Aalto University
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Future prospects of the Finnish environment industry

Logistics

Master's thesis

Tero Kajander

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Department of Information and Service Economy
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AALTO UNIVERSITY SCHOOL OF ECONOMICS ABSTRACT

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ABSTRACT

Objectives of the Study

Objectives of the study were to define the environment industry and its sub-sectors in a logical manner, to improve the understanding of meaningfulness of the industry for Finland, and finally to recognize the most critical uncertainties that guide the development of the Finnish environment industry until 2020.

The study can be beneficial for more detailed industry analysis. For example investors, researchers and environment industry companies can use this study for their purposes.

Academic background and methodology

This study is a scenario planning analysis. The study starts by conducting a literature review that employs a wide range of sources from academic publications to studies of private companies and governmental organizations. The outputs of the literature review are evaluated by environment industry professionals through structured interviewing. The structured interviews are conducted exclusively with persons that are involved in the Finnish environment industry and that posses a high level of knowledge in the area. The combined outputs from the literature review and the structured interviews are used as basis for crafting four scenarios for the Finnish environment industry in 2020, including related implications, options and early warning signals.

Findings and conclusions

The two most critical uncertainties affecting the Finnish environment industry by 2020 were assessed to be the capability of Finnish environment industry companies to generate more revenues from solutions than individual companies, and if the expertise and structures of the private financing organizations are well developed to serve the Finnish environment industry. The potential of bio-energy for the Finnish environment industry seems to be high, where in the surrounding of this research the potential of different environment industry sub-sectors was not analyzed thoroughly.

Keywords

Environment industry, cleantech, greentech, end-of-pipe technologies, scenario planning, foresight, Finland

AALTO-YLIOPISTON KAUPPAKORKEAKOULU TIIVISTELMÄ

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Pro Gradu-tutkielma

Tero Kajander

ABSTRAKTI

Tutkimuksen tavoitteet

Tutkimuksen tavoitteena on määritellä ympäristöteollisuus ja sen sektorit loogisesti, parantaa ymmärrystä ympäristöteollisuuden merkityksellisyydestä Suomelle, sekä tunnistaa kriittisimmät riskitekijät Suomen ympäristöteollisuuden kehitykselle vuoteen 2020 asti.

Tutkimus voi olla hyödyllinen tarkemman tason teollisuusanalyyseissä. Esimerkiksi sijoittajat, tutkijat ja ympäristöteollisuudessa mukana olevat yritykset voivat käyttää tutkimusta tarkoituksiinsa.

Kirjallisuuskatsaus ja metodologia

Tämä tutkimus on skenaarioanalyysi. Tutkimus alkaa kirjallisuuskatsauksella, joka hyödyntää lähteitä laajasti, alkaen akateemisista julkaisuista aina yksityisten yritysten ja julkisten organisaatioiden tutkimuksiin. Kirjallisuuskatsauksen tulokset evaluoidaan ympäristöteollisuuden ammattilaisten avulla, suorittamalla kysely. Kyselyyn osallistujat ovat kaikki mukana Suomen ympäristöteollisuudessa, ja heillä on tietotaitoa alueella. Kirjallisuuskatsauksen ja kyselyn yhdistetyt tulokset toimivat pohjana neljälle skenaariolle, jotka kuvaavat Suomen ympäristöteollisuutta vuonna 2020. Skenaarioihin liitetään myös päätelmät seurauksista, toimintamahdollisuuksista ja varoitussignaaleista.

Tulokset ja päätelmät

Kaksi kriittisintä epävarmuustekijää Suomen ympäristöteollisuudelle arvioitiin olevan Suomen ympäristöteollisuuden kyky hankkia enemmän liikevaihtoa laajojen ratkaisujen (solutions) kautta kuin yksittäisten teknologioiden avulla, ja yksityisten rahoittajien hyvä osaaminen ja rakenteet palvella Suomen ympäristöteollisuutta. Bio-energia sektorilla vaikuttaa olevan paljon potentiaalia, mutta tässä tutkimuksessa Suomen ympäristöteollisuuden eri sektorien potentiaalia ei tutkittu kattavasti.

Avainsanat

Ympäristöteollisuus, cleantech, greentech, piipunpääteknologiat, skenaariosuunnittelu, Suomi

ACKNOWLEDGEMENTS

This master´s thesis has been written in the surroundings of a double master program between the University of Cologne and the Aalto University School of Economics. This thesis has been submitted for evaluation at both universities under the same title according to the program regulations. The appearance of the thesis has been modified slightly to fit to the most important requirements of each university, where the contents remained exactly the same.

This seemingly straightforward industry analysis proved to be significantly more challenging and time consuming than estimated by me when planning the project. For this reason I know to appreciate the support received during the process.

Thank you to all who kindly agreed to answer the survey. I was positively surprised by the common willingness of the professionals in the Finnish environment industry to use their time and share their valuable knowledge for the benefit of this study.

Thank you to Professor Matti Rossi from Aalto University for the active and constructive supervision of the thesis. I would also like to thank Johanna Rosenbusch from the University of Cologne for acting as the co-supervisor of the thesis and for being a responsive and reliable contact person.

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1. Introduction

The topic of this thesis is the future of the Finnish environment industry in 2020. The environment industry is a relatively new and fast evolving industry sector, especially when considering the evolving cleantech sub-sector of the industry. Due to the newness of the environment industry and its dependency to the turbulent world economy and government regulations, forecasting the future of the Finnish environment industry in the long range is difficult. Information of the future of the Finnish environment industry is interesting for several stake holders. Governments, investors, potential partners and environment industry companies themselves would profit from an improved understanding of the possible state of the Finnish environment industry in approximately 10 years of time. As credible long range forecasting is difficult to conduct under the given circumstances, in this thesis scenario planning is used instead. I suggest scenario planning to be a more feasible but not perfect method for anticipating the future of the Finnish environment industry.

1.1. The research problem and objectives

The theoretical research problem in this thesis is to perform scenario planning in industry and local economy level analysis. In the context of this specific research the research problem is to conduct scenario planning in a way that supports the research objectives and allows finding feasible answers for the research questions.

This thesis addresses two research questions. First, what is the market position of the Finnish origin environment industry companies in Finland and worldwide in 10 years? For this first research question it is expected to find several feasible answers. Second, what are the most critical uncertainties affecting the Finnish environment industry development? The second question is a more specific one and the answer should enlighten the most critical uncertainties of the industry.

The research objectives of this thesis are such that they support the scenario planning process and are coherent with the research questions. The first research objective is to map the Finnish environment industry by discussing its significance to the Finnish national economy at the moment and finding out what are the central offerings of the Finnish environment industry. It is vital to understand the object of the analysis. Only by defining first the object of the analysis carefully it is later possible to use the chosen research method purposefully, in this thesis scenario planning. It can be recognized that the environment industry is a heterogenic industry sector. The heterogenic nature of the industry means that industry actors´ characteristics differ from each other in the sense of company size, maturity of offerings, high technology adoption, internationality and disruptiveness of innovation. If the environment industry proves to be very fragmented and interrelations between industry companies are few on the general industry level, this will be needed to take in consideration when thinking of the applicability of the scenarios to different environment industry sub-sectors.

The second research objective is to better understand the development and potential of the Finnish environment industry. A comprehensive understanding of the research objective is needed to conduct purposeful analysis. Understanding of what factors have driven the development of the Finnish cleantech industry to the current stand enlightens the background of the industry. The factors that have affected the industry development in the past or at the moment don´t necessarily determine the direction of future development, but are valuable information that induces the research conducted in this thesis. Potential of the Finnish environment industry is interesting for several stake holder groups. One central reason for interest in new and evolving industry sectors is the uncertainty and lack of growth in the European and Finnish economy. It would be beneficial to recognize those of the new and evolving industry sectors that could drive economic growth under these circumstances.

The third research objective is to prepare the numerous stake holder groups of the Finnish environment industry better for several outcomes of the upcoming industry development. Despite of what actually will be the direction and speed of the Finnish environment industry development, stake holder groups need some concrete suggestions of the upcoming development for decision making and for educational purposes. This third research objective is closely related to the choice of research methodology. The motivation for using scenario planning in this thesis is discussed next.

1.2. The research approach

It can be recognized that the existing academic research related to the Finnish environment industry consist for the most part of technological research. In this thesis it is tried to conduct industry wide research from business perspective, concentrating on the Finnish environment industry growth and competitive strength that is so far less studied. The research in this thesis can be described as proactive, as the research results might include aspects that are not expected from the target audience in advance. In the starting point of this research no hypothesis or similar pre-assumptions of the future of the Finnish industry future are handed.

The research in this thesis is conducted as a combination of desk research and structured interviews. The research methodology used is scenario planning. For the part of the research methodology, a literature review of the published academic literature, relevant reports and case studies is conducted. This is to justify the use of scenario planning in this thesis and to reflect appraisal of scenario planning to presented critique. The purpose of the literature review on scenario planning is also to set up a structure for the scenario planning exercise that will be the empirical part of this thesis.

A literature review will be conducted of the environment industry as well. This is to map the industry structure, to better understand the significance of the industry and to induce the empirical research. The literature review of the Finnish environment industry is less academic as the one on scenario planning. This is due to the limited availability of academic sources. The literature review of the Finnish environment industry is based to some extent on non-academic research reports and other timely publications related to the environment industry and to the global economy.

Besides the literature reviews and formal conduction of the scenario planning exercise, structured interviews with industry experts and researchers will be conducted. The interviews are to ensure that the most relevant critical uncertainties affecting the industry are used as the basis for crafting the scenarios, and that a heterogenic view to the industry is included in the scenario planning exercise to improve the quality and credibility of the research.

In the empirical part of this thesis a scenario planning exercise will be conducted along a purposeful scenario planning framework. The outputs from the literature review of the environment industry and from the conducted interviews are used as inputs for this scenario planning exercise.

1.3. Contents and organization of this thesis

Contents of this thesis are organized so that first the literature reviews of the environment industry and second on scenario planning are conducted. This order is purposeful, because the volume of published scenario planning literature is large. It is to consider that scenario planning literature presents a wide range of approaches that are classified roughly by the level of analysis and the different schools of scenario planning. By first conducting the literature review of the environment industry, the context of the scenario planning exercise conducted later in the empirical part will be better understood. When understanding well the context of the scenario planning exercise to be conducted, it is possible to direct the scenario planning literature review towards central and relevant parts of the published scenario planning literature.

After conducting the literature reviews of the environment industry and scenario planning, the scenario planning exercise will be then performed in the empirical part of this thesis. When the scenario planning exercise is performed, the knowledge gained from the literature reviews and structured interviews is used as inputs for the exercise and also to discuss the limitations of the research. As a research result, scenarios, their implications and related warning signals will be introduced as the output of this thesis. As the final part of this thesis, conclusions are discussed. These are to summarize the research and results. Sound critique towards the research methodology and conduction of the research is presented. Suggestions for further research will be given.

2. Definition of the environment industry

In this chapter the concepts of environment and cleantech industries are defined. The definitions and discussion are to clarify the object of the research of this thesis and to ensure that the needed level of knowledge is handed to conduct the following empirical research.

2.1. Industry background

Before the concept of cleantech was introduced, the concepts of environmental business and greentech were commonly used to describe an industry with same ambitions, but different types of technology employed, compared to cleantech. The concepts of environmental business and greentech were introduced already in 1970s - 1980s. Also the concepts of environmental industry and environmental technologies are used to describe this same industry. These all represent an industry that employs technologies called end-of-pipe technologies. End-of-pipe technologies are such that they reduce the environmental harms of currently employed technologies, as for example smokestack scrubbers do. (Cleantech Group 2011 a; Frankelius et al. 2011)

Since 1970s - 1980s the focus has shifted from end-of-pipe technologies towards technologies that already themselves are cleaner than the currently employed technologies, called 'cleaner technologies' or cleantech (Linnanen et al. 1997; Markusson 2011). Dechezleprêtre et al. (2010) suggest this shift was generally due to the environment industry growth drivers changing from energy prices towards the emerging climate and environmental policies. Despite the shift towards clean technologies, end-of-pipe technologies still play a role for the Finnish environment industry. One timely example of this are catalytic converters designed to reduce nitrogen oxide emissions of ships. Nitrogen oxide emissions of ships will shortly be subject to tight regulation in the North and Baltic seas. (Cleantech Group 2011 a; Wärtsilä 2011)

Frankelius et al. (2011) state that the concept of cleantech has been used the first times as late as in 2002 by the Cleantech Network that is known as the Cleantech Group today. The concept cleantech stands for clean technologies. Compared to end-of-pipe technologies employed by the environmental industry, the technologies employed by the cleantech industry are 'cleaner technologies' that already in themselves are cleaner than the ones currently employed (Markusson 2011). Electricity production by employing wind power instead of coal power is an example of cleantech. This example was to demonstrate only the cleanliness of the energy creation process itself.

In the following subchapters the concepts of environmental industry and cleantech industry are further defined and differentiated from each other by using technological and business perspectives. This is needed, because the parallel existence of these very closely related concepts causes confusion about what these actually include and how they differ from each other.

Next the central definitions of environmental industry and technologies and cleantech are presented to be analyzed later in this chapter. To notice is that some of the definitions to be introduced refer to technology and some to industry. This is due to the lack of existing compatible definitions. Under the concept cleantech both the industry and technologies are often being described. Between environmental industry and environmental technologies a difference again might be observable, depending on the specific definition. (Dechezleprêtre et al. 2010, 5-6)

2.2. Environmental technology and industry definitions

OECD (1999) discuss the concept of environmental industry in their manual for data collection and analysis for the environmental goods and services industry. OECD (1999) define environmental industry at the time the concept of cleantech was not explicitly introduced yet:

“The environmental goods and services industry consists of activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes cleaner technologies, products and services that reduce environmental risk and minimise pollution and resource use.”

The European Union takes stand to defining what cleantech is in their environmental technologies action plan (ETAP) for the European Union (EU 2004). EU (2004) define environmental technologies:

"Environmental technologies… include all technologies whose use is less environmentally harmful than relevant alternatives... They encompass technologies and processes to manage pollution (e.g. air pollution control, waste management), less polluting and less resource-intensive products and services and ways to manage resources more efficiently (e.g. water supply, energy-saving technologies). Thus defined, they pervade all economic activities and sectors, where they often cut costs and improve competitiveness by reducing energy and resource consumption, and so creating fewer emissions and less waste".

The comprehensive definition of the EU is based on the definition given by the United Nations for environmentally sound technologies EU (2004). UN (2011) state in their agenda for transfer of environmentally sound technology, cooperation & capacity building their definition of environmentally sound technologies:

"Environmentally sound technologies protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes. Environmentally sound technologies in the context of pollution are process and product technologies that generate low or no waste, for the prevention of pollution. They also cover end of the pipe technologies for treatment of pollution after it has been generated. Environmentally sound technologies are not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organisational and managerial procedures".

The Finnish Innovation Fund, FIF (2007) discusses cleantech as a part of the environment business, which they define:

"Environment business involves commercializing clean technologies in such a way that environmental expertise forms a key factor in competitiveness".

2.3. Cleantech definitions

Cleantech Group (2011 a) being supposedly the first one to define the concept of cleantech in 2002, define it as:

"...new technology and related business models that offer competitive returns for investors and customers while providing solutions to global challenges"

Further Cleantech Group (2011 a) states it is to recognize about cleantech as they define it:

"Cleantech represents a diverse range of products, services, and processes, all intended to:

- *Provide superior performance at lower costs, while*
- *Greatly reducing or eliminating negative ecological impact, at the same time as*
- *Improving the productive and responsible use of natural resources"*

The Finnish innovation fund (FIF 2007) defines the concept of cleantech in a similar way as Cleantech Group (2011 a), in the national action plan to develop environmental business of Finland. FIF (2007) define cleantech:

"Clean technologies (cleantech) include all products, services, processes and systems whose use results in less harmful impacts on the environment than their alternatives. Clean technologies offer clients added value while also reducing harmful impacts on the environment directly or elsewhere along value chains".

2.4. Analysis of the given definitions

Despite the clear foundational difference between 'cleaner technologies' and end-of-pipe technologies, defining the for this thesis central concepts of cleantech and environmental technologies is not self evident in the conceptual level and in the practice. Under a classification of the given definitions is shown in the table 2-1. The table represents the central common nominators and differences of the definitions that support their analysis from technological and business perspectives.

Table 2-1. Summary of the environment industry definitions

Definition						
	Cleantech	Cleantech	Environmental technologies	Environmentally sound technologies	Environmental goods and services industry	Environment business
Source						
	Cleantech Network (2011)	FIF (2007)	EU (2004)	UN (2011)	OECD (1999)	FIF (2007)
Emphasis						
Cleaner technologies	X	X	X	X	X	X
End-of-pipe technologies		(X)	X	X	X	(X)
Newness of technologies	X					
Products	X	X	X	X	X	X
Services	X	X	X	X	X	X
Returns for investors	X					
Value added to clients	X	X				X
Competitiveness	X		X			X

Technology perspective

The analysis of the given definitions from the technological perspective refers before all to the difference if 'cleaner technologies' and end-of-pipe technologies are discussed under the same definition or not. It is important for this thesis to decide under which concept the end-of-pipe technologies and 'cleaner technologies' should be discussed in the analysis of the Finnish environment industry.

Cleantech Group (2011 a) presents a definition of cleantech that explicitly discusses the newness of the employed technologies as a criterion for a technology to belong to the cleantech industry. This is due to their view stating that generally all technologies having to do with environmental industry that date back in the times before cleantech definition was used the first times in 2002, are end-of-pipe technologies. (Cleantech Group 2011 a)

Definition of cleantech by Cleantech Group (2011 a) makes a clear difference between 'cleaner technologies' that are cleantech and end-of-pipe technologies that do not belong under the cleantech concept. The FIF (2007) definition of cleantech again does not explicitly exclude end-of-pipe technologies in their cleantech definition, but the definition implies a similar approach to cleantech as the Cleantech Group (2011 a) definition, which excludes the end-of-pipe technologies.

EU (2004) define environmental technologies in the same spirit as UN (2011) defines environmentally sound technologies. Both EU (2004) and UN (2011) definitions include both 'cleaner technologies' and end-of-pipe technologies in their definitions. This observation is contradictory to the cleantech definitions presented by Cleantech Group (2011 a) and FIF (2007) that explicitly and implicitly suggest that environmental technologies include only end-of-pipe technologies.

OECD (1999) define the environmental goods and services industry and FIF (2007) the environmental business. OECD (1999) include both 'cleaner technologies' and end-of-pipe technologies in the concept of the environmental goods and services industry. FIF (2007) environmental business definition includes 'cleaner technologies' in the concept. It cannot be clearly interpreted if the FIF (2007) definition excludes or includes end-of-pipe technologies.

Business perspective

Besides the differences in technology that is included or excluded, differences in the views to the business perspective exist as well in the given definitions. Business opportunities for environmental technologies have traditionally been driven by relevant changes in the highly regulatory market environment. The cleantech industry again is at least claimed to be exposed to market forces and being driven by offered competitive returns for investors and customers instead of regulatory environment. (Cleantech Group 2011 a)

The ambitious definition of cleantech by Cleantech Group (2011 a) reflects to the older concepts of environmental technology and greentech from 1970s - 1980s that emphasize the highly regulatory market environment of the industry. Cleantech Group (2011 a) have an advanced view to the business perspective of the cleantech. The Cleantech Group (2011 a) definition refers to competitive returns to investors and value added to customers. These attributes imply that the cleantech industry is subject to the competitive forces and market economy as any other industry. FIF (2007) cleantech definition as well brings up the value added for clients, which further supports the interpretation of cleantech being an industry that is subject to competitive forces. (Cleantech Group 2011 a; FIF 2007)

The EU (2004) environmental technologies definition considers competitiveness as an attribute of it, but further notions regarding the business perspective are not given. UN (2011) in their definition of environmentally sound technologies do not make any implications of the business perspective related to the technologies. The lack of considerations from business perspective is logical, as here only technologies are explained, but this might also be the heritage of the regulations driven market environment.

OECD (1999) definition of the environmental goods and services industry lacks besides the recognition of existence of products and services all further notions of the business perspective of the industry. This is not the case in the more modern definition by FIF (2007) of the environmental business that discusses competitiveness of the industry. The OECD (1999) definition stems from the era, when cleantech as a concept still was not explicitly defined. This implies the environmental goods and services industry having been subject to a more regulatory environment, compared to the environment business defined by FIF (2007) in the era where cleantech already was defined.

