LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
Faculty of Technology
Degree Programme in Environmental Technology

Sanni Kontinen

GOVERNMENTAL MEASURES TO ENHANCE THE FINNISH INNOVATION SYSTEM TO RESPOND TO THE CHALLENGE OF MITIGATING CLIMATE CHANGE

Examiners Professor Lassi Linnanen
M.Sc (Tech.) Karoliina Auvinen

Instructor M.Sc. (Tech.) Karoliina Auvinen

ABSTRACT

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Governmental Measures to Enhance the Finnish Innovation System to Respond to the Challenge of Mitigating Climate Change

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Examiners: Professor Lassi Linnanen
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Climate innovations, that cover both technological applications and process and service innovations, play a key role in climate change mitigation. The purpose of this study was to examine how the Finnish innovation system could be enhanced with governmental measures so that the diffusion of climate innovations could be speeded up. During the study, it became evident that the governmental measures need to support the whole innovation chain, which comprises of research, development, demonstration and deployment. Only this can lead to the successful birth and diffusion of low carbon innovations.

The study found that the strengths of the Finnish innovation system are research and development, and the current national innovation policies strongly support these activities. However, these have been emphasised at the expense of the demonstration and deployment. Consequently, the biggest bottlenecks in the Finnish innovation landscape are the lack of pilot and demonstration projects and slow commercialisation, thus the high price of the innovation. To meet with the challenge, the government should firstly promote strict greenhouse gas emission reduction targets. This would boost up the innovation activities, which would also lower the prices of the innovations. To speed up the commercialisation process, measures that stimulate the domestic market, such as feed-in-tariffs and public procurements, are needed. Special attention should also be paid to the measures that could shift the traditional closed innovation chain towards open innovation. This means that the product development should involve experts from several fields such as the user and marketing experts to speed up the commercialisation. In addition, efficient innovation co-operation between both private and public sector is essential. Finally, as the domestic resources are not adequate for producing all the innovations needed, the domestic innovation activities should be focused on a few sectors, and at the same time promote efficient import policies.

TIIVISTELMÄ

Lappeenrannan teknillinen yliopisto
Teknillinen tiedekunta
Ympäristötekniikan koulutusohjelma

Sanni Kontinen

Valtiontoimet, joilla suomalaista innovaatiojärjestelmää voidaan vahvistaa kohtaamaan ilmastonmuutoksen hillitsemisen haaste

Diplomityö

2009

91 Sivua, 16 kuvaa, 1 taulukkoa ja 3 liitettä

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Ilmastoinnovaatioilla, jotka käsittävät sekä teknologiset ratkaisut että palvelu- ja prosessi-innovaatiot, on merkittävä rooli ilmastonmuutoksen hillitsemisessä. Tässä työssä tarkasteltiin, miten ilmastoinnovaatioiden leviämistä voitaisiin nopeuttaa valtiontoimin suomalaista innovaatiojärjestelmää vahvistamalla. Tarkastelussa selvisi, että koko innovaatioketjua, joka sisältää tutkimuksen, kehityksen, demonstraation sekä kaupallistamisen, on valtiontasolta tuettava erilaisilla tukimekanismeilla ja säädöksillä, jotta ilmastoinnovaatioiden synty ja käyttöönotto olisi mahdollisimman tehokasta.

Työssä selvisi, että Suomen innovaatiojärjestelmän vahvuuksia ovat erityisesti tutkimus ja kehitys. Suomalainen innovaatiopolitiikka perustuukin vahvasti näiden tukemiseen, mutta tutkimusta ja kehitystä on korostettu muiden innovaatio vaiheiden kustannuksella. Suurimmat pullonkaulat suomalaisessa ilmastoinnovaatioiden kehittämisessä ovat demonstraatio- ja pilottiprojektien puute, sekä innovaatioiden hidas kaupallistuminen ja korkea hinta. Haasteisiin voidaan valtion tasolta vastata tiukentamalla kasvuhuonekaasupäästörajoja, jolloin innovaatiotoiminta kehittyy alalla entisestään, mikä samalla laskee kustannuksia. Kaupallistamisen nopeuttamiseksi tarvitaan erilaisia kotimarkkinoita stimuloivia mekanismeja, kuten syöttötariffeja sekä ilmastoystävällisiä julkisia hankintoja. Erityistä huomiota tulisi kuitenkin kiinnittää suljetun innovaation kehittämiseen avoimeksi. Tuotekehitysprosessiin tulisi liittää mukaan laaja joukko asiantuntijoita, kuten asiakas sekä markkinointiosaajia kaupallistamisen tehostamiseksi. Suomessa tulisi erityisesti panostaa myös tehokkaaseen innovaatioyhteistyöhön julkisen ja yksityisen sektorin välillä. Kotimaiset resurssit eivät kuitenkaan riitä tuottamaan kaikkia tarvittavia innovaatioita ilmastonmuutoksen hillitsemiseksi. Onkin tärkeää, että kotimainen innovaatiotoiminta fokusoidaan muutamaan sektoriin ja sen lisäksi tehokasta innovaatioiden maahantuontia tuetaan.

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The Hague, The Netherlands. 30.9.2009

Sanni Kontinen

"NYT!"

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1 INTRODUCTION

Mitigating climate change is one of the greatest challenges of the modern society. The global warming is estimated to affect the whole Globe on a larger scale than any other environmental problem before. Now, as the scientific knowledge has increased significantly on the subject, it has been estimated that if the warming is not stopped at 2 degrees Celsius compared to the pre-industrial era, a vicious cycle could be generated after which a way out of it could be more or less impossible to find. The main drivers for the increase of emissions have been the increasing consumption of natural resources, growth of gross domestic product (GDP) per capita and population growth during the past three decades. The technological development especially in the energy sector has enabled the economic growth, but it has come with a heavy price, as majority of the industrial processes are based on carbon intensive fuels. Now, as the knowledge has increased on climate change and on its effects, it is essential to use the gained recourses to curb the greenhouse gas emissions. The task will be challenging, since the low carbon development faces several obstacles. One of the greatest challenges is to shift the carbon intensive processes to low carbon processes, which requires a technology revolution throughout the economy.

Accordingly, the low carbon innovations are considered to be in the core of the low carbon development. The promotion of these innovations is not, however, a simple task. The current innovation policies have mainly been designed around the national competitiveness goals, and so the low carbon innovations often lack funding and strong supporting measures. In addition, the innovations require a set of different regulatory and supportive measures, because some of the promising innovations are still in their developing stage and require research and development support, while others are more developed and need only market incentives for their commercialisation and diffusion. Efficient policies and measures would also need to attract the private sector to engage in the climate change mitigation. Accordingly, the policies should make the low businesses an attractive and profitable sector. This is why, the public sector has a key role in implementing a set of policies that could significantly speed up the low carbon development and make it a profitable business field for the domestic enterprises.

One way of supporting the climate change mitigation is to enforce the national innovation system, so that the production and diffusion of the low carbon innovations could be speeded up. This is why it is highly important that the national innovation system would be regularly analysed. The analysis should include estimates on how the innovation system actually functions at national, regional and sectoral levels. (Foxon & Pearson 2008, 157.) In the low carbon development, it would be essential that national policy makers would examine the best practises in other countries. There are numerous examples on international governmental measures that have significantly speeded up the diffusion of low carbon technologies or innovations. Even the radical innovations, which are required for climate change mitigation, have gained success with strong governmental will to support these innovations. Such an approach could allow leapfrogging where jurisdictions learn from each other and accelerate improved policy interventions (Foxon & Pearson 2008, 157).

The purpose of this study is firstly to find scientific proof to the hypothesis, that innovations and technologies play such a relevant role in the climate change mitigation. The analysis includes the very recent knowledge on climate change and on the measures that could be taken to curb the emissions. The main focus of this study, however, is on the governmental measures that could enhance the Finnish innovation system to meet the challenges of climate change. Accordingly, the theoretical framework is based on the basic theories of innovation and innovation process.

This study will concentrate especially in evaluating the strengths and weaknesses of the Finnish innovation system. The purpose is to create an understanding of the innovation system, and to present the governmental bodies in charge of the national innovation policies and the public organisations behind the innovation activities. The aim is also to evaluate the main barriers in the Finnish innovation landscape that prevent the effective diffusion of low carbon innovations. In addition, the major drivers to develop new low carbon innovations are estimated. Upon the facts found to be significant to the national innovation activities, the development suggestions will be given. The aim is to find effective international policy measures for low carbon innovations and examine how they would fit into the Finnish innovation system.

The research is mainly carried out by using two kinds of data, primary data from interviews and seminars, in addition to the secondary data from literature. The secondary data is gathered from previous researches, technical documents, application studies etc. The primary data will be collected by interviewing specialists and by attending seminars on the subject. The interviews will mainly be carried out after the literature survey and will focus especially on experts on the Finnish innovation activities. These include governmental bodies on innovation and representatives from research organisations. WWF Finland will use the results of this study in its’ political lobbying, so that efficient measures and policies, which would support the diffusion of low carbon innovations would be implemented in Finland.

The study will concentrate mainly on the Finnish innovation and technology development system and will not concentrate to a one specific low carbon innovation. No comparisons are made between different countries’ innovation systems.

2 THEORIES OF AN INNOVATION PROCESS

Innovation and innovativeness are today's buzzwords. However, there is much more to the subject than just a new product or a process. The understanding of the whole innovation process is important so that it would be possible to improve the system and its support mechanisms. Innovations are characterised with a great amount of uncertainty, and it is common that they do not get to reach the mass market. Accordingly, it would be important that the innovation process would be assessed and monitored, so that the possible bottlenecks in the process could be eliminated. Particularly it would be essential to assess and monitor the innovation process related to the climate change mitigation innovations (see Chapter 3), since they present radical solutions, services and technologies that would not reach the market without public support.

This chapter presents briefly different theories of innovation. First, traditional theories of innovation are presented. The concepts of innovation and technology innovation are clarified, in addition to the presentation of an innovation process. The innovation process consists of several different stages that require diverse support mechanisms. This is why, it is important that the whole innovation system is estimated and the large scale of the process is understood. Finally, as the old and traditional innovation thinking has offered innovators unique opportunities, it is highly important that the innovation process is altered to meet the requirements of the modern society. Accordingly, the new wave of innovation is also presented in this chapter. The new paradigm for innovation includes the concepts of open and user-led innovation.

2.1 The concept of an innovation

It is necessary to understand the concept of innovation for the further understanding of the subject. Innovation is more than just a new invention. The difference between an invention and an innovation is that an invention is creation of a new idea or a concept; however, an innovation means that the idea or concept is transferred into a commercial success or it is used extensively.

In general, innovations are fresh techniques, products, services, operating models, organizing methods or strategic approaches. Innovation can for instance be:

- A new process of production;
- Substitution of a different material - newly developed for a given task, in an essentially unaltered product;
- The organization of production;
- Internal functions or distributional arrangements leading to increasing efficiency, better support for given product of lower costs or an improvement in instruments of methods of doing innovation. (Kline & Rosenberg 1986, 279.)

In scholar literature, there are is a wide range of definitions to an innovation, but a mutual feature for these interpretations is that it is normally understood as the introduction of something new and commercially useful. (Ståhle et al. 2004, 11.)

The impact of an innovation varies considerably depending on the concept of the innovation and unfortunately, the effects of innovation are hard to measure (Kline & Rosenberg 1986, 279). Innovation can for example introduce a very new technology that will alter the market structure and on the other hand, an innovation can bring a small improvement to an existing concept or a process. Because of this, the overall concept of an innovation remains quite controversial, and researchers have not reached a consensus on the classifications on innovations (Ståhle et al. 2004, 12).

Technological innovations are regarded according to previous studies as the introduction into the economy of new knowledge or new combinations of existing knowledge. This means that innovations are regarded mainly as the result of interactive learning process. However, interactions in the economy different peaces of knowledge become combined in a new ways or new knowledge is created and sometimes this results in new process or products. Such interaction does not only take place in connection with research and development but also in relation to normal and everyday economic activities such as procurement, production, and marketing. (Edquist & Johnson 1997, 165.)

The interaction occurs within firms between different departments or individuals, between firms and consumers, between different firms and consumers, between different firms, or between firms and other organizations like public agencies. However, this does not mean that individuals can never innovate by themselves, for example without interaction, or that all new knowledge is the result of new combinations of already existing knowledge. Still, a more common standpoint to the innovation process claims that scientific research has an important but a more limited role. (Edquist & Johnson 1997, 165; Schienstock & Hämäläinen 2001, 52.)

2.2 The innovation process

Innovation is an ambiguous and uncertain process. Especially the technical and commercial risks are specific to the process. It is, for instance, very difficult to identify the adequate procedures that will lead to a technical solution for an existing problem (Schienstock & Hämäläinen 2001, 51).

Innovation is also regarded as a cumulative process. It has been empirically recognized that in many areas of technological change there is a strong cumulativeness in the form of innovation avenues or technological paths. Both these characteristics interactive and cumulative learning processes mean that the institutional set-up will affect innovation process. This is especially relevant for the analysis of innovation system. It has recently become increasingly common to study innovations within various kinds of innovation systems. (Edquist & Johnson 1997, 165-166.)

In the available definitions of innovations systems, the institutions play a key role. This means that systems of innovation are normally defined in institutional terms. Examples of such institutions are universities, R&D laboratories, schools, patent systems, labour market organizations, banking systems, various governmental agencies etc. In addition, there are other kinds of institutions in the sense of norms, habits, practices, and routines, which may be very important influences upon innovations and innovation systems. (Edquist & Johnson 1997, 165-166.)

The innovation process is commonly divided into three stages: invention, innovation and diffusion. However, the innovation process can be divided several different stages to picture especially for instance the energy technology development, which is relevant to this study. These phases include: basic research, applied research, development, market demonstration, commercialisation and diffusion. This chain is not necessarily linear as some of the studies of innovation claim. Each stage involves technology improvements and cost reductions, but the principal barriers and driving forces change across the different stages. (Grubb 2006, 18.)

2.2.1 Science push and demand pull theories

The current environmental innovation policy regimes are largely based on the linear model of innovation (Foxon & Pearson 2008, 150). Two models dominate the academic technology innovation literature leading to different economic explanations of what drives technological development: The two common models based on the linear model of innovation, presented in Figure 1, are the technology push, on the other hand, and market pull, on the other (OECD 2008, 13).

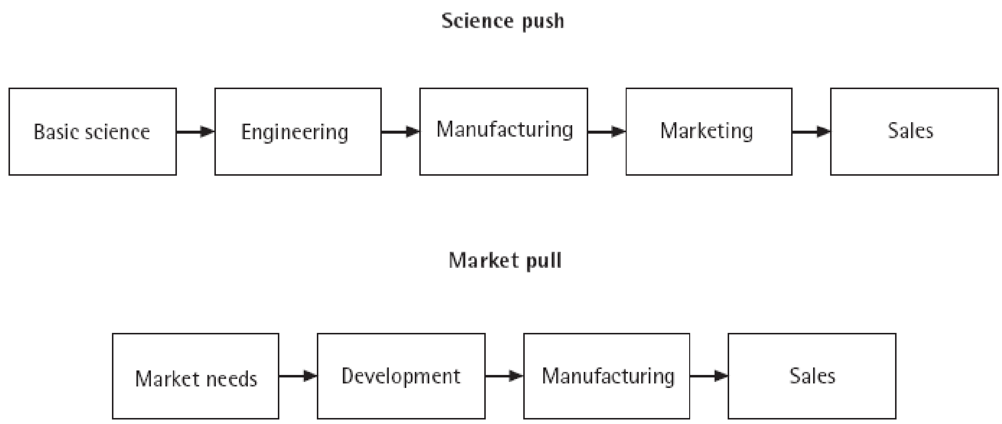

Figure 1 Traditional (linear) models of innovation. (Schienstock & Hämäläinen 2001)

The market pull theory refers to the dynamics of the market as the motor of technological change. According to this model, technological change must come primarily from the business sector and depends mostly on corporate investments in response to economic incentives. The market stimulates search processes for knowledge for those problems that solution for which are expected to be highly profitable. However, the disadvantage with the market-pull model is that often demand has to be first created for a specific innovation and it is not possible to always attribute an innovation to specific demand. In addition, the demand-pull model does not deal with the problem of technological uncertainty within innovation processes, since it assumes that a technical solution will emerge whenever there is a market demand. (OECD 2008, 13; Schienstock & Hämäläinen 2001, 53.)

According to the technology push view, technological change occurs mostly as the result of autonomous trends and public policy. The promoters of this view emphasise the need for governmental action for the development of technologies, most commonly through publicly funded R&D programmes. However, the technology-push model does not explain, why some innovations are successful and others not and why many innovations fail and have not been accepted by the market. (Grubb, 18; Schienstock & Hämäläinen 2001, 53.)

2.3 Research and development

Research and development (R&D) comprise creative work undertaken on a systematic basis in order to increase the amount of knowledge and to use this knowledge to device new applications. Generally, the terms research and development covers three separate activities: basic research, applied research, and experimental development. The basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. The applied research is also original investigation undertaken in order to acquire new knowledge. However, it is directed primarily towards a specific practical aim or objective. The experimental development is systematic, drawing on existing knowledge gained from research and/or practical experience, that is directed to producing materials, products or devices, or to improving substantially those already produced or installed. (OECD 2009, 164.)

The main aggregate used for international comparisons is gross domestic expenditure on R&D. This consists of the total expenditure (current and capital) on research and development by all resident companies, research institutes, university and governmental laboratories, etc. It excludes research and development expenditures financed by domestic firms but performed abroad. (OECD 2009, 164.)

The public sector can support research and development either directly, by governmental agencies, or departments or indirectly by, universities or research institutes. Larger and industrial players that perform and finance the activities in-house can also finance the research and development activities. It would be important to ensure that public sector research and development subsidies remained “smart subsidies” with clear exit strategies based on technology and innovations development milestones that lead toward demonstration and pre-commercialisation. (Makinson 2006, 23.)

