FI-00's	FI	AT	DE	DK	UK	NL	SE	US
Air pollution control					×				×	×
Solid waste management	×	×	×	×						
Water pollution control		×	×	×	×	×	×	×	×	
Renewable energy	×					×	×	×		×
-Biomass	×	×	×				×	×		×
-Geothermal		×		××	×			×	×	
-Hydro power		×		×××					×	
-Ocean		×	×	××		××	×××		××	
-Solar								×		
-Wind	××		×		×	×××			×	

× - RTA >1; ×× - RTA > 2; ××× - RTA > 4. RTA index value higher than 1 indicates that country has relatively more patent applications in this specialised area.

A strong support for Finnish cleantech sector comes from educational institutions. Finland's major universities, such as Helsinki University, Aalto, Turku, Jyväskylä, Oulu Universities, Lappeenranta and Tampere Universities of Technologies offer wide range of cleantech-related programmes, starting from bachelor and ending with doctoral level. Programmes range from environmental and construction engineering, to environmental biology, sustainable and renewable energy. Universities of applied sciences each year prepare hundreds of graduates with more technical and practical approach.

The biggest or most famous companies that are occupied in some of the cleantech segments are:

- Energy efficiency:
  - Wärtsilä - energy-efficient power plants, ship power solutions.
  - Fortum - generation, distribution and sale of electricity and heat. Sustainability is implemented mainly through energy efficiency.
  - Outotec - mining and metallurgical industries.
  - ABB - power systems, low voltage products.
  - Asema Electronics - energy efficient appliances, home automation, per appliance power measurement, tariff driven home appliance control.
- Biofuels and biomaterials:
  - Neste Oil – refining and marketing company concentrating on low-emission, high-quality traffic fuels.
  - St1 – bioethanol production, reducing the impact imposed on the environment by motor fuels and energy generation..
  - Ekolite – production of composite materials from biomass and industrial wastes.
  - Chempolis – bioethanol, biochemical, papermaking fibres.
- Recycling and waste management:
  - Metso – mining, construction, power generation, automation, recycling and the pulp and paper industry.
  - Kuusakoski – recycling services, recycled metal.
  - Enevo – optimising work of waste management companies, collection intervals, routes and equipment utilization by using fill level sensors and online analytics software.
- Materials:
  - Ruukki - steel production. Production and energy efficiency researches.
  - Fincument – sales, recycling of cables and other non-ferrous and ferrous metals.
- Transport:
  - Cargotec – logistics and production of highly energy-efficient machienery.
- Water treatment:
  - Kemira - water treatment, water chemistry.
  - Elozo – developing innovative, environmentally friendly hygiene solutions based on the application of ozone gas.
- Renewable energy:

- Global EcoSolutions - energy, water, waste, logistics and information management.
- The Switch - magnet generators and full-power converter packages for wind power and other New Energy applications.
- WinWinD - wind turbines, wind power.
- Beneq - glass coatings, photovoltaics and thin films for industrial applications.
- Moventas - wind turbine gears.
- Watrec - renewable energy from waste and industry byproducts in biogas plants.

As it was mentioned before, there are nearly 1500 companies that are occupied in cleantech. The biggest part of them is SMEs. Especially small and innovative companies are becoming very famous in international cleantech society. For example, such companies as Asema Electronics, Ecolite, Enercomp, Enevo, Metgen, Numcore, Pegasor and Ultranat were among top 25 Nordic most promising cleantech start-ups in 2011. In 2010 AkkuSer, BT Wood, Enevo, MHG Systems, Mzymes, Netcycler and ZenRobotics got the same nomination. All these companies operate in different areas of cleantech, from energy efficiency to recycling and environmental ICT. (Nordic Cleantech Open 2012)

4.5 Lithuanian clean technology sector analysis

In 2010 Lithuania approved the first large-scale Lithuanian Innovation Strategy. Along with biotech, laser technologies, electricity and optic equipment industry, cleantech was distinguished as one of the high-potential sectors. The Implementation Action Plan (2010-2013) followed the strategy and envisaged diverse instruments to promote business and science co-operation. Together with other EU member states, Lithuania took commitment to increase renewable energy share and has set 23 % target for 2020. Renewable energy share stood at 15 % in 2010. It is dominated by hydro power. According to Renewable Energy Development Strategy, by 2020 renewable energy share will reach 10 % in transport (currently 4.3 %), 21% in electricity manufacturing (currently 5 %), 36 % in heating and cooling sector (28 % in 2010), 60% in centralised district heating (15 % in 2010) (Invest Lithuania 2012, 3-4). All these ambitious goals were set just two years ago. But there has been progress made in cleantech sector since then. As it was mentioned before, Lithuania focuses mainly on high technologies, where Lithuania has already been quite successful – lasers, biotechnologies, IT, electrical and mechanical products. Unlike

Finland, it recognises cleantech as a new and highly potential sector, but still paying more attention to old and successful sectors.

In 2010 Lithuania was ranked as the 5^{th} country in the world with the highest relative cleantech value added, comparing to country's GDP (Slot *et al.* 2011, 18). Besides, the top 5 group consists of Denmark, China, Germany and Brazil (see Graph 11). This sector is quite young in Lithuania, but using the unique potential of human resources, know-how and experience in other technologies, especially electronics, Lithuanian cleantech sector grows fast, bringing extensive added value.

By now there are 5 Integrated Science, Studies and Business Centres (Valleys) established all over the country. Unlike in Finland, none of them specialise only in cleantech. The main goal behind each valley is to bring together businesses, science and education institutions. This multilateral co-operation would help boosting innovations in technology driven businesses, and transferring the newest technologies. More than EUR 600 million was allocated from the EU Structural Funds 2007-2013 for Lithuania to develop country's R&D sector. Nearly half of this amount went to the creation and development of valleys. (R&D in Lithuania 2012, 5) Each valley specialises in particular sector (see Table 7). Cleantech companies operate in each valley, but there are a few. Cleantech companies in two main valleys, Sunrise and Santaka, concentrate mainly on sustainable energy.

It is widely accepted that clusterisation is a very effective way of promoting innovations and co-operation. Even though, the meaning and the effect of clusterisation is understood, Lithuania is still on the early stages of clusterisation. However, 11 sectors of high potential to form clusters were identified. Despite the fact that laser manufacturing, biotechnology industry, chemistry industry, wood processing, textile and food industry have the highest potential, cleantech is still recognised and include into the list. So far there are 4 clusters operating and only one of them, Photovoltaics Technology Cluster, is cleantech-focused. At the moment there are 3 universities and 4 research centres, 1 foreign and 16 Lithuanian enterprises operating in different areas of PV technologies. In 2010 Precizika-MET SC together with Baltic Solar Energy, Baltic Solar Solutions and BOD Group revealed plans to build a $25000m^2$ facilities for solar cell and solar module production. 500 new jobs within this cluster are planned to be created by 2016-2018, with industry's share in Lithuanian exports reaching EUR 434 million. (Invest Lithuania 2012, 4)

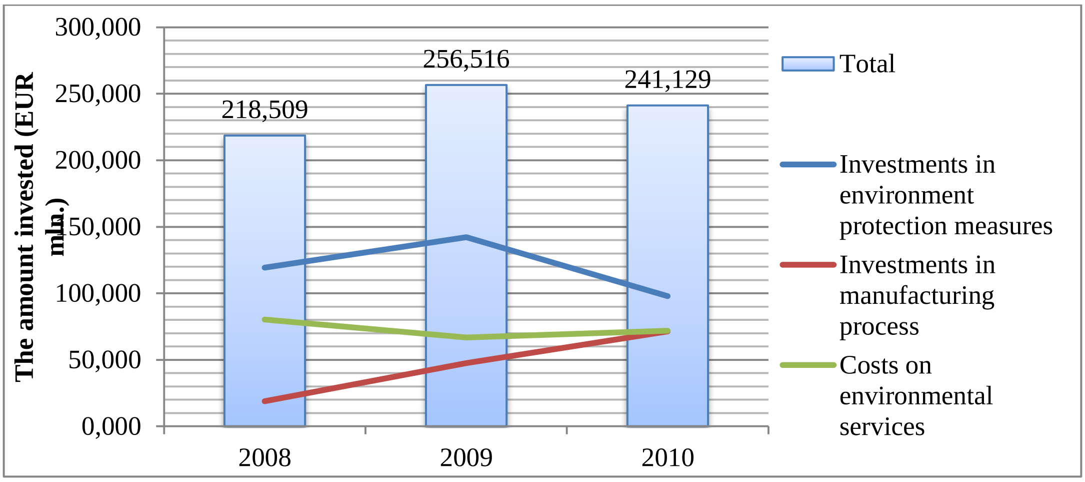
TABLE 7. Lithuanian R&D valleys (adapted from R&D in Lithuania 2012, 5)

Centre	Specialisation	Human resources	Members
Santara Valley (Vilnius)	Innovative medical technologies, molecular medicine **Ecosystems and sustainable development** ICT	800 scientists and researchers	− 11 science and education institutions; − Over 30 enterprises; − 6 medical institutions; − Business support organisations.
Sunrise Valley (Vilnius)	Laser and light technologies Material sciences and nanotechnologies Semi-conductor physics, electronics and organic electronics **Civil engineering, Renewable energy and environmental technologies** Life science, biotechnologies, genetics, microbiology ICT and creative industries	1000 scientists and researchers	− Vilnius Gediminas Technical university and Vilnius University with tens of faculties and institutes; − 36 enterprises, among which 4 are cleantech oriented: • Ineco – industrial ecology; • KG Energija – solar energy and heating; • Modernios E-Techologijos – electronics, solar energy; • Sustainable Business Solutions – cleantech consultancy.
Santaka Valley (Kaunas)	Sustainable chemistry and pharmaceutics **Future power engineering** ICT Mechatronics and electronics Biomedical engineering	2300 scientists and researchers	− Kaunas Technical University; − Lithuanian University of Health Sciences; − Lithuanian Energy Institute; − 3 Science and Technology Parks; − Over 100 enterprises, among which 6 are cleantech oriented.
Nemunas Valley (Kaunas)	Agro biotechnology Food technology, safety and health Forestry **Bioenergy**	1000 scientists and researchers	− 5 Universities with 9 institutes; − 5 major enterprise groups, occupied in agriculture, forestry and food industry.
Maritime Valley (Klaipėda)	Maritime environment Coastal research Maritime technologies **Environmental engineering**	600 scientists and researchers	− Klaipėda University; − 3 institutes and research centres; − 5 associations; − Over 50 enterprises, 4 of them – cleantech.