2.5. Definition used in this thesis

As seen from the analysis of the given definitions so far, the question how to define the Finnish cleantech industry is not trivial due to the confusion and incoherence of the terminology. Differences and controversies exist between the wide spread definitions of cleantech and the closely related concepts (FIF 2007; Alm 2011, 9). In this thesis the following classification presented in figure 2-1 will be used. This is to clarify the object of the research and to differentiate the industries using ‘cleaner technologies’ and end-of-pipe technologies:

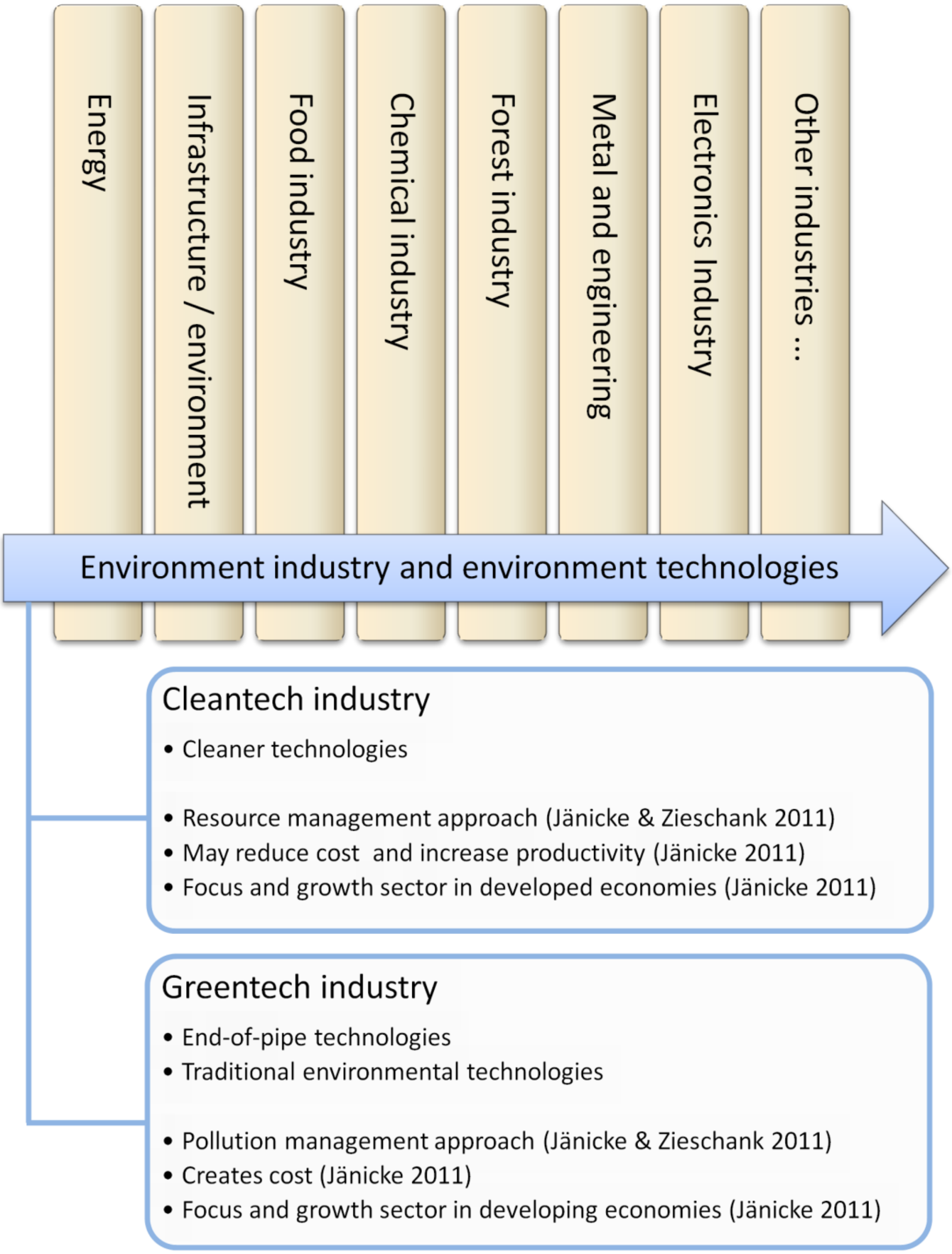

Figure 2-1. The environment industry. Traditional industry sectors in pillars adopted from FIF (2007, 10)

In this thesis environment industry is seen as a concept to which belong two from each other clearly separated industry sub-sectors, the cleantech industry and the greentech industry. Cleantech and greentech industries are defined below, as they will be discussed in this thesis.

Cleantech industry:

Cleantech industry includes the research, development, manufacturing and trade of 'cleaner technologies'. Cleaner technologies replace currently employed technologies in order to reduce the harms to environment and the usage of natural resources. Relevant products, services, solutions, materials and components are included in the cleantech industry.

Cleantech stands for new technologies, closed circulation, zero emissions, renewable energy, and material efficiency. Examples of cleantech are the choice of less polluting production methods, the use of renewable energy sources and the development of closed material circulation systems (FIF 2007).

Greentech industry:

Creentech industry includes the research, development, manufacturing and trade of 'end-of-pipe technologies' and 'traditional environment technologies'. End-of-pipe technologies are installed to function in affiliation with the currently employed technologies. End-of-pipe technologies reduce the harms caused to the environment by the currently employed technologies. Relevant products, services, solutions, materials and components are included in the greentech industry. Traditional environment technologies are employed to facilitate fresh water and waste water management.

Traditional environmental technologies stand for end-of-pipe technologies. Examples of traditional environmental technologies are water supply management, wastewater management, waste management and air protection (FIF 2007).

The effect of the market regulation to the greentech and cleantech industries is intentionally left out of consideration in the above presented definitions. There are implications of the greentech industry being driven more by market regulations than the cleantech industry (Cleantech Group 2011 a). Despite this the practice shows that the regulatory environment is a major growth driver for the cleantech industry as well, as can be seen for example in the cases of central cleantech solutions, wind power and solar power. For this reason it is difficult to argument for cleantech industry being significantly less dependent on the changes in the regulatory environment compared to the greentech industry.

3. Analysis of the environment industry

In this chapter a literature review is conducted of environment industry related studies. The challenges in monitoring of the industry are discussed and the industry development´s connections to the global economy are enlightened. Also the particularities of the Finnish environment industry and Finland as environment industry market are discussed.

3.1. Challenges in monitoring

In the practice it has proven itself challenging to classify companies as environment industry companies, cleantech companies or non-cleantech companies. Besides the newness of the cleantech industry, the challenges in extracting standardized and timely statistics could also explain the low number of published academic research of the Finnish cleantech industry with a business perspective. As the cleantech industry products and solutions penetrate almost all industries, this as well makes it harder to pinpoint a company or a technology to be cleantech. All this makes environment industry a more challenging industry sector to monitor, compared to traditional industry sectors. (FIF 2007; Lovio et al 2011; Jänicke & Zieschank 2008, 10)

It is not always understood by companies themselves either if they belong in the cleantech industry or not, so in the practice we can observe companies working with similar cleaner technologies and business models, of which some profile themselves as cleantech companies and some don´t (Alm 2011, 9). This issue is further driven by the common industry databases that are used to extract quantitative data to analyze industry sectors. In these databases companies or products are classified by the relevant industry. The classifications are often such that they allow the confusion to further exist, where similar companies with similar products are labeled differently.

The evaluation and analysis of company databases is not in the focus of this thesis, but is discussed here shortly, because the current problems with relevant databases have an effect to the choice of research method of this thesis. It can be recognized that the handed insufficiencies in classifications of company databases are a major hurdle for conducting quantitative research in the field of cleantech industry (Hernesniemi & Viitamo 2006).

There are three major reasons for the insufficiencies of the classifications in company databases. First, cleantech industry is an emerging industry that still is not established as a major industry or an industry sub-sector. Second, due to the confusion between related terminology the need for establishing an own class for the cleantech industry might be overseen. Third, there is usually much value put on the comparability of data between years. Changes in the database that affect the industry classifications fundamentally are done seldom from this reason. For these reasons cleantech is not classified separately. Typically cleantech companies are to find in the same class with all companies having to do with products and services for the environment industry (FIF 2007). The needed sub-classes to separate greentech industry from cleantech industry typically do not exist (FIF 2007).

The observed problem in the classification of cleantech companies in databases has consequences to cleantech industry research. As the entity of the cleantech industry is blurry in the practice, the research lacks a well-defined and standardized object of research (Hernesniemi & Viitamo 2006). The immediate consequence of this is that figures commonly used in industry research, as the industry annual turnover, annual investments, number of companies in the industry, and relevant distributions presented in published studies cannot be assumed comparable with other studies. This issue is especially noticeable in non-academic cleantech industry studies, where the background of presented figures is not explained explicitly enough to allow the repetition of the calculations that have lead to the presented figures.

The problem of insufficient data is recognized and at least partly to overcome when significant resources for the study are handed. In a research by Hernesnsiemi & Viitamo (2006) significant resources were employed in a national study of the Finnish cleantech industry. In this research the problem related to company classifications was addressed as a part of a study that was to define the cleantech industry and its statistical monitoring. By cross-referencing relevant Finnish and Nordic company databases assumptions were made about the structure and significance of the Finnish cleantech industry. This research is non-academic and done by a governmental organization, but is by far the most comprehensive and well-founded published research of the Finnish cleantech industry I could find. In this research, as well in other published research on the Finnish cleantech industry, the fragmented nature of the industry sector and the lack of sufficient methods of monitoring the industry sector development were discussed repeatedly. In the study by FIF (2007) it is stated that only mature clean technologies were comprehensively present in statistics. Respectively

Hernesniemi & Viitamo (2006) state that the Finnish cleantech sector is highly fragmented and the statistics describing its development are insufficient.

Besides cross-referencing of company databases, the problem of extracting data of cleantech companies and technologies can be tried to overcome by exploiting patent databases. In recent studies by Dechezleprêtre et al. (2010) and Palmberg & Nikulainen (2010) patent databases were employed in cleantech research. Patent databases allow a more detailed study of an industry compared to company databases, as patent databases´ technology classifications are more detailed and data is available of all countries. Patent databases are not the perfect tool for cleantech research, as these also have deficiencies in their classifications regarding to cleantech, but the situation is better compared to company databases. For this reason the research of patent databases doesn´t allow the research of the complete cleantech industry, but some technologies or sub-sectors of the industry can be observed (Dechezleprêtre et al. 2010, 6-7). Patents are not a measure of all innovation, but provide at least an indication of the results of innovative activity in an industry of a country (Dechezleprêtre et al. 2010, 7). European Patent Office (EPO) and OECD maintain a world-wide patent database PATSTAT that includes patent documents of all significant patent offices (Dechezleprêtre et al. 2010, 13; Palmberg & Nikulainen 2010).

3.2. Innovation activity

According to Rau et al. (2010) anticipation of the pace and deployment of cleantech innovations is an evolving area of study, where no conceptual framework is put in place so far. They state that a conceptual framework for anticipating the pace and deployment of cleantech innovations is needed to enable governments, investors and the cleantech industry to foresee the potential of different cleaner technologies for cost-effective prevention of pollution. Further they state that the most promising method of anticipation is assumed to be a framework or a rule of thumb that observes the relation between patenting activity and new installations of a specific clean technology that is employed in a similar way as Moore´s law. According to Moore (1965) and Intel (2005, 1) Moore´s law is a simple rule that states that the computer performance to double every two years. Intel (2005, 1) state that Moore´s law has indicated the development of information technology prices as well.

The equivalent for Moore´s law in the cleantech industry would be more complex according to Rau et al. (2010, 3). They state that it is the cleantech industry´s nature to include a vast number of technologies with respectively different degrees of complexity, lengths of investment cycles and technology specific risks. For this reason several equivalents for Moore´s law are needed to cover at least the most central cleantech industry sectors. Rau et al. (2010, 2) discuss a recent study from 2009 by Chatham House and CambridgeIP. According to Rau et al. (2010, 2) reporting the 2009 Chatham House and CambridgeIP study, the equivalent of Moore´s law for the cleantech industry could be the observed timely relation between new cleantech patents and new installations of the patented technology. Rau et al. (2010, 2) report that Chatham House and CambridgeIP found out in their study covering six cleantech sectors that the time-to-market for a technology could be predicted by comparing rates of technology rollout and patenting activity.

Rau et al. (2010, 2) present in figure 3-1 two examples of the results of the Chatham House and CambridgeIP study that suggest the cleantech innovation deployment is picking up and that comparison between patenting activity and technology rollout may be a feasible method to predict the market of at least some technologies.

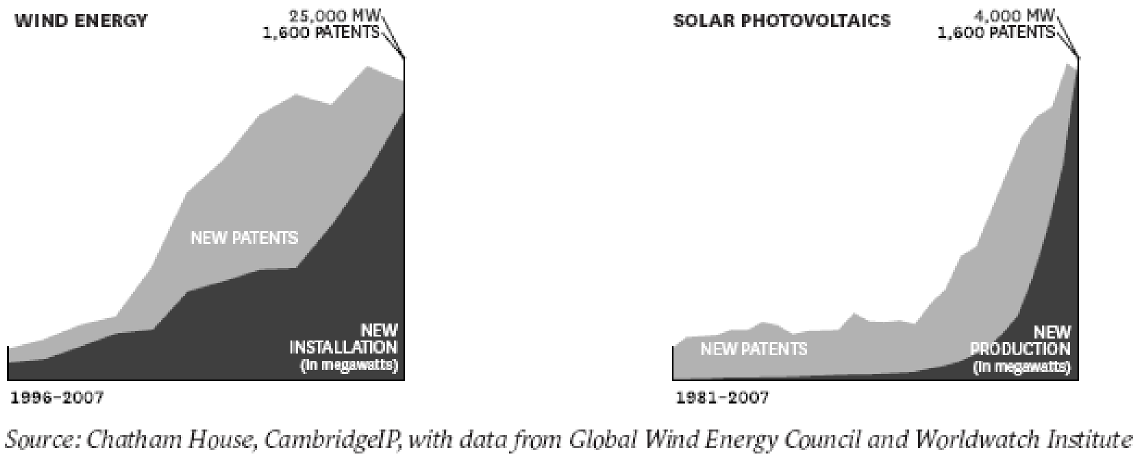

Figure 3-1. Renewable energy patenting and capacity increase. Adopted from and reported by Rau et al. (2010, 2), originally from Chatham House and CambridgeIP 2009.

The time between patenting activity and technology rollout can be described as time-to-market according to Rau et al. (2011, 2). Earlier Cohen at al. (1996, 177) have defined time-to-market as the time between begin of the product development and the market entry. Rau et al. (2010, 3) state that time-to-market is a central concept when discussing the potential and the future prospects of the cleantech industry. In their opinion the cleantech industry is an entrepreneurial industry whose future is highly dependent on newly developed technologies, inventions that then need to be commercialized into innovations - only this way contributions to the cleantech industry growth can be expected. According to Rau et al. (2010, 2) time-to-market can often be measured in decades, which causes problems also for the cleantech industry. In their opinion the long and unclear time-to-market of cleantech innovations causes the governments and businesses to perceive higher risk of investment, as the potential of the innovation in the practice remains unclear for too long.

According to Palmberg & Nikulainen (2010, 3) indicators for monitoring the environment industry are difficult to develop and compile, but the analysis of patent data and R&D investment data together allow a sufficient assessment of the position of the Finnish environment industry in international comparison. Their study exploits patent data from 1990-2007 extracted from OECD PATSTAT service and reveals similar outcomes as the Chatham House and CambridgeIP 2009 study reported by Rau et al. (2010).

For the part of renewable energy the study by Palmberg & Nikulainen (2010) shows significant increases in the global patenting activity of solar and wind power and biomass, where ocean power, geothermal power and hydro power patenting activity remains low. Considering other types of environment industry technologies, they report a significant increase in air pollution control technologies. Respectively water pollution control technologies remain globally significant but the development in patenting activity stays stagnant. From the significant environment industry technologies also solid waste management was studied by Palmberg & Nikulainen (2010). According to their report, the global patenting activity of solid waste management is reducing. The global development of environment industry technologies according to Palmberg & Nikulainen (2010) is depicted below in the figures 3-2 and 3-3.

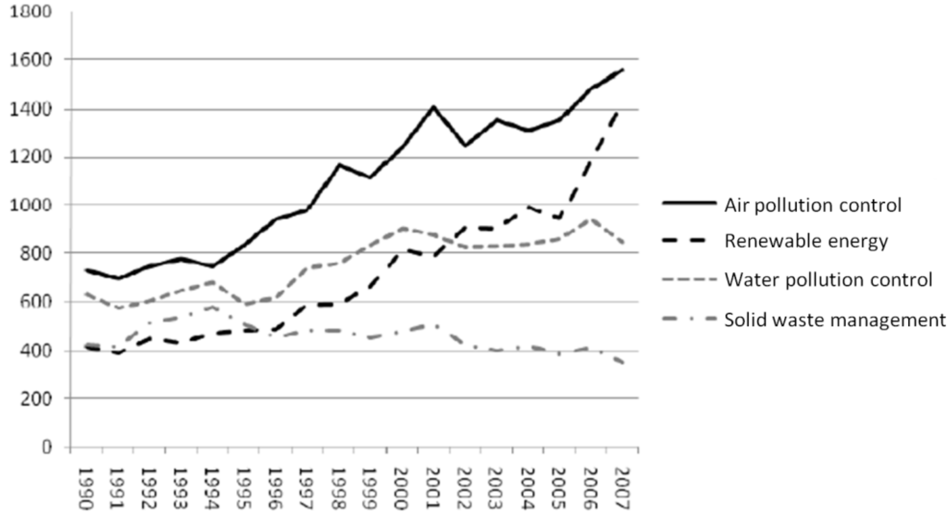

Figure 3-2. Patenting activity of environmental technologies globally. Number of patents. Adopted from Palmberg & Nikulainen (2010, 16), with original data from OECD PATSTAT.

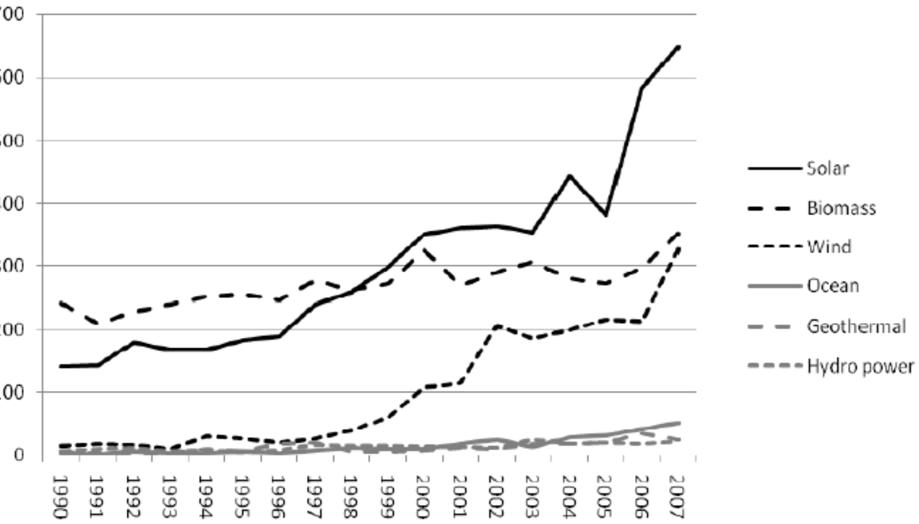

Figure 3-3. Patenting activity of renewable energy globally. Number of patents. Adopted from Palmberg & Nikulainen (2010, 16), with original data from OECD PATSTAT.

The Palmberg & Nikulainen (2010) study reveals that Finland is relatively well positioned in the environment industry technologies patenting activity in international comparison. Palmberg & Nikulainen (2010, 20) also note that the good overall performance of Finland does not indicate that Finland would possess a leading position in any of the environment industry related technologies listed in figures 3-2 and 3-3 above. They further state that the closer observation of the patent statistics from years 2004-2006 of the best 25 countries, as depicted in figure 3-4 below, shows that Finland is lacking specialization areas and is not among the leading countries in any of the studied environmental technology categories, independent of the measuring of patent activity is conducted in absolute or relative numbers.

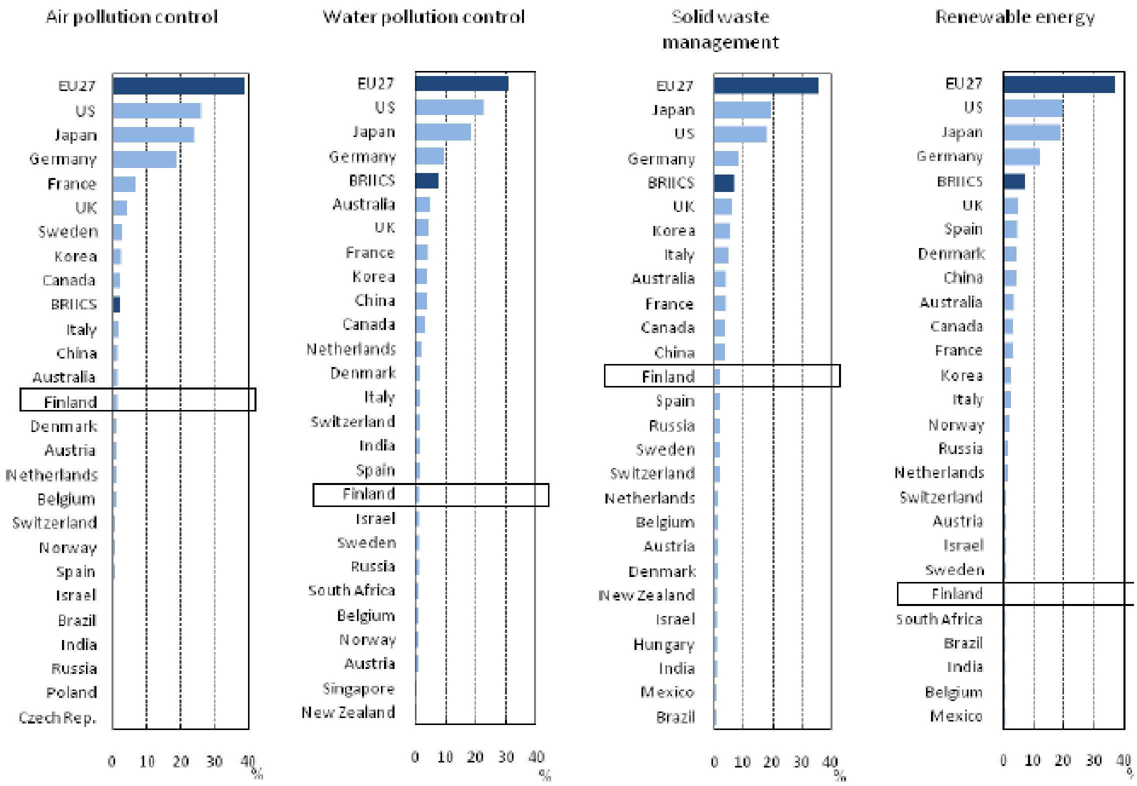

Figure 3-4. Top 25 environmental technologies patentig countries 2004-2006. In absolute numbers. Adopted from: Palmberg & Nikulainen (2010, 18), with original data from OECD PATSTAT.