2.4 Market demonstration

Research and development phases have been dominating the innovation study and only little attention has been left to the “preview” phase when users and support systems interact with developing products, to refine the commercial offering (Brown & Hendry, 2009, 1). The market demonstration phase in the innovation chain seeks to show to potential users and purchasers that the technology works in practice; it demonstrates its performance, viability and potential markets (Grubb 2006, 18). Demonstration projects basically attempt to shorten the time within which a specific technology makes its way from development and prototype to widespread availability and adoption by industrial and commercial users (Brown & Hendry 2009, 1).

The role of experimentation and learning in bringing new products to markets is widely recognized, especially for radical technology, where the early design phase is fraught with uncertainty. Especially concerns about climate change and energy security have caused governments to fund on demonstration projects and field trials in new energy technologies. Yet, there is little available advice on when and how to use such projects to accelerate commercialisation. The focus has instead mainly been on the role of research and development and market incentives. (Brown & Hendry 2009, 1-2.)

A particularly critical issue is how the end customer might use the product, which underlines the role of the demonstration projects. The aim with the projects is to make the product available to operators and users in controlled conditions, so that the design can be refined to meet real market conditions. Accordingly, the demonstration projects should not occur in isolation, but often in the context of ongoing research and development. These two learning processes learning-by-searching (R&D) and learning by doing (demonstration) need to be clearly linked to generate effective innovation. (Brown & Hendry 2009, 2.)

2.5 Commercialisation

The commercialisation of a technology might include its adoption by established firms or the creation of firms around the technology. This phase includes market accumulation, which occurs when the technology expands in scale, often through the accumulation of niche or protected markets. The commercialization of a new energy or low carbon innovation is a vital part of the whole innovation process. In fact, it is now regarded as one of the most central questions for European energy policies today. In practice, the key challenge is to improve the cost-effectiveness of the new innovations to enable market breakthrough. The whole issue is much about speeding up the commercialisation process, and finding effective policies for this purpose. (Lund 2008, 3.)

The commercialization process, illustrated in the Figure 2, or the basic innovation chain or parts of it underlies many different policies that either aim for technology push or market-pull measures (Lund 2007, 630).

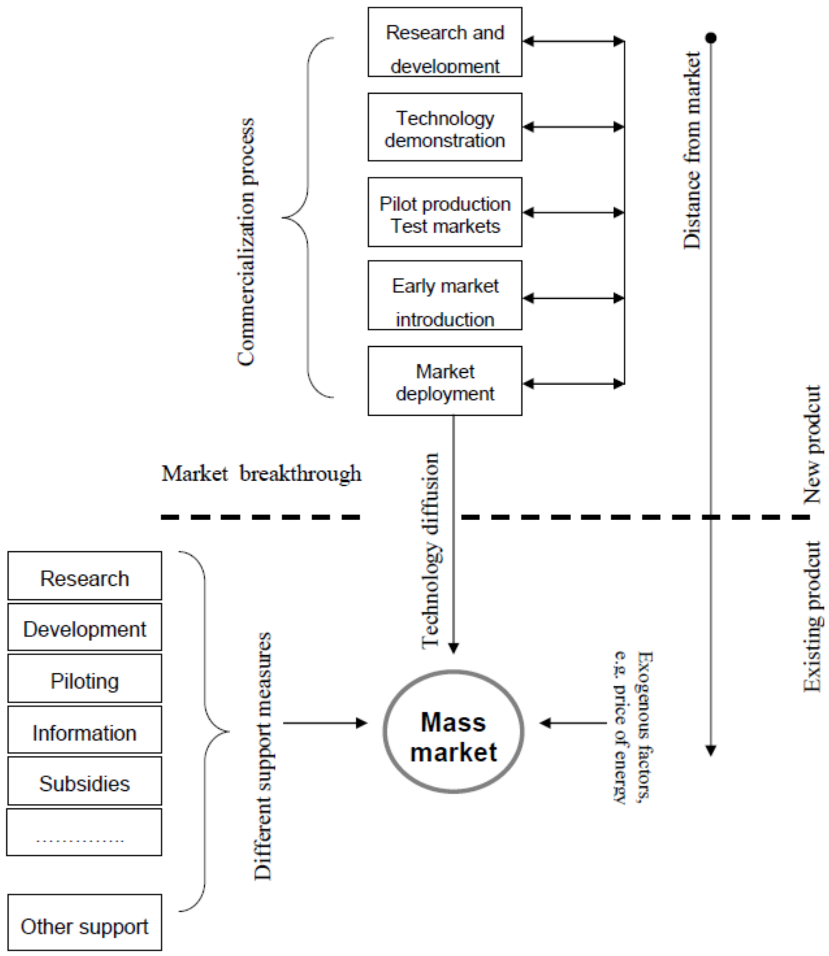

Figure 2 The commercialization process (Lund 2007, 3)

In the past, the innovation chain could be presented as a linear sequential process, but nowadays the different phases of the process proceed concurrently or interactively and with a faster phase. After introduced on the market, the innovation may need continued support if full competitiveness has not yet been reached. Different exogenous factors such as energy price, market size or non-energy factors may affect the outcome and impact as well. The amount of public support and time needed for penetration correlates to the distance from market. The distance from the market can be characterised for example by market or market share. (Lund 2007, 630.) Development and diffusion or commercialization of new technologies is largely a private-sector endeavour driven by market incentives. However, the public sector can play an important role in coordinating and co-funding of these activities and through policies in structuring market incentives. (Halsnæs et al. 2007, 155.)

2.6 Diffusion of innovations

In general, diffusion of innovations can be defined as a process by which an innovation is communicated trough certain channels over time among the members of a social system. The general diffusion model is often represented by the S-curve model, (Figure 3) with different timings of adoption ranging from innovators to laggards deciding the steepness of the curve.

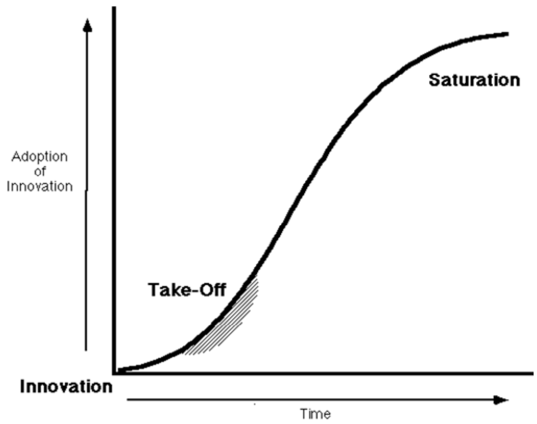

Figure 3 The general diffusion model (Rogers 1995)

After its conception, an innovation spreads slowly at first and the picks up speed as more and more people adopt it. Eventually it reaches a saturation level, where nearly everyone who is going to adopt the innovation has done so. Many innovations require a long period, often many years, from the time they become available to the time they are widely adopted. Therefore, a common problem for many individuals and organizations is how to speed up the rate of diffusion of an innovation. (Rogers 1995.) The rate of adoption is influenced by sets of variables and may be dependent on whether the innovation is a replacement or based on a completely new technology.

The Rodgers' definition for innovation suggests that the diffusion process is considered to be revolving around four key elements: an idea or innovation, channels of communication to spread knowledge of the innovation, time during which diffusion takes place and a social system of potential adopters where this occurs (Rogers 1995).

The *characteristics of an innovation* partly determine its' rate of adoption. Some innovations diffuse relatively slowly, while other innovations diffuse rapidly. The characteristics that determine the rate that an innovation will be adopted are its relative advantage, compatibility, complexity, trialability and observability. (Rogers 1995.) Overall, firms choose to develop and deploy new technologies to gain market advantages that lead to greater profits. (Halsnæs et al. 2007, 155.)

Communication channels are one of the key elements in the diffusion of new ideas. This is because the diffusion process is essentially social in nature as individuals share experiences on different innovations. Most individuals evaluate an innovation through the subjective evaluations of other people, not on basis of scientific research by experts. A communication channels is the means by which messages get from one individual to another. Mass media channels are more effective in creating knowledge of innovations, whereas interpersonal channels are more effective in forming and changing attitudes toward a new idea and thus in influencing the decision to adopt or reject a new idea. (Rogers 1995, 18.)

Time is involved in the diffusion of innovations in three different ways: Firstly, in the innovation diffusion process, where an individual or other decision-making unit passes from first knowledge of an innovation to forming an attitude towards the innovation, then to a decision to reject or adopt the innovation. Secondly, time is in the innovativeness of an individual or other unit of adoption (i.e., the relative earliness/lateness with which an innovation is adopted), compared with other members of a system. Finally, an innovation's rate of adoption in a system, usually measured as the number of members of the system who adopt the innovation in a given time period. (Rogers 1995, 20.)

The social system is defined as a set of interrelated units that are engaged in joint problem solving to accomplish common goals. The members or units of a social system may be individuals, informal groups, organizations and subsystems. The social system constitutes a boundary within which an innovation diffuses. Diffusion is affected by norms, which are the established behaviour patterns for the members of a social system, and by opinion leadership, which is the degree to which an individual is able to influence the attitudes or overt of other individuals in a desire way with relative frequency. (Rogers 1995, 20.)

2.7 The adoption of an innovation

Adoption of an innovation refers to the stage where an individual or an organization selects a technological for use. The innovation diffusion in a certain unit involves the adoption of the innovation by individuals in that unit. Innovation adoption can be seen as a networking process among people, who become committed to the innovation through transactions. The adoption is a process in which an organization analyses the positive and negative aspects of an innovation based on gathered information. Adoption takes place when the result of these analyses is positive. (Van de Ven 1986, 39.)

According to Rogers (1995), adopters can be classified into five different categories. Based on this theory, 2.5 percent of the adopters are in the innovators' category. The early adopters cover 13.5 percent of the adopters. The vast majority of adopters belong to the two different majorities in the share. Both, early and late adopters cover 34 percent of the adopters. Finally, the laggards account for 16 percent. (Figure 4)

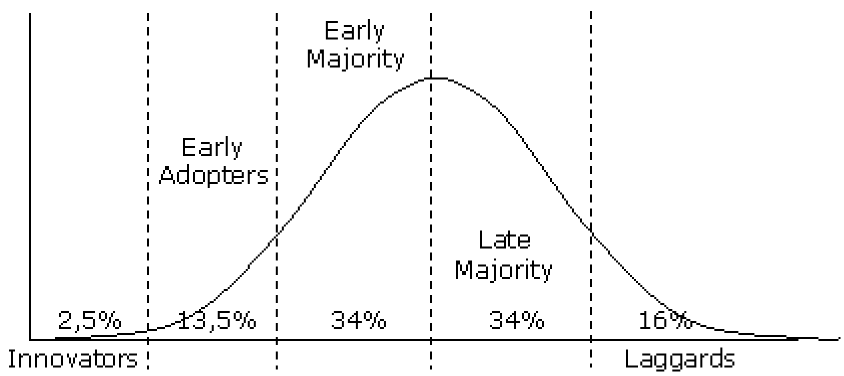

Figure 4 Rogers Adoption / Innovation Curve (Rogers 1995)

2.7.1 The role of early adopters in the innovation process

A key concept in understanding the nature of the diffusion process is the critical mass, which occurs at the point at which enough individuals have adopted an innovation so that the innovation's further rate of adoption becomes self-sustaining. The concept of the critical mass implies that outreach activities should be concentrated on getting the use of the innovation to the point of critical mass. These efforts should be focused on the *early adopters*, who are often opinion leaders and serve as role models for many other members of the social system. Early adopters are instrumental in getting an innovation to the point of critical mass, because potential adopters seek to early adopters' for an advice and information about the innovation and appreciate the knowledge that the early adopters have on the innovation. Therefore, they are instrumental in the successful diffusion and adoption of an innovation. (Rogers 1995.)

According to fresh studies on innovation, the early adopters play a significant role in the "down-stream" of an innovation process. The "down-stream" of an innovation process is considered to be the adoption and diffusion phases, and it is as important as the "up-stream" (R&D phases). The down-stream can be supported by different policies, tax relief's, allocated support mechanisms or by supporting the demonstration and marketing of a new technology. (Bhidé 2006.)

At the level of an individual firm, several factors have been studied to explain the adoption behaviour. Some of the factors that can be observed are the adopter industry environment, organization characteristics, decision maker information-processing characteristics, the innovation characteristics, and the supply side competitive environment. (Gatignon H & Robertson T. 1989.)

2.8 New innovation strategy

Open innovation has been proposed as a new paradigm for the management of innovation. According to the traditional innovation policies, organizations have relied on internal research and development to create new products. In many industries, large internal R&D labs were a strategic asset and represented a considerable entry barrier for potential rivals. In consequence, large firms with extended R&D capabilities and complementary assets could outperform smaller rivals. (Van de Vrande et. al. 2008, 1-2.)

The process in which large firms discover, develop and commercialize technologies internally has been labelled the closed innovation model. It is undisputable that this model has worked well for quite some time. However, the current innovation landscape has changed and will change even more in the future. Because of labour mobility, abundant venture capital and widely dispersed knowledge across multiple public and private organizations, enterprises can no longer innovate on their own, but rather need to engage in alternative innovation practices. (Van de Vrande et. al. 2008, 1-2.) Technological change has always meant that the innovation system has changed along with it (Salmelin, seminar presentation 12.5.2009). In the Table 1, the problems related to partial views of innovation are presented.

Table 1 Problems of partial views of innovation (Tidd et al. 2001, 44)

If innovation is only seen as…	*…the result can be*
Strong R&D capability	Technology that fails to meet user needs and may not be accepted
The province of specialists in white coats in the R&D laboratory	Lack of involvement of others, and a lack of key knowledge and experience input from perspectives
Meeting customer needs	Lack of technical progression, leading to inability to gain competitive edge
Technology advances	Producing products which the market does not want or designing process which do not meet the needs of the user and opposed
The province only of large firms	Weak small firms with too high a dependence on large customers
Only about 'breakthrough' changes	Neglect of the potential of incremental innovation. Also an inability to secure and reinforce the gains from radical change because the incremental performance ratchet is not working well
Only associated with key individual	Failure to utilize the creativity of the remainder of employees, and to secure their inputs and perspectives to improve innovation
Only internally generated	The 'not invented here' effect, where good ideas from outside are resisted or rejected
Only externally generated	Innovation becomes simply a matter of filling a shopping list of needs from outside and there is little internal learning or development of technological competence
Only concerning single firms	Excludes the possibility of various forms of inter-organizational networking to create new products, streamline shared processes, etc.

The table indicates that the innovation process should effortlessly combine the different actors of the whole innovation process. This means that experts from all fields of the economy should be introduced to the innovation process right from the beginning. This could make the diffusion of certain innovations more efficient.

The term user- and customer-driven innovation related to the open innovation. However, user-driven innovation theory emphasises the information feeds from the user side to develop products, services, and processes, as opposed to traditional creation and research and development. In this political paradigm, strong investments on scientific research are not seen as vital as a strengthening interaction between the (technology) developers and the users and, the generation of active markets for innovative findings. Especially public purchases are seen as a vital tool for the latter, though general purchasing policies prevent the innovativeness of the purchasing. Extensive user-driven innovation policies aim for highlighting the customers' needs and it has a strong emphasis on service sector. (Kolehmainen 2008, 6.)

Accordingly, open innovation theories recognise that customer involvement is one important alternative to inform internal innovation process. According to the theories, users are increasingly regarded not as just passive adopters of innovation, but they may rather develop their own innovations, which producers can imitate. User can, for instance, regularly modify their current machines, equipment and software to better satisfy process needs and because producers fail to provide an adequate supply. Firms may benefit from their customers' ideas and innovations by proactive market research, providing tools to experiment with and/or development products based on the design of customers and evaluating what may be learned from general product development. (Van de Vrande et. al. 2008, 1-2.) The role of the user has been identified broadly in the private sector. However, the public sector is still strongly engaged to the old innovation theories.

The role of the user is highlighted also in the most recent innovation theories. In many cases, technical improvements are realised during the diffusion phase by user feedback or re-invention by users (Rogers 1995). However, the term user is quite broad; users can bee seen as individual end-users, but very often in innovation studies, users are firms and organisations. Users can be involved in the design and dissemination of technologies at different levels of intensity. Early users can start off completely new technologies and designs, find and test new applications of a product, can be a source of incremental technical changes, or they can appropriate unconventional building technologies and design solutions in the course of collective planning process. (Ornetzeder & Rohracher 2006, 139.)

The paradigms of open and user-led innovation have faced criticism especially from the sectors that have gained success with the traditional innovation. Users are too often regarded only as passive consumers; however, the most successful companies today use the knowledge from the user side as a tool to shape their products. Accordingly, the new way of thinking could make the innovation process much more efficient and respond to the challenges of the modern society (Harmaakorpi, interview 2009).

3 THE CHALLENGE OF MITIGATING CLIMATE CHANGE

The discussion on climate change has gotten entirely new aspects as the scientific knowledge and proof has increased on the subject. The change presents threats that could jeopardise the modern way of life and threaten people around the world. For this reason, the international debate revolves especially around the measures that governments should perform in order to slow down the progress of the change. Currently the discussion on the governmental policies on climate change mitigation is on the same level with the current financial crisis.

This chapter presents the recent knowledge on climate change. For the more important part, the measures that need to be carried out to mitigate climate change are presented. The chapter aims at defining especially the role of technological development and innovations in the mitigation challenge as it would be important to find ways to support sustainable economic development. However, the costs of climate change mitigation are frequently used as a pretext of not acting. This is why, this chapter also presents the recent research results of different studies of the costs of climate change mitigation. Finally, the role of the governmental actions in the mitigation challenge is highlighted.