Lithuanian enterprise, Precizika MET-SC, pioneered Lithuanian solar industry development by launching PV Laboratory in 2010. Highly potential human resources, know-how and well developed micro-electronics sector were used as a basis for this laboratory. Solar batteries that are produced in this plant are mainly exported to Korea and Netherlands. (Invest Lithuania 2012, 4)

Unfortunately there are no databases in Lithuania, where Lithuanian cleantech companies would be enlisted. NACE classification does not recognise cleantech as a separate sector, so these companies are spread all over other sectors. At least a few numbers from Lithuanian Statistics department that are surely related to cleantech, show that as for 2012 there are: 332 electricity and gas supply companies; 66 water supply, collection and treatment companies; 42 wastewater treatment companies; 240 waste collection, treatment and material recovery companies (Statistikos Departamentas 2012). In addition to these numbers, renewable energy and energy efficiency companies, energy distribution, transportation, agriculture and material producing companies should be added. Not all of them use clean technologies in their operations, but still they would make a reasonable increase in total number of Lithuanian cleantech enterprises, which may reach up to 600.

To investigate the general trend of switching to clean or more environmentally-oriented technologies, it is important to look at environment-related investments of Lithuanian enterprises. General investments in environmental technologies by mining and quarrying, manufacturing, electricity and gas supply, water supply and waste water treatment, construction and transportation companies in 2010 reached EUR 241 million (see Graph 11). The most interesting trend, which shows that companies start using cleantech principles, is the decreasing investments rate in environment protection measures (end-of-pipe and alike). At the same time, much more financial resources were invested in improving manufacturing process to increase efficiency and minimise negative outcomes during the production process. The amount of such investments grows with a huge pace: from 2008 to 2010 the amount of investments in process improvement grew by 376 %. In 2010, on average one company invested around EUR 13 thousand in transforming to more eco-efficient. In 2010, 94 % of all these investments were made in water supply and waste water treatment (50 %), manufacturing (34 %), electricity and gas supply (10 %) sectors.



GRAPH 11. Companies' environment-related investments (adapted from Statistikos Departamentas 2012)

As it was mentioned before, Lithuania has set a goal to increase the share of renewable energy in total energy consumption from 17 % to 23 %, by 2020 (Europe 2020 targets, 2012). By 2009, only 3-4 % of electricity was produced by wind power plants, totalling

54MW. There were 20 wind power plant parks in Lithuania in the beginning of 2009. Altogether 47 wind power plants were operating (Šukienė 2010). Lithuania seeks to establish energy independence in the region, so a lot of attention is being paid strategic energy projects along the alternative energy sources. Implementation of the 3rd EU Energy Package made it possible to generate and sell electricity to other users. Hopefully, this will stimulate the establishment of more wind power plants in the nearest future. So far, vast majority of wind power companies import wind turbines from the foreign countries, and only a few Lithuanian companies produce low-capacity wind turbines.

The biggest or most famous companies that are occupied in some of the cleantech segments are:

- Energy efficiency:
  - Ekolaitas – innovative and highly energy-efficient LED street, industrial and home illumination;
  - Eco Sprendimai – illumination and energy saving solutions;
- Smart Grid:
  - LitGrid – electricity transmission system operator;
  - LESTO – electricity distribution and transmission operator;
  - Sky Energy - electricity distribution and transmission operator;
- Biofuels and biomaterials:
  - Bionovus – Biofuel production and waste processing plants;
  - Grasta – Solid biofuel production;
  - Axis Industries Group - biofuel plants, measurement tools, energy distribution and transmission tools, technical examinations.
- Recycling and waste management:
  - EMP Recycling – electrical equipment, metal recycling;
  - Ecoservice – collection, transportation and processing of household waste and secondary raw materials;
  - Atliekų tvarkymo centras – electrical equipment, oil, metal recycling;
- Water treatment:
  - INECO – wastewater treatment and heavy metal removal;
  - FinEco – wastewater treatment;
  - Traidenis – wastewater treatment;
- Renewable energy:
  - Precizika MET SC – solar cell and solar module production;
  - Lingoterma – biomass energy production;
  - Saulės energija – wind and solar energy production;
  - Modernios E-Technologijos – PV, energy saving and environmental technologies;
  - Baltic Solar Energy – PV energy production;
  - KG Energija – production of solar energy and solar thermal energy systems;

- Lietuvos Energija – hydroelectric power generation.

Majority of these companies can be referred to SMEs that employ only tens to hundreds of employees. However, energy distribution companies employ more people and generate bigger profit. Still, small companies are good, when it comes to innovations, co-operation and flexibility. Small and medium size enterprises can experiment way easier than their bigger counterparts. However, they face a few problems, such as the lack of finances for innovations, inability to commercialise their innovations and get the full advantage of them. The smaller the company is, the harder it finds to attract highly qualified employees.

Out of 24 universities and 24 colleges, Vilnius Gediminas Technological University, Vilnius University, Kaunas Technological University, Šaulių University and Klaipėdos University are the main scientific contributors to Lithuanian cleantech sector. Every year nearly 1500 mechanical and electrical engineering students graduate from these three universities (Invest Lithuania 2012, 6). All 5 universities prepare environmental engineering professionals who later on contribute to the creation of Lithuanian cleantech sector. All of these universities co-operate actively with each other, with business and authorities, operate in nearly all Lithuanian technology parks. For now, Lithuania has a pool of 18000 researchers and scientists.

Almost every university in Lithuania has a centre or at least a division which is responsible for entrepreneurship. A part of Lithuanian cleantech businesses were started in such centres, so they are very important for sector development. A good example of Finnish-Lithuanian co-operation in this area is a memorandum which was signed by Aalto Centre for Entrepreneurship (Aalto University) and Kaunas Technological University on February 2012. Two universities will co-operate in establishing an entrepreneurship centre in Kaunas, which will correspond the model of Aalto Centre for Entrepreneurship. The latter will supply Kaunas Technological University with advices on innovation commercialisation, co-operation between science and business.

4.6 Expert research of international co-operation possibilities in the development of clean technologies

In order to generate a better understanding of Finnish and Lithuanian cleantech companies' needs for the co-operation and their expectations, an expert interview was conducted.

Three experts from Finland and two from Lithuania took part in this interview. Each expert was interviewed separately by phone and e-mails. All five experts work in different cleantech companies:

- Elozo Oy – a Finnish company that specializes in water free cleaning, no waste water discharges; the expert has 5 years of technical and 15 years of managerial work experience, 9 of which in cleantech;
- Beneq Oy – a Finnish company occupied in solar energy and energy efficiency; the expert has 12 years of managerial experience, 7 of which in cleantech;
- Watrec Oy – a Finnish company that produces biofuels, is occupied in water treatment and energy efficiency; expert has 7 years of managerial experience in cleantech;
- UAB FinEco – a Lithuanian company which produces biofuels and biomaterials, and is occupied in recycling, waste and wastewater treatment; expert has 17 years of managerial work experience, 9 of which in cleantech;
- UAB Ineco – a Lithuanian company which is occupied in production of biomaterials and wastewater treatment; expert has 5 years of managerial experience in cleantech.

The following questions were discussed:

1. *What is your company's internationalisation level?*

Previous sections showed that a big part of the Finnish cleantech goods is produced and goes abroad. Two Finnish experts approved it by saying that their companies operate mainly for *foreign markets*. Watrec expert stated that Finnish cleantech is highly internationalized, and a big part of goods are exported, but the majority of companies operate for both, *domestic and foreign markets*. Lithuanian experts both stated that their companies operate equally for domestic and foreign markets. They also agreed that majority of Lithuanian cleantech companies do the same. According to all 5 experts, the number of companies that would operate only for domestic market is quite small, because of globalization, the EU, technologies and the global demand for cleantech products.

2. *Do you co-operate with foreign countries? If yes, what are your major partners?*

Of course, all the experts stated that their companies in one or another way co-operate with other states, i.e. they have supplier, customers, partners, subsidiaries or divisions there. Previous studies showed that the biggest market for Finnish cleantech at the moment is the EU. All three Finnish experts agreed on that. They mentioned *Sweden, Germany, Switzerland, France, Denmark, Norway, Spain and UK* as their biggest partners. Beneq expert mentioned the *global perspective,* saying that they have partners nearly all over the world. A little bit different situation is in Lithuania. FinEco co-operates closely with *Latvia,* while Ineco with *Poland, Sweden, Denmark, Russia and Belarus*. Both Lithuanian experts agreed that main partners for Lithuanian cleantech companies are and potentially can be Nordic countries and the closest neighbours.