Besides the Chatham House and Cambridge IP study from 2009 reported by Rau et al. (2010), Dechezleprêtre et al. (2010) and Palmberg & Nikulainen (2010) also Korotayev et al. (2011) have observed timely relations between market development and patenting activity. Korotayev et al. (2011) relate their study of patenting activity and market development to the Kondratieff cycle and the long waves of the economy that are discussed in the chapter 3.3. They see steady increases in the number of ‘patents granted annually per 1 million of the world population’ in the phase of upswing in Kondratieff cycles. Their interpretation is that a low total number of patents are granted in the downswing, but these are disruptive ‘breakthrough’ innovations in their nature. Supplementary, in the upswing of the Kondratieff cycle the total number of patents granted is high, but these are incremental, ‘improving’ innovations that are induced by the disruptive innovations for which patents were granted in the preceding downswing. According to Korotayev et al. (2011, 1280) the recent explanations of the Kondratieff cycle dynamics are distancing from the older research that explained the development of Kondratieff cycles by capital investment dynamics and are moving towards explaining the Kondratieff cycle by connections with the waves of technological innovation.

3.3. Long waves of economy

According to van Ewijk (1982) the Kondratieff cycle refers to a long wave of 40-60 years in the global economy that comprehends a cycle of strong growth, stagnation and decline led by a strong and distinguishable technology. Van Ewijk (1982, 469) and Metz (2010, 205) state that the existence of the Kondratieff cycle is disputed, because the research of the theory of Kondratieff cycle has lead to contradictory results. According to Gore (2010) the academic research has agreed for the most part on the timing of the first three observed Kondratieff cycles, but the timing of the following Kondratieff cycle(s) is disputed. According to Gore (2010) the world economy is now in the fourth Kondratieff cycle.

Van Ewijk (1982) interprets that the shift between Kondratieff cycles takes place when the dynamics of the current economic system breaks down. Gore (2010) suggests that the current economic and financial crisis, whose effects are still unfolding, could be interpreted as a situation where the reorientation of the economy will take place, hence a new Kondratieff cycle will start. According to Gore (2010), should the begin of a new Kondratieff cycle take place, only fixing the financial system would not suffice to reach sustained recovery of the global economy - the global development would be needed to redirect to facilitate new technological forces and even new geography. According to Schumpeter´s (1939, 98) analysis of Kondratieff cycle innovations tend to cluster to bunches that concentrate in specific industry sectors. Schumpeter (1939, e.g. 220) states further in his analysis that these clustered and concentrated innovations have lead to economical upswings followed by peak prosperity and recession.

Gore (2010, 728) sees that the current economical and financial crisis can be seen as a symptom of the old technological revolution lacking the potential for significant further innovation and the upcoming technological revolution still lacks the capability for significant innovations. He further states that the current economical and financial crisis is due to contradictories in the global development - income inequalities, increasing influence of the finance sector, inertia in business practices that delay or derail full employment of the new technological revolution, and finally still underdeveloped international regimes that struggle to manage the highly interdependent new world. Due to these contradictories existing, Gore (2010) does not see the shift to the fifth Kondratieff cycle inevitable right now as the contradictories can further exist and hinder the shift. Dependent of the pace of solving the contradictories, Gore (2010, 725 & 733) foresees a global economical upswing starting between now and the next 30 years. Gore (2010, 726) recognizes that in the moment we observe an upcoming end of a global development cycle and simultaneously mitigating the climate change has become an imperative. According to Gore (2010, 734) in this situation one possible direction of development would be new long wave of global development, global sustainable development that would address the issues of climate change and global income inequality. The Natural Edge Project (2005, 37) suggest in their relatively early report on profitable opportunities for greenhouse gas emissions reduction that the next wave of innovation could be driven by environmental technologies.

FIF (2007, 11) and Lovio et al. (2011, 9) discuss the environment industry as the potential lead industry that would start a new Kondratieff cycle in the global economy following the current Kondratieff cycle dominated by the information and information communication technologies that started through in the 1970s. According to FIF (2007, 11) similarities between the past development of IT and ICT and the cleantech industry exist - cleantech now enters all industry sectors and will be integrated in a similar way as IT and ICT in the past. Tekes (2011, 12) see the current economic crisis as an opportunity to support policies that enable a radical system level innovation that is necessary for reaching green growth. In the figure 3-5 below the research of the Kondratieff cycle (K-wave) and its connection to environment industry is summarized.

K-wave 1
- 1780-1845
- Cotton
- Industrial revolution
- Division of labor
- Steam engine
- Mechanical loom

K-wave 2
- 1845-1892
- Coal
- Railways
- Steel mechanization

K-wave 3
- 1892-1948
- Oil
- Electricity
- Automobile
- Mass production
- Chemical industry

K-wave 4
- 1948-1995 (Hagemann 2008)
- 1950s-2010s (Gore 2010)
- Atomic energy
- Computer
- Electronics
- Robots

K-wave 5
- Beginn 1995 (Hagemann 2008)
- Beginn 2010s-2040s (Gore 2010)
- Beginn 2000s (FIF 2007)
- IT, ICT
- Biotechnology
- Nanotechnology
- Environment technology (FIF 2007, Tekes 2011, The Natural Edge Project 2005)
- Global sustainable development (Gore 2010)
  - To address climate change
  - To address global income inequality

Figure 3-5. Kondratieff cycles (K-waves). Sources: FIF (2007), Gore (2010), Hagemann (2008), Korotayev et al. (2011), Lovio et al. (2011), Wonglimpiyarat (2004)

3.4. Global growth drivers and barriers

According to FIF (2007, 14) markets in general are steered by the mega trends that also affect the environmental industry: globalization, the climate change, urbanization, growing middle class and population in developing countries, wastage of natural resources, high prices and shortages of energy and raw materials, and scarcity of fresh water. In their opinion all these trends contribute to the rapid development of the environment industry. OECD (2010) make a notion of the possibility of other industries as bio technology, chemistry, material sciences, nano technology and engineering contributing to the environment industry growth. In the same spirit FIF (2006, 22) see breakthroughs in these other supportive industries enabling the market entry of solutions that are more environmental friendly and cost efficient.

FIF (2006) report that the following changes in the market forces have woken up the interest of investors in the environmental technologies:

- Deregulation of the energy sector
- Aggressive rise in the oil and gas prices
- Scarcity of natural resources (clean water, air and energy)
- The aging of water and energy infrastructure

- Increased competition in the global markets that is driving the point of gravity towards efficiency in use of resources and cost efficiency
- Consumer awareness of origin of products (especially food)
- Demands for the life-cycle management of products

Besides the governmental actions contributing to the environment industry growth, an increasing number of companies have recognized the positive effects of successful control of environmental issues to economical results or to share price development (Morgan Stanley & Oekom Research 2004; WEF 2004, xiv-xv). Cleantech Group (2011 b) recognize that corporations are becoming more active in cleantech innovations. They name General Electric and Siemens as good examples of this, as these corporations are active in the cleantech field as investors, customers, licensees, partners, and acquirers.

McKinsey (2011) studied the expected needs to increase the productivity of the usage of natural resources in order to avoid an era of higher, more volatile resource prices and increased risk of resource-related shocks. They identified opportunity areas, where the productivity increase of resource usage would be most beneficial in monetary terms, and the key barriers for achieving the productivity increases in these areas. From their estimations it can be seen that a wide range of barriers for increasing the productivity of resource usage is handed in the opportunity areas listed in figure 3-6. The barriers are not same ones for each opportunity area, but as a summary it can be concluded that the origins of the barriers are both in the private and public side, and that the barriers have to do with finance, politics and information. The list of the barriers for specific opportunity areas is handed in the figure 3-6. Especially high potential is seen by McKinsey (2011) in areas that according to my judgment are related to the environment industry sub-sectors for energy efficient building, municipal water service, iron and steel energy efficiency, electric and hybrid vehicle, end-use steel efficiency and power plant efficiency, as depicted in figure 3-6.

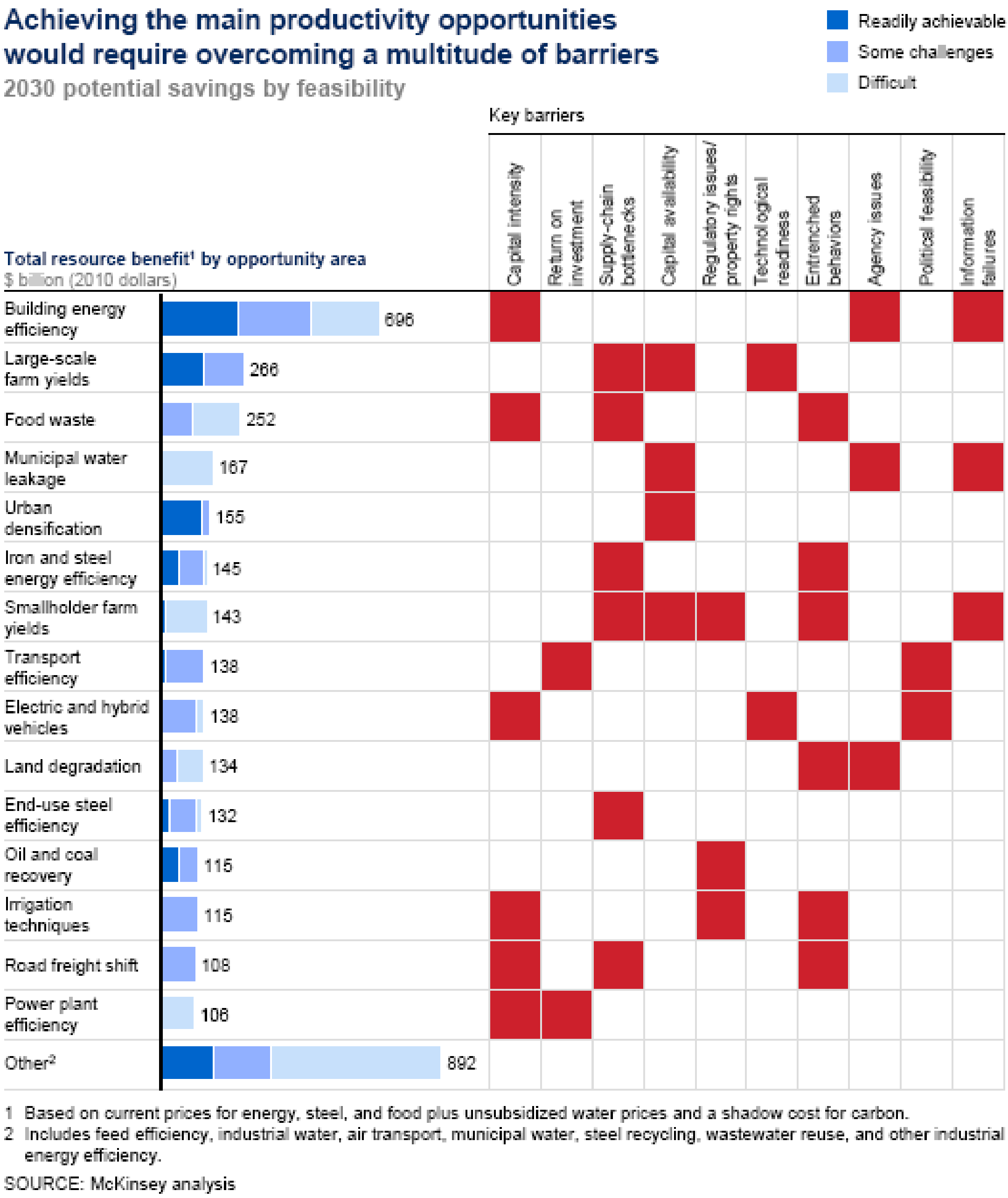

Figure 3-6. Main productivity opportunities and key barriers. Adopted from: McKinsey (2011, 87)

3.5. Size

EU, the U.S. and Japan are the largest actors in the global environment market. In the EU Germany is the largest actor (Dechezleprêtre et al. 2010). Asian markets, before all China is predicted to grow fast. The expansion of the EU markets to 27 countries contributes to the environment industry growth as well. The volume of the global environment industry was estimated at some EUR 550 billion in 2005 and respectively EUR 600 billion in 2006. EU accounts for some one third of this, thus EUR 200 billion. Markets of environmental technologies have developed faster than the markets in general under the past years, and the fast growth is expected to continue in the future (Ecotec 2002). The estimates and growth prognoses related to environment industry are to be observed critically due to the issues in monitoring the environment industry. (FIF 2006; FIF 2007; Ecotec 2002)

End-of-pipe technologies continue as the leading environment technology type in the environment industry volume estimates. Cleaner technologies still are not significantly present in the estimates, despite that cleaner technologies are observed to be the fastest growing technology type in the global environmental industry. In 2006 the annual global growth estimates for solar and wind power technologies lied at 20-30%, and for bio-energy at 10%. (FIF 2006; FIF 2007; Ecotec 2002)

Western Europe, the USA and Japan move clearly from end-of-pipe technologies towards cleaner technologies. For the part of cleaner technologies especially the energy sub-sector is important due to the ambitious agreements, as the Kyoto protocol, to reduce greenhouse gas emissions of energy production. In developing countries the end-of-pipe technologies are continuing as the dominant technologies in the environment industry. (FIF 2006, 18-19; Ecotec 2002)

Turnover of the Finnish environmental industry was estimated at EUR 3.4 billion in 2003 and respectively EUR 4.5 billion in 2006. These figures account to less than 1% of the global market volume. It is estimated that in 2003 foreign activities contributed to one third of the Finnish environmental industry turnover. (FIF 2006; FIF 2007; Ecotec 2002)

Early 2000s after introduction of the cleantech concept, the combined Finnish environment industry experienced yearly growths of some 3% only. The Finnish environment industry growth has improved since then, being 10% in 2006. (FIF 2007)

According to Palmberg & Nikulainen (2010, 26) 125 companies in Finland have environmental technology patents. Weighted with the share of environmental technology patents of all patents of a company, these 125 companies combined would show a EUR 7.5 billion annual turnover and they would employ some 16.000 persons. Palmberg & Nikulainen (2010, 26) state that if a threshold of 20% is set for the minimum share of environmental technology patenting of a company, and the minimum amount of environmental technology patents is set at three, there are 19 companies in Finland that can be regarded as environment technology companies. They further state that with the threshold, the Finnish environment technology companies can be evaluated to employ 12.000 persons, and their annual turnover would lie at EUR 3.5 billion. The estimated employment and turnover of the Finnish environment technology companies with and without the threshold by Palmberg & Nikulainen (2010) is presented below in table 3-1.

Table 3-1. Estimated environment technology related employment and turnover 2009.

	Companies included	No. of employees	Annual turnover EUR billion
Min. 3 patents and 20% treshold	19	12 000	3.5
Companies with environmental technology patents, weighted by share of environmental patents of total number of patents	125	16 000	7.5

Source: Palmberg & Nikulainen (2010, 28), with original data from OECD PATSTAT and Statistics Finland.

According to the available industry outlooks and development programs that discuss the Finnish environment industry or its sub-sectors, it can be observed that the growth of the Finnish environment industry lacks behind the international industry development. The Finnish environment industry growth that is lacking behind the internationally observed development can be regarded as underperforming and dissatisfactory. (FIF 2006)

The Finnish environment industry´s relatively poor performance is underlined by the notion that prerequisites for better performance are handed. The environmental image of Finland is internationally seen positive. Advanced know-how in environmental technologies exists in Finland and new environmental technologies are being developed continuously. (FIF 2006; FIF 2007)

These handed prerequisites for environment industry growth should enable to more successfully promote environment industry exports, the growth of the sector and to add jobs in the industry. This potential has not been able to fully exploit in Finland. More customer and market oriented activities in exports are needed. The scattered environment industry needs to be strengthened. Especially, the important networking and clustering in this scattered industry sector need to be developed to function more efficiently. (FIF 2006; FIF 2007)

The growth of the Finnish environment industry lies for the most part on the success of few internationally active large companies, of which the most are active in the machine industry. Some of these large environment industry companies are among business leaders in the environment sector. (FIF 2007, 20; Lovio et al. 2011)

The growth numbers of SMEs in the Finnish environment industry are weak for their part. The improvement of the industry growth for the part of SMEs is a central aspect in the Finnish environment industry development. SMEs in the environment industry have issues with exports, and for their part the growth is especially slow. Reasons for the slow growth are to find in the missing know-how in trade, the fragmented nature of the environment industry and unwillingness of national markets to adopt new innovations (FIF 2007, 20; Lovio et al. 2011).

Many SMEs in Finland are generating new technologies and solutions but commercializing of these has proved to be difficult. The national market plays a central role in commercialization of new technologies. Early success in domestic markets is often a prerequisite for success in export markets and in building networks with foreign actors. As the Finnish home market is small, rapid expansion abroad is necessary. (FIF 2006; FIF 2007, 20; Lovio et al. 2011; Herlevi 2011)

3.6. Public involvement

FIF (2007) state that the growth of environment business is increasingly driven by market mechanisms, but the role of regulations and incentives from the authorities remains important. According to FIF (2006) tightening legislation and international agreements are central methods of governments to support the environment industry development. To these agreements belong e.g. the Kyoto agreement, Glendale agreement of G8 countries, EU pollution trade and independent commitments by some states of the U.S. to increase their usage of renewable energies (FIF 2006).

Dechezleprêtre et al. (2010, 37-38) recognize a huge potential for environmental technologies in the developing countries in the southern parts of the world that could benefit the highly developed countries in the north possessing these technologies. They further state that besides this north-south exchange, a potential of south-south exchange is handed as well. According to Dechezleprêtre et al. (2010, 37-38) developing countries as China, Russia and South Korea are major innovators that can develop technologies that are even better tailored for the conditions of other southern countries, but currently flows between emerging economies are non-existent. If the developing countries would develop their environmental regulations, remove trade barriers, relax constraints on foreign direct investments and stress intellectual property rights, north-south transfers could be enhanced considerably (Dechezleprêtre et al. 2010, 37-38).

Herlevi (2011) states that government is a significant supporter of the cleantech innovation in Finland. According to Herlevi (2011) Tekes, The Finnish Funding Agency for Technology and Innovation is able to offer up to EUR 1 million financing for a start-up company, which is comparable to early stage start-up financing available for Silicon Valley companies. He further states that the government support for cleantech start-up companies is especially needed in Finland due to the small size of the home market. According to Herlevi (2011) and FIF (2007) Finland can be used as a test market only, and companies with new cleantech innovations need to go abroad fast.

Tekes funding is available in the form of project related loans and grants from hundreds of thousands of Euros to millions of Euros. This is often early stage financing. Tekes puts in cleantech roughly EUR 200 million yearly, when all investments in companies and university projects are taken in account. According to Hulkkonen (2011) public R&D spending in cleantech lies at EUR 1 billion annually in Finland, best in the world per capita. (Herlevi 2011)

Hug (2009) brings up the importance of demand-side policy instruments in supporting the environment industry growth. He sees the current EU demand-side innovations policy as insufficient when it comes to tackle the chicken and egg problem of commercialization. According to ten Cate at al. (2006, 4) by chicken and egg problem a situation is meant where 'manufacturers wait for demonstrated market demand before they will develop a new technology, but buyers in turn wait to see new products before making purchasing choices'. According to Hug (2009, 2) the valley of death that is depicted in the figure 3-7 by DTI (2006) is to be bridged especially by demand-side policies.

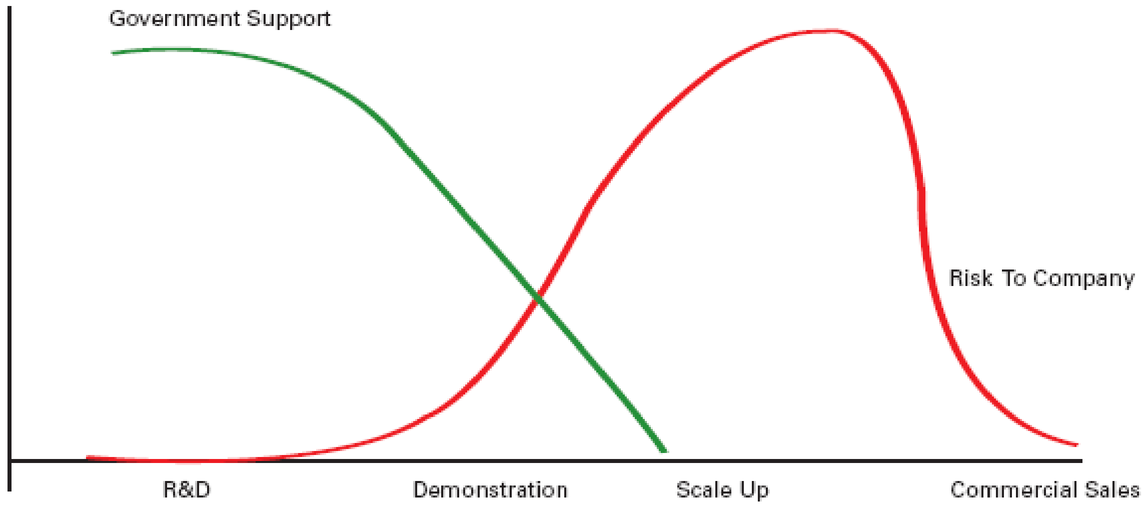

Figure 3-7. Chicken and egg problem. Adopted from: DTI (2006, 13)

According Hug (2009) related to the EU, especially public procurement programs could be beneficial demand-side policies and they also contribute to the European Commission framework for innovation, as ETAP. Also EU (2011, 14) and FIF (2007) recognize the influence of public authorities as consumers. EU (2011, 14) estimate EU public spending at some EUR 2 trillion annually, equivalent to 19% of the EU GDP. According to EU (2007, 7) the EU public spending reaches 40% of spending on construction and nearly 100% on defense, civil security and emergency operations. The significance of public spending for the environment industry growth is starting to realize in the U.S. according to Oreck (2011). He states that the U.S. department of defense, which does purchases in worth of USD 1 trillion yearly, will invest USD 7.1 billion in energy efficiency of the U.S. army within the next 10 years.

Hug (2009, 9-10) concludes that innovation procurement has already been applied in the EU in the areas of white appliances, components, housing, office buildings and public transportation. He suggests that the transport sector, wastewater treatment, chemical components, healthcare products and energy-efficient components could be suitable for greater demand-side policies in the EU.