3.1 Climate change

The predominant sources of the increase in greenhouse gases are from the combustion of fossil fuels. Human activities result in emissions of four long-lived green house gases: Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and halocarbons. The built up in the atmospheric concentration of greenhouse gas emissions occur when emissions are larger than removal processes. (IPCC 2007, 37)

The human activities between 1970 and 2004 have raised the global greenhouse gas emissions 70 percent from pre-industrial times. During the same time period carbon dioxide emissions, which is the most important greenhouse gas, have grown by about 80 percent from 21 to 38 gigatonnes. Overall, the atmospheric CO_2 concentrations have increased by almost 100 ppm since their pre-industrial level, reaching 379 ppm in 2005. The total CO2-equivalent concentration of all long-lived greenhouse gases is now about 455 ppm CO_2-equivalent. (Halsnæs et al. 2007, 96)

The main growth in pollutions have been from energy supply sector, transport and industry, while residential and commercial buildings, agriculture and forestry (including deforestation) sectors have been growing at a lower rate. Since 1970, greenhouse gas emissions from the energy supply sector have grown by over 145 percent; emissions from the transport sector have grown by over 120 percent and from the industrial sector by close to 26 percent. The main drivers behind these figures are the increasing use of natural resources and population growth, which both result in to increase of the energy related CO_2 emissions. (Halsnæs et al. 2007, 104-107.) The current share of different sectors in total anthropogenic greenhouse gas emissions in 2004 in terms of CO_2 –equivalent is presented in the Figure 5. The Figure indicates that the most important sectors concerning curbing the emissions are the energy supply sector and the industry.

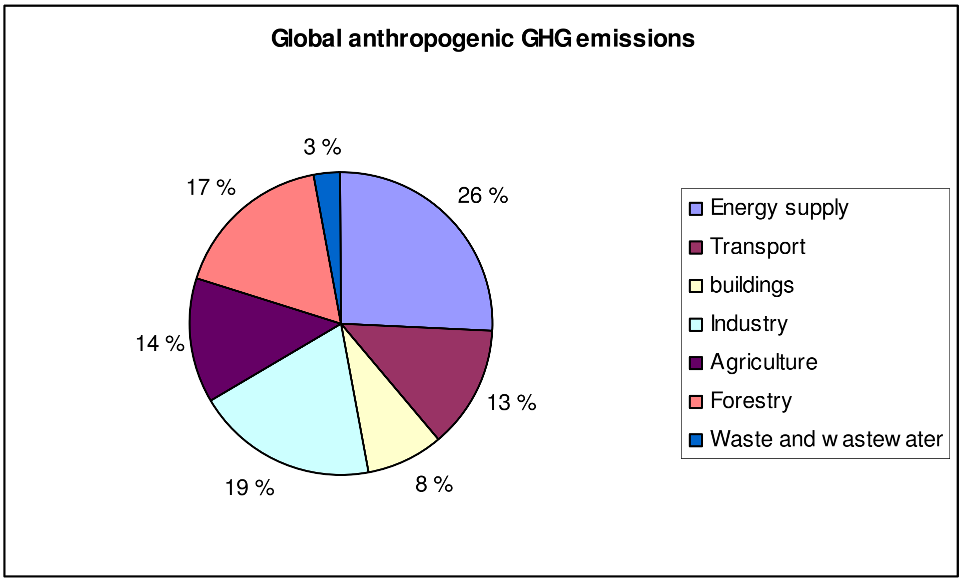

Figure 5 Share of different sectors in total anthropogenic greenhouse gas emissions in 2004 (IPCC 2007)

According to the IPCC and other expert organizations, the amount of greenhouse gas emissions need to be dramatically decreased so that the progression of the climate change could be slowed down and ultimately stopped. There is a widespread agreement that the concentration of the greenhouse gases need to be stabilized below 500 parts per million (ppm). According to the most recent estimates, CO_2 will need to be reduced to at most 350 ppm. (Hansen et al. 2008.)

The scientific research on climate change has already shown the effects of the resent warming. Observational evidences based largely on data sets that cover the period since

1970, from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases (IPCC 2007). A warming this magnitude, together with subsequent changes in precipitation, sea level and storm frequency, is likely to have severe effects on both the natural environment and human societies. If nothing is done to curb the emissions, it is highly likely that the next financial and humanitarian crisis will be formed as the result of the effects of climate change. Accordingly, societies and economists should respond to the scientific knowledge and understand the treat, while something can still be done (Hukkinen, interview 2009).

3.2 The role of technologies and innovations in climate change mitigation

Societies can respond to climate change by adapting to its impacts and by reducing greenhouse gas emissions (mitigation) and so, reducing the rate and magnitude of the change (IPCC 2007, 56). In theory, greenhouse gases can be reduced in two different ways. Firstly, changes in lifestyle and in consumption patters and by emphasizing resource conservation can contribute to a low-carbon economy. However, since lately the global trend has been the growing GPD and population, lifestyle changes are very challenging to obtain.

Secondly, innovations and technological applications that have a potential to reduce the amount of greenhouse gas emissions from different fields of the economy such as the energy production and service sectors can be implemented. This is why; innovations and technological applications are in the key role in the challenge of mitigating climate change. To gain additional greenhouse gas reductions from the energy production sector, for example, I would be highly important that new technologies and innovations would be implemented to replace and operate alongside the old technologies. This could make the production more efficient and less polluting. The new technologies concern especially the energy production and end-usage sectors in different fields including transport and other emission sources such as industrial processes and waste management. (Lehtilä et al 2008, 9.)

Accordingly, the technological applications are in key role in the goal of obtaining the required emission reduction targets. Figure 6 represents the abatement opportunities in the period between now and 2030 and they are divided into four different categories: energy efficiency, low-carbon energy supply, terrestrial carbon (forestry and agriculture), and behaviour change. The Figure 6 clearly indicates the role of technologies in the mitigation challenge.

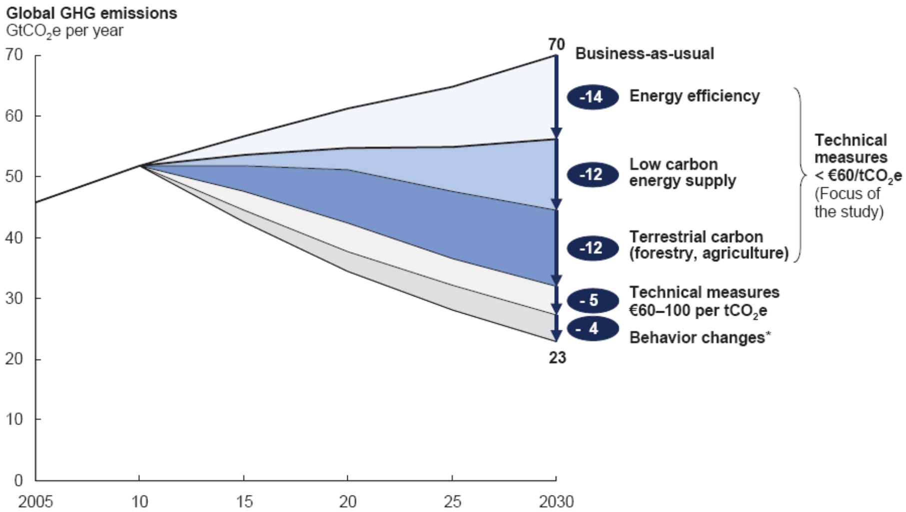

Figure 6 The opportunities to reduce global greenhouse gas emissions (McKinsey 2009, 11)

The focus on this study is on innovations that have the potential to reduce the amount of CO_2 emissions. This is because it is the dominant greenhouse gas from human activities and industrial-scale mitigation options already exist for subordinate gases such as nitrous oxide and methane (Pacala & Socolow 2004, 968).

The innovations that have a potential to reduce the amount of greenhouse gas emissions are usually called low carbon innovations. However, because the concept is relatively new, there is no clear definition to it. This is why, the definition for low carbon technologies and innovation needs to be derived from the concept of environmental technology.

3.3 Environmental technology and innovation

Even the concept of environmental technology does not have a clear definition or a standard. In general, it can be defined as the technological methods or procedures through which the environmental impacts of a certain activity can be reduced

(Environmental Administration 2008). However, the concept is used widely and in some cases, it can be misleading. Some technologies are said to be more sustainable, cleaner or less polluting, but because there is no standard of comparison these definitions leave many elementary questions open and leave space for interpretations. This is why, some manufacturers and engineers might use the term whenever they feel it is appropriate and benefit of the positive image of "greener production". (Kuehr 2007, 1317 - 1318.)

The environmental technologies were previously seen mainly as "end-of-pipe"[1] technologies. However, the modern way of thinking emphasizes life-cycle thinking. This means that all actions, process and products are reviewed throughout the entire life cycle to reduce all their consequent impacts on the environment. (Environmental Administration 2008.) For the reason that some cases can be very controversial, the life cycle analysis (LCA) is the only reliable way to evaluate the long term impacts of a certain process or a product.

To clarify the concept of environmental technology the United Nations Conference on Environment and Development (UNCED) provided more specific definition of environmental technology in its Agenda 21 in chapter 34. According to the agenda 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. The agenda also states that environmentally sound technologies in the context of pollution are "process and product technologies" that generate low or no waste, for the prevention of pollution. The also cover the end-of-pipe technologies for treatment of pollution after it has been generated. (UN 2004.)

Finally, environmentally sound innovations are not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures. This implies that when discussing transfer of technologies, the human resource development and local capacity-building aspects of technology choices, including gender-relevant aspects, should also be

[1] The end-of-pipe approach to pollution control concentrates upon effluent treatment of filtration prior to discharge into the environment, as opposed to making changes in the process giving rise to the waste.

addressed. Environmentally sound technologies should be compatible with nationally determined socio-economic, cultural and environmental priorities. (UN 2004.)

3.4 Low carbon innovations

According to the previous definition for environmental innovations, low carbon innovations can be considered as new technological applications, services, operation models, etc. that have a potential to replace carbon intensive processes like coal-fired power plants and the extensive use of crude oil in different industrial sectors. Accordingly, it is important to recognize the difference between a low carbon innovation and technology, since in addition to the technological development, several low carbon services can bring additional emissions reductions.

The task of mitigating climate change is challenging but not impossible. There are many opportunities to shift energy supply from fossil fuels to low carbon alternatives and make the current processes more efficient with energy efficiency innovations. In addition, so-called clean fossil technologies can be included into innovations that have the potential to reduce green house gas emissions. (McKinsey 2009, 12, Pacala & Socolow 2004, 969.) Some of these innovations are still in their developing stage and require public research, development, demonstration and deployment support, while others are more mature and need only market incentives for their deployment and diffusion (Figure 8). Some also need persistent efforts for public acceptance as well as resolution of legal and liability issues (Rogner 2007, 112).

Some attempts have been made to evaluate the emission reduction capacity of low-carbon innovations. For instance, Pacala and Socolow (2007) identify several so-called clean technology wedges for a dramatic reduction of greenhouse gas emissions. In their interpretation a wedge represents an activity that reduces emissions to the atmosphere that starts at zero today and increases linearity until it accounts for 1 Gt carbon per year of reduced carbon emissions in 50 years and thus, it represents a cumulative total of 25 Giga tons carbon of reduced emissions over 50 years. However, these activities would require a full energy technology revolution. (Pacala S. & Socolow R. 2004.)

3.4.1 Energy efficiency applications

Energy efficiency innovations involve inventions and technologies that make energy supply and use more efficient. The energy efficiency applications play a significant role throughout the energy system in mitigating climate change, especially at the end use side (Rogner 2007, 112). Most business could make savings of up to 20 % by introducing basic improvements in energy efficiency (Omer 2008, 2335).

In some cases, only 20 percent of the primary energy sources' potential is used to generate economic value. The Figure 7 presents the loss of energy potential in the value chain of energy production and indicates the opportunities for energy efficiency applications.

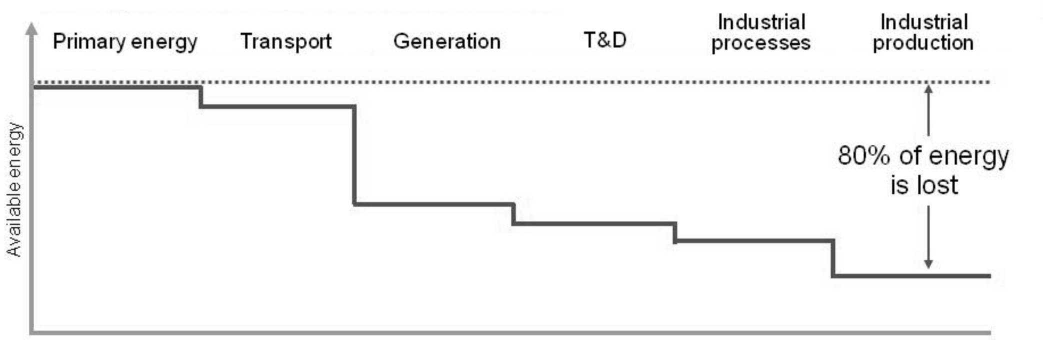

Figure 7 The lost of potential energy (Forsman, Seminar presentation 9.6.2009)

Accordingly, during the process, about 80 percent of the energy available is lost to conversion of processes, transportation and in operational inefficiencies. Accordingly, there are varieties of possibilities to reduce the overall energy consumption by improving the energy efficiency of industrial applications, buildings, vehicles etc. and thereby to reduce the amount of greenhouse gas emissions.

3.4.2 Renewable energy

Renewable energy plays a key role in governments' strategies for curbing greenhouse gas emissions. In addition, these energy systems contribute to the security of energy supply and protection of the environment (Sims 2007, 272). The term renewable energy usually means energy produced from renewable natural resources such as solar, wind, biomass, geothermal, and hydro power (IEA 2002, 3). In 2004, renewable energy accounted for over 15 percent of world primary energy supply including traditional biomass (7 %), large hydro-electricity (5.3 % being 16 % of electricity generated) and other renewable (2.5 %). (Sims 2007, 272.)

The developed renewable technologies such as large hydro, biomass combustion and geothermal have, for the most part, been able to compete in today's energy markets without policy supports. However, there is a need for second-generation renewables, since for example large hydro cannot be extensively added. The less developed technologies include for example solar water heating, wind farms on exceptional cites, second-generation ethanol (for example from waste), and forest residues for combined heat and power. They are not yet competitive but costs continue to decline because of increased learning experience. However, one of the key challenges for many of the renewable technologies is that some of the renewable energy sources are variable over hourly, daily and/or seasonal periods. In consequence, energy-storage technologies may be needed, particularly for wind, wave and solar, though stored hydro reserves, geothermal and bioenergy systems can all be used as back-up sources. (Sims 2007, 272-273.)

3.4.3 Clean fossil technologies

Fossil fuels are likely to remain part of the energy mix for many years to come in the industrial countries and in the rapidly developing countries such as China and India. In the medium term, it is therefore important that low carbon fossil fuel technologies are developed and deployed to reduce carbon emissions. The clean fossil technologies comprise of technologies such as carbon capture and storage (CCS), energy from waste and hydrogen production from non-fossil energy sources and fuel cells. (Rogner 2007, 112.)

Especially for the CCS technology, there are high hopes. The CCS technology strips carbon dioxide out of exhaust gases and stores it underground. The technology is estimated to reduce carbon emissions from power stations by 80 – 90 percent, but as life cycle factors are taken into account the real potential to reduce the emissions is about 67 percent. (Schiermeier 2008, 822.)

The capture of carbon dioxide can best be applied to large carbon point sources including coal-, gas- or biomass electric power-generation or cogeneration (CHP) facilities, major energy-using industries, synthetic fuel plants, natural gas fields and chemical facilities for producing hydrogen, ammonia, cement and coke. Storage of CO_2 can be achieved in deep saline formations, oil and gas reservoirs and deep unminable coal seams using injection and monitoring techniques similar to those utilized by the oil and gas industry. (Sims 2007, 285 – 286.) The role of CCS has generally been seen as a transitional technology and the technology still requires development. The deployment of the technology is estimated to be around 2020 and 2030. (Jussila (edit.) 2008, 77.)

3.5 The costs of reducing emissions

There is an ongoing debate about the costs of mitigating climate change and meeting the greenhouse gas emission reduction targets. According to several different reports, there are a number of ways to reduce greenhouse emissions in a cost effective way. In the report by McKinsey & Company, a cost curve is presented (Figure 8) that estimates the maximum potential of all technical greenhouse gas abatement measures below € 60 per tCO_2e if each lever was pursued aggressively.

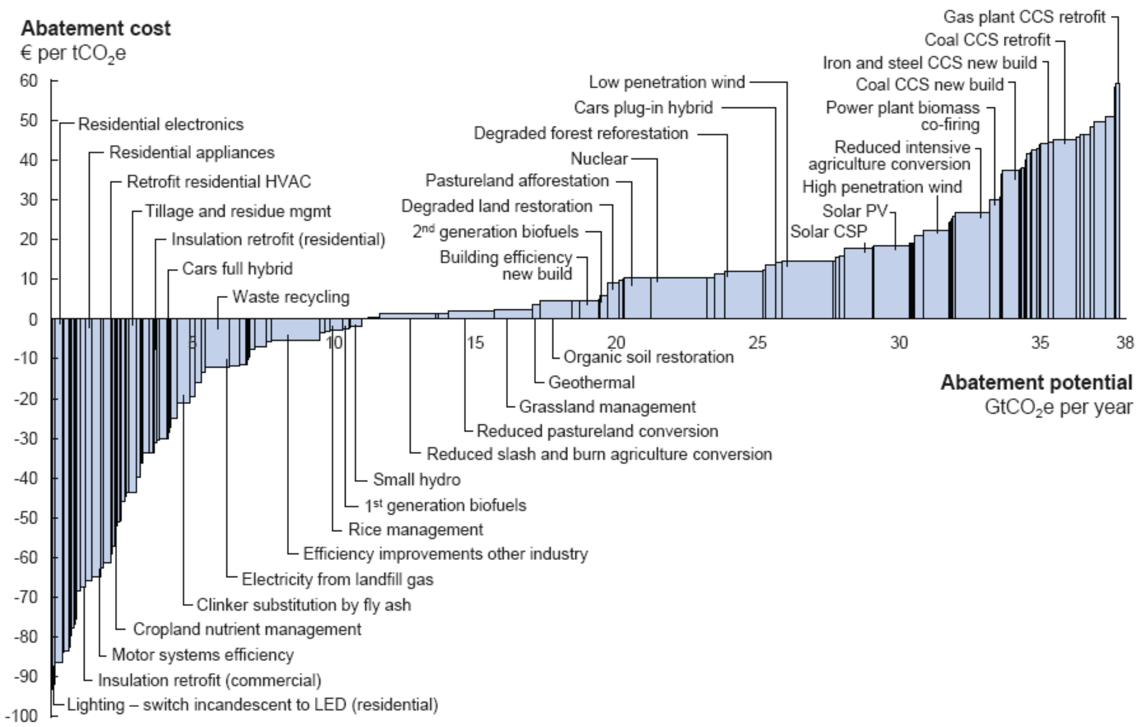

Figure 8 The abatement cost curve beyond BAU (McKinsey & Co 2009, 27)

Even though, the curve does not forecast of what role different abatement measures and technologies will play, and there is a high degree of fragmentation among individual abatement options, three major categories can be recognized from the curve: Energy efficiency opportunities, have the opportunity of decreasing 14 $GtCO_2e$ per year in 2030. Low carbon energy supply, and terrestrial carbon – forestry and agriculture have the opportunity of 12 $GtCO_2e$ per year in 2030. Terrestrial carbon – forestry and agriculture have the opportunity of 12 $GtCO_2e$ per year in 2030. (McKinsey & Co 2009, 26.)