3. *In what areas do you co-operate (or plan to) with Lithuanian (Finnish) companies?*

All three Finnish experts unanimously mentioned *exports to Lithuania*. Watrec expert, in addition to exports told about the plans to organize *expertise exchange* with Lithuanian companies. Elozo expert stressed that Lithuanian market is quite interesting for Finland, because of Lithuanian *re-exports possibilities* and ability to reach Russia, Belarus and Ukraine through Lithuania. Lithuanian FinEco imports cleantech goods from Finland and plans to start *joint projects* together with Finnish companies. Ineco does not co-operate with Finland, nor has any plans to do so. One of the Lithuanian experts said that imported goods from Finland are rather expensive, but they are of the highest standards and do not have substitutes of the same quality. In addition, Finnish quality is well known in Lithuania, so this maintains imports from Finland. Lithuanian experts also doubted if there are much of cleantech exports to Finland.

4. *What areas of co-operation between Finland and Lithuania should be further developed (concerning cleantech)?*

Here all the experts had different opinions. Elozo and Beneq experts recognised the need to co-operate on *intergovernmental level,* between Finnish and Lithuanian policymakers, jointly work on cleantech policies and support programmes. Both experts stated that both countries could *share their best practices* in policymaking and programme handling. Watrec and Beneq mentioned *common scientific activity,* stronger co-operation between universities and research centres. Both experts told that they are aware of strong scientific background of Lithuanian electric, electronic, nanotechnologies and ICT, and Finland could learn something from Lithuania in those areas, as well as Lithuania from Finland. As Beneq expert said, “two scientists separately can be strong, but together they can achieve even more”. When it comes to trade between countries, Elozo and Ineco experts mentioned *Finland importing cleantech products from Lithuania* and FinEco, Elozo and Watrec experts – *Lithuania importing products from Finland*. Only one expert from Beneq said that trade between Finland and Lithuania would not be that effective and beneficial, as, for example, scientific co-operation, or co-operation between policymakers. Ineco expert mentioned one more opportunity, which was not mentioned by anybody else – *expertise exchange*. Companies could exchange specialists to employ best available techniques and work on joint projects. Elozo and FinEco experts evaluated good geographical position of Lithuania and proposed the *intermediary role for Lithuania* when co-operating with the third countries, for example Russia, Belarus, Ukraine and Poland. Only expert from Elozo mentioned lower production costs in Lithuania than in Finland and identified a possibility to *co-operate in manufacturing*, for example, building plants or assembly centres in Lithuania. Lower costs would create a more competitive price for Finnish quality.

5. *What are or could be the barriers for co-operation with Lithuania (Finland)?*

4 out of 5 experts mentioned the *lack of information about cleantech industry and investment climate in Lithuania or Finland* as the biggest barrier. FinEco expert said that in his opinion nowadays it is easy to get necessary information about Finnish cleantech sector, so it is not a barrier any longer. Watrec expert mentioned the *lack of demand for cleantech in Lithuania* as one of the barriers, and only one Lithuanian expert was concerned about the *demand for Lithuanian cleantech products in Finland*. Beneq and Ineco experts faced *difficulties finding people with the necessary qualification* in order to handle the co-operation. Elozo expert told that *Lithuanian market size might be too little for Finland*. He also said, that "*Lithuania feels somehow more distant than it really is* and there is not much information available, if compared, for example, to Estonia which has nowadays a lot of interaction with the Finnish economy".

6. *What is Finland's (Lithuania's) strongest side in cleantech?*

Talking about Finland's strengths in cleantech, two experts mentioned *R&D, production quality and strong scientific base*. Also *support from the government* was named, along with *successful innovation commercialisation, technology transfer*, and strong *co-operation between business, science and authorities*. Ineco expert named Lithuania's strengths in cleantech and these are: *production quantity and quality, strong co-operation between business, science and authorities*. FinEco expert mentioned only one strength – a *strong government's support*.

7. *Should Finnish cleantech concentrate on foreign or domestic markets?*

Elozo and Beneq experts agreed that Finnish market is too small and foreign markets would bring more profit. Watrec expert stated that "cleantech is an international sector, so both foreign and local markets have to be addressed".

8. *Is clusterisation the most effective tool to develop cleantech sector?*

All five experts unanimously agreed that in order to promote cleantech sector in Finland or Lithuania, *clusterisation would be very effective*. All three Finnish experts from Beneq, Watrec and Elozo, are the members of the Finnish Cleantech Cluster. All three of them confirmed that being a cleantech cluster member gives a lot of advantages for a company and the whole sector. As well they agreed, there would be a possibility for Finnish-Lithuanian co-operation when creating a cleantech cluster in Lithuania, and both countries would gain from it.

4.7 SWOT analysis of Finnish clean technology sector

After analysing Finnish legal issues related to environmental and clean technologies, overlooking Finnish cleantech sector, country's specialisation, innovation programmes and main businesses, it is worth summarising all this information into a single file, underlining sector's strengths, weaknesses, opportunities and threats (see Table 8). In order to enhance Finnish cleantech sector, weaknesses have to be minimised or eliminated, threats – transformed into opportunities, and opportunities brought to life by transforming them into strengths. This analysis focuses mainly only international aspect of cleantech sector.

The significance of this SWOT analysis is not only in describing Finnish cleantech sector. It will also be necessary when identifying the most beneficial co-operation opportunities with Lithuania. Finnish weaknesses that can be minimised, and opportunities that can be brought to life, could find solution in the strengths of Lithuanian cleantech sector. For this reason, Lithuanian SWOT analysis is also performed.

TABLE 8. SWOT analysis of Finnish cleantech cluster

Strengths	Weaknesses
• World-known brand of Finnish environmental technologies and cleantech; • Environment-oriented thinking of the society; • Strong support of cleantech by government and public institutions using financial tools; • Well established network of business-science-studies-authorities co-operation (science, business and technology parks, Cleantech Cluster, etc.); • Strong legislation (especially on air and environment, water, recycling and waste management), concrete strategy and action plan,	• Inability to use full potential of innovations, moderate commercialisation and technology transfer practices; • Inability to compete with other cleantech-leading countries in renewable energy production (especially in wind and solar), because of geographical reasons; • Small domestic market, which limits the demand for cleantech products and services within Finland; • Finnish labour force is rather expensive, so it is costly to produce cleantech goods in Finland for foreign consumption;

TABLE 8. (Continues)

effective division of responsibilities; • Strong governmental support of innovative start-ups and SMEs; • Presence of big and widely-known enterprises, such as Wärtsilä, Cargotec, ABB, Neste Oil, etc., that fully or partly contribute to cleantech sector; • A big pool of highly-qualified professionals, researchers and students; • Strong ties and co-operation with big market countries, such as Russia, China, India, Brazil, etc. • Ability to apply Finnish cleantech to other states; • Plenty of resources for bio-energy production; Strong specialisation in wind, biomass energy, water pollution control and waste management;	
Opportunities	**Threats**
• Small domestic market requires companies to be international almost from the start of the work; • Small domestic market does not require big production amounts, so Finland can focus mainly on quality, innovations and R&D rather than quantity; • Co-operation with big market countries can generate great demand for Finnish cleantech products and services, and stimulate R&D; • Further co-operation with the EU countries could enhance Finnish scientific potential; • Co-operation with Lithuania would open access to Lithuanian market, scientific potential, cleantech achievements and the gates to neighbouring countries, such as Belarus and Poland; • Present situation in the economy creates an opportunity for cleantech companies to employ a wide range of professionals that had been laid off from other hi-tech companies; • Strengthening Finnish cleantech brand; • The demand for cleantech is growing globally;	• Failure to commercialise more innovations and increase technology transfer rate can result in Finland loosing its position as cleantech innovation leader; • High production costs can make Finnish cleantech products uncompetitive comparing to cheaper substitutes; • Finnish innovations can be applied and produced in other countries with lower production costs, and later come back to Finland; • Environmental technologies are already being used and are widely applied throughout Finland, so as long as they work, the demand for cleantech may not grow rapidly;

4.8 SWOT analysis of Lithuanian clean technology sector

Based on previous analysis of Lithuanian legal acts related to environmental and clean technologies, review of Lithuanian cleantech sector, businesses and innovation system, SWOT analysis of Lithuanian cleantech sector was compiled (see Table 9). This SWOT analysis focuses mainly only international aspect of cleantech sector.

Two SWOT analyses were necessary to identify common strengths and opportunities of Finland and Lithuania. What is even more important – to find strengths of one party that could bring to life opportunities in another party, or decrease its weaknesses. Such co-operation would bring value to both sides. Using SWOT analyses of Finnish and Lithuanian cleantech sectors, the solutions for bilateral co-operation will be introduced in the next chapter.