EU (2011, 4) more recently recognize that green public procurement in the EU level is done at least for the part of:

- Energy efficient computers
- Office furniture from sustainable timber
- Low energy buildings
- Recycled paper
- Cleaning services using environmentally friendly cleaning products
- Electric, hybrid or low emission vehicles
- Electricity from renewable sources

FIF (2007) makes a notion of the need to strengthen the venture capital funds in Finland to strengthen and internationalize the fragmented SMEs in the environment industry. In the U.S. venture capitalists are investing more in such environmental industry companies and ideas that are based on new technology and that are improving the efficiency and cleanliness of current technologies in a cost-efficient manner (FIF 2006). Business proposals that are based on the markets generated by regulatory mechanisms or governmental subsidies to environmental technologies are not able to convince U.S. investors (FIF 2006, 22). Hug (2009, 3) recognizes that financing issues exist in the private sector, as banks and traditional lenders have not set up structures for working with environmental technology companies. FIF (2007) suggest tax incentives to be put in place in order to generate financing for environmental technologies and to encourage consumers to make environmental choices. They further state that a broader understanding of environmental issues is needed at all levels, and that this problem could be tackled by integrating innovative business approaches and environmental technologies better into education.

According to Palmberg & Nikulainen (2010, 1) the worldwide R&D investments in the emerging environmental technologies are growing and the recent environmental stimulus packages have caused the investments to surge even more. They state that globally the share of nations´ total stimulus packages directed to environmental technologies is in the region of 6-15%, which is equivalent to USD 180-460 billion in total to be distributed over the years 2010-2013.

Globally the investments in environment technologies are now following the trend of renewable energy, but this trend cannot be observed in the public R&D funding of Finland (Palmberg & Nikulainen 2010, 22-23). The largest of the public R&D funding institutions, Tekes – the Finnish Funding Agency for Technology and Innovation, has since 1997 financed the development of Finnish environment technologies in the surroundings of some 20 programs, whose combined value lies at some EUR 1 billion. These programs have supported a wide range of environmental technologies, not lifting any specific technologies as leading ones (Palmberg & Nikulainen 2010, 22-23).

Cleantech Group (2011 b, 1) evaluate solar energy and biofuels as cleantech industry sub-sectors that are maturing and consolidating in the near future. They further discuss energy efficiency as the most timely cleantech industry sub-sector and that broader cleantech and energy efficiency solutions have become more important. This again has lead to increased success among water and material companies (Cleantech Group 2011 b, 1). According to FIF (2006) the fast growth of nations as China and India having large populations has lead to the importance of solutions related to improving energy, water and air quality to grow. Coherently FIF (2006, 124) state the largest segment of the environment industry being water, waste water and sludge handling. They state that solid waste management is the second largest segment of the environment industry.

3.7. Finnish focus areas

According to Herlevi (2011) numerous activities related to wind, biomass, clean processes and energy efficiency take place at the moment in Finland. He also names renewable energy and electric vehicles as fields that are very active. Herlevi (2011) states that Tekes has formed a EUR 8 million electric vehicle development program 2011 in Finland. The program is to put some hundreds of electric vehicles into the traffic in the surrounding of a demonstration project. The electric vehicle project includes the testing of the necessary infrastructure besides the vehicles. The project is not only about the technology, but also should help to understand the related business models and opportunities for service business around the electric vehicle. (Herlevi 2011)

Herlevi (2011) states that the wind energy sector is active in Finland. According to him examples of companies active in the Finnish wind energy sub-sector are WinWind and The Switch. The handed good engineering capability is seen as the key for these two wind energy companies to develop solutions that find use also outside Finland (Herlevi 2011).

FIF (2007) claim that the focus areas of the Finnish cleantech are:

- Renewable energy
- Recycling of materials
- Resource saving processes
- Energy saving technologies
- Water treatment

According to FIF (2006) and FIF (2007) the most significant environment industry sub-sectors in Finland are: waste water management, air and climate protection, recycling and waste management, raw water, and renewable energies and energy saving. FIF (2006, 87) further states that Finland possesses strong know-how in these environment technologies:

- Clean energy production, especially in wood based bio-energy, combined production of electricity and heat, components of wind power plants
- Energy efficient building
- Reduction of particulates
- Measuring technology and management of environmental data
- Clean process technologies, e.g. in the forest industry
- Waste recycling and utilization

The Finnish Innovation Fund (FIF) facilitated a seminar in 2005 where Finnish company executives and leading representatives in the fields of finance, administration and research examined the future of the environmental technologies from the Finnish perspective. Some 50 persons participated in the seminar, where the following SWOT analysis was prepared by a work group at the seminar (FIF 2006, 21):

Strengths

- good cooperation between companies, research and administration
- demanding home market forces efficiency and innovativeness
- strong technological know-how in several sub-sectors
- good state of environment in international comparison
- good surroundings for innovation created by goal-oriented and flexible regulatory policy of Finland

Weaknesses

- Environmental issues spread under several ministries from administrative view
- Lack of financing for start-ups
- Narrow home market
- Only few technology related services
- Unwillingness to pay for environment
- Unwillingness to take risks and go international

Opportunities

- Politically seen environmental technologies are an opportunity to improve competitiveness
- Internationalization of SMEs can have much potential
- Good level of know-how in systems and integration possibilities (for example in IT)
- Exploiting the good environmental reputation of Finland

Threats

- Shortsighted politics/ too strong emphasis on regional policy
- Stuck in the traditional successful companies and sectors
- R&D investments of companies reduced due short sighted profit maximizing
- Inability to make a difference between matters that are more and less important for the environment

Special good things about Finland

Finland is consistently ranked among the top countries in the world in comparisons of environmental performance: high global competitiveness (WEF), gender equality, PISA, low corruption (Transparency International), high Environmental Sustainability Index (WEF), high Environmental Performance Index (WEF) (FIF 2007). According to FIF (2007, 15) Finland has a sound environmental image and early recognition of environmental priorities, which can be demonstrated by high level of environmental research. They further claim that Finland is a society that has a large capacity to handle environmental issues and challenges.

Hulkkonen (2011) underlines that the harsh winters and surroundings make Finland a good laboratory and test market, and that the ICT cluster is well developed. In the same spirit Herlevi (2011) makes a notion of the long distances in the country.

In Finland a sound co-operation between universities and companies takes place. When The Finnish Funding Agency for Technology and Innovation (Tekes) funds a research project at a school of applied sciences, companies are invited to participate in the projects. By doing this it is tried to enable the finding new break through solutions that actually are needed by the industry. (Herlevi 2011)

According to Oreck (2011) the U.S. will build a USD 100 million, one of a kind innovation centre in Finland in the near future. He states that the centre is to facilitate conversations leading to implementation of new energy solutions and that anywhere in the 170 U.S. embassies in the world a similar innovation centre does not exist.

Special uncertainties of Finland

According to FIF (2007, 20) Finnish environment industry companies need to strengthen their international business knowledge in environmental business. This can be observed as the transformation of new ideas into profitable business has proved to be the bottleneck (FIF 2007, 21). They further state that in the case of a Finnish environment industry company, the presence in the international markets is a precondition for success. This is the case not only due to the small home market, but also due to lack of innovativeness of Finland as a first market (FIF 2007, 21). In the same spirit Lovio et al. (2011, 12) state that Finland is lacking a clear and explicit strategy and policy for greener growth despite many initiatives. According to FIF (2007, 34) environment industry companies in general are dispersed due to the newness of the sector. They state further that a network-based co-operation would give the Finnish environment industry a competitive advantage.

Lovio et al. (2011, 12-14) name biofuels, electric vehicles and renewable energy as cleantech industry subsectors that could have potential for Finland, but where evidence for success is still lacking. Lovio et al. (2011, 34) refer to the study of patenting activity by Palmberg & Nikulainen (2010) and states that in terms of the distribution of the patents the position of Finland is worrying. Finland is lacking a specific specialization profile, where other countries as Austria, Australia, Denmark and the UK have developed such (Lovio et al. 2011). According to the patent distributions presented in the table 2-3 the specialization of Finland in wind technology has eroded since 1990s. Table 3-2 presents the relative technological advantage in selected environmental technologies of selected countries in the 1990s and 2000s. A higher number of x indicate a comparatively higher specialization of a country.

Table 3-2. Relative technological advantage in environmental technologies.

Technology	Finland - 90s	Finland - 00s	Finland	Austria	Australia	Germany	Denmark	UK	Netehrlands	Sweden	US	South-Korea
Air pollution control						X				X	X	
Solid waste management	X	X	X	X	X							
Water pollution control		X	X	X	X	X	X	X	X	X		X
Total - Renewable energy	X				X		X	X	X		X	X
Biomass	*X*	*X*	*X*					*X*	*X*		*X*	X
Geothermal		*X*		*XX*		*X*			*X*	*X*		
Hydro power		*X*		*XXX*	*XXX*					*X*		
Ocean		*X*	*X*	*XX*	*XX*		*XX*	*XXX*		*XX*		
Solar					*X*				*X*			X
Wind	*XX*		*X*			*X*	*XXX*			*X*		

Source: Adopted from Palmberg & Nikulainen (2010, 19), with original data from OECD PATSTAT.

3.8. Summary

The purpose of the literature review conducted of the environment industry was to clarify the environment industry concept and structure in order to understand better the contents and nature of it. The Finnish environment industry size and specialization areas were enlightened, as well as the connections of the Finnish environment industry to the regulatory environment and to the global economy. The research that was discussed handled the environment industry widely from different perspectives. This was important to ensure that no central aspects of the industry remain neglected in the scenario planning exercise that follows in the empirical part of this thesis.

The closer analysis of the literature review will follow in the form of the scenario planning exercise in chapter 5. On the basis of the conducted literature review the uncertainties and indicators related to the Finnish environment industry development are going to be highlighted later in the empirical research in chapter 5.

4. Analysis of scenario planning

In this chapter the background of scenario planning is discussed in the surrounding of a literature review. Also the application of scenario planning in this thesis is described, and evaluation and critique of scenario planning is discussed.

4.1. Background of scenario planning

Scenario planning tries to answer the challenge of experienced unsatisfactory quality of forecasts. Unsatisfactory quality of forecasts is experienced before all in situations where historical data is non-existent or too extensive, the situation is complex, rapid change is occurring, disruptive elements are present in the observed environment or the planning horizon is very long. Scenario planning is not claimed to be a solution for forecasting problems, but addresses in its underlying assumptions some relevant issues that can explain poor performance of forecasts under the circumstances described above. (Bunn & Salo 1993; Foster 1993; Huss 1988; Schoemaker 1991 & 1995; Wack 1985 b)

According to Raubitschek (1988) Kahn and Wiener (1967) provided one of the earliest scenario definitions: *'a hypothetical sequence of events constructed for the purpose of focusing attention on causal processes and decision points'*. McNulty (1977) defined scenario as *'a quantitative or qualitative picture of a given organization or group, developed within the framework of a set of specified assumptions'*. Porter (1985) again defined a scenario as *'an internally consistent view of what the future might turn out to be'*. Wack (1985 a) states that scenarios serve before all protective and entrepreneurial purposes. According to him the protective purpose refers to anticipating and understanding risk, and the entrepreneurial purpose again refers to discovering strategic options of which one was previously unaware.

According to Harries (2003) probability and plausibility of an event is a central aspect in scenario planning. She states that plausible events with high probabilities are handled as plausible events with low probabilities, which is a difference compared to forecasting methods. Millet (2003, 20) claims that assigning a higher probability for some crafted scenario would inevitably lead to the others being neglected in corporate planning. In the same spirit Schnaars (1987, 109) claims that probabilities assigned to scenarios are misleading, as these would indicate precision that actually is not handed.

Similar to the probabilities assigned to scenarios, the number of scenarios crafted and the fundamental logic behind the scenarios need to be considered: According to Ogilvy & Schwartz (1998) it is tempting to choose one of the scenarios as a leading ‘middle of the road’ scenario, if the crafted scenarios are based on a continuum where low, medium and high alternatives are handed, or if the number of crafted scenarios is uneven.

Schoemaker (1991, 550) sees that the focus of scenario planning is to bound uncertainty and not to forecast the future or to fully characterize its uncertainty. According to Schnaars (1987, 106) the advocates of scenario planning claim it is more reasonable to offer several plausible outcomes of the future as a basis for decision making, than trying to predict what will happen in the future by forecasting. Ascher (1979) reports about his earlier large study from 1978 that showed weaknesses in forecasting results despite the development of forecasting methods. Ascher (1979) further explains poor forecasting performance by before all out dated assumptions underlying the forecasts. According to Schnaars (1987, 106) scenario planning is far better in doing this.

Wack (1985 b, 73) states that scenario planning started to gain popularity after the oil crisis that hit in the 1970s, after the relatively stable era after the Second World War. To the increasing popularity of scenario planning among businesses contributed the example of Royal Dutch Shell and their ‘Year 2000’ scenarios: according to Chermack et al. (2001) Royal Dutch Shell was well prepared for the oil crisis that hit in 1973 compared to its competition because of employing scenario planning. Wack (1985 b) states that the most important findings of the Shell scenarios were that the oil market could switch to a seller´s market after a long era of oversupply and that the important Middle East oil production could be limited in the future. According to Bradfield et al. (2005, 800) and Millet (2003, 20) General Electric crafted their first scenarios at the same time as Shell in 1971 of global and US economic and sociopolitical conditions in 1980.

4.2. Schools of scenario planning

After the Second World War in 1950s a U.S. based researcher Herman Kahn started with scenario planning to address the lack of realism in the future expectations of the military. This was the start of the ‘intuitive logics’ school of scenario planning. The intuitive logics school of scenario planning is known for its winningly qualitative approaches to scenario planning.

Later the U.S. based scenario planning research has advanced to include also the 'probabilistic modified trends' school comprehending cross-impact analysis (CIA) and trend-impact analysis (TIA) approaches that have quantitative parts in them and that are not discussed as a part of the intuitive logics school. The U.S. based research on scenario planning is the most studied area of scenario planning research. (Bradfield et al. 2005; Huss & Honton 1987)

According to Bradfield et al. (2005, 802) Gaston Berger in France started to work on an approach for long-term planning to address the issue of poorly performing forecasts roughly parallel to Herman Kahn. This scenario planning approach induced by Berger is known as 'La Prospective' that has developed to a school representing winningly quantitative approaches of scenario planning (Bradfield et al. 2005).

Bradfield et al. (2005) divide the existing schools of scenario planning in three: One class is the intuitive logics school, the second class combines CIA and TIA into probabilistic modified trends (PMT) methodology, and the third class is the La Prospective school. They state that in general the purpose of using scenario planning can be seen in once only problem solving or ongoing surviving, and in opening-up exploration or closure decisions. In the table 4-1 below, the different schools of scenario planning and their purposeful areas of scenario work are summarized.

Table 4-1. Purposeful scenario work.

	Once only problem solving	Ongoing surviving/thriving
Opening-up exploration	**Making sense** *Intuitive logics* *La Prospective* *PMT*	**Anticipation** *Intuitive logics*
Closure decisions	**Developing strategy** *Intuitive logics* *La Prospective* *PMT*	**Adaptive organizational learning** *Intuitive logics*

Source: Adapted from Bradfield at al. (2005, 805-806)

In their study Bradfield et al. (2005, 805-810) discuss the features of the three schools of scenario planning in great detail, but in the surrounding of this thesis it is just mentioned that all the named scenario planning logics schools support crafting scenarios for a time frame of 3-20 years or even longer and that intuitive logics is the only school not assigning probabilities for the scenarios.

According to Chermack et al. (2001) and Bradfield at al. (2005), as a result of the different schools of scenario planning emerging, defining scenario planning in a concrete way has become challenging. They state that there are many definitions for what a scenario is, but the despite the differences in wording the same spirit and underlying assumptions are recognizable, so defining a scenario is not as complicated as defining scenario planning where the methodological differences cause confusion. Millet (2003, 16) sees the major challenges for the future scenario planning research in resolving the confusion over the definitions and methods, clarifying and enlarging the appropriate applications, and in reducing the resources required to perform scenario planning. When scenario planning is discussed, several overlapping terms are still used that refer to this discipline, as planning, thinking, forecasting, analysis, and learning (Bradfield et al. 2005, 796),

Schoemaker (1991, 550) states that it is difficult in practice to say when scenario planning should be used. He suggests that using scenario planning would be favored by the following type of conditions: uncertainty is high, many costly surprises occurred in the past, insufficient new opportunities are perceived and generated, the quality of strategic planning is low, the industry has experienced significant change or is about to, a common language and framework is desired, strong differences of opinion exist, or competitors are using scenario planning.

4.3. Levels of conduction

Schoemaker (1991) states that scenario planning can be conducted on several levels. According to Bradfield et al. (2005) scenarios can be used by crisis management, the scientific community, public policy makers, professional futurist institutes, educational institutes and businesses. Huss (1988, 380) states scenarios being best suited for 'long term, macro, uncertain environments which are typified by a scarcity of data and a large number of non-quantifiable factors'. In the same spirit, Schriefer (1995, 35) states about scenarios that these 'can be global, based on a broad, environmental perspective, or they can be focused on a single investment decision or departmental issue'. According to Schoemaker (1991) scenarios can be crafted of macro, industry, firm or decision level. In the figure 4-1 below the levels of scenario planning are summarized by Schoemaker (1991, 558).

Porter (1985) makes a notion of industry sub-sectors having a structure as an industry, and that the subsectors might be objected to different challenges and competitive environment. For this reason it is important that that several environment industry sub-sectors are not subjected to the same scenarios, implications and related early warning signals without further consideration. This is a challenge for the research in this thesis due to the fragmented nature of the environment industry. A comprehensive and recent taxonomy that shows in how many sub-sectors the environment industry is scattered is presented for example by Cleantech Network (2011 a). When performing the scenario planning exercise in this thesis it has to be critically evaluated for which environment industry sub-sectors the scenarios crafted can be applied.

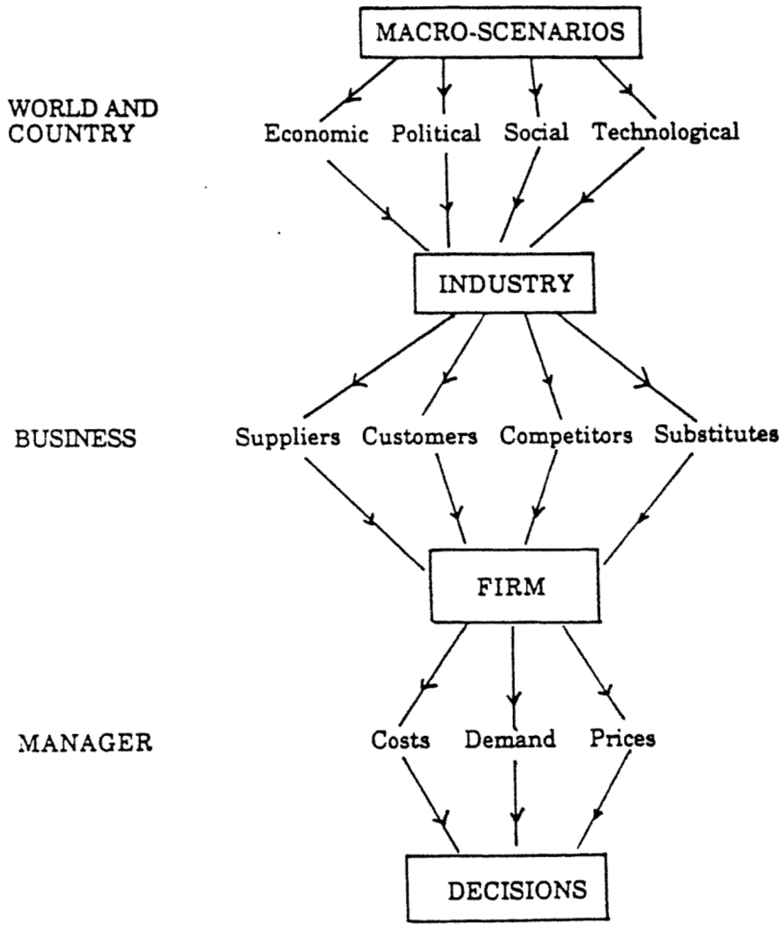

Figure 4-1. Levels of scenario planning. Source: Adopted from Schoemaker (1991, 558)

Scenario planning conducted in this thesis can be mirrored to the levels of scenario planning presented in the figure 4-1 by Schoemaker (1991, 558) above. The macro-economical scenarios enlighten risks and opportunities on a broad level and can be described as generic scenarios. These are partly criticized in the scenario planning research due to the lack of direct influence into decision making on organizational level. But it is also recognized in the research that macro-economic scenarios can be useful also on organizational level, because these can be used for inducing more detailed level scenario planning exercises. The position of macro-economic scenarios in organizational level scenario planning is a part of the environmental analysis. (van der Heijden 1996; Porter 1985)

Scenarios crafted on the organizational level can be used for strategic planning. Some researchers suggest the implementation of 'robust' strategies, where the organization´s strategy is planned so that the strategy should work under all the crafted scenarios. This approach includes the risk of creating a strategy that is not especially powerful under any scenario and competitive advantage potentially is lost. The other approach on the organizational level would be to be well-prepared for all the crafted scenarios. This approach requires more resources, as preparing an early warning system and action to take for all scenarios takes much effort and time. Also compromises between these two extreme approaches are suggested in the literature. For example to design a strategy that would create value in several of the crafted scenarios, and building early warning systems and a game plans for the rest of the scenarios. (Porter 1985; Bunn & Salo 1993)

Besides only using the scenarios as inputs for more detailed level exercises or as a part of strategic planning on organization level, scenarios broaden our understanding of what is possibly facing us in the future and enhance organizational learning. For this reason the alternative plans remain important. (Harries 2003; Huss 1988)

4.4. Process and logics

The pattern of conduction of a scenario planning exercise is fairly standardized. The general structure is found in very similar forms in the published scenario planning literature. This is the case despite the literature being published under several decades, on different levels of analysis and within different schools of scenario planning research. It is widely recognized in the literature that scenario planning exercises serve a purpose, and that the scenario planning exercise can be modified to serve this better as necessary. (Bradfield et al. 2005)

According to Ratcliffe (2002) the process and participants of a scenario planning are largely determined by the nature, timescale and resources of the specific exercise. According to him the amount of resources invested in the scenario planning exercise does not correlate directly with the quality of the exercise. Also a short and otherwise limited scenario planning exercise can be successful (Ratcliffe 2002).