A noteworthy fact on the Figure 8, is that it gives relatively big abatement opportunity for nuclear power and hence it is regarded as one relatively cost effective way of reducing the emission. Nuclear power is also stated by the IPCC as one answer for reaching the emission reduction targets. However, there is not a unanimous standpoint on the issue. On the other hand nuclear power does reduce the amount of emissions if compared to fossil fuel fired plant and so far it has relatively low fuel costs. However, there is no agreed solution to the problem of how to deal with the problem of hazardous nuclear waste that has been generated over the past 50 years (Schiermeier 2008, 818). Accordingly, the topic on fission nuclear energy as environmental technology remains controversial. This is why, this study focuses on technologies that reduce greenhouse gases in more sustainable way.

The McKinsey research estimates that there is a potential by 2030 to reduce emissions by approximately 35 per cent compared with 2005 levels and 70 per cent compared to business as usual, meaning that the world would fail in taking action in curbing emissions. If this full potential were captured, emissions would peak at 480 ppm and the start to decrease. However, the task is challenging since greenhouse gas emission reductions targets are strongly dependent on policy makers in agreeing on and implementing effective emission reduction policies, and for companies, consumers and the public sector to take action in making it a reality. (McKinsey & Co 2009, 26.)

However, it can be argued that the statements that different emission reduction targets are too expensive to industrial sectors or harmful national economy are not entirely true. As an example, energy efficiency applications can bring noteworthy cost savings in addition to the emission reductions. Even the current financial and economic crisis cannot be used as a pretext for forgetting the climate change commitments. In the end, it is certain that the costs of not acting to the challenge of climate change will be greater than acting.

3.6 The role of the public sector

The governmental actions have an exceptional role in the promotion of low carbon solutions, as the technologies and innovations face several barriers. Today's market is rapidly changing and so, the governments have to find smarter and more effective ways to get involved in the effort of reducing the emissions. Effective government intervention catalyses low carbon innovation and provides the operating frameworks that financiers need to take long-term investment decisions. Policies that help to create markets, reduce risk, provide acceptable rates of return for investment and create conditions for a low carbon development, are needed. This leads to long-term regulatory frameworks supported by finance mechanisms that address barriers and gaps to financing low carbon solutions. (BASE 2005, 10.)

Supportive regulatory and tax environments are key drivers of the development and financing of innovations. However, these macro approaches are not always enough to create the true enabling environment needed for a large-scale investment in sustainable innovations, since in technology development, several financial gaps exist in the various stages of the innovation chain. Accordingly, the public mechanics need to be designed in an integrated manner that allows barriers and gaps to be addressed at various stages of market development (BASE 2005, 10). The governmental measures that could speed up the diffusion of the sustainable technologies are estimated later in this study, in Chapter 6.

4 DESCRIPTION OF THE FINNISH INNOVATION AND TECHNOLOGY DEVELOPMENT SYSTEM

Finland is frequently proposed as a model country for innovation systems. This has been enabled by the high investments in research and development activities and the high commitment to education. In just a few decades, Finland has gone from being one of the least R&D-intensive OECD countries to being to the top in R&D-intensive today. (Georghiou et al. 2003, 63; OECD 2008.) However, as stated in the previous chapter, the public measures need to support the whole innovation chain and not just the research and development phases.

This chapter aims to give a general picture of the Finnish innovation system and thereby to provide a frame within which to evaluate how the development of the low carbon innovations stands in the national innovation landscape. Accordingly, the chapter will present the governmental institutions that implement the national innovation policies. In addition, the institutions that carry out research, development and deployment activities are presented.

4.1 The national innovation system

Previous studies define the national innovation system as the network of institutions in the public and private sectors, whose activities and interactions initiate, import, modify, and diffuse new technologies and innovations. This interpretation stresses the positive role of government, working closely with industry and the science base, to create vision and provide long-term support for the development and marketing of the most advanced technologies. This in an integrated approach to R&D, design, procurement, production and marketing within large firms; and the high level of generation education and scientific culture, combined with thorough practical training and frequent up-dating industry. Accordingly, the governmental actions on innovation have a key role across the innovation process. (Foxon & Pearlson 2002, 20; OECD 2008.)

The Finnish innovation system consists of producers and users of new information and knowledge and expertise. At the core of the innovation system are education, research and product development, and knowledge intensive business and industry. The producers of new technology include universities and polytechnics, research institutes and business enterprises. The users are mostly enterprises, private citizens, decision-makers and authorities responsible for societal and economic development. The role of scientific information in societal and economic development has been constantly growing, which increase the significance of cooperation and networking both between the public and the private sectors. A key task for science, technology and innovation policies is to ensure a balanced development of the innovation system and strengthening cooperation within it. Alongside this, increasingly important are also cooperation relationships with other sectors, such as economic, industrial, labour, environmental and regional policies or social welfare and health care services. The prerequisites for knowledge-based development are created within different policy sectors. (Seppälä 2006.) The Figure 9 presents the structure of the Finnish innovation system.

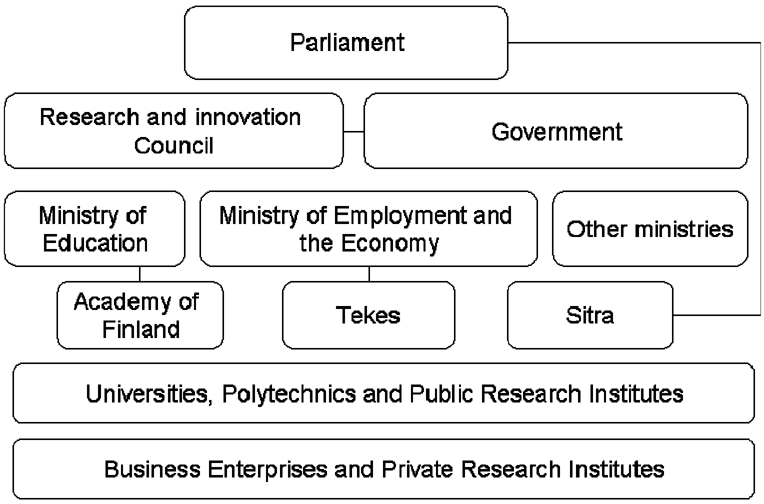

Figure 9 The Finnish innovation system

The formulation of national science, technology and innovation policies has been assigned to an expert body, the Research and Innovation Council. The leading organisations responsible for science and technology policies are the Ministry of Education and the Ministry of Employment and the Economy. The Ministry of Education handles matters relating to education and training, science policy, universities and polytechnics, and the Academy of Finland. The Ministry of Employment and the Economy is in charge of matters pertaining to industrial and technology policies, the Finnish Funding Agency for Technology and Innovation (Tekes), and the VTT Technical Research Centre of Finland. Nearly 80 per cent of the government R&D

funding is channelled trough these two ministries. (Seppälä 2006.) Later in this chapter, the actors in the Finnish innovation landscape will be presented.

The Finnish innovation system has so far been relatively successful. Approximately 3100 commercially successful technological innovations have been generated in Finland during 1945 - 2000. The main drivers, according to the statistics for innovations, have been recognition of a market niche (90 %) and fulfilling the needs of a client (80 %). In addition, there are several of other sources for innovations but they do not play such a major role in the field. They are price competitions (30 %), environmental factors (25 %), threat of a rivalry innovation (25 %), standards and regulations (25 %), public research, or a technology program (20 %), new scientific observations (17 %). Only a small role has left for the public purchases (8 %) (Figure 10). (Hyvärinen & Rautiainen 2006, 22.)

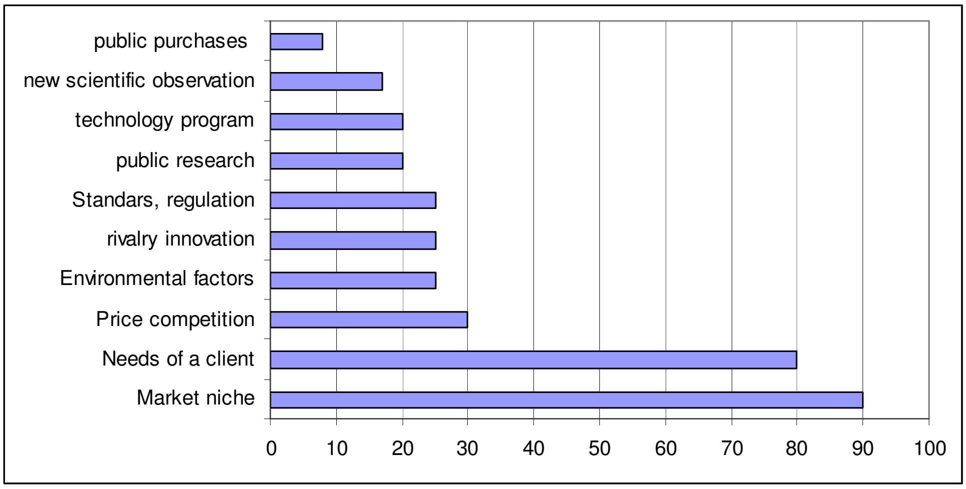

Figure 10 The drivers for technology innovation in Finland

According to these facts, the product market conditions combined with technology push are the most important factors in Finland to innovate. Accordingly, market related issues are very important and customers' demands help initiate projects. This is why, it is highly important to recognize the market niches, collaborate and to get feedback from customers. In addition, the consumer knowledge and commercialisation are highly critical factors on technology and marketing innovations (Kaitasalo 2000). The past studies have also recognised the importance of market niches. They suggest that a new technology will typically first commercialise in niche markets, where the particular technology's or an innovation's advantages are the strongest. These markets allow the technology to benefit from learning effects so that costs reduce and the technology's performance can improve. If this occurs sufficiently, the new technology may then become competitive with the existing technology in the wider market. (Foxon & Pearson 2008, 155-156.)

4.2 National innovation policies

National innovation policies in Finland rest on several pillars: direct subsides for research projects within thematic programs, promotion of SMEs in three promotion lines that are innovation, cooperation, technology consulting and four types of support: subsidies, loans, venture capital and infrastructure supply in the fields of information and consulting. In general, organisations can compose from the different pillars an individual mix of public support that best suits the firm's specific challenges. In contrary to other EU member states Finland does not have fiscal incentives for research and development. (Ebersberger 2005, 63.)

During the recent years, Finland's technology policy has focused on the creation and application of new knowledge and skills, on the integration of well-being and sustainable development and the capacity for continuous renewal. Finland has striven to create a favourable environment for innovation and business activities. Finland has based both economic and societal development on developing and diffusing high technology both domestically and internationally. Finland has, indeed, ranked as one of the leading European countries for innovation as measured in terms of growth, competitiveness, technological sophistication and infrastructure. However, not all studies agree on this, especially when environmental and societal aspects are taken into account. (Ebersberger 2005, 61.)

4.2.1 Ministries in charge of innovation policies

The Research and Innovation Council is the former Science and Technology Policy Council. Originally, the council was established in 1987 and it became the Science and Technology policy council in January 2009 (Ministry of Education, 2008). It has played a key role in coordinating innovation policy activities at the national level (Ebersberger 2005, 62).

The council is chaired by the Prime Minister and it advises the Council of State (government) and its' Ministries in matters concerning research, technology, innovation and their utilisation and evaluation. The council is responsible for the strategic development and coordination of Finnish science and technology policy, in addition to the national innovation system as a whole. In contrary to the previous Science and Technology Policy the membership criteria of the council have been changed. Expertise in broad innovation policy is taken into account and there will be fewer quota-based memberships though the total number of members (max.18 members) will remain unchanged. (Ministry of Education, 2008.) Previously the council membership consisted of the Minister of Education, the Minister of Trade and Industry, the Minister of Finance, four other ministers and ten other members well versed in science or technology (Representatives from the Academy of Finland, the National Technology Agency and industry and employers' and employees' organizations) (Ebersberger 2005, 62).

The Ministry of Education is the highest education authority in Finland, supervising publicly subsidised education and training provision, from primary and secondary general education and vocational training to polytechnic, university and adult education. The main instrument for the execution of the research policy is the Academy of Finland, which is also supervised by the Ministry. (Aaltonen 2007, 6.) The Ministry of education and the National board of education are responsible for implementing education policy and for administering the education system at the central governmental level (Ministry of Education, 2006). High education has been one of the primary sources of the national innovation success. The source of this education is the extensive university network. There are 20 universities in Finland, which work on the principles of academic freedom and autonomy. This means that they are very independent in their decision-making, thus all universities are state-run and the government provides some 70 % of their budgets. In addition to universities, there are 28 polytechnics in the Ministry of education sector, which are run by either by local authorities or by private foundations. They are co-financed by the government and local authorities. (Ministry of Education, 2006.)

The ministry of Employment and the Economy is responsible for technological policy and for providing support for industrial research and development. In this context, the ministry was assigned with the practical task of drawing up the national innovation strategy. On October 2008, the Council of State approved an innovation political report, which contains key strategic lines needed to develop the innovation policy and environment in Finland. The basic policies behind the national innovation strategy will steer the innovation environment and its development in Finland. The strategy focuses on broadly based innovation policy, and the changes and reforms necessary for its implementation. However, it does not consider questions of the allocation of resources to different areas of content. The action plan highlights the main new or changing tasks and focal points. Together with the current strengths of the innovation environment, they form a whole, enabling Finland, in the long term, to claim its position as a productive and attractive innovation environment. (Ministry of Employment and the Economy, 2009.) The Ministry of Employment and the Economy has the prime responsibility for issues related to EU research in Finland. The administrative field of the field of the Ministry contains a number of business support organizations influencing the innovation activities of Finnish firms. The Ministry also takes care of matters relating to industrial and technology policy, the Technology Development Centre (Tekes), and the Technical Research Centre of Finland (VTT). (Ebersberger 2005, 62.)

4.3 Public research

In Finland, the public funding for research institutions has an important role in the innovation activities. From the beginning of the 1980s' about two thirds of the innovations have gained public funding. Overall, about 70 percent of the finance for research and development is from the private sector and the 30 percent from the public sector. The Finnish government budget appropriations on research and development for 2009 amount to 1.9 billon Euros. Increase from the previous year us 102 million Euros. In nominal terms, research expenditure is set to rise by 6 percent. According to the amount of funding the main research institutes in Finland are Tekes, universities, the Academy of Finland and other governmental research institutes, (see Figure 11). (Statistics Finland 2009.)

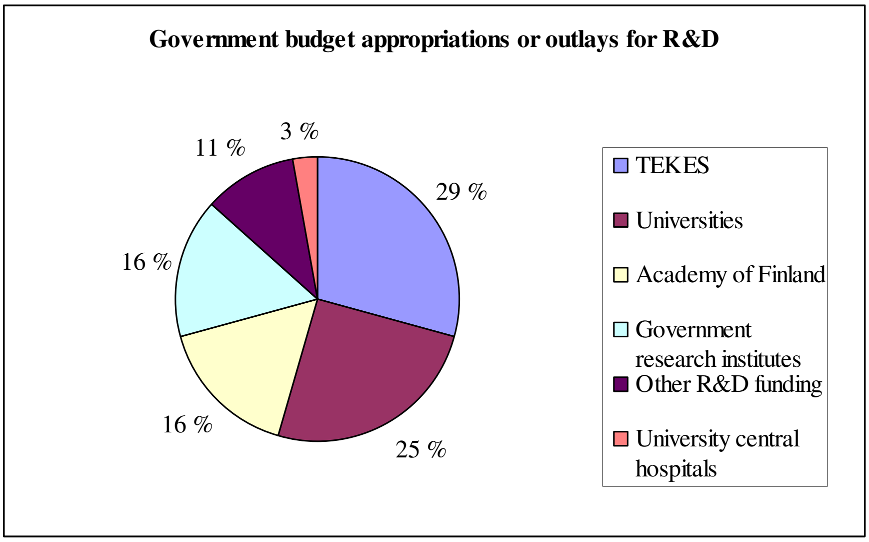

Figure 11 The governmental budget appropriations for R&D (Statistics Finland, 2009)

From the total appropriations, Tekes received approximately 575 million €, the universities received 490 million €, The Academy of Finland received 309 million €, governmental institutes received 299 million €, other research funding was 188 million € and University central hospitals received 40 million € (Statistics Finland, 2009).

4.3.1 Research in universities

Universities and other higher education institutes are one of the key elements of science in all EU countries. The role of universities is to perform research and train researchers and other skilled personnel and their role in the innovation system has broadened in recent years. In addition, universities have established closer links with business through cooperative research, networks and exchange information. In consequence, networking and close university-industry cooperation is one of the key strengths in Finland. (Ebersberger 2005, 66.)

Universities have increasingly been assigned an important role in the process of technological development. The basics idea behind the linear model is based on the assumption, that firms' innovation activities depend on the creation of new scientific knowledge, and that new technology is step by step transformed into new products or processes and it has historically created a legitimate basis for public funding of basic research in universities. It has been argued that if the basic research would be left to the market it would lead to sub-optimal allocation of resources, as companies systematically under-invest in basic research. In addition, only large companies could afford to invest in basic research and exploit the produced knowledge and that could give them a monopolistic position. It has also been argued that publicly funded research provides diversity and can therefore avoid the risk of a lock-in. (Schienstock & Hämäläinen 2001, 152-153.)