TABLE 9. SWOT analysis of Lithuanian cleantech sector

Strengths	Weaknesses
• Strong governmental support of innovations through national programmes and funding; • A large pool of scientists and researchers; • Feed-in-tariffs strongly stimulate energy production using renewable energy sources; • Relatively cheap and highly qualified labour force can contribute to competitive production; • Well functioning network of technology, science and business parks; • Strong science and research institutions; • Two Free Economic Zones contribute strongly to creation of start-ups and attracting foreign companies to operate in Lithuania; • Successful work of governmental agencies that attract foreign capital to Lithuania and promote Lithuanian entrepreneurship and internationalisation (Invest in Lithuania and Enterprise Lithuania); • Plenty of resources for bio-energy production; • Strong economic relations with Russia, Belarus, Latvia and Poland, well established and functioning logistics networks; • Know-how and experience in electronics and nanotechnologies contribute to creation of strong cleantech sector;	• Lack of concrete cleantech oriented national strategy and obscure action plan; • Hardly identified place of cleantech in Lithuanian R&D and innovations system; • Because of present financial challenges, more attention is being paid to National Strategic Projects, while cleantech is laid off to the second position; • Lack of a single cleantech cluster, or at least cleantech-oriented technology park, forces companies to operate in different parks and areas, without having a common base for co-operation; • Most of the Lithuanian cleantech companies are rather small and are forced to operate for only domestic or local and foreign markets; • No widely-known cleantech companies, and no companies in cleantech-related ratings; • Lack of a common cleantech centre or association forces business to operate on their own; • Lithuanian cleantech brand is not formed yet; • Inability to commercialise a big part of innovations and transfer technologies from science institutions to businesses and other organisations; • Small domestic market, which limits the demand for cleantech products and services in Lithuania;
Opportunities	**Threats**
• Strong support of alternative energy sources gives cleantech a great opportunity to use its potential; • Environmental technologies are not used as widely as in Finland, so there is a niche for cleantech, because the demand for eco-friendly and energy efficient technologies grows fast; • The demand for cleantech is growing globally, creating possibilities for Lithuania and others; • Creating Lithuanian cleantech brand, focusing, for instance, on PV, would be beneficial in all senses; • Possibility to reach bigger markets, for example Russia, and export Lithuanian cleantech goods there; • Growing investments in manufacturing processes create huge possibilities for cleantech; • Implementation of the 3rd EU Energy Package should stimulate massive establishment of private power plants that would use renewable sources;	• Lack of concrete strategy and action plan may lead to low number of cleantech companies, innovations and misuse of the sector's potential; • Failure to commercialise more innovations and transfer technologies can separate science and business, so one will not meet the needs of another; • Very hard to catch up with the leading cleantech countries in sense of production and innovations; • It can be difficult to compete with Poland in sense of quantity, because it has the market and capacity to produce more cleantech products; • Absence of cleantech cluster will result in lack of co-operation between Lithuanian cleantech companies and lower efficiency;

5 SOLUTIONS FOR INTERNATIONAL CO-OPERATION IN THE DEVELOPMENT OF CLEAN TECHNOLOGIES

Upon analysing theoretical and practical aspects of clean technologies and international co-operation as a part of internationalisation processes, the solutions for co-operation between Finland and Lithuania in the development of clean technologies can be proposed. Willingness to co-operate should come from both parties and both of them have to contribute to building stronger ties. That is why the solutions are divided into two parts: a set of solutions for Finland, and a separate set for Lithuania.

5.1 Solutions for developing international co-operation in the area of clean technologies in Finland

This thesis revealed the potential of Finnish cleantech sector. Only a part of this potential is being used at the moment. However, huge progress was made in developing cleantech sector in Finland over the last decade or so. The results can be easily observed. As it was mentioned before, both SWOT analyses were focused mainly on international aspect. This means that strengths, weaknesses, opportunities and threats were analysed from the viewpoint of international co-operation, or its absence. If the same analyses were based on national aspects, there would be partly different elements.

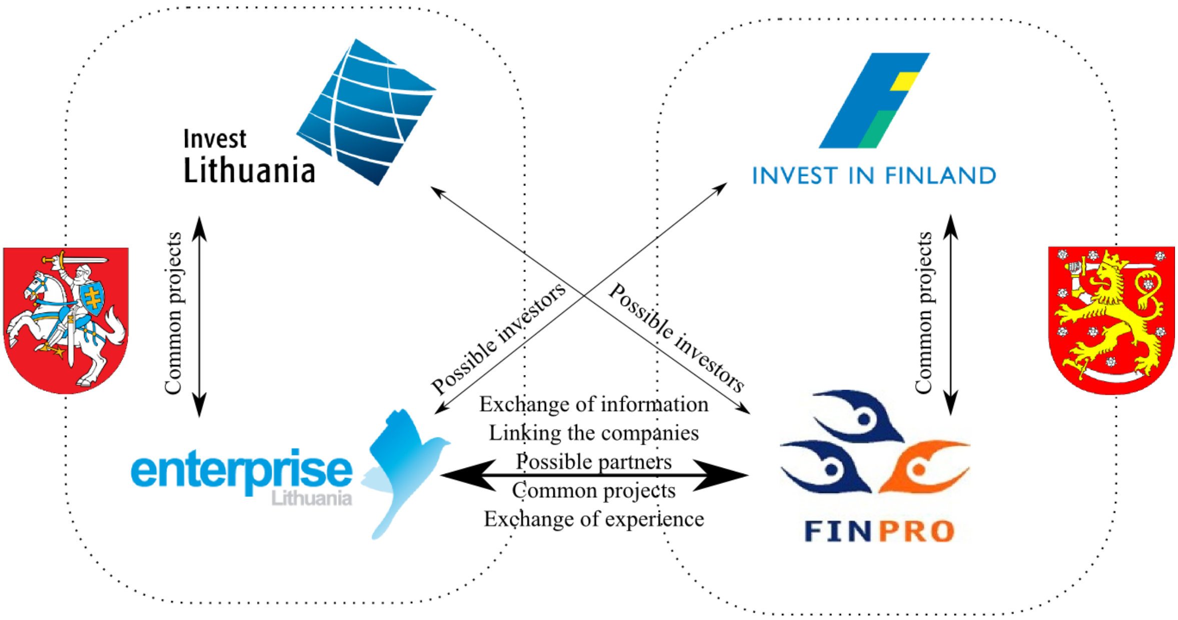
As well as SWOT analysis, the solutions for development of cleantech sector in Finland are based on international co-operation aspect, i.e. they propose the ways of utilising international co-operation possibilities in order to develop Finnish cleantech sector. In case of this thesis, co-operation is pointed directly to Lithuania, and indirectly to its neighbouring countries. The solutions will be divided into four groups: 1) science, innovations and R&D; 2) networking; 3) production and sales; 4) future perspectives.

Science, innovations and R&D. A recently started co-operation between Aalto Centre for Entrepreneurship (ACE), which operated under Aalto University, and Kaunas Technological University is a great example international co-operation between two science institutions. Through this centre for entrepreneurship in Kaunas, Finland can promote its own start-ups and SMEs. In case of cleantech, such entrepreneurship centre would give a great possibility for Finnish cleantech companies to find partners in Lithuania, who would specialise in innovations or would be interested in imports from Finland and distribution in Lithuania, etc. Having in mind growing demand for cleantech in Lithuania, ACE should run campaigns to promote Finnish cleantech companies as potential partners, with experience, products, technologies, professionals and so on, for young Lithuanian companies. Through the entrepreneurship centre in Kaunas, ACE could reach not only Lithuanian market, but also Latvian.

As it was mentioned before, alongside biotechnologies, mechatronics and ICT, Lithuania specialises in electric and electronic engineering, laser technologies, and nanotechnologies. The last three can be effectively used in Finnish waste management, energy efficiency, hydro and wind energy industries. Nanotechnologies can be used even wider. These are the areas that Finnish universities and research institutions should concentrate on when organising joint programmes with Lithuanian universities and institutions. There are five universities of high interest for Finland: Kaunas Technological University, Vilnius Gediminas Technological University, Vilnius University, Klaipėda University and Šiauliai University. These universities have high scientific potential and have strongly contributed to the development of laser and nanotechnologies, electric and electronic technologies in Lithuania. Co-operation could start from common seminars, forums, staff exchange and later go to the establishment of joint laboratories, test centres, and entrepreneurship centres, such as ACE.

Using the present and future relations with top Lithuanian universities, Finnish science institutions should “pull” Lithuanian expertise in electric, electronic, laser and nanotechnologies to Finland by establishing an expertise centre. The model for co-operation could be similar to the future entrepreneurship centre in Kaunas, but it would have to work other way round. Lithuanian university would consult its Finnish partner on its expertise areas, sharing experience of technology transfer. This co-operation would be beneficial for both parties: Finland would get knowledge and experience of the latest achievements in Lithuanian nanotech, laser technology, electric and electronic industry, and would get a possibility to apply those in cleantech; Lithuania would get a chance to promote its national brand, apply and test its achievements in different areas.

Networking. Both, Finland and Lithuania have institutions that specialise in investment attraction or internationalisation of companies. Finland has: “Invest in Finland” – attracts investments from abroad; “FinPro” – occupied in internationalisation of SMEs. Lithuania has similar kind of institutions: “Invest Lithuania” – attracts investments from abroad; “Enterprise Lithuania” – promotes internationalisation of Lithuanian SMEs. All four institutions mainly work directly with target companies. In Lithuanian case, there is a lot of co-operation between these two institutions, especially through different projects. In addition, there could also be co-operation with appropriate Finnish institutions (see Graph 12). For example, “FinPro”, which helps finding partners for a Finnish company (let’s assume - in Lithuania), has to scan the foreign market to find suitable companies. At the same time “Invest Lithuania” has extensive knowledge about situation in Lithuanian market and “Enterprise Lithuania” also looks for foreign partners for their clients in Lithuania. If these three institutions would co-operate closely, they would easily find necessary companies. In other words, they would link Finnish and Lithuanian companies much easier.



GRAPH 12. Co-operation model between Finnish and Lithuanian investment and internationalisation institutions

When it comes to cleantech, all four institutions recognise it as a sector and try to promote it. This means that there would be no problems in compiling a sort of databases with information about Lithuanian and Finnish cleantech companies. Later on, a simple exchange of information would be needed, so that Finnish institutions would know what Lithuanian companies look for partners in Finland, what segment they operate in, and so on. The same process would work other way round. More intensive exchange of information would be between “FinPro” and “Enterprise Lithuania”, as they deal with

SMEs. Co-operation could go beyond common database and information sharing to common projects (such as, launching joint Finnish-Lithuanian companies, and similar) and exchange of experience via seminars, forums, etc. “Invest in Finland” and “Invest Lithuania” – generally look for big investor and try to attract big companies. Of course they work with SMEs too. However, co-operation between the last two institutions would be hard to imagine, because from one point of view, they are competitors.