Examples of structures or steps of a scenario planning exercise are presented for example by Foster (1993, 125), Garvin & Levesque (2006, 5), Godet (2000, 10), Schoemaker (1991, 556) and Schwartz (1991, 226-233). To show an example of the general structure of a scenario planning exercise, the check list for developing scenarios by Peter Schwartz (1991, 226-233) is presented below in the table 4-2. This check list covers the central steps of a scenario planning exercise.

Table 4-2. Steps of developing scenarios

Step One	Identify focal issue or decision
Step Two	Key forces in the local environment
Step Three	Driving forces
Step Four	Rank by importance and uncertainty
Step Five	Selecting the scenario logics
Step Six	Fleshing out the scenarios
Step Seven	Implications
Step Eight	Selection of leading indicators and signposts

Source: Adopted from Schwartz (1991, 226-233)

Schwartz (1991) describes the steps of developing scenarios more closely: A focal issue or decision describes the problem that is to be tackled. Key forces in the local or micro environment highlight differences that make a difference for the particular object of the study. Driving forces again are the major trends and trend breaks of the macro environment, which influence the key forces in the local environment. Defining the driving forces is the most research-intensive step in the scenario planning process. The defined key forces in the local environment and driving forces are to be ranked by degree of importance and uncertainty. Elements that can be identified as predetermined will not be used for crafting the scenarios, as these don't present uncertainty. The most important and most uncertain key forces in the local environment and driving forces are then used as the basis for crafting the scenarios.

According to Schwartz (1991) the selection of the scenario logics includes the decisions on how many scenarios there will be and the method of how each scenario will be crafted. Ogilvy & Schwartz (1998) recognize two logics exist to decide how many scenarios will be crafted - the inductive and the deductive approach. The inductive approach has two versions. In the first version a scenario of 'the official future' by central decision makers is crafted, and then the most uncertain key forces in the local environment and driving forces are connected to this scenario. Following, alternative scenarios to the official future are crafted. The second version of the inductive approach is a method where an individual emblematic event is used for crafting each scenario. The deductive approach is a more systematic approach, where the ranking of the key forces in the local environment and the driving forces directly leads to the choice of axes along which the scenarios are crafted. Usually a 2 x 2 matrix is constructed, but depending on the object of analysis one axis or three axes models can be feasible as well. (Ogilvy & Schwartz 1998; Schwartz 1991)

Scenarios are fleshed out by adding information to the skeletal scenarios crafted using chosen scenario logic. Besides the key forces in the local environment and the driving forces, also less important and less uncertain forces, even predetermined forces are included to some extent in the fleshed out scenarios in a way that supports the logic of the skeletal scenarios. As scenarios are fleshed out, the simplistic skeletal scenarios gain complexity, and the risk of oversimplifying of the focal issue is reduced. Systems thinking can be applied to deepen the scenario plots, narratives for lengthening the skeletal scenarios to stories and characters for populating the scenarios with illustrative persons. (Ogilvy & Schwartz 1998; Schwartz 1991)

According to Schwartz (1991, 231) implications refer to reflecting the fleshed scenarios to the focal issue. Implications and options are crafted for each scenario to allow an improved understanding of the consequences of a scenario becoming reality and of what actions should be taken in each case (Schwartz 1991; Garvin & Levesque 2006). Depending on the level of the scenario planning exercise, it can be possible to pursue after a 'robust strategy' that would suffice for several or even all of the scenarios (Porter 1985; Schwartz 1991).

According to Schwartz (1991, 232) leading indicators and signposts are put in place for each scenario to indicate some of the scenarios to unfold as early as possible. He states that these are to be monitored in an ongoing basis. Garvin & Levesque (2006, 4) describe the leading indicators and signposts as early warning signals. They also state that scenarios have to be developed further and new ones created in near future.

4.5. Evaluation and critique

According to Chermack et al. (2001, 28) evaluation of the scenario planning discipline is almost completely missing in the scenario planning literature. Harries (2003, 801-803) sees that evaluation of the discipline has been done almost exclusively on the basis of case reports and that this is widely recognized. Harries (2003, 802) sees the evaluation of scenario planning on the basis of case reports as problematic. She states that the case reports are often self reported and that the number of case reports probably reflects a only small fraction of the number of times scenario planning actually has been performed.

According to harries (2003) the evaluation of scenario planning requires measurement of learning and knowledge, and this is very difficult to do. Harries (2003, 802) states about the challenges in evaluation that *'causal relationships between team personalities, environmental pressure, decision making processes, organizational structure and organizational success are difficult to disentangle'*. Especially including predictability and impact of events in each time period in the evaluations is difficult (Harries 2003, 804).

Schnaars & Topol (1987) criticize the claimed performance of scenario planning. On the basis of their empirical test related to sales forecasts, scenarios could not reduce the degree of surprise to outcomes compared to forecasting. Phelps et al. (2001) on the other hand claim in their study that scenario planning is beneficial for a range of industries that face a turbulent future. Schriefer (1995) notes that scenarios have been criticized due to claimed lack of decision focus. She reports that created scenarios may become irrelevant to the focal issue and strategic planning. In the same spirit Porter (1985) criticizes macro level scenarios by claiming these to be too general to support strategic planning of an industry. According to Porter (1985) for this reason macro level scenarios have encountered skepticism among companies. Wack (1985 b, 77) recognizes the value of macro level scenarios in that they enable the process of creating the next generation of more specific scenarios.

According to Linneman & Klein (1979, 88) U.S. industrial companies tend to prefer qualitative, intuitive logics type scenario planning methods instead of quantitative CIA and TIA models, where researchers again often are more supportive to the more structured quantitative models. Bunn & Salo (1193, 294) suggest that this could be due to a general emphasis on the development of shared insight, communication and organizational learning. Cairnes et al. (2004, 233) state about scenario development that it is a creative process and can be described as more of an art than a science. Porter (1985) reminds in the same spirit that scenarios are not the end in themselves.

Bunn and Salo (1993) approach the evaluation of scenario planning quality by setting criteria for aims of scenario planning and the crafted scenarios. According to them scenario planning should aim to neutralize cognitive biases, to enhance managerial learning and contribute to strategic decision making. As the central quality measure of scenarios they see the credibility, which is handed when scenarios are comprehensive, consistent and coherent. According to Bunn and Salo (1993, 299) scenarios should not be evaluated by predictive accuracy due to the long time horizons. Wack (1985 a, 146-147) again recommends testing the value of created scenarios by asking what do they leave out and do they lead to action. He further suggests that in 5-10 years the crafted scenarios must have warned of important events and scenarios must have pushed to actions or decisions other than indicated by past experience.

4.6. Summary

When discussing scenarios, three underlying assumptions should be addressed: First, scenarios as a part of the output of a scenario planning exercise must not be interpreted as a forecast, but as plausible outcomes of the future. Second, in a scenario planning exercise a set of scenarios is crafted, in that the scenarios are in a relation to each other. This relation needs to be addressed in the scenarios. Third, scenarios are presented in a narrative form. This is to support the reader to better relate to the scenarios.

The evaluation of the scenario planning discipline or the crafted scenarios is not quite straight forward due to the nature of scenario planning. Scenario planning process itself can be seen as value adding and the time horizons are long. For these reasons the typical direct comparisons with other more output oriented methods or before-after comparisons are not feasible. Scenario planning and crafted scenarios can still be evaluated, even if the evaluation methods still need to be researched and developed largely. The evaluation of the scenarios depends from the initial purpose of the scenario planning exercise. Despite the varying purposes for scenario planning, some general guide lines for evaluating scenarios can be given. Here credibility of the created scenarios is central. The value of scenarios can also be evaluated by asking questions: Scenarios should not leave out important events that could happen and they should always lead to action.

Despite the different schools and areas of conduction, the scenario planning process is fairly standardized. It can be modified as needed, in order to suite best for the analysis of the specific question or focal issue. Further the resources handed for the scenario planning exercise affect the design of the scenario planning process.

5. Scenario planning exercise

In this chapter scenario planning is performed to address the research questions presented in chapter 1. The scenario planning exercise is performed on the basis of the literature reviews in chapters 3 and 4. Structured interviews are conducted additionally. The scenario planning exercise in this chapter will follow roughly the eight steps presented in chapter 4.4. in table 4-2 by Schwartz (1991, 226-233).

5.1. Execution of steps 1-5

As stated already, the scenario planning exercise in this chapter will follow roughly the steps presented by Schwartz (1991, 226-233). Before the steps can be taken, some preparatory work is necessary.

First, I produced a provisional list of uncertainties and revised this for better overview. Here all risks of the environment industry in general are taken in consideration. The list of provisional uncertainties is based on the literature review chapter 3 and includes 142 recognized risks. Possible synonymous expressions and duplicates are included in the list. The list presents the recognized risks in the order of appearance in chapter 3. The order of appearance of the provisional uncertainties assigns each uncertainty a reference number. The list of provisional uncertainties extracted from the literature review replaces the typical combination of desk research and brainstorming in groups that is often performed in exercises that have more resources in use. The list of provisional uncertainties is presented in appendix 1.

Next, I revised the provisional list of uncertainties. Duplicates and synonymous expressions were combined and reformulated so that these can be presented as one uncertainty. Also recognized risks that are too detailed for the industry level analysis were combined with suitable more general level risks. According to Ratcliffe (2002, 27) this is often done as a group exercise, but in the surrounding of this study it was done by the author. The revision and grouping of the original list allows a clearer overview of the risks affecting the environment industry. The list of uncertainties was reduced from 142 uncertainties to 36. The downsized list of provisional uncertainties is presented in appendix 2.

The downsized list of provisional uncertainties in appendix 2 is needed as inputs for the scenario planning exercise. From this point on the scenario planning exercise will follow roughly the steps presented in chapter 4.4. by Schwartz (1991, 226-233).

The focal issue

This thesis tries to answer two research questions: First, what is the market position of the Finnish origin environment industry companies in Finland and worldwide in 10 years? Second, what are the most critical uncertainties affecting the Finnish environment industry development?

Key forces in the local environment

From the downsized list of uncertainties key forces in the local environment are to be identified. This is done by the author. The local environment relates directly to the Finnish environment industry. Here the relevant market regulation and other legal measures of Finland and EU can be lifted up for further analysis. Similarly the active monetary mechanisms of Finland and EU that support the demand and development of environment technologies can be regarded as key forces in the local environment.

In the local environment the success of specific environment industry sub-sectors can be regarded as an uncertainty that affects the Finnish environment industry. For this reason the question of some specific environment industry sub-sectors being successful in the future is raised. The list of key forces in the local environment is presented in appendix 3.

Driving forces

Driving forces are macro level uncertainties that affect the Finnish environment industry by affecting the key forces in the local environment. In the literature review several mega trends were identified by the author and also other global trends that affect the world economy and the environment industry. The list of driving forces is presented in appendix 3.

Ranking by importance and uncertainty

Ranking the key forces in the local environment and the driving forces is done partly by the author and partly in the surrounding of structured interviews. By the author some of the uncertainties presented in appendix 3 are labeled as predetermined forces. This is feasible, because the predetermined forces can be directly assessed not to include a high risk. For example some mega trends and governmental policies can be expected to remain constant over the time frame of this scenario planning exercise. It can be claimed that such uncertainties are not needed to analyze further when it counts to reveal the most critical uncertainties for the Finnish environment industry.

In the list of 36 provisional uncertainties I recognized 14 predetermined forces. 22 uncertainties remained to be analyzed further. This is the state to which it was sufficient to continue with the scenario planning exercise on the basis of the literature review and rationing by the author. With the help of structured interviews the remaining 22 uncertainties are now to be ranked by importance and uncertainty.

Since this thesis is an independent student project, engaging other persons in the scenario planning exercise is challenging. For this reason direct inputs from other persons are included only in the phase where critical uncertainties are ranked by importance and level of uncertainty. Here structured interviews are conducted. I regard this as the most efficient way to utilize the valuable inputs of others for the exercise, given the resource limitations of the research. The reason for this is that the literature review already reflects the views of several researchers and industry actors. The structured interviews should help to target the known uncertainties even better for the purpose and time frame of this particular scenario planning exercise.

According to Ratcliffe (2002) unstructured, semi-structured and structured interviews are all interview types that are used in scenario planning exercises. For the purpose of further analyzing and ranking an existing list of uncertainties, I regard structured interviews as the most efficient and explicit method of interviewing. In this scenario planning exercise a survey is conducted to perform the ranking of the given uncertainties by the importance and level of uncertainty. The list of uncertainties is rigid and standardized, as the method of structured interviewing as well. According to Ratcliffe (2002, 20), in structured interviewing all the respondents are asked the same questions and response categories are limited. Structured interviewing also enabled anonymous answering that proved to be helpful in attracting respondents to the survey.

Selecting the scenario logics

The number of scenarios crafted under this exercise and the logic they follow influence the scenario planning exercise. I have decided to craft the scenarios in the form of a 2X2 matrix, where the horizontal and vertical axes represent the two most critical uncertainties. The ends of each axis represent the extremes of the most critical uncertainties. This logic is a deductive and systematic approach to scenario planning, as described earlier in chapter 4.4. This scenario logics supports well the purpose of highlighting the most critical for the Finnish environment industry. The chosen scenario logics also works well together with structured interviews conducted. The survey can be embedded to the scenarios in a traceable and logical manner.

Survey execution

Ratcliffe (2002, 28) presents a method for ranking uncertainties that supports the crafting of scenarios in the chosen logic. He suggests a survey formulary where the uncertainties are listed, and the participants will grade each uncertainty by the perceived likelihood and impact. Both variables are rated by the respondents in a scale from 1 to 5 that represents a low-high continuum. As the survey results are compiled and analyzed, a set of highly critical uncertainties should be found. This set includes uncertainties that have reached a perceived high impact for the Finnish environment industry in 2020 and simultaneously a perceived high uncertainty of occurring. From this set the two most critical uncertainties are chosen. In appendix 5 the survey formulary is presented that was used for ranking the 22 uncertainties. The survey form design is adopted from Ratcliffe (2002).

The respondents of the survey were selected so that they posses significant knowledge of the Finnish environment industry. All survey respondents have contact to the Finnish environment industry or the supportive industries in their daily work. The survey respondents included specialists, middle management and directors. They work in the private and public sectors. To the organizations that were contacted to attract respondents belonged companies, research institutions, policy makers, funding organizations and entities promoting the industry. In order to find the suitable respondents, I searched after the central working groups and associations that are involved in the research, policy making, financing and promotion of the industry in Finland. After having this done, I additionally searched after Finnish industry companies to include more opinions of large corporations and smaller companies in the study.

I contacted directly persons whose position I was aware of. For the part of the working groups, the working group member lists were accessible online, so I could make sure that potential belonged to the target group.

For the most part the respondents were contacted directly by the author by phone and asked if they are willing to participate to an online survey. After having agreed to participate, the respondents received an information letter and a link to the survey form by e-mail. The rest of the respondents were attracted through engaged contact persons of relevant working groups, who agreed to selectively inform other group members about the survey when this was possible and correct. The information letter and survey form were available in Finnish and English. The survey form is presented in appendix 5.

The above described method of attracting survey respondents was chosen, because I wanted to emphasize the quality of the survey answers over quantity. This is the recommended emphasis when interviews are conducted in the surrounding of a scenario planning exercise (Ratcliffe 2002, 26). The uncertainties evaluated by the respondents were strategic and environment industry specific, so the respondents needed to posses significant knowledge in the area of Finnish environment industry. Increasing the number of contacted persons to some extent would have been beneficial for the credibility of the research, but difficult to execute in the practice. According to Ratcliffe (2002, 26), already 5 to 20 interviews suffice for most scenario planning exercises.

Survey results

In appendices 6-8 the summary of survey results is presented. The survey was answered by 15 respondents. In the figure 5-1 the calculated averages for the 22 risks are presented as their positions in an impact-uncertainty matrix. The way impact is depicted in the matrix follows the logic of the survey form scale low (1) - high (5). Low impact is indicated by a position in the left half of the matrix and high impact respectively in the right half of the matrix. For the part of likelihood, the survey results that originally followed the scale low (1) - high (5) were re-scaled to better represent uncertainty. When measuring likelihood, the answers in the mid range are the most uncertain. In order to achieve a more logical appearance of the impact-uncertainty matrix likelihood was re-scaled to depict uncertainty on a scale low (1) - high (5). By doing this the set of most critical uncertainties can be positioned in the top-right corner of the impact-uncertainty matrix. The readability of the matrix was so improved to be more intuitive. The re-scaling logic is presented in detail in appendix 8.

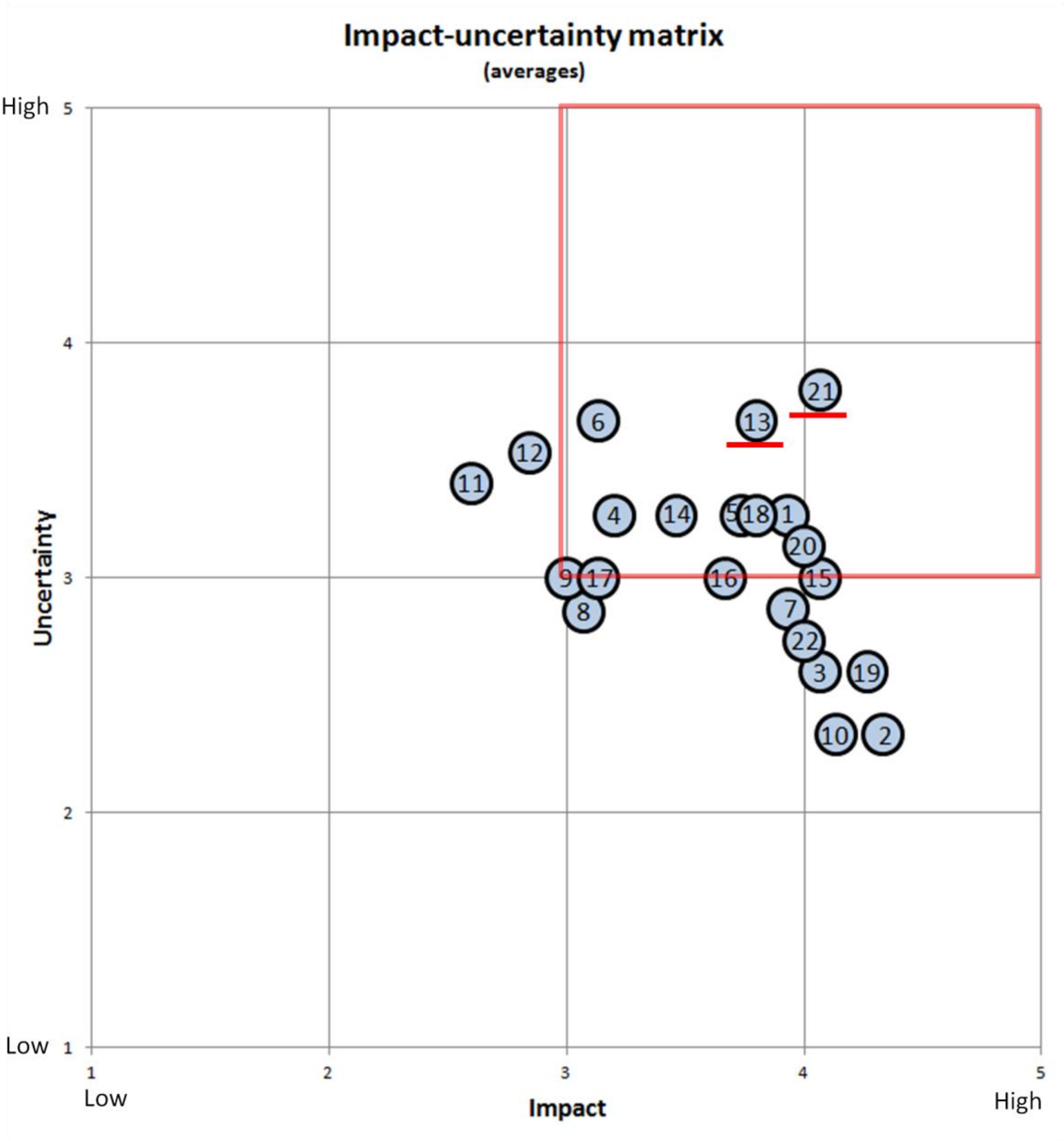

Figure 5-1. Impact-uncertainty matrix. Results of the survey, 15 survey forms submitted.

From the survey results it can be obtained that risk 13 and risk 21 showed to be the most critical ones. These are underlined with red in figure 5-1. Also other risks were classified as clearly critical by the respondents. Other risks that are clearly inside the top-right corner of the impact-uncertainty matrix are risks 1, 4, 5, 6, 14, 18 and 20. Not a single risk was classified as a low impact and low uncertainty risk, which indicates that the risks listed in the survey were relevant for the industry. In the survey formulary respondents were encouraged to avoid using the mid-range answer 3 in evaluation of the risks. The most critical risks that are located in the top-right corner of the impact-uncertainty matrix are listed for convenience in table 5-1. All the risks presented in the survey are to find with their references in appendix 4.

Table 5-1. The set of critical uncertainties.