Since the beginning of the 1990s, the university-industry linkages have gained political prominence in Finland. As the national innovation system approach became the focal policy perspective, universities were encouraged to strengthen their relationship with industry and other users of knowledge. Universities increasingly develop contacts with external, non-university actors and raise external funding. However, the situation differs significantly among disciplines. Technical, natural and medical research is financed by the industry largely, while social sciences are mostly financed by public administration. The Finnish mechanisms has set up a trend that there is a continued increase in financing of basic research, unlike in Europe where the general trend has been cutting back the finance for basic research. (Schienstock & Hämäläinen 2001, 154-155.)

Compared to other OECD countries the cooperation between universities and industry is relatively intensive. According to OECD data, Finland has the second largest (after Sweden) share of firms with cooperation agreements with universities or governmental research institutes. (Ebersberger 2005, 66.) Despite the somewhat intensive cooperation, there are differences between Finnish industry and university R&D. The research in universities is often limited to narrow and abstract problems and the research team consists of scientists only from one disciplinary. The industrial research and development laboratories are accustomed to interdisciplinary research activities, since they deal with technological problems, the solving of which often needs integrated knowledge from different disciplines. Therefore, interdisciplinary research teams are much more common in industry than in universities. This is why, the cooperation between the industry and universities and the formation of so-called hybrid groups can be rather difficult. (Schienstock & Hämäläinen 2001, 158-159.)

4.3.2 Academy of Finland

The Academy of Finland's mission is to advance scientific research and its application, support international scientific cooperation, act as an expert organ in science policy issues and allocate funding to research and other advancement of science. (Academy of Finland, 2007) The academy is the most important funding agency for basic research. Approximately 16 % of the all-governmental research funding is channelled through the Academy. (Aaltonen 2007, 6.) The Academy's mission is to advance research and its application, support international scientific cooperation, act as an expert organ in science policy issues and allocate funding to research and other advancements of science. The Academy finances a wide range of basic research, which underpins innovative applied research and the utilisation of research findings. Most of the Academy funding is channelled to university research. The Academy, jointly with Tekes, administers EU research programmes and international research organisations in Finland. (Ministry of education 2, 2006.)

4.3.3 Public research institutes

There are also 18 State-owned research institutes and several science parks, business incubators and technology centres. The government research institutes have an important role in the higher education sector, and in the innovation system, as developers of knowledge based society. On average 55 per cent of the research institutes financing comes from the state budget. In terms of research volume, the largest institute is the Technical Research Centre of Finland (VTT) in the ministry of Employment and the economy sector (30 percent of the public funding). VTT also has the greatest external funding of the state institutes. The other research institutes are related to different activities, such as the Finnish Environmental institute (SYKE), Finnish Forest Research Institute, National Institute for Health and Welfare etc. (Finnish science and technology service, 2009.)

VTT is the biggest multi technological applied research organisation in the Northern Europe. Sustainable use of natural resources and a clean environment are emphasised in VTT's research and it has several joint research projects with industry related to energy and the environment. VTT has broad research for example concerning fuel cells and energy production. (Finnish science and technology service, 2009.)

4.4 Other key agencies supporting innovation

As stated earlier the public funding for innovative activities are highly important. The Figure 12 presents the main Finnish public and private funding organisations. The organisations have been categorised according to the services they provide (Linnainmaa & Teppo 2006, 5).

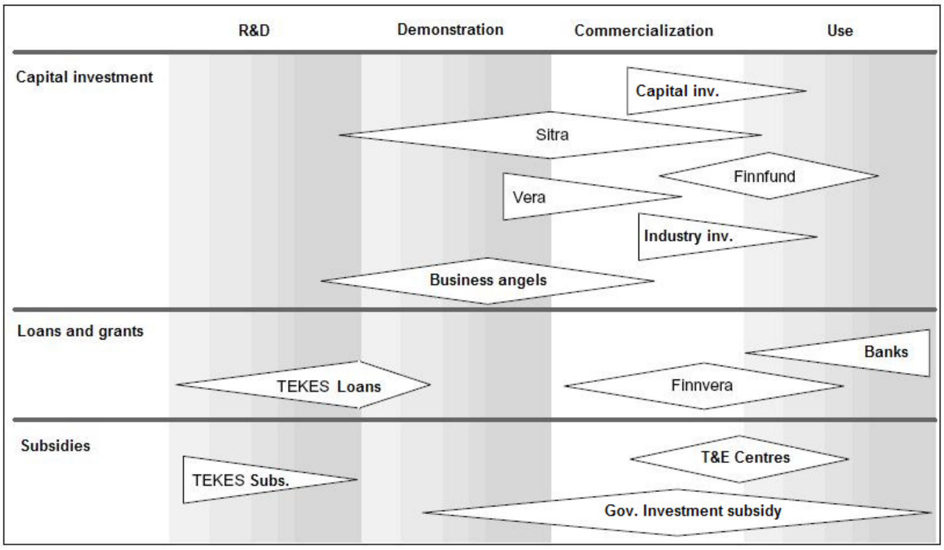

Figure 12 The public funding organizations for innovation in Finland (Linnainmaa & Teppo, 2006)

In the following, the public funding organisations in the Finnish innovation landscape are briefly presented.

4.4.1 The Finnish Funding Agency for Technology and Innovation (Tekes)

The Finnish Funding Agency for Technology and Innovation (Tekes) is the main government financing and expert organisation for research and technological development in Finland. The role of Tekes is to prepare funds and coordinate national research programs, and to provide funds for applied technical research. As it is administered by the Ministry of Employment and the Economy, it also contributes to the preparation of national technology policy. Tekes controls 27,1 percent of governmental R&D appropriations and it is so the largest organizations in the field. In 2003, Tekes supported R&D efforts through industrial grants (39.8 %), research funding for universities and research institutes (41.3 %), industrial R&D loans (10.2 %) and capital loans for R&D to companies (8.7 %). The type of funding depends on the stage of the innovation and the nature of the project. (Ebersberger 2005, 69.) Tekes acts also as a catalyst for private R&D funding, since the involvement in the Tekes projects necessitates own financial involvement of the companies (Aaltonen 2007, 6). In all programmes, companies have to provide some funding. Only if the research is of strategic value Tekes will provide 100 percent financing but on average about 50 percent of the funding comes from Tekes. (Schienstock & Hämäläinen 2001, 193.)

Tekes supports different types of networks in its various technology programmes. The aim of the programmes is to cover the whole value chain from R&D to marketing. (Schienstock & Hämäläinen 2001, 157). Tekes focuses on supporting firms and scientific institutes and it is the main source of public funding for applied technological research and industrial R&D. It funds and activates challenging scientific research in firms, universities and research centres. It seeks to promote the competitiveness of Finnish industry and the service sector by promoting research and applications in the field of technology development. (Ebersberger 2005, 69) Large companies cannot get Tekes financing without cooperating with either small companies or research institutes. The reason for this is that large companies should buy more research from research institutes and that they should share their knowledge with small companies. (Schienstock & Hämäläinen 2001, 193.)

Even thought Tekes states the commercialisation of innovations as one of its objectives, according to previous studies, the currently existing technology programme ways to support commercialization of innovations are limited. Commercialisation actions would require strong marketing actions such as market analysis, the development of strategies, the recruitment of personnel for marketing and sales, the identification of distribution channels, possible recruiting of key persons in target countries, etc. Currently, the available funding enables only a fraction of these activities. (Valtakari et. al 2004, 44.)

4.4.2 Sitra

The Finnish National Fund for Research and Development (SITRA) is an independent foundation and it is responsible for market entry funding along with private capital investors. Sitra under the supervision of the Finnish Parliament, and it invests about 100 M € annually. The main goal is to provide venture capital and to give support to companies conducting experimental research and explore new areas. The purpose is to provide a source of know-how for decision makers and national debate so that successful national strategies and experiment new operative models. The organisation works especially on the interface between the private and public sector. To sum up, the difference between the three funding agencies is that the Academy of Finland supports basic research, Tekes supports generic technology and Sitra supports explorative activity. The mechanism is created so that the three agencies complement each other. (Ahlbäck 2005, 12.)

4.4.3 Finnvera Plc

Finnvera plc is a specialised financing company owned by the State of Finland. It provides its clients with loans, guarantees, venture capital investments and export credit guarantees, that promote the competitiveness of Finnish enterprises, enable optimum financing solutions for their start-up, growth and international success. The State gives interest subsidy for the loan granted by Finnvera and participates in compensation of credit and guarantee losses. This enables Finnvera to take higher risks and to share risks with other financiers. The ministry of Employment and the Economy steers Finnvera's activities through annually fixed objectivities related to ownership and industrial policies. (Linnainmaa & Teppo 2006, 6.) Finnvera is expected to operate on the principle of economic self-sustainability. The company strives to cover its operating expenses and the credit and guarantee losses at it own responsibility, with income received from commercial operations. By offering environmental loans and guarantees, Finnvera encourages Finnish SMEs to invest in environmental protection. (Finnvera 2007, 4.)

4.4.4 Veraventure Ltd

Veraventure Ltd is a subsidiary of Finnvera Plc and entirely owned by its parent company. It was established in 2003 to manage regional evergreen funds development and investing activities on behalf of the state. It makes capital investments in regional funds organised as limited companies. The company's operations are based on the alignments of the Ministry of Trade and Industry as well as on the goals set by Finnvera Plc. (Veraventure 2008.)

Seed fund Vera Ltd is a national wide seed fund for innovative SMEs that are at their early stages and it makes capital investments. The purpose of the investments of Seed Fund is to eliminate the point of discontinuity existing between financing schemes for product development and private venture capital investment. The fund has no personnel of its own. Veraventure Ltd together with Finnvera plc`s regional offices and technology centres/science parks are responsible for the fund's practical activities. The investment grants are meant for young enterprises that have a business plan that is credible and feasible and the products should have clear market potential. (Veraventure 2009.)

4.4.5 Regional Employment and Economic Development Centres (TE Centres)

The national innovation cluster policy is also implemented trough the regional Employment and Economic Development Centres (TE-centres). They provide several financial and consultancy services for companies and farmers of their area of operation. The services provided are from three different administrative sectors namely the Ministry of Trade and Industry, the Ministry of Labour, and the Ministry of Agriculture and Forestry. There are 15 TE-centres in Finland and they were established in 1997. The TE-centres provide grants, for example, to: star-up of a business, to the development and adoption of technologies, the development of the enabling environment, and the growth and internationalisation of companies. (Aaltonen 2007, 6.)

4.4.6 Strategic Centres for Science, Technology and Innovation (SHOK)

A strategic centre for science, technology and innovation is a centre for the development of innovations that is formed together by companies, research units and financiers. At its core is a central organization in limited-company form that gathers around it a network consisting of Finnish and foreign companies. The policies and start-up of the activities of the strategic centres for science, technology and innovation are the responsibility of the Science and Technology Policy Council. In 2006 five centres were established. These include: The forest cluster, Energy and the environment, metal products and mechanical engineering, health and well-being, and information and communication industry and services. (Finnfacts 2008.)

The SHOK for the energy and environment is the Cleen Ltd, which is based on the common vision and strategic research agenda defined by the centre's owners (i.e. companies and research institutes). (Finnfacts 2008) The start up of the cleen Ltd is still on the process and so, it can not be estimated on what kind of effect it will have on the Finnish low carbon sector. In addition, it is not yet clear on which low carbon sector the organisation will concentrate. (Saarnivaara, Seminar presentation 9.6.2009.)

5 SPECIFIC FEATURES FOR THE DEPLOYMENT OF LOW CARBON SOLUTIONS

The pathway to a low carbon society faces barriers that slow the development down remarkably. This is because the low carbon technologies and innovations present a completely new paradigm for instance for the energy infrastructure. In consequence, the new applications face a great amount of different barriers and assumptions. To overcome the obstacles it is important to evaluate the possible weaknesses of the current innovation system. This chapter presents the barriers for the low carbon solutions and evaluates the barriers especially in the Finnish innovation landscape.

There are, however, several drivers that encourage governments and the private sector pursue for the low carbon development. The development has many secondary benefits of the development in addition to the emission reductions. Accordingly, after the barriers these special drivers are presented.

5.1 Barriers for the diffusion of climate innovations

There is a wide agreement on a scientific level that climate change is real, and it presents a threat to humans and other species that are uniquely adapted to the current climatic conditions. On the other hand, there is evidence that technologies exist that can lower the carbon intensity of economic activity on a cost effective manner (see Figure 8). These include both energy efficiency innovations and some renewable energy applications, which offer a win-win, no regrets opportunity for policy makers to act on climate concerns. Accordingly, a question arises: if technologies that are cost-effective and help minimize climate-forcing emissions, why are the technologies not diffusing more rapidly? (Unruh & Carillo-Hermosilla 2006, 1185.)

New technologies and innovations must overcome a range of technical and market hurdles to enter into widespread commercial use. Some of these factors are such as performance, cots, consumer acceptance, safety, financial risks (available financing instruments), enabling infrastructure, inventive structures (for example licensing fees, royalties etc.), regulatory compliance, and environmental impacts. The diffusion potential of an innovation depends on all above factors. If the innovation fails even in one of these dimensions, it will not achieve significant global penetration. (Halsnæs et al. 2007, 156.) Accordingly, the diffusion of low carbon technologies is especially vulnerable because several different factors effect to the willingness to adopt the new technologies. In the following, the factors that have an effect to the diffusion of new technologies are examined on a wider scale. Overcoming these obstacles requires strong policy measures and action from the governmental level.

5.1.1 Infrastructure provision and investment

Two types of interaction between firms and infrastructures seem to be important: firstly, with physical infrastructures usually related to energy and communications, and secondly with science-technology infrastructures such as universities, publicly supported technical institutes, regulatory agencies, libraries and databanks, or government ministries. However, because of their large scale, indivisibilities and very long time horizons of operations, they are unlikely to be adequate provided by private investors. These problems indicate a role for public sector supports. (Smith 2000, 94-95.)

5.1.2 Transition to new technologies

Innovations involve, as stated earlier, a fundamental degree of uncertainty and any unwillingness or inability of firms to bear the risk involved will reduce the level of innovation below its theoretically optimal value (Foxon 2003, 27). In many cases the main barrier for the efficient diffusion of low carbon technologies is not the lack of funds but rather the mobilisation of the funds and the willingness to take risks in investing in new technologies. Because existing firms, especially small companies can be quite limited in their technological capabilities and horizons, they are likely to experience great difficulties in responding to technological changes. Firms usually concentrate on what they know best and so, they concentrate on the products and technologies where they have experience and skills, and they try to bring a high level of expertise to the technologies which exploit these skills. Because of this, a situation is created where firms have a strong competence within their area of technologies knowledge, but relatively limited capabilities even in closely related areas. (Smith 2000, 95.)

A special feature for energy efficiency investments is that their positive affects are underestimated because the immediate impacts of energy efficiency measures are often “invisible”. It is unlikely that an investment will be made, if it is not possible to calculate at the outset how an energy efficiency measure adds value to the company’s product or productivity. (Makinson 2006, 16.) These are seen as “passive investments” in contrary to the “productive investment”. It seems to be awfully common that investments on energy efficiency are seen to have too long payback period and benefits are regarded as inadequate. There is evidently a lack of knowledge on the benefits that these solutions have.

In addition, one major fundamental barrier to invest in energy efficiency applications and renewable technologies is the fact that energy prices do not reflect the real costs of carbon and other environmental externalities. (Makinson 2006, 16). The low energy prices produced on current technologies combined with the high production costs that make the clean technologies too expensive and therefore uncompetitive (OECD 2008, 15). Especially in Finland, the relatively low energy prices prevent the shift to the new technologies. According to the statistics, the Finnish electricity prices were even below the EU-27 average (Bosch et al. 2009, 106).

5.1.3 Slow commercialisation

One of the key questions in the effective diffusion of low carbon technologies seems to be the rapid commercialization of the innovations. If new technologies and innovations commercialise slowly it is highly likely that they will not reach the market at all. Especially many low carbon innovations remain trapped in the cycle of small volume and high costs hence, the adoption of these technologies is relatively slow. (OECD 2008, 18) The slow commercialisation is a result of several different reasons. One typical reason is the financial gaps within the innovation chain. According to previous studies on innovation systems, the financial gaps typical for technology innovation occur between the demonstration and commercialisation phases. This is not only a problem in the Finnish low carbon innovation landscape, but it seems to be a global problem with low carbon innovations (Tuhkanen, interview 2009).

As investments for research and development are seen inevitable, it is common that the research and development stages of an innovation are emphasised at the expense of demonstration and piloting stages. Hence, the financial gaps are most frequently encountered during the pre-commercialisation stage of technology innovation and the project-planning stage for project deployment. This is because of the high risks that for example renewable energy technologies have. (Tuhkanen; Teppo, interviews 2009). The Finnish low carbon culture also lacks the expertise in marketing and economics. Even if the new low carbon applications would offer cost-effective options, the technology developers do not know to promote their products successfully, thus the commercialisation remains weak (Tuhkanen, interview 2009).

According to several specialists, the slow commercialisation of the low carbon applications in Finland is also a result of the rather limited domestic markets. The small domestic markets are seen as inadequate to support long-lasting business operations. In consequence, it is typical for Finnish companies to aim only for the international markets and the commercialisation is strongly connected with export and internationalisation. (Heiskanen, interview 2009.) However, the international business has greater risks for small and medium-size enterprises. This is why gaining market experience at home is especially important in the case for the SMEs (OECD 2008).

5.1.4 Dependence on existing technologies

Path dependence, or "lock-in" to existing technologies is a strong feature of innovation systems. This means that certain technologies are closely linked with their social and economic environment. In consequence, technological alternatives must compete not only with components of an existing technology, but with the overall system in which it is embedded. Technological paradigms persist because they are a complex of scientific knowledge, engineering practises, process technologies, infrastructure, product characteristics, skills and procedures which make up totality of technology and which are exceptionally difficult to change in their entirety. (Smith 2000, 95 – 96.)