Nowadays information is precious. A common problem for young SMEs that wish to go international is the lack of information and knowledge about target market. To solve this and promote Finnish cleantech enterprises, as well among Lithuanian companies, would be to create of a specialised single information system, which would contain at least database of Finnish cleantech industry members with the information about their products or services, experience, expertise, references, contacts, etc. So far, Cleantech Cluster administers more or less similar information portal, but it concerns only cluster members. From a wider perspective, this information portal could go beyond cluster boundaries and include as many Finnish cleantech companies as possible. Of course it would be possible to mark, or separate companies that are the members of the cluster. Such system would provide necessary information directly to potential Lithuanian partners.

Manufacturing and sales. Low manufacturing costs, relatively cheap, but educated, professional and loyal labour force, access to latest achievements in electric, electronic, laser and nanotechnologies, great geographical position, connection with Finland over the sea and air, road and railway connections with Russia, Belarus, Ukraine, Poland and Latvia, strong investment support by the government – these are just a few reasons why Lithuania is a very attractive place for Finnish manufacturing. Having in mind high production costs in Finland, Lithuania is becoming even more attractive place for Finnish companies.

Lower production costs in Lithuania, good geographical position and possibility to reach neighbouring countries were mentioned as the top aspects that Finnish cleantech companies are interested in. With the support of Lithuanian institutions Finnish cleantech companies could easily start manufacturing operations in one of the technology parks or free economic zones. Manufacturing plant could be entirely Finnish or joint Finnish-Lithuanian. “Invest Lithuania” could be the major agent, which would help establishing such plant. Technology parks would be more beneficial for an innovation intensive production and R&D centres. They are more suitable for research and small scale production. One out of two free economic zones (FEZ) should be used for bigger scale production and distribution throughout Lithuania, as well as to other countries. Companies that choose Kaunas or Klaipėda FEZ, are supported by the government via tax discounts: first 6 years the company pays 0 % income tax and the next 10 years – 7.5 %, that is twice less than in any other place in Lithuania; real estate tax is 0 %, while in any other place – 1 %; no tax on dividends, while everywhere else – 15 %. Klaipėda FEZ is located in the harbour city and Kaunas FEZ has good highway and railway connection with Klaipėda, so Finland can be reached by the sea, road (via Tallinn) and air.

Growing demand for cleantech products (especially energy-efficiency technologies, PV and recycling) in Lithuania can be satisfied in two ways: imports or local production. Finland can, and should make use of this possibility. Because of high manufacturing costs in Finland, Finnish cleantech products might be too expensive for Lithuanian market. Producing Finnish cleantech good in Lithuania would make the price of Finnish cleantech more competitive. Later the products could be sold in Lithuanian market, exported back to Finland, or exported from Lithuania to eastern and western neighboring countries. Lithuania can act as a gateway to such countries as Russia, Belarus and Ukraine, where the demand for cleantech grows too. These countries offer a big market for Finnish cleantech products. Cleantech products manufactured in Lithuania would offer Finnish quality for a more competitive price. Such combination could be quite successful in the before-mentioned countries. Also exports from Lithuania could also go to other EU countries, especially Germany, Poland, Sweden, Denmark, Czech Republic, Slovakia, Slovenia, and others.

Future perspectives and brand building. A good opportunity to promote Finnish cleantech and start co-operation on a large scale should be used at the annual Finnish-Lithuanian economic forum. Three years ago this forum took Finnish-Lithuanian-Belarusian shape, which is even more beneficial for Finland. The forum is attended by the authorities of all three countries, universities and enterprises. In order to promote cleantech, Finnish representatives should “push” on creating separate environmental technology discussion group. In such group Finland could be represented by Cleantech Cluster, and major cleantech companies. Definitely this group would attract attention from Lithuanian side, because, as it was mentioned before, the strong interest in Finnish cleantech exists among the Lithuanian authorities, as well as universities and companies.

This event would help networking and lobbying on all levels. As well, through such representation, Finnish companies would enhance Finnish cleantech brand, which is getting more known in Lithuania.

5.2 Solutions for developing international co-operation in the area of clean technologies in Lithuania

Legislation. After comparing Finnish and Lithuanian cleantech-related legislation, the difference became obvious. Even though cleantech is recognised in Lithuanian legislation and is mentioned among top priorities of Lithuanian technological development, concrete plans of developing this sector are absent. Cleantech is not addressed as a whole and different segments of it are regulated by separate acts. A single strategy and action plan is something to be desired. Before building a strategy, a thorough sector analysis is needed. At this point Lithuanian policy makers and institutions could learn a lot from Finnish colleagues. Sharing experience goes in line with the values of the EU. Co-operation should be implemented on ministerial level, especially between ministries of economy, between research promoting institutions (from Finland – Tekes, Sitra, VTT, and SYKE; from Lithuania – LMT, LIC, MITA, and APVA). Ministry of Economy would have to co-ordinate other institutions when getting information from Finnish institutions and analysing the situation in Finland. After this, in co-operation with the before mentioned institutions, a strategy and action plan could be drafted, following the Finnish example. More or less similar actions, but between other ministries, are now being practiced in other areas, for example building of Lithuanian cyber security system and strategy, which follows Finnish and Swedish example. The same thing can be done regarding cleantech.

Science, innovations and R&D. Co-operation between Aalto University and Kaunas Technological University in establishing an entrepreneurship centre in Kaunas is a recent great example between two educational institutions. Other four major Lithuanian universities should follow this example and co-operate with major Finnish universities and universities of applied sciences, going beyond student and personnel exchange. Co-operation in technology transfer, joint research projects, entrepreneurship – this is entirely different level.

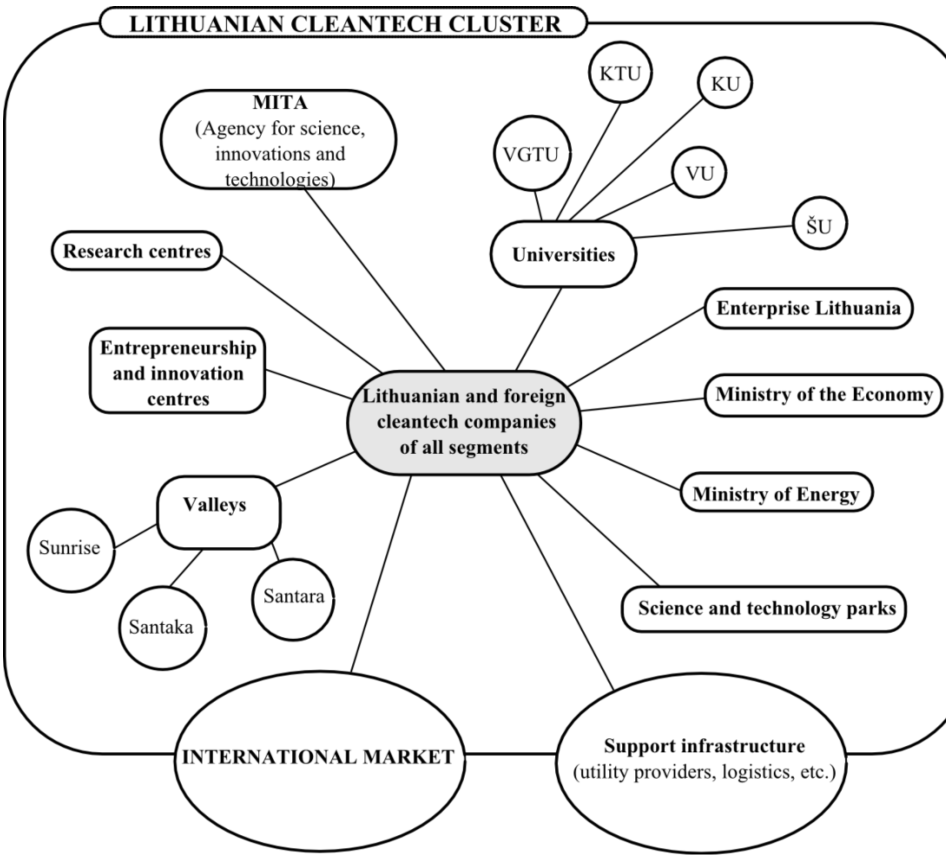
Finnish companies and universities have a lot of experience in environment protection and environmental engineering. Lithuanian innovation industry is well advanced in electric and electronic engineering, laser technologies, nanotechnologies, biotechnologies and a few others. The experience in first four areas could be combined with Finnish expertise in environmental technologies to create more advanced cleantech. A few major Lithuanian and Finnish universities, for instance KTU, VU, VGTU, Helsinki University and Aalto University could work on establishing a joint, entirely research-oriented centre, which would specialise in improving energy efficiency of envirotech, increasing performance of wind, solar and ocean energy technologies, materials and recycling. An optimal place for such centre would be in Vilnius (Santara or Sunrise Valley) or Kaunas (Santaka Valley). The place would depend on the co-operating universities. Part of the staff should be permanent (mainly Lithuanian scientists) and another part temporary (Finnish scientists). Co-operation could be based on projects and Finnish scientists could work at the centre with the projects that are of high importance for Finland, for instance wind energy, recycling, etc. Of course they would work hand-in-hand with Lithuanian scientists that would share their experience in nanotech, electric engineering and others. At the same time, Lithuanian scientists would work on projects that are important for Lithuania and the Finnish experience would be at hand.