Survey question no.	Survey question
13	Broader solutions generate more revenues for the Finnish environment industry than individual technologies
21	Expertise and structures of private financing organizations are well developed to serve the Finnish environment industry (for example banks and venture capital funds)
1	Start of a global economical upswing between 2010 and 2020
4	Environment industry is driven winningly by market mechanisms (subsidies and regulations are less meaningful)
5	Public spending, public procurement programs and tax incentives support the demand of the environment industry effectively (at least in Finland and in EU)
6	Stimulus packages, public funding and tax incentives for R&D support the environment industry effectively (at least in Finland and in EU)
14	The Finnish environment industry lacks specific specialization areas
18	Commercialization of inventions is the bottle neck of the Finnish environment industry growth (for example unwillingness to take risks and go international)
20	Effective and up-to-date legislation related to environment issues is in place in Finland

The purpose of the survey was to ensure that the scenarios are built around relevant matters that actually pose uncertainty for the Finnish environment industry. The survey results support this purpose well, and for the scenario planning analysis no deeper statistical analysis of the results is necessary. The average results of impact and likelihood re-scaled to uncertainty are to find in appendices 6 to 8.

Besides the impact-uncertainty matrix, the original survey including questions about impact and likelihood is also interesting to analyze. By the likelihood estimation such listed risks can be pointed out, that seem to be very unlikely or highly likely to realize. This information is interesting for the scenario planning exercise, because highly likely events can be the embedded as background or context to the entire set scenarios. The likelihood evaluation of risks can also indicate what type of technologies will be important for the Finnish environment industry by 2020, depending on the way the risks were presented in the survey. Next, the impact-likelihood matrix is presented in figure 5-2.

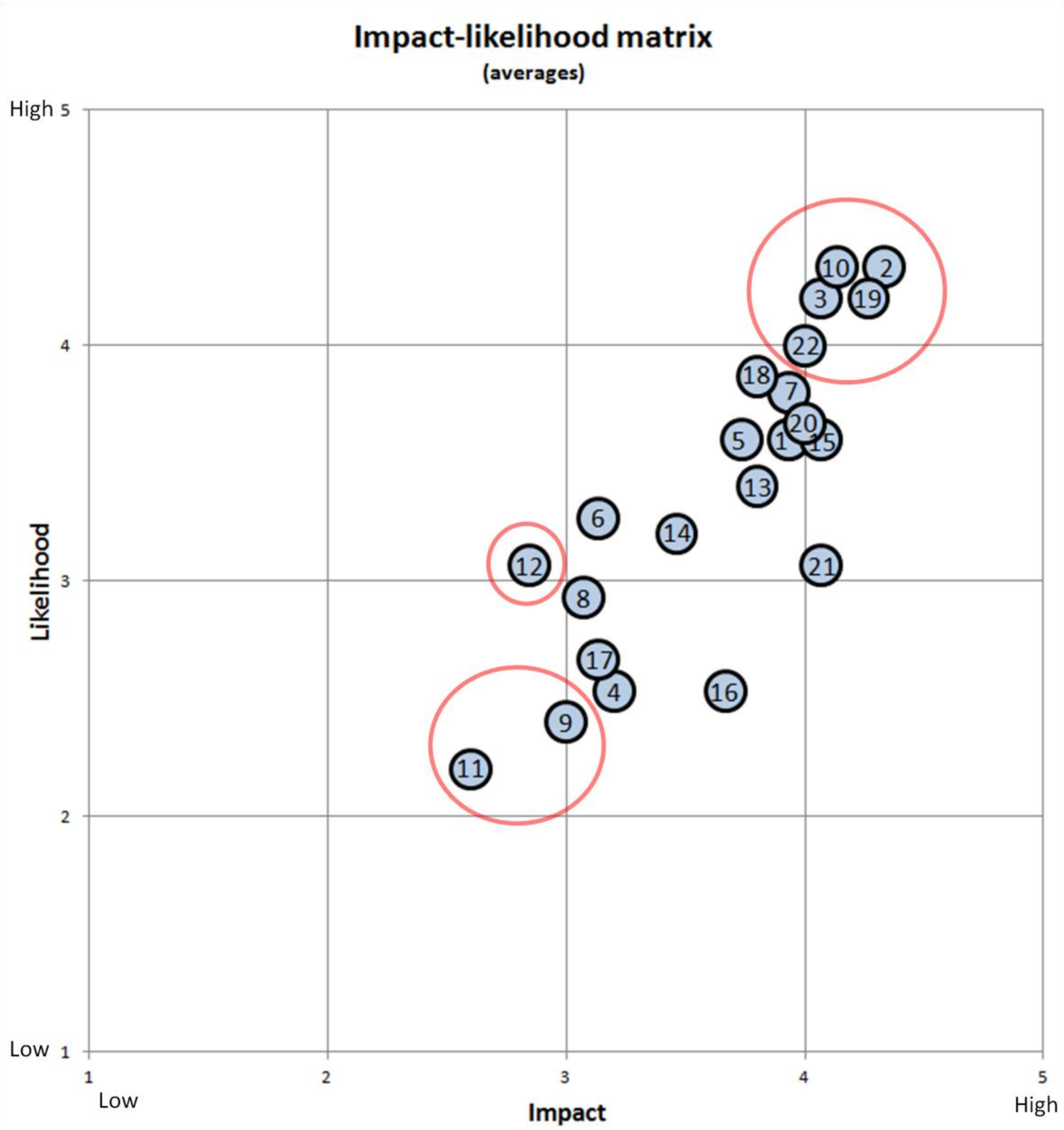

Figure 5-2. Impact-likelihood matrix. Results of the survey, 15 survey forms submitted.

From the impact-likelihood matrix in figure 5-2 it can be seen that risks that were evaluated as high impact were usually given a high likelihood as well. The dependency seems to be almost linear.

In the top-right corner of the impact-likelihood matrix such risks are found that were evaluated as very likely and high impact. Especially risks 2, 3, 10, 19 and 22 were such. These risks don´t belong to the most critical ones, because their re-scaled uncertainty of occurring is low. When looking into the other extreme of the impact-likelihood matrix, only the risks 9 and 11 were evaluated as comparably unlikely to occur. The risks that were marked with red circles in the impact-likelihood matrix are listed in the table 5-2 below.

Table 5-2. Risks of high and low likelihood.

High perceived likelihood of occurring	
Survey question no.	Survey question
2	Markets of environmental technologies develop faster than the markets in general
3	Greenhouse emissions reduction can be a profitable business
10	Bio-energy is the leading Finnish cleantech sub-sector (for example bio-fuels, power plants)
19	Developing economies are the most important revenue sources for the Finnish cleantech industry (for example newer countries of EU 27 and BRICS)
22	Breakthroughs in supportive industries, as bio-technology, chemistry, material sciences, nano-technology, engineering and ICT
Medium perceived likelihood of occurring	
12	End-of-pipe technologies are the leading technologies of the Finnish environment industry (air and water pollution control, waste management and similar)
Low perceived likelihood of occurring	
9	Wind energy is the leading Finnish cleantech sub-sector
11	Solar energy is the leading Finnish cleantech sub-sector

The likelihood of risks 9, 10 and 11 is interesting to observe with the likelihood of risk 12. Risk 12 with a perceived intermediate likelihood indicates that both cleantech and end-of-pipe technologies would remain important for the Finnish environment industry. The low perceived likelihood of risks 9 and 11 again indicates that wind and solar energy would not be significant revenue sources for the Finnish cleantech sub-sector in 2020. The high perceived likelihood and impact of risk 10 indicates high expectations for bio-energy related business to contribute to success of the Finnish cleantech industry sub-sector.

The risks from table 5-2 that were evaluated as highly likely to occur and high impact for the Finnish environment industry will be taken in account when crafting the scenarios. These risks 2, 3, 10, 19 and 22 will be affecting all the scenarios in the background, because the likelihood and impact evaluations are so high that these risks cannot be neglected. In the same way the risk 12 indicating a high likelihood for that neither cleantech nor end-of-pipe technologies would become dominant in the Finnish environment industry will be included in the background of all four scenarios. In one survey all aspects of the environment industry cannot be studied in great detail, so the observations related to outlooks of technology types give some indication, but by far not a complete picture. The survey results of risk 2 indicate a high likelihood for the market growth of environment industry to outperform the general market development. The survey results of risk 3 again indicate that greenhouse emissions reduction a profitable business with a high likelihood in 2020. The combined average results of impact and likelihood are to find in appendices 6 to 8.

Next, in figure 5-3 the scenario logics is depicted. The purpose of the figure 5-3 is to help the reader to understand better on which assumptions the scenarios are based. The figure 5-3 makes it more clear, which uncertainties are assumed to change between scenarios and which of them again are assumed to occur under all scenarios on the basis of the survey results. The two most critical uncertainties 13 and 21 are the axes of the 2X2 scenario matrix, and the skeletal scenarios are based on these. Additionally the six uncertainties 2, 3, 10, 19, 22 and 12 that were interpreted as high impact and high likelihood in the survey are depicted as green layers. The green layers are to interpret as a stable foundation that holds constant independent of changes in the 2 most critical uncertainties. These six uncertainties that were interpreted as high impact and high likelihood deserve attention in the scenarios due to their perceived high importance among the survey respondents and due to their relevancy to the research questions.

Also some other uncertainties that were evaluated as lower impact and less uncertain are going to be present in the fleshed out scenarios. Lower impact and lower uncertainty risks are embedded to the scenarios where suitable, but their function is rather to fulfill the scenario stories and the usage is not systematic as for the part of the two most critical uncertainties and the six high impact and high likelihood uncertainties depicted in figure 5-3.

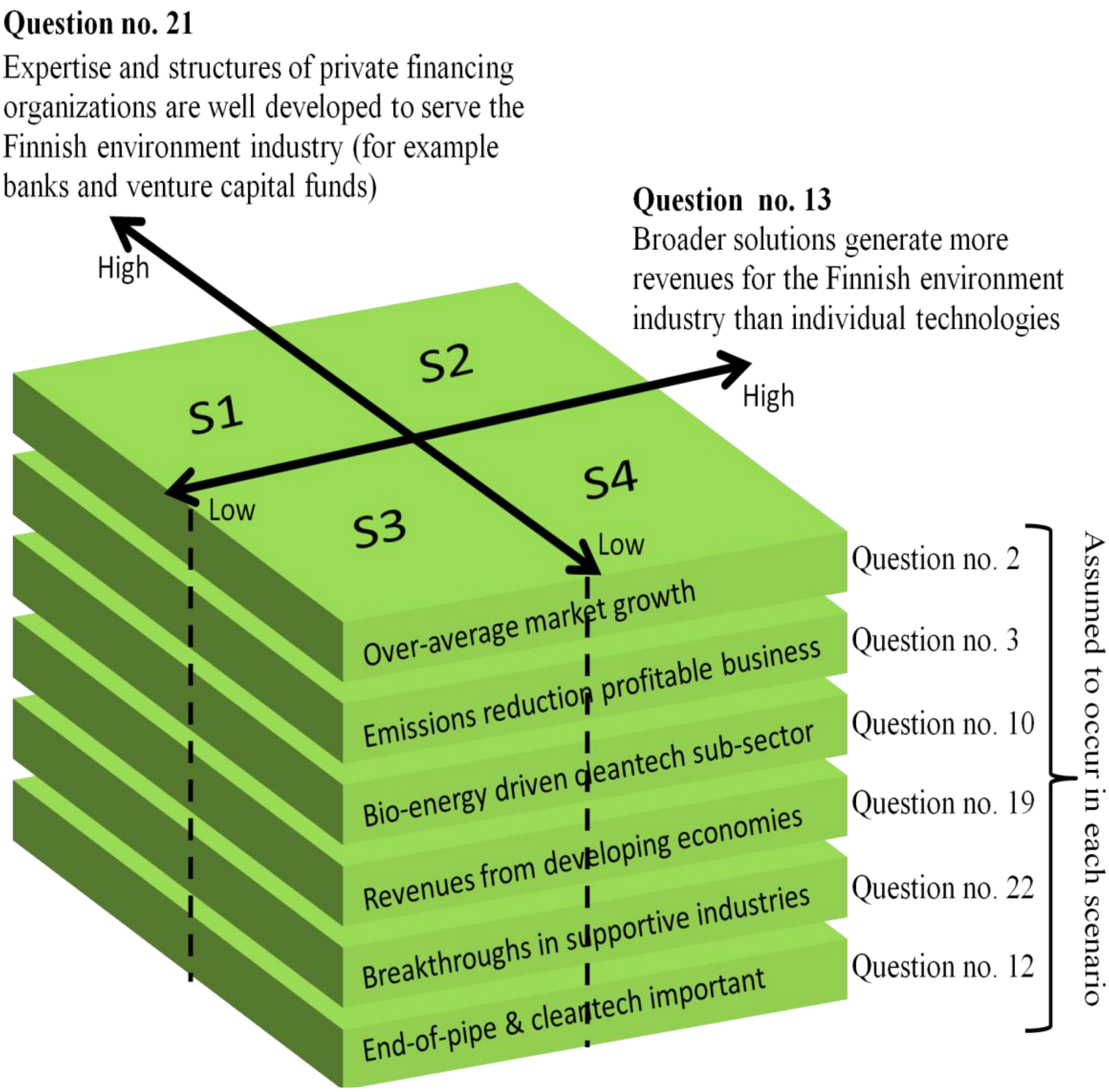

Figure 5-3. Specified scenario logics.

5.3. Execution of steps 6-8

After having determined the most critical uncertainties and having decided how to embed the gained knowledge to the scenarios it is now time to flesh them out. In this chapter the last scenario exercise steps 6, 7 and 8 are taken. These steps include writing the scenarios as well as their related implications, options and early warning signals.

First, the fleshing out of scenarios is discussed and then the final scenarios are presented. These last steps 6-8 of the scenario planning exercise differ from the steps taken so far in the sense that the steps 6-8 already present the research results, where in the steps 1-5 analysis was conducted to enable the completion of the research.

Fleshing out the scenarios, implications, options and early warning signals

Fleshing out the scenarios, implications, options and early warning signals in this stage of the scenario planning exercise is a creative writing process that is subject to boundaries according to the specified scenario logics discussed in detail already in chapters 4.4. and 5.2. and depicted in figure 5-3. By creative writing here is meant brainstorming and rationing by the author to find a way to translate the combined knowledge gained under the research into narrative form.

The scenarios in this exercise will take the form of narratives that are stories in a contextual and live form with a realistic touch. Scenarios can take for example the form of a news paper article or a video clip. In this thesis the scenarios will take the form of a short story that could be a news paper article. The titles of each scenario are designed to describe the overall state of the Finnish environment industry and to suit well to the situation of the two most critical uncertainties.

Besides the information that is gained from the literature review and the survey, recent news from the media will be used as inspiration for writing the scenarios. Despite the notion of realistic touch of the scenarios, they are not meant to present common truths. Scenarios should present out-of-box thinking and break old stereotypes. The set of four scenarios crafted in this exercise should also be coherent, so that the scenarios relate to each other in a logical way. (Garvin and Levesque 2006)

According to the logics that is used in this thesis the interpretation of the scenarios is such that all the scenarios represent a possibly emerging future. All of the scenarios can contain positive and negative aspects in them. This means that none of the scenarios can or should be labeled as best case or worst case. Similarly the used scenario logics does not represent estimates or indications of the probabilities of a scenario occurring. (Garvin and Levesque 2006)

Implications refer to the state of the Finnish environment industry companies under a given scenario. Also more specific implications related to technology type or company size can be discussed, as specified in the implication. Options are to help putting together game plans by companies, their partners and potential investors under a scenario occurring. Early warning signals are leading sign posts that can interpreted to indicate a scenario to occur. As in fleshing out the scenarios, the literature review, scenario logics, survey results and inputs from media are used for guiding the creative writing of the implications, options and early warning signals.

Next, the four scenarios are presented:

Scenario S1 - In the shadows of the global growth

According to recent statistics the global environment industry growth keeps up since 5 years now. The increased cost of pollution and raw materials, more predictable regulatory policies and the global economic upswing is reported to contribute to the growth.

All significant lenders and investors active in Finland have included services for the environment industry in their portfolios. Especially Finnish SMEs have profited from the improved capability of lenders to assess the risks and potential related to technologies and business models of the industry. According to recent studies most Finnish SMEs have not been able to realize the potential of the market situation though. SMEs continue to rely on their engineering capability as the demand driver and remain passive in reaching for international customers and in building networks able to deliver complete solutions under one brand. Promising Finnish SMEs are often acquired in early stages by large corporations and investors looking to complement their current environment industry technologies and other holdings.

Only large Finnish machinery companies with strong brands and traditions in exports have been able to realize the benefits of the market situation to some extent. These companies have set up business units for environment industry sub-sectors that support their current business. They are able cross sell to their existing customers and to attract new ones even in markets of high entry barriers. Their competitive situation is still challenged, since their offerings are narrow and more driven by technologies than comprehensive solutions.

Implications

- Increased predictability of environmental regulations enables environment industry companies to target their R&D better
- Traditionally strong exporting companies of various industry sectors have best changes to profit from environment industry growth
- The significance of the environment industry leads to increased interest of investors and lenders to get involved in the industry
- SMEs not able to find places in the value chains for solutions

Options

- Large corporations and investors to analyze if targeted acquisitions of SMEs with useful technologies and patents suit to their strategy
- Large corporations to analyze if beneficial to pursue after coordination responsibility and ownership of environment industry solutions value chains
- SMEs to plan if feasible to sell out to large corporations
- SMEs to develop a strategy to integrate themselves better into international value chains and networks
- Make plans for internationalization
- Make plans to co-operate with other companies to share development and marketing costs

Early warning signals

- Stagnating or negative growth of Finnish environment industry according to approximations based on patenting activity
- Stagnating or decreasing number of Finnish companies active in environment industry according to approximations based on patenting activity
- Only few news of orders to Finnish environment industry especially in developing economies
- Private financing organizations offer no or few services targeted to the environment industry
- Foreign multinational industry companies offering services for different industries envelope promising environment industry technologies and their customers

Scenario S2 - Sustainable success

Finnish environment industry companies are performing well in the global market place. The positive development was induced by the start of a global economic upswing in 2015 that has lead to a strong increase in the environment industry demand. Lenders and investors active in Finland have given more attention to the growing industry and significantly increased the supply of financing. This has enabled Finnish companies to develop complete environment industry solutions with their partners in Finland and internationally.

Test sites for new solutions are built in Finland more frequently that helps to demonstrate the capability of the solutions to prospective international customers. It has become easier for Finnish SMEs to win customers in international markets, because their technologies are now marketed as complete solutions with demonstrated capabilities. Large Finnish machinery and energy corporations complement to the success by selling their widening spectrum of environment industry solutions to their international customers. According to recent reports the Finnish environment industry companies can expect the growth to continue. Reasons for this are to find in their competitive solutions offerings and increasingly tightening environmental regulations.

Implications

- Finnish corporations and SMEs are competitive in their own environment industry sub-sectors in the export markets
- Finnish corporations have been able to build value chains to provide solutions
- Finnish SMEs have been able to find their places in international networks and value chains for solutions
- Environment industry is a significant export industry for Finland

Options

- Analyze feasibility of acquiring competitors to win market share and to integrate important parts of solution value chains to own organization
- Evaluate need of protecting own market position through strategic alliances and networks
- Make use of test sites built in Finland and use these as references in export markets
- Plan if improved supply of financing is sensible to use for scaling up operations

Early warning signals

- International recognition for environment industry solutions with Finnish companies involved
- Increasing market volume of environment industry
- Increasing patenting activity relevant for specific environment industry solutions
- Finnish environment industry companies acquiring others in Finland and abroad
- Increasing turnover development of both Finnish SMEs and large corporations with relatively high numbers of environemnt industry patents

Scenario S3 - Empty shell

Demand for environment industry solutions remains strong, but Finnish companies are not able to make use of the opportunity. SMEs lack the needed financial resources and know-how to commercialize their offerings as solutions with partners. Investors and lenders in Finland are not convinced of the potential of the Finnish environment industry, as proven track record of successful solution implementations is missing. Lenders and investors see the Finnish environment industry as a scattered field of technologies that do not find demand in large scale.

Many potential large Finnish corporations do not develop their environment industry offerings in a strategic manner. Despite the demand for environment industry, corporations see the industry as too small and the uncertain regulatory environment is reported to further increase their skepticism. They offer few environment technologies and solutions to the market where this is doable without significant investments and based on their existing know-how and spill-over effects. Recent reports suggest that the Finnish environment industry is not growing. Foreign corporations and networks of suppliers have been able to win significant market shares in a short period of time in the most important export markets. Some Finnish SMEs have been recently acquired by foreign competitors for low prices.

Implications

- Finnish companies lose market share in a growing market
- Foreign competitors will overtake market positions
- Finnish SMEs suffer under financing problems
- Very limited resources for long term R&D and internationalization
- Finnish corporations withdraw from the market
- Many SMEs with promising technologies are sold to foreign investors for inexpensive prices

Options

- Develop a plan to build strategic networks and alliances to share solutions development cost and to create and protect important partnerships
- Plan a program to acquire companies with useful technologies for targeted use in solution value chains if finances allow
- Start building environment industry brands to improve competitive position and to pursue after growth

- Make use of experiences and existing customers of other products in export markets
- Plan a controlled exit to reduce harms if hopeless

Early warning signals

- Low international visibility of solutions with Finnish companies involved
- Statistics on patenting activity indicate continuous lack of specialization areas of the Finnish environment industry
- Statistics indicate decreasing R&D investments and funding in environment industry in Finland
- Increased aqcuisition activities of foreign actors in Finland related to environment industry companies
- Negative turnover development of Finnish corporations and SMEs having significant portions of their patents in environmental technologies

Scenario S4 - Corporations lead the way

Demand for environment industry continues in a steady rise in 2020. The growth keeps up despite the continuously unstable world economy, because companies through all industries experience severe pressures to cut down their cost. Analysts say that especially energy and raw material consumption is tried to cut down. The increased volume of the environment industry and the need to find new revenue sources attracts now large Finnish corporations from several industries. Earlier we have used to see mostly SMEs working in the area in a far smaller scale. Finnish SMEs have tried to enlarge their operations to abroad and to put together value chains with partners to provide complete solutions, but the notoriously scarce supply of private financing and lack of knowledge in international business has lead most of the projects to fall apart.