Lock-ins' do not only exist in firms, but industries and the completely socio-economic system may not be able to switch away from the existing technologies. Unfortunately, it is very unlikely that movement away from such complex system could be introduced by tax policies, on a particular input. The elements of a technological paradigm interlock with each other and a change in a techno-economic paradigm must involve a complex and integrated process of change in all activities, including science, engineering practices, physical infrastructure, social organization, plant design and so on. (Smith 2000, 69.) Perhaps the most important case at the present time concerns the role of the carbon-based energy system, the “carbon lock-in”. Firstly, the problem lies in the current economic and social activities, where carbon-based technologies are used as inputs in virtually all activities. Secondly, lock-in problems arise because of the complexity of the energy system, which includes the production, distribution, and the use of energy. (Unruh & Carillo-Hermosilla, 2006, 1193; Smith 2000.)

5.1.5 Institutional barriers

An integrated set of public and private institutions, regulatory systems and the policy systems creates a framework of opportunities and barriers to innovation firms. These include for example technical standards, risk-management rules, health, and safety regulations and so on. The regulatory system also includes the general legal system regulating to contracts, employment and intellectual property rights (patent and copyright law) within which firms operate. (Smith 2000, 96-97.)

A special barrier for the low carbon development is that the current national innovation strategies and policies are not sufficient in supporting rapid diffusion of climate technologies. The innovation strategies have primarily been designed around national competitiveness priorities, and thus not to produce global public goods. Competition has been a crucial factor in driving innovation but it does not fully capture all of the global public good aspects of low carbon technologies. The low carbon innovation and knowledge have the classic elements of a global public good, as at a fundamental level, the benefits of a low carbon innovation are non-excludable and non-rivalrous in consumption across national borders. That is to say that the use of new low carbon knowledge and innovation by one country does not prevent others benefiting from it, and when one country decarbonises all will gain from reduced global emissions. This means that in the absence of additional multilateral action, private markets will under-invest in low carbon innovations relative to the global social optimum. (Tomlinson et al. 2008, 28-30.)

In addition, there is a wider context of political culture and social values that shape public policy objectives. These include barriers like subsidies and technology owners lobbying power. (Smith 2000, 96-97; OECD 2008 17.) In Finland especially the pulp and paper industries have exceptionally strong lobbying power over the energy issues. This is because Finland has a long history in pulp and paper production and the national welfare has been based on the “green gold”. The energy sector has been built to support the energy intensive industries and it is based on big energy production units. The pulp and paper sector has accounted for half of the industrial sector energy consumption and even higher share of industrial sector electricity consumption (Bosch et al. 2009, 92). Currently the lobbying is particularly fierce as there is clear pressure to curtail pulp and paper production because of low profitability.

For the reasons mentioned above, the performance of different institutions and systems concerning innovation should be monitored and assessed, and if they are judged to be creating unnecessary barriers, policy changes or interventions should be considered (Foxon & Pearson 2008, 157).

5.1.6 Weaknesses of the Finnish innovation system

The Finnish innovation system and the support policies, presented in Chapter 4, are strongly based on the linear model of innovation. The role of extensive research and development activities are emphasised in the national innovation landscape, and so far according to the statistics, the innovation development system has been successful. The strong investments to R&D presents, however, one of the problems in the low carbon innovation development in Finland. It has been characteristic to the innovation system that there is a lack of funding for pilot and demonstration projects. In addition, the slow commercialisation, due to different reasons, seems to be a problem for the domestic innovations. There is for example a genuine lack of marketing and economic expertise for the low carbon innovations. In consequence, the innovations will not reach the domestic mass markets.

Some support mechanisms have been implemented to reduce the gaps within the Finnish innovation system. However, it has been questioned, if these mechanisms efficiently support the low carbon innovations’ development. Even the new mechanisms

(SHOKs) seem to support the linearism in the innovation system, and do not really bring anything radically fresh to the system.

As the revolutionary trend is to involve the user in the innovation process, the innovation theories seem to shifting towards the open innovation, where the role of the user is emphasised. Accordingly, the Finnish innovation system should open up, and be a forerunner in the innovation system development. For example, in the case of energy systems users are still usually treated as passive consumers of energy, rather than active participants. Accordingly, user involvement in the energy system is still in its infancy. It should be noted that greater focus on the role of users in low-carbon innovation could open up the market to a much wider range of opportunities and solutions in Finland. In addition, successful low-carbon innovations can come from all corners of the economy, not just from the energy sector, or from the environmental industries. Real progress can be made when a series of innovations link together, setting a chain reaction of change. (Willis et al. 2007, 6.)

There are also problems with the university – industry co-operation. Despite the fact that innovative companies in Finland cooperate more than other European countries with universities, there are many companies, especially SMEs, which are not aware of the potential benefits of such co-operation. Non-cooperating companies see the lack of information as a key factor that holds back the establishment of linkages between the company and universities. Naturally, the companies that already cooperate with universities have better access to information on university research, training and other activities than non-cooperating ones. (Schienstock & Hämäläinen 2001, 157.)

One problem of the Finnish innovation system is the current overlap within the system. As the importance of climate change mitigation has been noticed, several of the public research institutions in the field, fund and promote similar programmes. The problem is that the different research institutions have contradictory research cultures and separate administrative boards. This has led to a situation where the co-operation is limited. Since the funding is always limited, unnecessary overlap should be avoided. In addition, the funding for projects can sometimes be somewhat impossible to reach. Some of the funding institutes are characterised with unnecessary bureaucracy that can lead the researches unwillingness to even apply for governmental funding for their project. (Saarnivaara, Seminar presentation 9.6.2009.)

5.2 The drivers for mitigating climate change

The main driver for climate change mitigation is usually considered to be the international treaties that obligate countries to curb the greenhouse emissions. Accordingly, the Kyoto protocol is seen as the main driver for promoting the climate change mitigation. In the past the emission reduction targets have traditionally been seen to have a negative impact for example to the industry sector and national economy. However, the climate change mitigation has several secondary benefits that might not have been getting enough attention in the mitigation discussion. For example the low carbon innovations promote more efficient use of natural resources, improve local air quality, and improve the energy security and have development benefits.

5.2.1 International agreements

The main driver for curbing the amount of greenhouse gas emissions is of course the climate change mitigation. As the society has been built upon the carbon pathway, there needs to be regulatory means to promote the low carbon development. The most efficient ways of promoting the development are international agreements that obligate several countries at the same time to curb the emissions.

As precedents, UNFCCC and Kyoto Protocol have been significant in providing a means to solve a long-term international environmental problem. However, they are only the first steps towards the implementation of an international response strategy to combat climate change. The Kyoto protocol’s most notable strategy achievements are the stimulation of an array of national policies, the creation of a carbon market and the establishment of new institutional mechanisms. (Gupta et al 2007, 748.) The impacts of the treaties can be seen directly or indirectly in several public fields. The Kyoto mechanisms help stimulate green investments and help Parties meet their emission targets in cost-effective way.

Accelerating the development of low-carbon innovations and promoting their global application is a key challenge in stabilizing greenhouse gas emissions. In consequence, technology will be one of the key issues also in the post-Kyoto negotiations. The new international agreements on climate protection will become a strong driver for innovations and technology development. The upcoming agreement is expected to create pressure for the developed countries to provide a fair share of adequate, predictable and timely financial assistance required for appropriate mitigation and adaptation by developing countries. (Korppoo et al. 2009, 19.)

According to statistics the Kyoto Protocol has induced more innovation in the recent period. While innovation in climate change technologies and innovation in all technologies were growing at the same pace until the mid-nineties, the former is now developing much faster. (See Figure 13) Between 1998 and 2003, innovation in climate mitigation technologies has been growing at the average annual rate of 9 percent. This increase has taken place in Annex 1 countries that have ratified the Kyoto Protocol (not in the USA). However, there is no visible effect of the Kyoto protocol on technology transfer. The international technology flows have been increasing in the recent period, but the growth rate is the same as the average. (Dechezleprêtre 2009, 12-13).

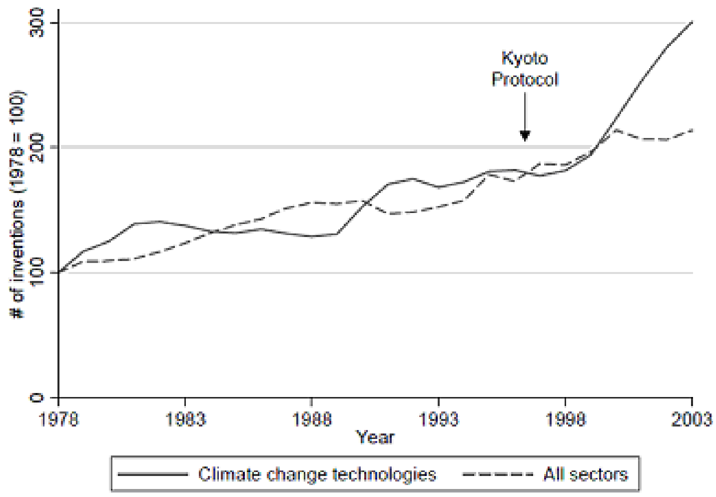

Figure 13 The innovation trend. Climate technologies compared to all sectors (Dechezleprêtre 2009, 12).

Accordingly, the emission reduction targets promote innovative activities and it is necessary to promote strict emission reduction targets. This fits also well in to the previous outlook of the birth of innovation and technology. A niche market needs to be always generated for innovations.

5.2.2 Increasing the energy security

The importance of mitigating climate change has been recognized broadly, but another challenge and a remarkable driver to shift to the renewable energy is the improvement of energy security. The most long-lasting cause of energy insecurity is the concentration on fossil fuel sources to certain regions of the world. Also the fuel exploration, production and the transportation to the market are characterised by a certain degree of concentrations as well. Furthermore, it is common that the fossil fuel resources are situated in certain regions that are politically relatively unstable. The transportation of a fossil fuel is also exacerbated by geographic constrains. In consequence, as the fossil fuels are playing a dominant role in our energy system even a small political crisis or a cataclysmic event can affect almost the entire existing energy system. For example, different political conflicts in the Middle East have caused several oil crises, which have led to a significant increase in the oil prices. In consequence, the renewable energy resources that are less sensitive to different variables are becoming increasingly popular in different policy actions.

As oil is one of our primary energy sources, the past oil crisis have had a serious effect on national and global economy. Now, as we are nearing the end of the era of cheap oil it would be vital to reduce our dependence on oil to avoid further conflicts. There are some examples how the high oil prices have effected positively low carbon development. For example, the oil crisis in the seventies led Japan to adopt the first energy efficiency standards as far back as 1979 (Korppo et al. 2009, 75). In general, it is clear that the evolution of crude oil prices seem to have had a significant influence on the low carbon and especially renewable energy development (Dechezleprêtre et al. 2009, 14). However, it would be essential that efficient policies promoting renewable energies would be implemented as soon as possible, before the oil runs out.

5.2.3 Technology transfer to developing countries

Technology transfer to developing countries could bring great business opportunities for low carbon technology developers. Technology transfer has become one of the major issues in the international climate negotiations. For instance, EU and Japan agree on the fact that technology transfer to developing countries would be essential for climate change mitigation. The EU emphasises that a significant contribution from developing countries and particularly from economically more advanced developing countries is essential under the new climate agreement. In consequence, the EU has called developing countries as a group to limit the growth of their greenhouse gas emissions to 15 – 30 percent below business as usual by 2020. To meet this target, the EU proposes that all developing countries design and implement national low-carbon development strategies, which outline a set of mitigation actions covering all key emitting sectors. To meet these targets the developing countries require financial and technological assistance. (Korppoo et al. 2009, 18.)

Until now, the technology transfer activities have mainly occurred between developed countries. The exports from developing countries to emerging economies are still fairly limited. However, they are growing rapidly. This suggests a huge potential for the development of North-South transfer. (Dechezleprêtre 2009, 30.) If strong policies for technology transfer are created, it can be possible that developing countries have an opportunity to avoid carbon lock-in because they have not yet built their national energy infrastructures. Their latecomer status theoretically allows these countries to "leapfrog" straight to superior climate technologies and infrastructures. This is an important issue because, by some estimates, 70 percent or more of future energy demand is expected to be in developing countries. However, at the present there is little evidence that climate relevant energy technology leapfrogging is occurring. (Unruh & Carillo-Hermosilla 2006, 1186.) The emerging economies such as India and China are currently relying strongly on fossil fuels in their rapid economic growth. For this reason, the leapfrogging could occur mainly in the least developed economies. In all cases, the technology transfer could bring business opportunities to the domestic technology and innovation developers.

5.2.4 The economic opportunities

The climate change mitigation and emission reduction obligations will create significant business opportunities. The future markets for the low carbon technologies and services could be one of the main reasons why the private and the public sector see the climate change mitigation as an opportunity and might participate in the mitigation challenge in a one way or another. The low carbon innovations do not just help to reduce emissions, but they have a potential of boosting the economy worldwide. These markets could grow to be worth hundreds of billion dollars each year, and the employment in several sectors could expand accordingly. In addition, successfully commercialized technologies could have many other secondary and long-lasting benefits. If designed well, new low carbon innovations could easily be transferred and used worldwide.

According to the IEA the demand for energy will increase globally by 40 percent by 2030 and the demand in Asia will double. As we can no longer rely on fossil fuels, the low carbon innovations have terrific market opportunities (Teppo, Seminar presentation 9.6.2009). Sustainable energy has also a positive economic impact trough job creation. The employment figures from UNEP and the International Labour Organisation (ILO) for the renewable energy industry, suggest that it already generates more jobs than employment in fossil fuels. (Hohler et al. 2009, 24.)

To gain the maximum benefits of the low carbon development, the market analyses have an extremely important role. One of the challenges for the Finnish climate cluster is the promotion of the development of right technologies and innovations. For instance, Tekes has studied the market prospects for Finnish low carbon technologies. According to the survey on the international possibilities (Vanhanen et al. 2006), the size and growth rate of the markets varies considerably between the different sectors of the Finnish environmental cluster. Figure 14 presents the potential markets for the Finnish climate cluster. The size of the ball is equivalent to market position of the Finnish companies in the global markets.

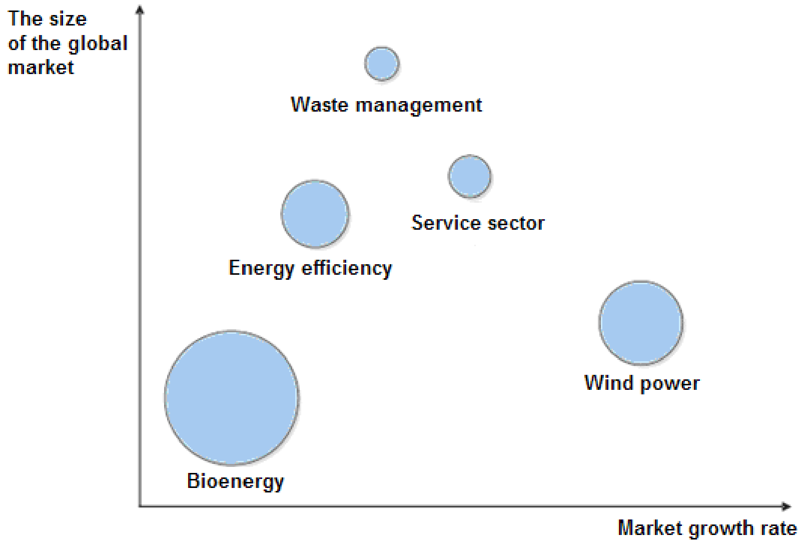

Figure 14 The possibilities of Finnish climate cluster (Vanhanen et al. 2006, 80)

The size and the growth rate of the bioenergy market are steady but Finnish companies have a strong position. Bioenergy has the strongest position in the Finnish climate sector. However, the global growing rate has been somewhat moderate – about 2 – 3 % annually. The resources for bioenergy are divided unevenly globally and the prospects for growth vary considerably. The markets for wind power are slightly bigger but they are growing rapidly worldwide. The global annual growth for wind power is estimated to be about 8 billion euros and for the past years, the markets have grown approximately 16 percent annually. Energy efficiency, service sector and solid waste management have even greater markets, but the growing rate is still slower than with wind power.

As stated above, estimations on which low carbon technologies will play a key role in the future low carbon and energy sector are extremely vital. This is because governments want to, of course, gain maximum profits of the R&D investments. Accordingly, adequate amount of resources should be used for analysis and estimations on the possible future low carbon technologies and innovations that will play a major role, both economically and for the mitigation challenge.

6 THE GOVERNMENTAL MEASURES FOR SUPPORTING LOW CARBON INNOVATIONS

The previous chapters have highlighted the importance of governmental measures in the climate change mitigation. Accordingly, the governmental measures have an exceptional role in the low carbon development. The low carbon innovations face numerous obstacles and a rapid low carbon development is not possible without governmental support mechanisms. The government can implement several policy measures to speed up the diffusion of low carbon innovations. However, as the obstacles for low carbon innovations are so numerous, there needs to be a set of different measures that remove the barriers. It is impossible to determine just one policy measure that would remove these obstacles.

There are several international examples on how public policies and measures aimed in particular to support low carbon development have speeded up the diffusion process. This chapter will present some of the measures, that have internationally been successful and that could enhance the Finnish innovation system and help to remove the current obstacles. These measures are needed in the Finnish innovation landscape, if the government wants to boost up the low carbon development.

6.1 Environmental regulation and emission reduction targets

The emission reduction targets from the governmental level promote the improvement of technology and the birth of innovations in two different ways. Firstly, the targets create a pressure for the markets to increase the funding for research and development, which lowers the prices of clean technologies. Secondly, emission reductions lead to the commercialization of clean energy technologies, which also have a positive effect on the prices. According to the previous studies, there is an important relationship between environmental regulation and innovative activity on environmental technologies. (Halsnæs et al. 2007, 155.)

There is growing recognition that mitigation policies or scenarios aimed at reducing greenhouse gas emissions have also important secondary benefits. These potentially include reduction in air pollution, reduction in other environmental burdens, increase in security of energy supply and diversity, improved competitiveness, increased employment, and innovation. (Watkiss et al. 2005.) Therefore, a key challenge for governments is to design policies that deliver the required emissions reductions, while minimising the negative growth impacts of such interventions. While well-designed policies could deliver emissions reductions at around 1 % of global GDP by 2050, badly designed policy could significantly raise costs (Defra 2009, 10).