Another advantage of such co-operation for Lithuania would be the creation of a strong Lithuanian innovation brand, focusing on electric and electronic engineering, laser technologies, and nanotechnologies.

Networking. Co-operation solution between investment and internationalisation institutions “Invest Lithuania”, “Invest in Finland”, “Enterprise Lithuania” and “FinPro” was described in the previous section. It is beneficial for both countries, so it can be also applied in Lithuania. Common seminars, forums and other co-operation means that were mentioned earlier should be held in both countries (see Graph 12). That would be a great opportunity for Lithuanian cleantech companies to present themselves and find partners in Finland.

A Lithuanian database of potential partners, separating cleantech companies, could be supervised by one of Lithuanian institutions and promoted by corresponding Finnish institution. This interaction, for example between “Enterprise Lithuania” and “FinPro”, could be used by Lithuania to give the Finnish market understanding about Lithuania and its cleantech sector. As an expert from Elozo Oy said, Lithuania feels to be more distant than it really is, because there is lack of information about Lithuanian industry and market, and information exchange between countries is quite poor. This should be fixed by “Enterprise Lithuania” and “Invest Lithuania”.

During the qualitative study, all 5 Finnish and Lithuanian experts agreed that clusterisation is one of the most effective ways to promote the development of cleantech sector. A great example of this can be observed in Finland. Creation of Lithuanian cleantech cluster would foster this sector, unite many cleantech producers that operate separately at the moment, would create more attractive environment for foreign investments into Lithuanian cleantech sector, establish work places, enhance Lithuanian brand. The cluster could unite science institutions (possibly KTU, VGTU and VU), governmental institutions, technology parks and centres, Lithuanian and foreign companies (see Graph 13). Before creating such cluster, Finnish example could be thoroughly studied. For better results, close co-operation with the Finnish Cleantech Cluster and technology parks would be necessary. Finland in this case could act as a consultant or a stakeholder. Combining both options would be even more beneficial for Finnish cleantech companies and sector as a whole.



GRAPH 13. A model of Lithuanian Cleantech Cluster

Manufacturing and sales. Because of the factors that were enlisted in the previous section, manufacturing would be more beneficial in Lithuania than in Finland. Manufacturing possibilities in Lithuania were as well mentioned earlier. Recently both Lithuanian FEZ were promoting their activity outside the country, as well in Finland. Their representatives take part in many events for businesses in Finland. However, all the Finnish experts that took part in qualitative study unanimously mentioned the lack of information about Lithuanian cleantech industry and market as the biggest barrier for co-operation, this factor has to be taken into consideration. Both FEZ should intensify their campaigns, co-operate closely with “Invest Lithuania” and “FinPro” by exchanging information about potential customers.

For now cleantech imports in Lithuania are higher than exports. Majority of Finnish experts mentioned Lithuania as a target market for their sales. At the same time Lithuanian experts agreed that currently companies are mainly importing from Finland. Exports to Finland in some cleantech companies are rather small or do not exist. Exports to Finland have to be increased, but that will only be done after Lithuanian cleantech industry and its specialisation is recognised by Finland. To achieve it, networking, brand building and scientific co-operation have to be implemented intensively.

In order to increase cleantech sales in Lithuania, an informative campaign would be needed to increase the awareness about cleantech in the society. Again, Finnish Cleantech Cluster can act here as a consultant and a partner, when creating a project similar to “solved.fi”. Tens of experts from different Finnish cleantech companies take part in this project and consult other companies and individuals on any questions related to cleantech. This kind of project could boost up the popularity of cleantech sector inside the country and abroad. However, implementation of such project would be more complicated than in Finland, because there is no organisation that would unite these experts. The establishment of Lithuanian cleantech cluster would solve this problem.

Future perspectives and brand building. As it was mentioned before, the brand of Lithuanian cleantech is unknown in Finnish market. Lithuania has to take advantage of annual Finnish-Lithuanian-Belarusian economic forum, to introduce Lithuanian cleantech sector. Also more information should be provided to Finnish-Lithuanian Trade Association. In addition, the brand will be formed after years of co-operation with Finland in all fields related to cleantech: research, technology transfer, manufacturing, sales.

6 CONCLUSION

Upon analysing theoretical and practical aspects of international co-operation in the development of clean technologies, the following conclusions can be deduced:

1. Cleantech refers to products, services or processes that deliver value using limited or zero non-renewable resources and create significantly less waste than other technologies. Clean technologies proved to be ecologically less harmful or not harmful at all, and economically less demanding, i.e. more profitable in a long-term. They are more focused on resource efficiency, advanced materials, energy technologies, underpinned by strong economic drivers. Cleantech include air and environment technologies, agriculture, energy efficiency, energy storage, recycling, waste and water treatment technologies, wind, solar and bio-energy, biofuels, transportation, energy storage and smart grids.
2. Cleantech solves a global problem and has a global market, so in order to develop cleantech, strong international co-operation is needed. Not a single internationalisation theory can fully describe international co-operation processes. These theories partly describe this phenomenon, but the process changes much faster than the new theories emerge, so there are new features that even new theories do not explain.
3. The need for sustainable development is fully recognised globally, as well as in the EU and on the national levels. In the EU, Finland and Lithuania all the features of cleantech are strongly supported in the legislation and are perceived as the main tools of bringing sustainability to development. Cleantech innovations are supported by a range of programmes and institutions. The EU and Finland have well defined cleantech development goals, strategies and action plans. In this sense, Lithuania is not that advanced, because its goals are quite obscure and strategy is unclear. Hopefully, forthcoming national Eco-AP roadmaps will bring more clear goals and will describe more precise actions on developing cleantech sector in Finland, Lithuania and the whole EU.
4. Between 2008 and 2010 global cleantech sector grew by 31 % per year and is expected go grow by 10-15 % annually, valuing around EUR 290-360 billion in 2015. Finnish cleantech sector comprises of approximately 1300 companies, research centres, technology parks and universities. All together they generate total revenues of around EUR 4.5 bn. Half of the revenues were generated from exports. Business-science-authorities co-operation within Finland is well organised and centred by Cleantech Cluster. Domestic cleantech market grew by 5.6 % in 2010, and was expected to grow by 9.6 % in 2011.

Energy efficiency contributes almost half of the turnover of cleantech companies in Finland. Renewable energy production, transmission and distribution are believed to be the fastest growing segments, in line with water management, waste management and waste water treatment. Finland ranks as the 4th country in the world with the highest cleantech innovation index. Finland specialises in wind, ocean and biomass energy, water pollution control, waste water management, energy efficiency and smart grids.

5. In 2010 Lithuania was ranked as the 5th country in the world with the highest relative cleantech value added, comparing to country’s GDP. Lithuanian cleantech sector is on its early stages of development. Business-science-authorities co-operation is not as organised as in Finland and is rather divided into many separate co-operation centres. The total number of cleantech companies in Lithuanian may reach up to 600. The amount of investments in sophisticating manufacturing process grows with a huge pace: from 2008 to 2010 the amount of investments in process improvement grew by 376 %. In 2010, on average one company invested around EUR 13 thousand in transforming to more eco-efficient operations. Concerning cleantech, Lithuanian specialises in solar photovoltaics, electric and electronic engineering, nanotechnologies and materials, biofuels.

6. The expert interview revealed the need to co-operate between Finnish and Lithuanian cleantech companies. The interview also showed that majority of cleantech companies are highly internationalised and operate for both domestic and foreign markets. In experts’ view more co-operation should be done in scientific, R&D and political areas. Enhancing international trade might not turn out to be that effective, because of the small markets. Lithuania is interesting for Finland as a manufacturing location and international trade with east markets intermediary. Finland is interesting for Lithuania as a source of innovations and best experiences. One of the strongest barriers for co-operation is the lack of information about Lithuanian (and Finnish) markets and investment climates.

7. SWOT analyses of Finnish and Lithuanian cleantech sectors showed the strong sides that countries could exchange, weaknesses that should be minimised by the strong sides, opportunities that can be developed in co-operation and threats that have to be avoided.

8. In order to make the best use of Finland and Lithuania’s cleantech potential, a well organised and channelled co-operation between these two countries is needed. Based on the studies, interview and SWOT analyses that were carried out in this thesis, the solutions for international co-operation were proposed. They concern co-operation in legislative, science, innovations and R&D areas, networking, manufacturing and sales, future perspective and brand building.