Large corporations again have been seen to acquire SMEs and patents of environment technologies. Large corporations have started through with business units that are dedicated to deliver environment industry solutions and services in large export markets. Recent reports verify that Finnish SMEs are not able to win customers with their scattered and individual technology offerings in Finland or abroad where solutions providers are able to do this.

Implications

- Finnish corporations of different industries are dedicated and competitive in the global environment industry markets
- Environment industry is a significant export industry for Finland
- SMEs loose significance in the industry
- SMEs struggle with financing

Options

- SMEs to throw a plan for feasible co-operations that would help to set a foothold in the market
- SMEs to put effort in networking and joined brand building to leverage credibility among prospective customers and financers
- Corporations to put effort in R&D and brand building in order to compete for market positions under the influence of uncertain global economy
- SMEs to develop a plan to map and reserve the market niches not interesting for large corporations

Early warning signals

- Finnish corporations acquire environment industry related Finnish and foreign SMEs in increasing numbers
- Ownership of Finnish environment technology patents even more consolidated
- Significant decrease in number of applications for public R&D funding by environment industry SMEs
- Negative turnover development of SMEs with environment technology patents

5.4. Summary

In chapter 5 the scenario planning exercise was performed. Performing of the exercise lead to the research results of this thesis. The exercise resulted in scenarios and their related implications, options and early warning signals. These were based on the logics where a comprehensive list of uncertainties was downsized and ranked to lift up the most critical uncertainties to the Finnish environment industry. The task proved to be challenging as many uncertainties showed themselves as relevant and influential, and these all could not be included in scenarios that were to remain readable and coherent.

As a summary it can be said that the Finnish environment industry seems to subject uncertainties that are known from other Finnish industries as well. Especially the commercialization of the well engineered technologies to attractive solutions is critical. Second, the capability of private lenders and investors in Finland to handle and service the environment industry is critical for the industry, especially for SMEs.

6. Conclusions

In this chapter the thesis is concluded. For the part of practical consequences implications, options and early warning signals were already discussed in chapter 5.3.
The evaluation and applicability of the scenario exercise is discussed in this chapter. The research results are reflected to earlier research and suggestions for further research are given.

6.1. Evaluation and applicability of the scenarios

As discussed earlier in chapter 4.5. evaluation of scenarios is not quite straight forward. Researchers suggest scenarios have to lead to action, be able to recognize important risks and be credible and coherent. If the scenarios of thesis will lead to action, and if the risks recognized are the right ones can be evaluated under the timeframe of the scenarios until 2020. The credibility of the scenarios in this thesis was tried to ensure by conducting thorough literature reviews that allowed a wide range of risks to be recognized from earlier relevant research. Also the survey with carefully selected respondents should strengthen the credibility of the scenarios, because the scenarios are based on the survey results. The coherency of the scenarios was tried to ensure by the author. This was done by making it clear in figure 5-3, which risks are present in which scenarios and by ensuring that the scenarios and their interaction are logical.

One central aspect of scenarios is their applicability. In this exercise regional industry level analysis was conducted of the Finnish environment industry. Porter (1985) claimed that this level of scenario planning is too general for concrete decision making. I tried to include company perspective to the implications and options in order to bring the scenarios closer to firm level from the more general industry level. When thinking about the applicability of the scenarios to companies, the question of applicability of the scenarios in specific environment industry sub-sectors and different sizes of companies is raised. I have tried to include implications and options for SMEs and large corporations. The applicability to specific environment industry sub-sectors is intentionally left without close analysis in the narratives and in this sense the scenarios stay on a general industry level. This is due to the large number of greentech and cleantech sub-sectors that can play a role for the Finnish environment industry. Indication of the potential of the bio-energy sector was obtained from the survey results and included in all scenarios in the background, but this alone does not entitle to rule out the potential of other sub-sectors that were not given attention in the survey. Here the development and production of bio-fuels and power plants could be realistic in the light of the literature review. In one exercise all aspects of the industry cannot be perfectly covered due to the large amount of information to process. For this reason it is feasible to conduct scenario planning on a specified level of analysis, and proceed to more detailed analysis in the surrounding of another exercise in the next level.

Because the survey played a central role in the scenario planning exercise, its quality has an effect to the quality of the entire exercise. The number of survey respondents (15) could have been higher, even if Ratcliffe (2002) suggested 5 to 20 interviews of good quality to be sufficient for most scenario planning exercises. A higher number of respondents could have increased the credibility of the scenarios. The quality of survey respondents was given a high emphasis in this study, and this target was achieved. All respondents possess significant knowledge of the Finnish environment industry.

The survey design itself affects the quality of the survey results. By encouraging the respondents to avoid intermediate answers in the 1-5 scale, it was aimed to achieve clearer differences between assessed uncertainties. This was achieved, but the survey results showed a nearly linear dependence between likelihood and impact, where most of the uncertainties were at least close of being assessed as both high impact and high likelihood. The minimal number of risks assessed as low impact/low likelihood indicates that the survey questions were relevant. The low number of risks assessed as low impact/high likelihood and high impact/low likelihood can be interpreted in the same way. On the other hand the large number of risks that were assessed as high impact/high uncertainty meant that many of the risks could have been feasibly labeled as the two most critical uncertainties. As so many risks were relevant for the scenarios, it became difficult to leave some of these out of further analysis, which again was necessary in order to keep the scenarios understandable, accountable and coherent. Even scenarios cannot handle large numbers of variables without complications.

The survey respondents gave feedback of the survey that revealed also room for improvement in the survey. One respondent regarded the impact variable as unintuitive or other ways difficult to interpret. One respondent wished that that the survey questions would have been more precise. For example if investments in Finland or Finnish exports were meant when asked about the possible leading position of the cleantech sub-sector. One respondent made a notion of the lack of questions related to Finland´s competitive taxation position as a market for venture capital investments. On the other hand one respondent noted that the survey questions were relevant. Under phone calls the study was regarded as interesting and timely by many of the persons contacted. All contacted persons agreed to participate in the survey or gave advice for finding a more suitable contact person.

6.2. Reflections to earlier research

The research results of this thesis are well aligned with the earlier research presented in chapter 3. This is only natural, because the scenario planning exercise and the survey questions were based on the thorough literature review that in total includes the claims and arguments of tens of researchers and other experts of the global economy and the environment industry. The strength of the research in this thesis was to combine this vast amount of information and lift up the most interesting questions and risks from a list of 142 preliminary uncertainties. It is noticeable, how earlier research and reports have presented as results relatively high numbers of factors to consider when the future of the industry is tried to foresee. This might have lead to an understanding that the issues of the Finnish environment industry are especially complicated and difficult to tackle.

In this thesis the issues of the Finnish environment industry where presented mainly as two critical uncertainties in figure 5-1. These most critical uncertainties revealed that the Finnish environment industry suffers from the same problems as any other Finnish industry sector. Commercialization and financing issues are known hurdles to come over for the Finnish companies in general.

6.3. Suggestions for further research

Environment industry companies, their potential partners and investors can make use of the outputs of this scenario planning exercise and use them as inputs in their more specific scenario planning exercises or analysis of other kind. The survey and its results are given in detail in the appendices, so that the data can be used for other types of analysis as needed. Other recent environment industry studies that could be helpful for sub-sector and company specific analysis represent for example “The future of cleantech - online brainstorming” (Finpro 2012).

The way scenario planning was performed in this thesis could be interesting for organizations that want to conduct their own scenario planning exercises. The conducted literature review of environment industry can be updated under time and the resource efficient method of conducting the scenario planning exercise suits also for smaller organizations. In this thesis alternative methods for scenario planning are presented, so organizations can easily modify the exercise according to their preferences.

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APPENDICES

Appendix 1 - Provisional list of uncertainties

Provisional uncertainties identified in Chapter 2. Presented in the order of appearance in the chapter.

Innovation activity (2.3.)

1. Development of foresight and anticipation frameworks (Rau et al. 2010)
2. Technologies with different degrees of complexity, lengths of investment cycles and technology specific risks (Rau et al. 2010)
3. Pace of cleantech innovation deployment (Rau et al. 2010)
4. Wind energy and photovoltaics global capacity increase (Rau et al. 2010)
5. Time-to-market of cleantech innovations (Rau et al. 2010)
6. Long and unclear time-to-market leads to higher perceived risk of investment (Rau et al. 2010)
7. Dependency of cleantech industry on newly developed technologies (Rau et al. 2010)
8. Ability to commercialize inventions into innovations (Rau et al. 2010)
9. Dependency of patenting activity and technology employment (Palmberg & Nikulainen 2010)
10. For the part of environmental technologies increased patenting activity of air pollution control and renewable energy (Palmberg & Nikulainen 2010)
11. For the part of renewable energy increased patenting activity of solar power, wind power, biomass globally (Palmberg & Nikulainen 2010)
12. Stagnating global patenting activity of ocean power, geothermal power and hydro power (Palmberg & Nikulainen 2010)
13. Declining global patenting activity of solid waste management and water pollution control (Palmberg & Nikulainen 2010)
14. Finland is relatively well positioned in the environment technologies patenting activity in the overall comparison (Palmberg & Nikulainen 2010)
15. Finland is lacking specialization areas in environmental technology patenting (Palmberg & Nikulainen 2010)
16. Low numbers of patents granted at a time for a technology indicate the timely emergence of breakthrough innovations (Korotayev et al. 2011)
17. High numbers of patents granted at a time for a technology indicate improvements for existing technologies being developed (Korotayev et al. 2011)

Long waves of economy (2.4.)

18. Current economic and financial crisis (Gore 2010)
19. Reorientation of the economy will take place (Gore 2010)
20. A new Kondratieff cycle will start (Gore 2010)
21. Redirection of global development to facilitate new technological forces and geography (Gore 2010)
22. Upcoming technological revolution lacks the capability for significant innovations (Gore 2010)
23. New technological revolution will be delayed or derailed
24. Income inequalities (Gore 2010)
25. Increasing influence of finance sector (Gore 2010)
26. Inertia in business practices (Gore 2010)
27. Underdeveloped international regimes (Gore 2010)
28. Start of a global economical upswing between now and 30 years (Gore 2010)
29. Mitigation of climate change is imperative (Gore 2010)
30. Existence of profitable opportunities for greenhouse emissions reduction (The Natural Edge Project 2005)
31. Environment industry as a lead industry starting a new Kondratieff cycle (FIF 2007; Lovio et al. 2011)
32. Cleantech industry development comparable to past IT and ICT industry development (FIF 2007)
33. Current economical crisis as opportunity to support policies that enable radical system level innovation (Tekes 2011)
34. Radical system level innovation needed to reach green growth (Tekes 2011)

Global growth drivers and barriers (2.5.)

35. Globalization (FIF 2007)
36. Climate change (FIF 2007)
37. Urbanization (FIF 2007)
38. Growing middle class and population in developing countries (FIF 2007)
39. Wastage of natural resources (FIF 2007)
40. High prices and shortages of energy and raw materials (FIF 2007)
41. Scarcity of fresh water (FIF 2007)
42. Bio-technology (OECD 2010)

43. Chemistry (OECD 2010)
44. Material sciences (OECD 2010)
45. Nano-technology (OECD 2010)
46. Engineering (OECD 2010)
47. Breakthroughs in supportive industries (FIF 2006)
48. Deregulation of the energy sector (FIF 2006)
49. Aggressive rise in the oil and gas prices (FIF 2006)
50. Scarcity of natural resources (FIF 2006)
51. Aging of the water and energy infrastructure (FIF 2006)
52. Increased competition in the global markets driving towards efficiency in use of resources and cost efficiency (FIF 2006)
53. Consumer awareness of origin of products (FIF 2006)
54. Demands for the life-cycle management of products (FIF 2006)
55. Companies recognize positive effects of successful control of environmental issues to economical results or to share price development (Morgan Stanley & Oekom Research 2004; WEF 2004)
56. Corporations becoming more active in cleantech innovations (Cleantech Group 2011 b)
57. High potential for productivity increases in energy efficient building, municipal water leakage, iron and steel efficiency, electric and hybrid vehicle, end-use steel efficiency and power plant efficiency (McKinsey 2011)

Size (2.6.)

58. Growth of Asian environment markets, especially China (FIF 2006)
59. Growth of newer markets of the expanded EU 25 (FIF 2006)
60. Markets of environmental technologies develop faster than the markets in general (Ecotec 2002)
61. Cleaner technologies are the fastest growing technology type in the global environment industry (FIF 2006)
62. In developing countries end-of-pipe technologies continue as dominant environment technologies (FIF 2006)
63. In developed countries cleaner technologies continue as dominant environment technologies (FIF 2006)
64. Foreign activities contributed to one third of the Finnish industry turnover (FIF 2006)
65. Finnish environment industry growth is improving (FIF 2007)

66. Finnish environment industry growth lacks behind international industry development (FIF 2006)
67. New environmental technologies are being developed continuously in Finland (FIF 2007)
68. Advanced know-how in environmental technologies exist in Finland (FIF 2007)
69. More customer and market oriented activities in exports are taking place (FIF 2007)
70. Networking and clustering in the scattered industry is developing (FIF 2007)
71. Growth of the Finnish environment industry lies for the most part on the success of few internationally active companies (FIF 2007)
72. SMEs in the Finnish environment industry are weak (FIF 2007)
73. SMEs have problems with exports (FIF 2007)
74. SMEs lack know-how in trade (FIF 2007)
75. Fragmented nature of the environment industry hinders growth (FIF 2007)
76. Unwillingness of national markets to adopt new innovations hinders environment industry growth (Lovio et al. 2011)
77. Commercialization of new technologies is the bottle neck for Finnish companies (FIF 2006)
78. Rapid expansion abroad is necessary due to the small home market (Herlevi 2011)

Public involvement (2.7.)

79. Environment business is increasingly driven by market mechanisms (FIF 2007)
80. Regulations and incentives from the authorities remain important for the environment business (FIF 2007)
81. Tightening legislation and international agreements are central methods of governments to support the environment industry development (FIF 2006)
82. North-South exchange (Dechezleprêtre et al. 2010)
83. South-South transfers (Dechezleprêtre et al. 2010)
84. Development of environmental regulations in developing countries (Dechezleprêtre et al. 2010)
85. Removing of trade barriers in developing countries (Dechezleprêtre et al. 2010)
86. Relaxing of constraints on foreign direct investments in developing countries (Dechezleprêtre et al. 2010)
87. Stressing intellectual property rights in developing countries (Dechezleprêtre et al. 2010)

88. Governmental support of cleantech innovation in Finland (Herlevi 2011)
89. Finland only a test market (FIF 2007)
90. Early stage financing (Herlevi 2011)
91. Demand-side policy instruments (Hug 2009)
92. Chicken and egg problem (Hug 2009)
93. Public procurement programs (Hug 2009)
94. Public spending (EU 2011)
95. Green procurement (EU 2011)
96. Strength of venture capital funds in Finland (FIF 2007)
97. Ability of business proposals that are based on the markets generated by regulatory mechanisms or governmental subsidies to convince investors (FIF 2006)
98. Financing issues in the private sector (Hug 2009)
99. Banks and traditional lenders have structures for working with environmental technology companies (Hug 2009)
100. Tax incentives are put in place in order to generate financing (FIF 2007)
101. Broader understanding of environmental issues is achieved at all levels (FIF 2007)
102. Environmental stimulus packages (Palmberg & Nikulainen 2010)
103. Trend of renewable energy (Palmberg & Nikulainen 2010)
104. Public R&D funding lifting specific technologies as leading ones in Finland (Palmberg & Nikulainen 2010)
105. Energy efficiency as the most timely cleantech sub-sector (Cleantech Group 2011 b)
106. Broader cleantech and energy efficiency solutions become more important (Cleantech Group 2011 b)
107. Importance of energy, water and air quality grows (Cleantech Group 2011 b)

Finnish focus areas (2.8.)

108. The Finnish industry is active in wind, biomass, clean processes and energy efficiency (Herlevi 2011)
109. Good engineering capability is handed in Finland (Herlevi 2011)
110. Good co-operation between companies, research and administration (FIF 2006)
111. Demanding home market forces efficiency and innovativeness (FIF 2006)
112. Strong technological know-how in several sub-sectors (FIF 2006)
113. Good state of environment in international comparison (FIF 2006)

114. Good surroundings for innovation created by goal-oriented and flexible regulatory policy of Finland (FIF 2006)
115. Environmental issues spread under several ministries from administrative view (FIF 2006)
116. Lack of financing for start-ups (FIF 2006)
117. Narrow home market (FIF 2006)
118. Only few technology related services (FIF 2006)
119. Unwillingness to pay for environment (FIF 2006)
120. Unwillingness to take risks and go international (FIF 2006)
121. Politically seen environmental technologies are an opportunity to improve competitiveness (FIF 2006)
122. Internationalization of SMEs can have much potential (FIF 2006)
123. Good level of know-how in systems and integration possibilities (for example in IT) (FIF 2006)
124. Exploiting the good environmental reputation of Finland (FIF 2006)
125. Shortsighted politics/ too strong emphasis on regional policy (FIF 2006)
126. Stuck in the traditional successful companies and sectors (FIF 2006)
127. R&D investments of companies reduced due short sighted profit maximizing
128. Inability to make a difference between matters that are more and less important for the environment (FIF 2006)
129. Sound environmental image of Finland (FIF 2007)
130. Early recognition of environmental priorities in Finland (FIF 2007)
131. Large capacity of Finland as a society to handle environmental issues and challenges (FIF 2007)
132. Finland as a good laboratory and test market (Hulkkonen 2011)
133. Well-developed ICT cluster of Finland (Hulkkonen 2011)
134. Unique co-operation between universities and companies (Hulkkonen 2011)
135. Weaknesses of Finnish companies in international business knowledge (FIF 2007)
136. Transformation of new ideas into profitable business is the bottle neck (FIF 2007)
137. Lack of innovativeness as a first market (FIF 2007)
138. Finland is lacking a clear and explicit strategy and policy for greener growth despite many initiatives (Lovio et al. 2011)
139. Environment industry companies are dispersed due to the newness of the sector (FIF 2007)

140. Competitive advantage for Finnish companies through improved network-based co-operation (FIF 2007)
141. Biofuels, electric vehicles and renewable energy as potential cleantech sub-sectors for Finland (Lovio et al. 2011)
142. Finland is lacking a specific specialization profile, where other countries as Austria, Australia, Denmark and the UK have developed such (Lovio et al. 2011)

Appendix 2 - Downsized list of provisional uncertainties

In this dowsized list of provisional uncertainties douplicates and synonymoys expressions are combined under the same uncertainty and uncertainties are regrouped.

Reference numbers	**Uncertainties**
51	Aging of the water and energy infrastructure
4, 10, 11, 12, 13, 103, 107, 108	Bio-energy is the leading Finnish cleantech sub-sector (for example biofuels, power plants)
7, 42, 43, 44, 45, 46, 47, 123, 133	Breakthroughs in supportive industries, as bio-technology, chemistry, material sciences, nano-technology, engineering and ICT
34, 106, 118	Broader solutions generate more revenues for the Finnish environment industry than technology
36	Climate change
64, 65, 66, 67, 68, 69, 77, 109, 120, 135, 136	Commercialization of inventions is the bottle neck of the Finnish environment industry growth (for example unwillingness to take risks and go international)
53	Consumer awareness of origin of products
54, 101	Demands for the life-cycle management of products
58, 59	Developing economies are the most important revenue sources for the Finnish cleantech industry (for example newer countries of EU 27 and BRICS)
33, 88, 114, 115, 121, 125, 138	Effective and up-to-date legislation related to environment issues is in place in Finland
13, 61, 62	End-of-pipe technologies are the leading technologies of the Finnish environment industry (air and water pollution control, waste management and similar)
31, 32	Environment industry as the lead industry globally (as for example IT/ICT since 1970s)
26, 48, 79, 97	Environmental industry is driven winningly by market mechanisms
102, 104	Environmental stimulus packages, public funding and tax incentives for R&D support the environment industry effectively

25, 90, 96, 98, 99, 116	Expertise and structures of private financing organisations are well developed to serve the Finnish environment industry (for example banks and venture capital funds)
78, 89, 111, 113, 117, 130, 131, 132, 137	Finland functions as a test market that supports rapid expansion abroad
35	Globalization
124, 129	Good environmental image of Finland contributes to the Finnish environment industry growth
39, 40, 41, 49, 50	High prices and shortages of energy, raw materials and fresh water
29, 128	Inability to make a difference between matters that are more and less important for the environment
24	Income inequalities
52, 105	Increased competition in the global markets driving towards efficiency in use of resources and cost efficiency
1, 2, 3, 5, 6, 9, 16, 17, 57, 127	Long and unclear time-to-market leads to a high perceived risk of investment
60, 61, 62, 63	Markets of environmental technologies develop faster than the markets in general
30, 119	Profitable opportunities for greenhouse emissions reduction exist
91, 92, 93, 94, 95, 100	Public spending, public procurement programs and tax incentives support the demand effectively (at least in Finland and EU)
56, 71, 72, 73, 74, 97, 122	SMEs lead the way for the Finnish environment industry growth
4, 10, 11, 12, 13, 103, 107, 108	Solar energy is the leading Finnish cleantech sub-sector
18, 19, 20, 21, 22, 23, 28	Start of a global economical upswing between 2010 and 2020
14, 15, 112, 126, 142	The Finnish environment industry lacks specific spezialization areas
70, 75, 139, 140	The Finnish environment industry structure has developed towards a network and a cluster

27, 80, 81, 84	Tightening international environment legislation and new environmental agreements
76, 82, 83, 85, 86, 87	Trade barriers in developing markets are significantly reduced (for example constraints on foreign direct investment or issues with intellectual property rights)
110, 134	Unique co-operation between universities and companies
37, 38	Urbanization and growing middle class in developing countries (for example in BRICS)
4, 10, 11, 12, 13, 103, 107, 108	Wind energy is the leading Finnish cleantech sub-sector

Appendix 3 - Provisional uncertainties classified

Here the provisional uncertainties are presented in a form, where duplicates an synonymous expressions are combined and the uncertainties are regrouped. Key forces in the local environment, driving forces and predetermined forces are separated.