Finland, as a member of the European Union, is obligated to fulfil the targets set by the Union. However, in the future climate negotiations it is likely that the developed countries are to commit to deeper greenhouse gas reductions so that a sharp decline in the total emissions could be reached. The scientific research on climate change supports the need of more than 25 - 40 percent emission reductions by 2020 from 1990 levels and it is highly likely that more ambitious reduction targets are inevitable. Therefore, Finland should voluntarily set new, more ambitious emission reduction targets. The governmental bodies in Finland have in many statements highlighted that the climate technologies will be next success story of the national technology development. However, the unobtrusive greenhouse gas reduction targets prevent Finland from being one of the forerunners in the field.

There are quite a few different examples of ambitious climate regulations that have currently been implemented in the world. For example, the British government has committed the United Kingdom to cut greenhouse gas emissions by 80 percent by 2050. In addition, the Chinese government has set very ambitious energy-efficiency targets for China and Spain has made solar panels mandatory in new buildings. (WWF 2009.) Therefore, even if Finland has very efficient R&D system for technology development, the government should enforce the development and deployment of climate technologies and innovations with strong climate policy measures.

Mandatory renewable energy target (MRET) or also called the renewable portfolio standard (RPS), are relatively new policy mechanism used in several countries. In its most common design, this policy requires that a fixed percentage of electricity in each retail suppliers’ portfolio be generated by renewable resources.

This measure enables the policy design can be tailored to specific domestic market. (Lewis & Wiser 2007, 1854.) This sort of measures could be one option for the Finnish energy production as well (Teppo, interview 2009).

6.2 The public policies for supporting technology change

As the technological change is in the key role in the climate change mitigation, technology policy considerations are increasingly considered in climate policy analyses. There are two different approaches on the subject, which seem to be more or less controversial; technology push and demand pull policies. There is an ongoing debate around the two different approaches. The policies on technology-push emphasizes the role of policies that stimulate research and development, especially those aimed at lowering the costs of meeting long-term objectives with technology that today is very far from economic in existing markets. The policies might include public-funded R&D or R&D tax credits. (Halsnæs et al. 2007, 156.)

The demand-pull emphasizes the use of instruments to enhance the demand for lower-emission technologies, and so increasing private incentives to improve these technologies and including any learn-by-doing effects. Demand-pull instruments might include emission taxes or more direct approaches, such as renewable portfolio standards, adoption subsidies or direct public-sector investments. The technology development cycle and its main driving forces are presented in Figure 15. It differs from the traditional linear model of innovation (Figure 1) so that it emphasises the roles of different actors, the importance of feedbacks, both positive and negative between the different parts of the system. (Halsnæs et al. 2007, 156; Foxon 2003, 18.)

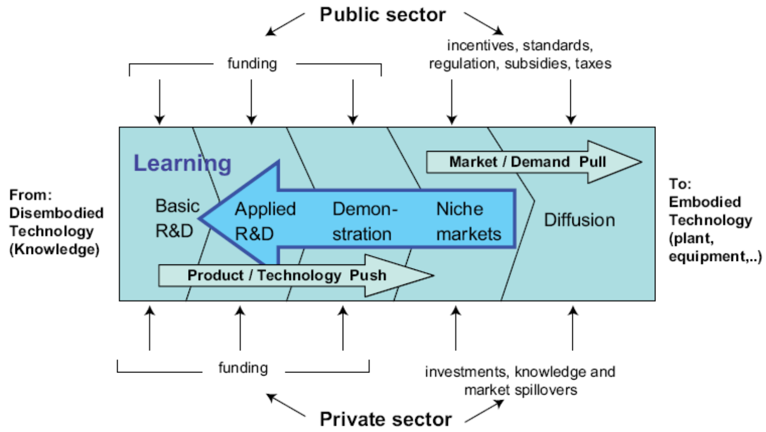

Figure 15 Technology development cycle and its main driving forces (Halsnæs et al. 2007, 157)

Successful innovations require a balance between the push and pull factors along the innovation chain, with varying levels of public-private finance and policy interventions at different stages (Tomlinson et al. 2008, 25). The following chapter present different technology push and demand pull mechanism that the government can promote to speed up the diffusion of low carbon innovation.

6.3 Public mechanisms for support technology push

As stated earlier, the technological applications play a key role in the goal of curbing green house gas emissions. This is why, the public funding for research and development activities are seen to be in a key role when trying to meet the emission reduction targets. The mechanisms for supporting research and development activities are regarded as a public good, since the private sector may not adequately support the research and development activities.

Research and development from across the economic field is important to climate change. Energy-focused R&D, basic or applied, in addition to the R&D in other climate relevant sectors, like agriculture can directly influence the greenhouse gas emissions associated with these sectors (CO_2, CH_4). Simultaneously, research and development in seemingly unrelated sectors may also provide spill over benefits to climate relevant sectors. For example, advances in computers over the last several decades have enhanced the performance of the majority of energy production and use of technologies. (Lewis & Wiser 2007, 1853.)

However, the funding for R&D in climate policies is not unproblematic. The increased research and development spending are often seen as a solution to the climate change problem on a political level. Such spending offer the political cover of doing “something” about the climate change, while the more painful costs that may come from regulations requiring emission reductions are avoided. This is why, it is necessary to question, do the policies increasing the funding on the R&D impact the global climate and can R&D subsidies substitute for more restrictive emission policies. (Popp 2006, 311.)

Accordingly, climate policies based solely on research and development are not efficient for the goal of reducing emissions. The problem is that these policies do not set limits for the use of carbon-intensive fuels. The emissions are effectively reduced only if the investments for R&D are so great that the price of clean technology is below the price of coal intensive fuels, even if there is no charge for the emissions. Another challenge is the allocation of the funding for R&D. For example, an efficient allocation of the public funding for R&D is extremely challenging since the knowledge has spread to both public and private sector. The biggest challenge is the allocation of the funding to projects that have the greatest potential for the public good. (Urpelainen 2008, 17.)

6.3.1 Domestic research and development

It can be stated that the Finnish innovation and climate policies have strongly been based on R&D support mechanisms. The most important research and development project in Finland about the climate change mitigation was the Tekes ClimBus-programme during 2004–2008. The programme financed several different research projects on climate change mitigation possibilities and scenarios. These included researches on CCS technology, renewable energy, nuclear power development etc. The programme gained good results and the timing for the programme was planned exceptionally well. However, as the scale of the ClimBus-programme was remarkably broad and the funding is still limited for the climate sector, the future domestic research programmes probably cannon be implemented in such large scale.

The challenge for the Finnish research and development landscape is that the field of operation is relatively extensive and the operations include several different institutions.

This has led to a situation where the funding is fragmented to the numerous institutions and to their different projects. All of these institutions see their role from a certain perspective and they are characterised with different research cultures. Because of this, an efficient co-operation between the researchers has been, to some extent, hard to reach. Accordingly, there would need to be efficient communication channels and research networks between the institutions so that the possible overlaps could be eliminated, and that the research would be more efficient. The Climbus programme performed as a link between the researchers, but as the programme has now ended, new collaborative actions are required. Nevertheless, with certain actions well-organized co-operation could be reached in Finland since the innovation landscape is still not as spread as in some other countries. (Saarinivaara, Seminar presentation 9.6.2009.)

As there are several promising innovations that play a significant role in the climate change mitigation, the Finnish innovation system would need to concentrate to only a few promising technologies. For a small nation with an exceptionally developed innovation and research system, the research activities would need to be built on a strong political will that aims at developing only certain technologies. These technologies should be selected on the base of already available knowledge, so that the research would not need to start from scratch (Tuhkanen, interview 2009). This also highlights the importance estimates and analysis on the future low carbon innovations. If there was a mutual political will and a clear strategy how the goal could be reached, it could lead to steps towards climate change mitigation in addition offering Finnish entrepreneurs clear opportunities to utilise the expanding low carbon markets (Saarnivaara, Seminar presentation 9.6.2009).

6.3.2 International R&D co-operation

Globalisation has contributed to a growing number of international research and development and innovation partnerships. The growing number of international cooperation and cooperation is a natural outcome of the expansion of firms into new markets and countries since this process makes firms face new realities and challenges. Some of the high cots of managing international projects have been reduced by the availability and wide diffusion of new information technologies. Associated reductions in communication costs and increases in the potential to coordinate activities across countries have certainly contributed to the boom of international R&D cooperation. (Faria & Schmidt 2007, 6-7.)

However, now in the governmental level collaborative research and development is very weak outside long term areas such as nuclear fusion. As stated earlier, the national innovation strategies are mainly designed around the national competitiveness priorities and in consequence, they work against effective international R&D co-operation. In the energy area, there are many co-operative agreements at the IEA and the public research and development activities are somewhat better between developed countries. However, there is significant policy failure in national research and development programmes. Currently multilateral institutions do not sufficiently address cross-border issues of risk management and networks of innovation. Therefore, action is required at the multilateral level to build on national efforts and correct the market failures to fully capture the global public good aspects of low carbon innovation. (Tomlinson et al. 2008, 32.)

6.4 Stimulating the domestic markets

The stimulation of the domestic market is seen as one of the key aspects in speeding up the commercialisation of low carbon innovations. The government has a key role in implementing certain market pull activities that stimulate the domestic markets. This can be done with well-designed actions and policies that spur innovation and government measures that contribute to creating and consolidating domestic markets for environmental technologies constitute a basis for success in global markets. The weak domestic markets also to some extent hinder the potential use of customer-driven innovation thinking. This is because the company has a limited contacts and no common ground with the potential user. Strong cultural differences and diverse backgrounds can negatively affect the diffusion of a new technology if a company aims straight for the international markets. Accordingly, the stimulation of the domestic markets is essential also for the promotion of customer-driven innovation (Heiskanen, interview 2009).

The main challenge with the stimulation of the markets is that well designed mechanisms would ultimately need to be technology neutral. This would increase competition with different technologies. The current mechanisms and regulations are somewhat targeted to only certain technologies and this can create distortion to the innovation activities (Saarnivaara, Seminar presentation 9.6.2009). Achieving a sizable, stable local market requires aggressive implementation of different support policies (Lewis & Wiser 2007, 1854). In the following some support mechanisms that have outside Finland successfully created domestic demand for innovations and technologies are presented. These mechanisms support the market pull theory and so, stimulate the domestic markets.

6.4.1 Feed-in tariffs

A frequently referred policy instrument for promoting renewable electricity is feed-in-tariff. The tariff provides a guaranteed reimbursement on produced renewable energy such as wind or solar power over a long period. The tariffs have historically offered the most successful foundation for domestic wind manufacturing, as the can most directly provide a stable and profitable market in which to develop different projects. The most successful examples on the use of feed-in-tariffs come from Germany, Denmark, and Spain. All of these countries have a history of stable and profitable feed-in-tariff policies that promote wind power development. (Lewis & Wiser 2007, 1854.)

For the efficient diffusion of climate technologies, the private financing is essential, since the governmental mechanisms can finance the only part of the process. However, for example implementing big renewable energy projects have greater risks than conventional technologies, so the private funding, from example from a bank can be somewhat hard to get. This is why, it is extremely important that the private financier, usually a bank, is familiar with the support mechanisms that partly fund the projects. As the feed-in-tariffs have proven to be efficient, they might be the reason for a bank to join a low carbon project. Some new support mechanisms might on the contrary, discourage the private funding because there is no experience of it and so, the risks might be unbearable. (Linnainmaa & Teppo, interview 2009.)

Finland is currently implementing the feed-in-tariffs for wind power and biogas production. Like in many other countries, they are expected to boost the wind power industry and encourage companies to invest in the wind power production. However, there has been some scepticism that the current feed-in-tariffs are inadequate in reality to explode the wind power productions in Finland. (Teppo, interview 2009.)

6.4.2 Public procurements

The public sector has a vital role in the diffusion of climate change innovations, in driving patterns of consumption, in sectors such as infrastructure, buildings, vehicle standards and public transportation. In consequence, public sector purchasing agreements are a vital tool to accelerate innovation in certain key sectors (Tomlinson et al. 2008, 71). Technology procurement has been applied successfully in several countries. The procurement is applicable on single components or on systems, single or multi-staged. However, the most of the known procurement examples relate to energy-efficiency applications rather than to renewable energy projects (Lund 2007, 631).

One of the most well known examples of public procurement processes is the heat pump procurement in Sweden in the 1990s'. The goal of the procurement was to stimulate the development of more efficient, more reliable and cheaper heat pumps and heating systems for use in detached houses being heated mainly with electricity. The objective was to achieve the potential energy saving within 15 years, which could involve sales of about half a million heat pump systems in the Nordic countries. To achieve this objective new, creative solutions were required that could make the heat pump into a viable, attractive investment for individual property owners, despite, at that time, a bad reputation on the market. (Neij et al. 2008, 5.)

In the technology procurement process, the development of the technology was set by the requirements of the potential users and purchasers. Besides helping to draw up the performance specification and evaluating the entries received, the purchaser group also ensured that at least 2000 units would be sold of the winning model. The specification defined a heat pump 30 percent more effective and 30 percent cheaper than the existing model on the market. A third party was set to test the prototypes to ensure credibility. To further support market introduction of these energy efficient heat pumps, the procurement program was supported with investment subsidies and information and education programs. The technology procurement program involved several organisations and institutions from the beginning, including heat pump manufacturers, researchers, retailers, potential buyers and agencies. After the first year, sales exceeded the expectations and at the same time interest for heat pumps from abroad started to increase. (Neij et al. 2008, 5.)

This spring the Finnish government announced that the public sector would promote sustainable public procurements. The state is obligated to consider environmental aspects in all of the procurements by 2015. However, the municipalities are only recommended to pay attention for the environmental aspects for 25 percent in 2010 and half of the procurements in 2015. Accordingly, the targets are mandatory for the central government, but only recommended for the municipalities and state-owned enterprises. (Finnish government 2009.)

Even if this was a good start, in the Finnish landscape it would be highly important that sustainable procurements would reach the municipal level. However, the problem is often the lack of funding. In the municipal level, the procurement process is highly characterised with expenses and so, the environmental aspects are often passed at pretext of higher price of the procurement (Harmaakorpi, interview 2009). To overcome this obstacle new innovative funding mechanisms are needed to support the public procurements. For example on the municipal level, the cots of energy efficiency applications could be paid with the gained savings. This could boost for example the public procurements of different energy efficiency applications.

6.4.3 Financial and tax incentives

Different financial support mechanisms are frequently used for supporting sustainable energy. The financial incentives of various forms, whether based on electrical production of capital investment and whether paid as a direct cash incentive or as a favourable loan program, can also be used to encourage renewable energy development. However, without a long-term power purchase agreement, this policy mechanism has been found to generally play a supplemental role to other policies in encouraging stable and sizable growth in renewable energy markets. (Lewis & Wiser 2007, 1854.)

According to the previous outlook on the Finnish innovation strategy, capital grants and R&D funding are the main support instruments in Finland. For example wind energy has received a maximum 40 %, in practice 30 % subsidy of the total investments. Accordingly, the market growth has been slow (Lund 2007). However, the target for the financial and tax incentives need to be closely assessed, since there is a evident need to support the demonstration with different methods.

6.5 Demonstration sites

One efficient way of promoting the diffusion of innovations is proper demonstration projects. As stated in earlier the demonstration phase is one of the critical phases in the development of an innovation. However, there is a lack of information on when the demonstration should be carried out. A unique example of a large-scale demonstration site concerning renewable energy is the island of Lolland in Denmark. The site is called Lolland Community Testing Facilities (CTF). This demonstration site is a good example of creating enabling environment for innovations and technologies. At the same time, the numerous projects have created numerous job opportunities for the local people. (Venter 2008.)

The island is said to be universities' and private companies' backyard and a research and development hub for renewable-energy projects. In 2008 on the island there were currently 50 private and public sector experiments running including biogas, biomass, hydrogen, wind, and wave projects. As the result of the enabling environment companies feel that it is easy for them to come to the island and carry out research projects. The projects have created jobs, skill and even an entirely new industry in Lolland. As a result, the unemployment rate that had reached 40 percent on the island only a few years ago, has dropped down to 3 percent. The demonstration site offers companies financing incentives, grants and co-finance opportunities, low-cost product testing, faster commercialisation, and the opportunity to see how real people respond to their technology. As traditional projects flow allows for around two to three years before implementation, but the experience from Lolland has shown that up to one year can be saved from this. This is because Lolland offers a fast-track permitting process in getting a project up and running. This is a huge advantage when a certain products are on the demonstration and commercialization phase. In addition, the site could enable international cooperation between companies and innovative partnerships. (Venter 2008.)

The programs in 2008 included ambitious programmes, like a project to create liquid fuel for cars by using windmills, and to establish the world's first hydrogen society. There is also a project to grow algae, which will then be used to produce natural gas and ethanol, and several projects to turn waste into energy. The experience from Lolland could be copied with a great amount of political will and some financing. The finance to set up the projects in Lolland got some financing from the European Union. (Venter 2008.)

As stated earlier there is a genuine lack of demonstration programmes in Finland. Far too often, the innovations from a research programmes in Finland do not reach the commercialisation phase and the progress ends right after research and development phases. Accordingly, it would be important that the whole innovation chain is covered right until marketing, especially covering piloting and demonstration phases. The case from Lolland sets a good example of innovative thinking and political will of implementing enabling environment for the low carbon innovations.

6.6 Information instruments

Information instruments, such as public disclosure requirements and awareness or education campaigns can positively affect environmental quality by allowing consumers to make better-informed choices. When companies and consumers lack the necessary information about the environmental consequences of their action, they may act inefficiently. While some research indicates an information provision can be an effective environmental policy instrument, we know less about its efficacy in the context of climate change. Examples of information instruments include labelling programmes for consumer products, information disclosure programmes for firms and public awareness campaigns. (Gupta et al 2007, 764.)

Information instruments can often be used to improve the effectiveness of other instruments. Another feature common to all information instruments that makes them unique from other environmental policies is that they do not impose penalties for environmentally harmful behaviour. The costs of information instruments could be relatively low, however depending on the programme design. (Gupta et al 2007, 764.) The UNFCCC secretariat notes that there is a general lack of resources, limited technical skills and poor regional coordination relating to information and education campaigns (UNFCCC 2006, 5).