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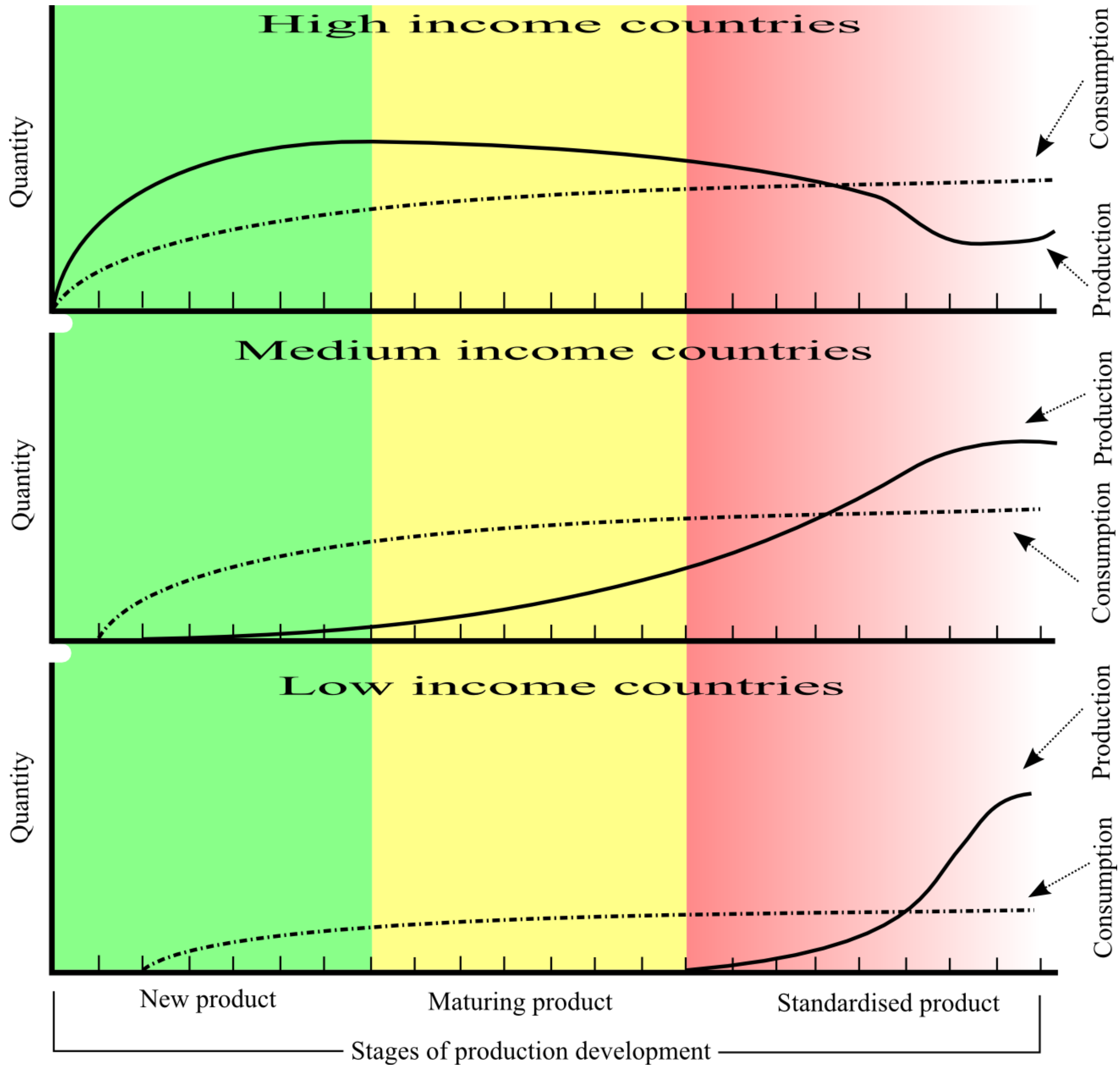
Product life cycle theory (adapted from Radzevičienė 2011)



APPENDIX 2

Europe 2020 targets of the EU, Finland and Lithuania (adapted from Europe 2020 targets 2012)

		EU headline target	EU estimated[1]	Finland		Lithuania	
				2010	2020 target	2010	2020 target
1.	Employment rate (%)	75 %	73.7-74 %	73 %	78 %	64.4 %	72.8 %
2.	R&D (% of GDP)	3 %	2.65-2.72 %	3.87 %	4 %	0.79 %	1.9 %
3.	CO_2 emission reduction	-20 % (compared to 1990 levels)	-20 % (compared to 1990 levels)	-6 %	-16 %	-4.3 %	15 %
	Renewable energy	20 %	20 %	30.3 %	38 %	17 %	23 %
	Energy efficiency – reduction of energy consumption (Mtoe[2])	20 % increase in efficiency equalling 368 Mtoe	206.9 Mtoe	-	4.21	-	1.14
4.	Early school leaving (%)	10 %	10.3-10.5 %	10.3 %	8 %	8.1 %	<9 %
	Tertiary education (%)	40 %	37.5-38 %	45.7 %	42 %	43.8 %	40 %
5.	Reduction of population at risk of poverty or social exclusion (persons)	20000000	n/a[3]	16.9 % of pop.	150000	33.4 % of pop.	170000

[1] – Addition of national targets.
[2] – Millions of tonnes of oil equivalent – the amount of energy generated by burning one tonne of crude oil.
[3] – Result cannot be calculated because of differences in national methodologies.

APPENDIX 3/1

Segments	European Union 27	The Republic of Finland	The Republic of Lithuania
Air and environment	• Decision 406/2009/EC on reducing GHG by 2020 • Decision 280/2004/EC on mechanism for monitoring GHG emissions (implementation of Kyoto protocol) • Directive 2003/87/EC on GHG emission allowance trading scheme • Council Regulation (EC) 71/2008 setting up the Clean Sky Joint Technology Initiative (JTI) • Regulation (EC) 1692/2006 establishing the Marco Polo II programme • Directive 2004/35/EC on environmental liability • Decision 1982/2006/EC on Seventh Framework Programme (2007-2013) • Council Directive 85/337/EEC on assessment of the environmental impact of projects • Directive 2008/50/EC on pure air for Europe • Directive 2001/81/EC on national emission ceiling for certain atmospheric pollutants • Directive 2010/75/EU on industrial emissions • Directive 1999/13/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations	• Nature Conservation Act (1096/1996) • Government Decree on limiting emissions of sulphur dioxide, nitrogen oxides and dust from combustion plants and gas turbines with a rated thermal input of at least 50 megawatts (1017/2002) • Act on Compensation for Environmental Damage (737/1994) • Environmental Protection Act (86/2000, amended – 647/2011) • Act on Emissions Trading (311/2011) • Decree on allowances in the emissions trading period 2013-2020 (544/2011)	• Act on environment protection (2011, Nr. I-2223) • Act on air protection (1999, Nr. VIII-1392) • Act on environmental impact assessment of planned economic activity (2005, Nr. X-258) • Act on environmental monitoring (2006, Nr. X-595) • Government decree on environmental monitoring programme for 2011-2017 (2011, Nr. 315) • Act on Climate Change Management financial instruments (2009, Nr. XI-329)
Agriculture	• Council Regulation (EC) 1290/2005 on financing the common agricultural policy • Regulation (EC) 2003/2003 on fertilisers • Council Directive 91/676/EEC on agricultural nitrates	• Decree on the restriction of discharge of nitrates from agriculture into waters (931/2000) • Decree on the compensatory allowances and agri-environmental subsidies in 2007-2013 (366/2007)	• Act on adoption of a program for reduction of pollution sources from agriculture (2008, Nr. 3D-686/D1-676)
Energy efficiency and energy storage	• Regulation (EC) 663/2009 on European Energy Programme for Recovery • Council Regulation (EU, Euratom) 617/2010 on information on investment projects in energy infrastructure • Decision 1639/2006/EC on Competitiveness and Innovation Framework Programme (CIP) (2007-2013) • Directive 2010/31/EU on energy performance of buildings	• Government Decision on Energy Efficiency Measures • Act on product eco-design and energy labelling requirements (1005/2008) • Act on energy companies providing energy efficiency services (1211/2009)	• Act on Energy (2003, Nr. IX – 1644) • Resolution on endorsement of financing rules for projects concerned with energy manufacturing efficiency and the use of renewable energy sources (2008, Nr. 4-442) • Resolution on the approval of the National Energy Strategy (2002, Nr. IX-

	• Directive 2009/125/EC on ecodesign for energy using appliances • Commission Communication COM(2006) 583 final on the Global Energy Efficiency and Renewable Energy Fund • Commission Communication COM(2009) 519 on investing in the Development of Low Carbon Technologies (SET-Plan)		1130)
Renewable energy (wind, solar, biomass, biofuels, geothermal, etc.)	• Directive 2001/77/EC on the promotion of electricity from renewable energy sources • Communication from the Commission on Biomass Action Plan [COM(2005) 628 final] • Directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport • Commission Communication COM(2006) 847 final - Towards a European Strategic Energy Technology Plan • Commission Communication COM(2008) 768 final on promotion of offshore wind energy • Directive 2009/28/EC on promotion of the use of energy from renewable sources	• Act on renewable energy sources in electricity production support (1396/2010) • Act on promotion of biofuels in transport use (446/2007) • Decree on the support of bio-energy production (607/2008)	• Act on Renewable energy (2011, Nr. XI-1375)
Transportation	• Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles • Regulation (EC) 443/2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles • Directive 98/70/EC relating to the quality of petrol and diesel fuels	• Act on public procurement practices concerning the transport, energy and environmental impact aspects (1509/2011) • Government Decree on limitation of internal combustion engine exhaust gas and particulate emissions (41/2012) • Act on transport emissions trading (34/2010)	• Act on Biofuel, Biofuels for Transport and Bio-oils (2009, Nr. XI-138)
Water	• Directive 2000/60/EC establishing a framework for Community action in the field of water policy • Directive 91/271/EEC concerning urban waste water treatment • Directive 2008/1/EC concerning integrated pollution prevention and control • Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources	• Act on Water Resources Management (1299/2004) • Government Decree on Water Resources Management (1040/2006) • Government Decree on Substances Dangerous and Harmful to the Aquatic Environment (1022/2006) • Government Decree on Urban Waste Water Treatment (888/2006)	• Water Act (2003, Nr. IX-1388) • Act on Marine environment protection (2008, Nr. VIII-512) • Act on drinking water supply and waste water management (2006, Nr. X-764)