Reference numbers	**Driving forces**
18, 19, 20, 21, 22, 23, 28	Start of a global economical upswing between 2010 and 2020
60, 61, 62, 63	Markets of environmental technologies develop faster than the markets in general
30, 119	Profitable opportunities for greenhouse emissions reduction exist
26, 48, 79, 97	Environmental industry is driven winningly by market mechanisms
91, 92, 93, 94, 95, 100	Public spending, public procurement programs and tax incentives support the demand effectively (at least in Finland and EU)
102, 104	Environmental stimulus packages, public funding and tax incentives for R&D support the environment industry effectively
1, 2, 3, 5, 6, 9, 16, 17, 57, 127	Long and unclear time-to-market leads to a high perceived risk of investment
29, 128	Inability to make a difference between matters that are more and less important for the environment

Reference numbers	**Key forces in the local environment**
4, 10, 11, 12, 13, 103, 107, 108	Wind energy is the leading Finnish cleantech sub-sector
4, 10, 11, 12, 13, 103, 107, 108	Bio-energy is the leading Finnish cleantech sub-sector (for example biofuels, power plants)
4, 10, 11, 12, 13, 103, 107, 108	Solar energy is the leading Finnish cleantech sub-sector
13, 61, 62	End-of-pipe technologies are the leading technologies of the Finnish environment industry (air and water pollution control, waste management and similar)
34, 106, 118	Broader solutions generate more revenues for the Finnish environment industry than technology

14, 15, 112, 126, 142	The Finnish environment industry lacks specific spezialization areas
70, 75, 139, 140	The Finnish environment industry structure has developed towards a network and a cluster
78, 89, 111, 113, 117, 130, 131, 132, 137	Finland functions as a test market that supports rapid expansion abroad
56, 71, 72, 73, 74, 97, 122	SMEs lead the way for the Finnish environment industry growth
64, 65, 66, 67, 68, 69, 77, 109, 120, 135, 136	Commercialization of inventions is the bottle neck of the Finnish environment industry growth (for example unwillingness to take risks and go international)
58, 59	Developing economies are the most important revenue sources for the Finnish cleantech industry (for example newer countries of EU 27 and BRICS)
33, 88, 114, 115, 121, 125, 138	Effective and up-to-date legislation related to environment issues is in place in Finland
25, 90, 96, 98, 99, 116	Expertise and structures of private financing organisations are well developed to serve the Finnish environment industry (for example banks and venture capital funds)
7, 42, 43, 44, 45, 46, 47, 123, 133	Breakthroughs in supportive industries, as bio-technology, chemistry, material sciences, nano-technology, engineering and ICT

Reference numbers	**Predetermined forces**
51	Aging of the water and energy infrastructure
36	Climate change
53	Consumer awareness of origin of products
54, 101	Demands for the life-cycle management of products
31, 32	Environment industry as the lead industry globally (as for example IT/ICT since 1970s)
35	Globalization
124, 129	Good environmental image of Finland contributes to the Finnish environment industry growth

39, 40, 41, 49, 50	High prices and shortages of energy, raw materials and fresh water
24	Income inequalities
52, 105	Increased competition in the global markets driving towards efficiency in use of resources and cost efficiency
27, 80, 81, 84	Tightening international environment legislation and new environmental agreements
76, 82, 83, 85, 86, 87	Trade barriers in developing markets are significantly reduced (for example constraints on foreign direct investment or issues with intellectual property rights)
110, 134	Unique co-operation between universities and companies
37, 38	Urbanization and growing middle class in developing countries (for example in BRICS)

Appendix 4 - survey questions with references

Survey formulary questions numbered as in the formulary, with references.

Reference numbers	**Survey question no.**	**Survey question**
18, 19, 20, 21, 22, 23, 28	1	Start of a global economical upswing between 2010 and 2020
60, 61, 62, 63	2	Markets of environmental technologies develop faster than the markets in general
30, 119	3	Greenhouse emissions reduction can be a profitable business
26, 48, 79, 97	4	Environment industry is driven winningly by market mechanisms (subsidies and regulations are less meaningful)
91, 92, 93, 94, 95, 100	5	Public spending, public procurement programs and tax incentives support the demand of the environment industry effectively (at least in Finland and in EU)
102, 104	6	Stimulus packages, public funding and tax incentives for R&D support the environment industry effectively (at least in Finland and in EU)
1, 2, 3, 5, 6, 9, 16, 17, 57, 127	7	Long and unclear time-to-market leads to a high perceived risk of investment (in and outside of Finland)
29, 128	8	Inability to make a difference between matters that are more and less important for the environment
4, 10, 11, 12, 13, 103, 107, 108	9	Wind energy is the leading Finnish cleantech sub-sector
4, 10, 11, 12, 13, 103, 107, 108	10	Bio-energy is the leading Finnish cleantech sub-sector (for example bio-fuels, power plants)
4, 10, 11, 12, 13, 103, 107, 108	11	Solar energy is the leading Finnish cleantech sub-sector

13, 61, 62	12	End-of-pipe technologies are the leading technologies of the Finnish environment industry (air and water pollution control, waste management and similar)
34, 106, 118	13	Broader solutions generate more revenues for the Finnish environment industry than individual technologies
14, 15, 112, 126, 142	14	The Finnish environment industry lacks specific specialization areas
70, 75, 139, 140	15	The Finnish environment industry structure has developed towards a network and a cluster
78, 89, 111, 113, 117, 130, 131, 132, 137	16	Finland functions as a test market that supports rapid expansion abroad
56, 71, 72, 73, 74, 97, 122	17	SMEs lead the way for the Finnish environment industry growth
64, 65, 66, 67, 68, 69, 77, 109, 120, 135, 136	18	Commercialization of inventions is the bottle neck of the Finnish environment industry growth (for example unwillingness to take risks and go international)
58, 59	19	Developing economies are the most important revenue sources for the Finnish cleantech industry (for example newer countries of EU 27 and BRICS)
33, 88, 114, 115, 121, 125, 138	20	Effective and up-to-date legislation related to environment issues is in place in Finland
25, 90, 96, 98, 99, 116	21	Expertise and structures of private financing organizations are well developed to serve the Finnish environment industry (for example banks and venture capital funds)
7, 42, 43, 44, 45, 46, 47, 123, 133	22	Breakthroughs in supportive industries, as bio-technology, chemistry, material sciences, nano-technology, engineering and ICT

Appendix 5 - Survey form

Survey form - Finnish environment industry in 2020

The research is about the future prospects of the Finnish environment industry in 2020. You are asked to evaluate the listed trends and uncertainties. These are to evaluate in the context of the Finnish environment industry.

The parameters used for evaluation are impact to the Finnish environment industry and likelihood of happening. Please try to minimize the use of 3 as a level of rating.

Impact to the Finnish environment industry

5 = most important/ very high impact	4 = important / high impact
3 = modest importance	2 = unimportant / low impact
1 = Trivial	

Likelihood of happening

5 = most certain by 2020	4 = likely
3 = as likely as not	2 = unlikely
1 = almost impossible by 2020	

First I would like to ask what is your area of work and position:

Your area of work or industry ________________________________

Your position ____

1. GLOBAL TRENDS

no.	Issue / trend by 2020	Impact (1=low to 5=high)	Likelihood (1=low to 5=high)
1	Start of a global economical upswing between 2010 and 2020		
2	Markets of environmental technologies develop faster than the markets in general		
3	Greenhouse emissions reduction can be a profitable business		
4	Environment industry is driven winningly by market mechanisms (subsidies and regulations are less meaningful)		
5	Public spending, public procurement programs and tax incentives support the demand of the environment industry effectively (at least in Finland and in EU)		
6	Stimulus packages, public funding and tax incentives for R&D support the environment industry effectively (at least in Finland and in EU)		
7	Long and unclear time-to-market leads to a high perceived risk of investment (in and outside of Finland)		
8	Inability to make a difference between matters that are more and less important for the environment		

These technologies are to be observed individually. It is tried to find out, which of these technologies are more and less likely to be influential for the Finnish environment industry. In 2020...

no.	**2. SELECTED TECHNOLOGIES** **Issue / trend by 2020**	**Impact (1=low to 5=high)**	**Likelihood (1=low to 5=high)**
9	Wind energy is the leading Finnish cleantech sub-sector		
10	Bio-energy is the leading Finnish cleantech sub-sector (for example bio-fuels, power plants)		
11	Solar energy is the leading Finnish cleantech sub-sector		
12	End-of-pipe technologies are the leading technologies of the Finnish environment industry (air and water pollution control, waste management and similar)		
13	Broader solutions generate more revenues for the Finnish environment industry than individual technologies		

no.	3. GOVERNANCE, FUNDING AND LEGISLATION **Issue / trend by 2020**	**Impact (1=low to 5=high)**	**Likelihood (1=low to 5=high)**
14	The Finnish environment industry lacks specific specialization areas		
15	The Finnish environment industry structure has developed towards a network and a cluster		
16	Finland functions as a test market that supports rapid expansion abroad		
17	SMEs lead the way for the Finnish environment industry growth		
18	Commercialization of inventions is the bottle neck of the Finnish environment industry growth (for example unwillingness to take risks and go international)		
19	Developing economies are the most important revenue sources for the Finnish cleantech industry (for example newer countries of EU 27 and BRICS)		
20	Effective and up-to-date legislation related to environment issues is in place in Finland		
21	Expertise and structures of private financing organizations are well developed to serve the Finnish environment industry (for example banks and venture capital funds)		
22	Breakthroughs in supportive industries, as bio-technology, chemistry, material sciences, nano-technology, engineering and ICT		

Submitting of the formulary and comments

If you wish, you can write comments and critique below. The filled in formulary is submitted by pressing the button "Submit" below.

Research results
If you type your e-mail address in the relevant field below, you will receive a direct link to the finished research paper after its publication.

Confidentiality
Your survey answers are not directly traceable to your person or organization. The survey results will be presented only in compiled form, from which the answers given by individuals cannot be separated.

Thank you for your effort! Without you answering to the survey the empirical part of the study could not be completed.

Contact information
Tero Kajander
e-mail tero.kajander@aalto.fi
mobile 050-3007633

Here you can write comments and critique

Your e-mail address ____

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Kyselylomake - Suomen ympäristöteollisuus vuonna 2020

Tutkimus keskittyy Suomen ympäristöteollisuuden näkymiin vuonna 2020. Teitä pyydetään arvioimaan 22 trendiä ja epävarmuustekijää skaalalla 1-5. Arvioitavana on vaikuttavuus Suomen ympäristöteollisuuteen ja tapahtuman todennäköisyys. Yrittäkää minimoida 3:n käyttöä vastatessa.

Vaikuttavuus Suomen ympäristöteollisuuteen
5 = erittäin suuri vaikutus / erittäin tärkeä
4 = suuri vaikutus / tärkeä
3 = kohtalainen vaikutus
2 = ei tärkeä / vähäinen vaikutus
1 = mitätön vaikutus

Todennäköisyys tapahtumalle
5 = erittäin todennäköistä vuonna 2020
4 = todennäköistä
3 = yhtä todennäköistä kuin epätodennäköistä
2 = epätodennäköistä
1 = lähes mahdotonta vuonna 2020

Kysely on jaettu kolmeen osioon:
1. Globaalit trendit
2. Valittuja teknologioita
3. Hallinto, rahoitus ja lainsäädäntö.

Aluksi kysymme taustatiedoksi toimialanne ja asemanne:

Toimialanne ____

Asemanne____

1. GLOBAALIT TRENDIT

nro	Teema / trendi vuonna 2020	Vaikuttavuus (1=matala, 5=korkea)	Todennäköi-syys (1=matala, 5=korkea)
1	Globaali talouden noususuhdanne alkaa 2010 ja 2020 välillä		
2	Ympäristöteknologiamarkkinan kasvu on nopeampaa kuin markkinoiden yleisesti		
3	Kasvihuonepäästöjen vähentäminen voi olla voitollista liiketoimintaa		
4	Ympäristöteollisuus on enimmäkseen markkinavetoista (julkiset tukitoimet ja säännöstely vähemmän merkittäviä)		
5	Julkisen sektorin kysyntä ja osto-ohjelmat, sekä verokannustimet tukevat ympäristöteollisuuden kysyntää tehokkaasti (ainakin Suomessa ja EU-tasolla)		
6	Elvytyspaketit, muu julkinen rahoitus ja verokannustimet tukevat ympäristöteollisuuden tuotekehitystä tehokkaasti (ainakin Suomessa ja EU-tasolla)		
7	Ympäristöteollisuudessa tuotekehityksen (time-to-market) pitkä ja epäselvä kesto aiheuttaa sen, että sijoitusten koettu riski on korkea (sekä Suomessa että muualla)		
8	Ei osata erottaa asioita, jotka ovat enemmän ja vähemmän tärkeitä ympäristölle		

Valittuja teknologioita on tarkoitus käsitellä erillään. Tässä yritetään selvittää, mitkä teknologiat voivat olla enemmän ja vähemmän merkityksellisiä Suomen ympäristöteollisuudelle vuonna 2020.

nro	**2. VALITTUJA TEKNOLOGIOITA** **Teema / trendi vuonna 2020**	**Vaikuttavuus (1=matala, 5=korkea)**	**Todennäköisyys (1=matala, 5=korkea)**
9	Tuulienergiasektori on johtava cleantech-teollisuuden ala Suomessa		
10	Bioenergia on johtava cleantech-teollisuuden ala Suomessa (esimerkiksi biopolttoaineet ja biovoimalaitokset)		
11	Aurinkoenergia on johtava cleantech-teollisuuden ala Suomessa		
12	Piipunpääteknologiat (end-of-pipe) on johtava ympäristöteollisuuden ala Suomessa (esimerkiksi ilmansaasteiden ja veden puhdistus, jätehuolto)		
13	Laajemmat ratkaisut (solutions) tuottavat enemmän liikevaihtoa Suomen ympäristöteollisuudelle kuin yksittäiset teknologiat		

nro	**3. HALLINTO, RAHOITUS JA LAINSÄÄDÄNTÖ** **Teema / trendi vuonna 2020**	**Vaikuttavuus** **(1=matala, 5=korkea)**	**Todennäköi-syys** **(1=matala, 5=korkea)**
14	Suomen ympäristöteollisuus ei ole erikoistunut tietyille sektoreille (fokus puuttuu)		
15	Suomen ympäristöteollisuuden rakenne on kehittynyt kohti verkostoa ja klusteria		
16	Suomi toimii testimarkkinana joka tukee nopeaa laajentumista ulkomaille		
17	PK-yritykset johtavat Suomen ympäristöteollisuuden kasvua		
18	Keksintöjen kaupallistaminen on Suomen ympäristöteollisuuden kasvun pullonkaula (esimerkiksi haluttomuus riskinottoon ja kansainvälistymiseen)		
19	Kehittyvät taloudet ovat tärkein tulonlähde Suomen ympäristöteollisuudelle (esimerkiksi uudemmat maat EU 27:ssä ja Brasilia, Venäjä, Intia, Kiina, Etelä-Afrikka)		
20	Suomessa on tehokas ja ajantasainen ympäristölainsäädäntö		
21	Yksityisillä rahoittajilla on hyvä osaaminen ja rakenteet palvella Suomen ympäristöteollisuutta (esimerkiksi pankit ja riskisijoitusrahastot)		
22	Läpimurrot ympäristöteollisuutta tukevilla aloilla (esimerkiksi bioteknologia, kemia, materiaalit, nanoteknologia, insinööritieteet ja ICT)		

Lomakkeen lähettäminen ja kommentit

Halutessanne voitte kirjoittaa kommentteja ja kritiikkiä alle. Valmiin lomakkeen saatte lähetettyä painamalla sivun alareunasta "Submit".

Tietosuoja
Antamianne vastauksia ei voida yhdistää suoraan teihin tai organisaatioone. Kyselyn tulokset esitellään vain koosteina, joista ei voida erotella yksittäisen kyselyyn osallistuneen vastauksia.

Tutkimustulokset
Jos kirjoitatte sähköpostiosoitteenne sille varattuun kenttään alla, saatte suoran linkin tutkimuspaperiin kun se on julkaistu.

Kiitos vaivannäöstäsi! Ilman vastauksianne tutkimuksen empiirinen osa jäisi valmistumatta.

Yhteystiedot
Tero Kajander
e-mail tero.kajander@aalto.fi
mobile 050-3007633

Tähän voitte halutessanne lisätä kommentteja ja kritiikkiä

Sähköpostiosoitteenne ____________________________________

Appendix 6 - Statistics of impact

15 Survey forms submitted.

Number of answers in classes	*Impact*					**Answers submitted**	**Answer rate**	**Average answer**
	1	***2***	***3***	***4***	***5***			
Question no. 1	0	1	2	9	3	15	100%	**3,93**
Question no. 2	0	0	1	8	6	15	100%	**4,33**
Question no. 3	0	1	1	9	4	15	100%	**4,07**
Question no. 4	0	6	2	5	2	15	100%	**3,20**
Question no. 5	0	2	2	9	2	15	100%	**3,73**
Question no. 6	0	4	5	6	0	15	100%	**3,13**
Question no. 7	0	1	3	7	4	15	100%	**3,93**
Question no. 8	0	6	3	3	2	14	93%	**3,07**
Question no. 9	1	4	6	2	2	15	100%	**3,00**
Question no. 10	0	0	4	5	6	15	100%	**4,13**
Question no. 11	2	6	3	4	0	15	100%	**2,60**
Question no. 12	2	5	1	3	2	13	87%	**2,85**
Question no. 13	0	2	4	4	5	15	100%	**3,80**
Question no. 14	0	3	4	3	3	13	87%	**3,46**
Question no. 15	0	1	3	5	6	15	100%	**4,07**
Question no. 16	0	3	1	9	2	15	100%	**3,67**
Question no. 17	1	3	6	3	2	15	100%	**3,13**
Question no. 18	0	1	4	7	3	15	100%	**3,80**
Question no. 19	0	0	3	5	7	15	100%	**4,27**
Question no. 20	0	2	1	6	5	14	93%	**4,00**
Question no. 21	0	0	3	8	4	15	100%	**4,07**
Question no. 22	0	1	4	4	6	15	100%	**4,00**

Appendix 7 - Statistics of likelihood

15 Survey forms submitted.

Number of answers in classes	***Likelihood***					**Answers submitted**	**Answer rate**	**Average answer**
	1	***2***	***3***	***4***	***5***			
Question no. 1	0	2	2	11	0	15	100%	**3,60**
Question no. 2	0	0	1	8	6	15	100%	**4,33**
Question no. 3	0	0	2	8	5	15	100%	**4,20**
Question no. 4	1	8	4	1	1	15	100%	**2,53**
Question no. 5	0	2	5	5	3	15	100%	**3,60**
Question no. 6	0	3	5	7	0	15	100%	**3,27**
Question no. 7	0	2	2	8	3	15	100%	**3,80**
Question no. 8	1	6	1	5	1	14	93%	**2,93**
Question no. 9	3	6	4	1	1	15	100%	**2,40**
Question no. 10	0	0	1	8	6	15	100%	**4,33**
Question no. 11	2	8	5	0	0	15	100%	**2,20**
Question no. 12	1	3	6	4	1	15	100%	**3,07**
Question no. 13	0	2	7	4	2	15	100%	**3,40**
Question no. 14	0	5	3	6	1	15	100%	**3,20**
Question no. 15	1	1	3	8	2	15	100%	**3,60**
Question no. 16	3	5	3	4	0	15	100%	**2,53**
Question no. 17	2	6	3	3	1	15	100%	**2,67**
Question no. 18	0	0	5	7	3	15	100%	**3,87**
Question no. 19	0	0	2	8	5	15	100%	**4,20**
Question no. 20	1	0	5	6	3	15	100%	**3,67**
Question no. 21	0	4	6	5	0	15	100%	**3,07**
Question no. 22	0	1	3	6	5	15	100%	**4,00**

Appendix 8 - Statistics of uncertainty

Original likelihood scale as in the survey 1 (low) - 5 (high) likelihood		**Likelihood converted to uncertainty** 1 (low) - 5 (high) uncertainty
1 = almost impossible	↔	1 = low uncertainty
2 = unlikely	↔	3 = intermediate uncertainty
3 = as likely as not	↔	5 = high uncertainty
4 = likely	↔	3 = intermediate uncertainty
5 = most certain	↔	1 = low uncertainty

15 Survey forms submitted.

Likelihood converted to uncertainty

Converted answers in classes	***Uncertainty***					**Answers submitted**	**Answer rate**	**Average answer**
	1	***2***	***3***	***4***	***5***			
Question no. 1	0		13		2	15	100%	**3,27**
Question no. 2	6		8		1	15	100%	**2,33**
Question no. 3	5		8		2	15	100%	**2,60**
Question no. 4	2		9		4	15	100%	**3,27**
Question no. 5	3		7		5	15	100%	**3,27**
Question no. 6	0		10		5	15	100%	**3,67**
Question no. 7	3		10		2	15	100%	**2,87**
Question no. 8	2		11		1	14	93%	**2,86**
Question no. 9	4		7		4	15	100%	**3,00**
Question no. 10	6		8		1	15	100%	**2,33**
Question no. 11	2		8		5	15	100%	**3,40**
Question no. 12	2		7		6	15	100%	**3,53**
Question no. 13	2		6		7	15	100%	**3,67**
Question no. 14	1		11		3	15	100%	**3,27**
Question no. 15	3		9		3	15	100%	**3,00**
Question no. 16	3		9		3	15	100%	**3,00**
Question no. 17	3		9		3	15	100%	**3,00**
Question no. 18	3		7		5	15	100%	**3,27**
Question no. 19	5		8		2	15	100%	**2,60**
Question no. 20	4		6		5	15	100%	**3,13**
Question no. 21	0		9		6	15	100%	**3,80**
Question no. 22	5		7		3	15	100%	**2,73**