Recycling and waste treatment	• Directive 2008/98/EC on waste • Council Regulation 1493/93 on shipments of radioactive substances between the Member States • Council Directive 2006/117/Euratom on the supervision and control of shipments of radioactive waste and spent fuel • Directive 2008/1/EC concerning integrated pollution prevention and control	• Waste Act (646/2011) • Ministry of the Environment Decree on the list of the most common wastes and of hazardous wastes (1129/2001) • Council of State Decision on packaging and packaging waste (962/1997) • Government Decree on Waste Electrical and Electronic Equipment (852/2004) • Government Decree on End-of-Life Vehicles (581/2004)	• Waste Act (2002, Nr. IX-1004) • Act on packaging and packaging waste (2001, Nr. IX-517) • Decree on waste management of electrical and electronic equipment (2004, Nr. D1-481) • Decree on adoption of the strategic plan for waste treatment (2007, Nr. 1224) • Resolution on End-of-Life Vehicles treatment (2003, Nr. 710)
Smart grid	• Commission Communication COM(2011) 202 on Smart Grids: from innovation to deployment • Decision 1364/2006/EC on Trans-European energy networks • Directive 2005/89/EC on measures to safeguard security of electricity supply and infrastructure investment	• Act on Electricity Market (386/1995, amended by 1172/2004)	• Act on Electricity Energy (2012, Nr. XI-1919) • Resolution on formation of a working group to set the Smart Grid development directions (2010, Nr. 1-34)
Cleantech in general, R&D, innovations and other areas	• Commission Communication COM(2010) 2020 final on Europe 2020 strategy for a smart, sustainable and inclusive growth • Commission Communication COM(2009) 512 final on developing a common strategy for key enabling technologies in the EU • Regulation (EC) 614/2007 concerning the Financial Instrument for the Environment (LIFE+) • Commission Communication COM(2009) 184 final on a strategy for research on future and emerging technologies in Europe • Regulation (EC) 1080/2006 on the European Regional Development Fund (ERDF) (2007-2013) • Commission Communication COM(2004) 38 final on stimulating technologies for sustainable development: an environmental technologies action plan for the European Union • Commission Communication COM(2011) 899 final on the Eco-innovation Action Plan (Eco-AP)	• Government Decree on granting financial aid for environmental projects in Finland's neighbouring areas in CEE (1197/2002) • Act on the European Community Eco-label Award Scheme (958/1997) • Act on the plans and programs on the environment (200/2005) • Act on voluntary participation in EMAS (121/2011) • Decree on research, development and innovation funding (298/2008)	• Act on voluntary participation in EMAS (2011, Nr. AV-208) • Decree on National sustainable development strategy (2009, Nr. 1247) • Resolution on National innovation strategy for 2010-2020 (2010, Nr. 163) • Decree on adoption of the concept of Integrated Science, Study and Business Centres (Valleys) (2007, Nr. 321)

APPENDIX 4

Four projects to promote environmental business in Finland (adapted from Cleantech Finland 2007, 8)

Project	Action	Responsible parties	Period	Recommendations
Finland – the most well known cleantech country globally	Environmental experience into a top brand	Finpro, companies, Lahti Science and Business park, Sitra, Environment Forum	2007-2012	• Marketing and communication programme • Building a brand utilising Finland's image • International networks with Finland and the EU as channels
Finland as the optimal growth platform for the environmental business	Finland as a pioneering market	Ministry of Employment and the Economy, Ministry of Agriculture and Forestry, Ministry of Finance, Environment Forum	2007-	• Environmentally and innovation friendly public procurement • Verification of eco-efficiency • Broad co-operation between the private and public sectors • The best material efficiency service centre in the world • Environmental business into education • Capital fund for environmental work • Tools for financing reference plants and feasibility studies
	Environment and business views into education	Ministry of Education, Environment Forum	2008-	
	Financing system supportive of innovations	Ministry of Employment and the Economy, Sitra, Ministry of Finance	2008-	
Finnish excellence in focal areas	A Strategic Centre for Science, Technology and Innovation (SHOK)	Companies, Academy of Finland, Tekes	2008-	• SHOK to become the engine of national development • Developing environment based business through SHOK • Centre of Expertise programme develops regional co-operation, the division of labour, and the national cleantech centres • Foresight system operational • Basis for evaluations and a focus for developing environmental expertise and research
	Centre of Expertise programme	Lahti Science and Business park, National Cleantech Cluster, Ministry of Employment and the Economy, Ministry of the Interior	2007-2012	
	Foresight	Ministry of the Environment, SHOK, Finpro, Sectoral Research Institutions	2008-	
	Evaluating environmental know-how	Ministry of Education, Academy of Finland, SHOK	2008-	
Most efficient international corporate networks	Incentives and practices for networking	Environment Forum, Finpro	2008-	• Creation of co-operation concept based on the lead company model in order to internationalise SMEs • Development of the best practices of networks • Faster growth for middle-sized companies with the help of the Growth company programme
	Programme for growth companies	Ministry of Employment and the Economy, Finpro, Technology Centres, Ministry for Foreign Affairs	2008-	

APPENDIX 5

Institutions that are occupied in promotion of R&D and innovations in Finland

Tekes, the National Technology Agency	The main public financing organisation for research and technological development. Tekes funds come from the state budget through the Ministry of Economy and the Economy. It holds a budget of around EUR 400 million and funds approximately 2000 projects annually. Tekes finances half of the project, while the other half has to be covered by the participating companies and research institutes.
The Academy of Finland	Expert organisation for research funding. Several funding instruments are used to support research in almost all disciplines (including cleantech), e.g. research programmes, projects and posts, the centres of excellence. Cleantech is usually financed by the Research Council for Natural Sciences.
Sitra, Finnish National Fund for Research and Development	Independent public foundation under the supervision of the Parliament. “Environmental Programme – Cleantech Finland” is a programme launched by Sitra. Its purpose is to promote Finnish cleantech sector, boost its competitiveness for global markets.
The Finnish Environmental Cluster Research Programme	A programme between private sector, authorities, researchers and funding institutions. The purpose is to raise the level of environmental know-how, connect it with entrepreneurship and integrate environmental issues into system of innovation. The programme is mainly financed by the Ministry of Environment (also acts as a coordinator), Ministry of Employment and the Economy, Tekes and the Academy of Finland.
VTT, the Technical Research Centre of Finland	Wide range of technology and applied researches. Services range from clean product research, the research of to production processes, environmental protection, monitoring and assessment technologies. Cleantech is one of the strategic research areas in VTT.
SYKE, the Finnish Environment Institute	A research institute and a centre of expertise. SYKE employs multi-disciplinary perspective and integrates social, natural and engineering sciences. Special attention is paid to the assessment of environmental policies. This Institute acts as a national Best Available Technique (BAT) contact point. (Finnish National Roadmap 2005)
OSKE, the Centre of Expertise Programme	Integrates research activities with technological, design and business competence. It creates a co-operation network of companies, universities, and research institutions. The Finnish Cleantech Cluster, where approximately 60% of Finnish cleantech businesses and 80% of cleantech research is concentrated, operates under OSKE programme. OSKE is co-ordinated by a Committee that is comprised of the representatives from relevant ministries, Tekes, and other interest groups. (OSKE 2012)
SHOK, the Strategic Centres for Science, Technology and Innovation	Public-private partnerships that develop and apply innovations, which would meet the demand of Finish industry within five to ten years. There are six centres in operation: CLEEN Ltd (energy and the environment), FIMECC Ltd (metal products and mechanical engineering), Forestcluster Ltd (forestry and wood-based materials), RYM Ltd (built environment innovations), SalWe Ltd (health and wellbeing), TIVIT Ltd (information and communication industry and services). (SHOK 2012)

Institutions that are occupied in promotion of R&D and innovations in Lithuania

LMT - The Research Council of Lithuania	Counsellor to the Lithuanian Parliament on R&D issues. It promotes the development of Lithuanian researcher resources, supports research activities of science and education institutions.
LIC - Lithuanian Innovation Centre	A public non-profit institution. It provides innovation support services to companies, associations and different institutions. It co-ordinates the activity of Enterprise Europe Network in Lithuania, on a project basis organises different activities to promote innovation in various areas.
MITA - Agency for Science, Innovation and Technology	A governmental institution, which is responsible for implementation of innovation policy in Lithuania. Established in 2010 for the purpose of fostering business and science co-operation and enhancing environment for innovations. MITA co-ordinates national high-tech and industrial biotechnology programmes, international programmes FP7, CIP, EUREKA and EUROSTARS, provides financial schemes, such as innovation vouchers, intellectual property rights, clusterisation, technology transfer, and provides other financial support to programme participants. (MITA 2012)
LVPA - Lithuanian Business Support Agency	A governmental non-profit institution, which administers EU support and seeks to promote R&D, tourism and energetics business activities within Lithuania. Its three out of four areas of competence (R&D, energetics and business) could be used when promoting Lithuanian cleantech industry.
APVA - Agency for Environmental Projects Management	A governmental institution, which is responsible for implementation of environmental projects. These usually concern waste treatment, water and air purification, emission cutting and alike. This agency could and is used more like a technology transfer institution, rather than innovation or R&D centre. Anyway, APVA could play an important role in commercialising clean technologies.
Integrated Science, Studies and Business Centres (**Valleys**)	By now there are 5 valleys established all over the country. The main goal behind each valley is to bring together businesses, science and education institutions. This multilateral co-operation would help boosting innovations in technology driven businesses, and transferring the newest technologies. Each valley is specialised in a particular sector. All five valleys unite 11 Science and Technology Parks. Their aim is to bring together innovative companies from particular regions, and promote region development through enhancing innovations, strengthening networking and co-operation.
INVEGA	Provides financial support for SMEs, finances projects, provides guarantees, implements financial engineering measures, etc. (MITA 2012)