As stated earlier, there is a clear lack of understanding and experience related with the benefits of energy efficiency applications. Raising the awareness of the importance of and opportunities provided by energy efficiency is crucial to ensure procurements from all parties including the general public, industry and financial institutes. The more mainstream energy efficiency becomes as a sector, the more investment will be available (Makinson 2006, 43). The campaigns for energy efficiency could entail campaigns with several different approaches, depending on the target. Apparently, there is a need for general and clear information that would describe the measures that can be taken to reduce energy consumption in homes and in commercial or industrial settings, including cost-savings.

It would also be important to enhance public disclosure on high emission industries and private sector activities, and residential sector via programmes that change market perceptions of value of energy efficiency and risks of inaction. In addition, education and training programmes would be important to strengthen the culture of energy efficiency and efficient use by all consumers, including good practises information exchange on successful initiatives at the local, national or international level. (Makinson 2006, 44.) However, it would be highly important that impartial experts would be used as a provider of the information to avoid possible green washing[2].

6.6.1 Raising the banker awareness

There are clear sings that the commercial lenders lack understanding and experience on low carbon projects and this can be one of the principle barriers from a project developer's perspective. This is why, the extra costs associated with satisfying the higher "burden of proof" that a bank's loan committee would normally apply to their

[2] The term is used to refer to sustainability initiatives by companies, which are perceived to be more about marketing than about acting responsibly. (Laine et al. 2008, 3)

first few low carbon loan requests usually fall on the project developer. These learning curve issues can be remedied to some extent through public sector facilities. These mechanisms can include institutional strengthening interventions, such as training and technical assistance to banks for putting in place appropriate credit rating and due diligence procedures, or project specific support facilities that share some of the elevated transaction costs. Raising awareness is crucial within smaller commercial lending institutions, particularly in emerging markets, but also in larger institutions where education management and board members can help raise the profile of low carbon investing in addition to improve the general understanding of sector trends and market opportunities. (BASE 2005, 28.)

6.7 Technology imports

In technology development, especially in the low carbon sector, it has to be beard in mind that Finland is a small country and the financing for innovation activities are limited. With only 5 million people, we cannot expect that all the innovations and technologies used would be domestic. A small technology development program can have greater financial support for example in The United States than a relatively big project has in Finland (Linnainmaa, Interview 2009). For this reason, the technology transfer issues are especially vital for the low carbon development.

For the successful development of the national economy, it is highly important to ensure the success of the national economy and the competitive capacity of Finnish companies. In consequence, authorities need to aim to an active import policy and reduce and remove barriers to import. The question on import should be aimed especially at high technology sectors instead of only concentrating in energy supply sector and the provision of necessary raw materials. In this context, a more comprehensive policy would be necessary.

Today’s business world is more dispersed than it used to be. It is characterised by a dispersed value chain, which means that research, development, production and marketing can take place in different countries and that such fields as component imports play an increasingly critical role in business. As a result, there is a broad range of networks and partners in different parts of the world. Therefore, import promotion has become on of the ways in promoting exports. (Ministry for foreign affairs of Finland, 2008.)

Active and open import policies are also highly important in the means of protecting consumers and in ensuring effective competition on the domestic market. The diversification of sources of supply has many vital benefits: it improves the effectiveness of the domestic market, in increases price competition and it expands the range of items available on the market. Hence, the domestic production must be able to operate in an open competitive environment. From the point of view of regional policy, security of supply or availability of basic services for example, the most appropriate yardstick for allocating resources is not always the market but the establishment of barriers to import is also justified. (Ministry for foreign affairs of Finland, 2008.)

The common question with technology imports is that do they crowd out local innovations. However, the Figure 16 shows that the volume of imports is positively correlated with the volume of local innovations. The figure also shows the differences in these activities between different countries (Dechezleprêtre et al 2009, 29).

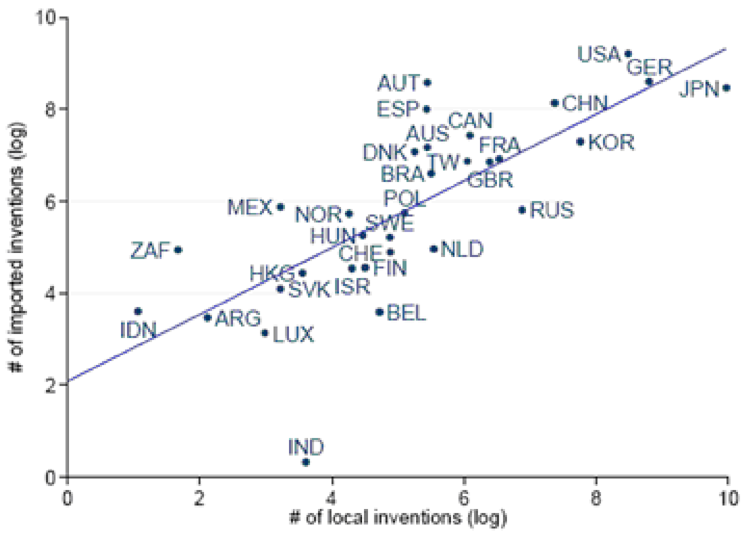

Figure 16 Number of local inventions and number of imported innovations (log) for different countries (1998-2003) (Dechezleprêtre et al 2009, 29).

6.8 Emphasising the new innovation strategy

According to the scientific knowledge on climate change and the mitigation challenge, the low carbon pathway requires a technology revolution. A technology revolution has always meant that the innovation system has changed dramatically as well. This is why it would be essential, that the national innovation system would be altered to meet with the upcoming challenges (Salmelin, Seminar presentation 12.5.2009). As stated earlier, the current innovation system and its' supportive policies are strongly based on the linear model of innovation and this can slow down the diffusion of radical innovations. This is why, it would be important that the open innovation was used as a one way to enforce the birth and diffusion of low carbon innovations. In the following, the ways that the new wave of innovation can used in the case of low carbon innovations.

6.8.1 The customer approach

It is likely that the innovation landscape will alter in the near future, and the customer-driven innovation approach will become increasingly important as a competitive advance. In the last years, there has been unprecedented surge in media attention and overall discussion into issues of sustainability and awareness of the global threat of climate change and the implication of for example on energy prices. Because of this, there has been a change at the consumer level, and the current trend is that the consumer behaviour is shifting towards consumption that is more ethical (Laine et al. 2008, 1). In consequence, consumers have begun to use their purchasing power in a new way as the awareness on the importance of climate change issues has risen dramatically among the common people. The size of carbon footprint[3] has risen as an important issue in buying behaviour and environmentally aware customers have begun to demand for environmentally sound products.

Nevertheless, as this is a relatively new trend, it seems like in the Finnish companies the awareness of sustainability issues is not very high. There is a perception that due to strict regulations, there is no need to improve further in this area. However, there is a growing realization that sustainability issues will become more important in the future

[3] Carbon footprint is the total set of greenhouse gas emissions caused directly and indirectly by a n individual, organization, event or product (UK Carbon Trust, 2008)

and that companies in other markets, consider sustainability as being of high importance. (Laine et al. 2008, 1.) If the customer approach, especially the views of the early adopters, was taken as one of the aspects of the innovation process, companies could asses the future demands better.

An important factor of the user approach is that it allows both the user and innovator to gain valuable information on the product or a service. The innovator can develop the product according to the demands, which reduces the risk that the innovation will not get adopted. An important factor of the user approach is also that if customer has been included in the R&D process, he will get valuable information of the application or for the service that the company provides. This could speed up the diffusion process remarkably, as stated above there is a genuine lack of knowledge on for example energy efficiency applications. Accordingly, the user approach decreases the information gaps within the innovation system, when information during the innovation process is transferred on both ways.

On the governmental level, the need to change the traditional innovation policies has been recognised. The Ministry of Employment and the Economy has set up a new team in its innovation department that aims to plan and implement customer- and user-oriented innovation policies (Peltonen, interview 2009). However, the national innovation strategy defines neither what the customer-driven innovations actually means nor how it would be integrated as a part of innovation system. In consequence, as the current innovation system is strongly based on research and development mechanisms, the shift to customer-driven innovation policies may be somewhat hard to obtain.

For this reason, it is highly important that the new innovation-strategy would be emphasised right from the educational level. This could open the business industries' innovation processes as well. Additionally, it would be extremely important to integrate the lateral thinking into the public support and financial services for innovation. For now, users or communities have not been considered in any way for example in financing programmes for innovations. The need for the customer approach, has been identified also by Tekes (Saarnivaara, Seminar presentation 9.6.2009). As Tekes is mainly focused on research activities it could answer to the challenge by researching the possibilities of user-led innovations more closely, and so promoting the new innovation strategy.

6.8.2 Service innovations

Service innovation may either be a new way of providing a customer with a service or a brand new service altogether. Competitive services are crucially important for economic growth and the creation of jobs. The technology imports also support domestic service innovations. Service innovation may either be a new way of providing a customer with a service or a brand new service altogether. For example it is commonly accepted fact that cars are imported to Finland. However, the services related to the maintenance etc. services are domestic hence creating numerous business opportunities for the local entrepreneurs.

For the present, however, the service sector in Finland is very much underdeveloped compared to many other western countries. This is partly because of the systematic nature of the public sector. Many different factors would need to change for comprehensive innovations. However, in the public landscape this is not very easy to obtain. Finland should aim at developing new forms of support, use actively public procurements and focus on demand and competition. With these measures, the service sector could develop to meet the western standards. The regulation instruments have to be turned to make them favourable to services and entrepreneurships. An example would be further improvement to the domestic help credit to make it more supportive of service development (Kolehmainen 2008).

One good example of the service innovations in the low carbon sector are energy audits. It is a simple way to introduce proven and cost effective energy efficient measures for example best practice technology. It has been estimated that 55 – 80 percent of audits to service and industrial buildings lead into energy efficiency investments with relatively short ca two years payback time. (Lund 2007, 638.) The service sector and especially energy efficiency in buildings and construction sector could both reduce carbon emissions and create jobs in the process. (Hohler et al. 2009, 24.)

7 CONCLUSIONS

Climate change mitigation will be one of the greatest challenges that the modern society has faced. According to the recent scientific knowledge, the warming needs to be stopped at two degrees Celsius compared to pre-industrial time so that the extreme effects of climate change could be avoided. However, as the society has been built upon carbon intensive raw materials and sources of energy, the pathway to the low carbon society requires entirely new way of thinking. The low carbon pathway can be obtained by changing our consumption behaviour and for the most important part; new technologies and innovations must replace the carbon intensive processes. Currently there is a wide consensus on the fact that the low carbon innovations are in the core of the low carbon development. However, the low carbon development faces several barriers. This is why now, as the society's carbon intensity needs to be minimised, the governmental actions play a key role in the development. This means that there is a need for clear political will to support the low carbon development and countries need to implement measures that would speed up the diffusion of the low carbon innovations.

This study focused on the Finnish innovation system and on the governmental measures that would enhance the Finnish innovation landscape so that the adoption of low carbon innovations could be speeded up.

It is impossible to determine only one governmental measure that should be implemented to enhance the national innovation system in the context of low carbon innovations. An efficient innovation system is comprised of a set of different measures that directly or indirectly affect the innovation activities. One of the most important findings of this study is that the whole low carbon innovation chain, which comprises of research, development, demonstration, and deployment, needs to be supported with governmental measures. If a promising innovation fails even in one of the phases, it is highly likely that the innovation will not reach the mass markets. Currently the main problems are the financial gaps within the innovation system and the slow commercialisation of the low carbon innovations.

The Finnish innovation chain is strongly based on the linear model of innovation and especially technology push mechanisms have traditionally been highlighted in the national innovation policies. This means that the Finnish innovation system has been based on strong research and development mechanisms. This innovation system has been successful and has gained appreciation both nationally and internationally, in which the roles of Tekes and Sitra are indisputable. As found in this, and in other studies, the Finnish innovation mechanisms are regarded to be one of the model systems in the world. However, in the context of low carbon development, some areas need to receive greater attention.

Because of the limited resources for low carbon development in Finland, the research and development activities should be concentrated to only a few sectors on the field. Currently, there seems to be a lot of research in many areas and no particular area is emphasised. The concentration of activities would possibly lead to fewer domestic innovations, but on the contrary, the development areas would have better possibilities for adequate financing. This could help fill the financial gaps within the current innovation system and the development of the applications could be faster. It is not, however, certain which innovations will play a major role in the future Finnish low carbon cluster. That is why it would be essential to use part of the gained resources for analysing and anticipating on the low carbon innovations that would possibly have the greatest benefits both in curbing the emissions, as well as for the national economy. This is one of the most important aspects of the future studies. For now, there has been a shortage of high quality analysis on future low carbon innovations concerning the Finnish innovation landscape.

Another problem within the national research and development activities in Finland, are the numerous actors on the field. The problem is that different research institutions have contradictory research cultures and separate administrative boards. Since the funding is always limited, unnecessary overlap should be avoided. Accordingly, the national innovation institutions should concentrate on efficient cooperation. This study found that one of the key issues for the efficient diffusion of low carbon technologies are different networks and communication channels, also emphasised in the innovation theory. Efficient communication between the institutions helps to avoid overlaps and make the governmental financing more efficient. Accordingly, the innovation institutions in the Finnish low carbon sector need to find efficient ways to work together, and share the information as much as possible. There have been some well-organised communication channels in the field, but additional co-operation is still needed. In addition, it would be important to promote the international research co-operation.

For the low carbon development, extensive financing for research and development is indeed required since the climate change mitigation requires a set of innovations that can replace the old carbon intensive processes. The strong research and development policies are not, however the only answer to the challenge. The problem is that too often the support measures after the research and development phases do not get adequate financing. The technology push thinking has in many cases led to a situation where the research and development phases have been emphasised at the expense of the following phases of the innovation chain. Accordingly, the biggest bottlenecks of the Finnish low carbon innovations seem to be the lack of funding for demonstration and piloting projects and for commercialisation. The problems of the national innovation chain have been noticed among the researchers, but so far there has not been development in the issue. To support the piloting and demonstration, the technology developers need to seek efficient co-operation from both private and public sector. One governmental measure for supporting the demonstration phase in innovation, could be a demonstration site like the Lolland Island in Denmark, which has gained successful results from the demonstration of low carbon innovations.

One of the key aspects of the moderate adopting of the low carbon innovations is the slow commercialisation, which results that the innovations do not reach the critical mass and prices remain high. This slows low carbon development even more, since the innovations are competing with the old, and relatively cheap, carbon intensive processes. There are several governmental measures on how the government can support the commercialisation of the low carbon innovations. One of the most important factors is to stimulate the domestic markets. Currently the Finnish markets are regarded as inadequate for supporting long lasting business operations, so the common trend is to apply straight for the international markets. It would be, however, highly important to gain market experience from the domestic market, since the international markets have greater risks, especially for the SMEs.

International experience has shown that the most efficient ways of supporting the domestic markets are feed-in-tariffs, public procurements and investment grants. However, the challenge with these governmental measures is that they would ultimately need to be technology neutral. This is because it is hard to estimate which technology will bring the most emission reductions. For the present, the support mechanisms are targeted for example only to wind-power. This is another reason why the estimations on the future low carbon innovations are so essential. As the governmental measures are usually meant for longstanding support, there needs to be reliable analysis on the future technologies and innovations. The implementation of the market stimulating measures is still in its infancy in Finland. The feed-in-tariffs are currently being implemented to wind power and sustainability will be a part of the public procurement process in the near future. It is, however, still unsure as to how efficient these measures will be.

Another problem with extensive R&D funding is that it does not set limits for the use of carbon intensive products and processes. R&D funding is often seen as doing something for climate change, while more painful measures are ignored. This seems to be one of the main problems also for the Finnish innovation landscape. This is why, it is essential that the low carbon development is supported with strict greenhouse gas emission targets. As an indication of their importance, international treaties, such as the Kyoto protocol, have significantly boosted the low carbon innovation activities. Accordingly, one of the most important drivers for curbing the emissions seems to be pressure and regulation from the governmental sector. Finland has shown, however, a lack of ambition in the curbing of greenhouse gas emissions and the limits set by the EU are mainly seen to slow down the economy and are only barely attained. The lack of ambition prevents the Finnish low carbon innovation landscape from being one of the forerunners in the field. As the market-prospects are unique in this sector, the governmental bodies have stated that the environmental and climate technologies will be next success story in the Finnish innovation landscape. However, strong regulative measures would be needed to boost the domestic low carbon activities. A clear political will seems to be missing from the national climate change mitigation activities.

The lack of financing seems to be one of the key aspects of low carbon development. However, this study found, quite surprisingly, that some low carbon applications that could offer both greenhouse gas emission reductions and cost savings are not diffusing either. This barrier concerns especially the energy efficiency applications. There seems to be a genuine lack of basic knowledge on the benefits of different solutions. Accordingly, to support the diffusion of low carbon innovations, informative instruments have proven to be highly important. It is important to realise, that the informative instruments could bring a solution to the lack of financing and support the other possible measures. Because the public sector cannot finance all the projects, it would be highly important that the private financiers, mostly banks, engaged in the low carbon business. For now, there is however, a lack of knowledge and thus unwillingness to participate in these activities. One simple way of reducing the lack of knowledge would be informative campaigns from the public sector. Especially vital would be to increase the banker awareness on the subject. This could boost up the investments in the sector and speed up the low carbon development.

One of the most recent challenges for the national innovation landscape is to implement the fresh innovation thinking into the innovation processes. The traditional linear support mechanisms have so far been successful, but as the low carbon development requires a technology revolution, the innovation landscape is expected to change in the near future. One way of responding to the challenge is the paradigm of open innovation and the user approach. Because of labour mobility, abundant venture capital and widely dispersed knowledge across multiple public and private organizations, enterprises can no longer innovate on their own, but need to engage in alternative innovation practices. This means that the closed linear innovation system should be opened. One way of doing this would be to include experts from all sectors of the economy to the innovation process as part of the team right from the research and development phases. For example, the commercialisation process could be speeded up if economic experts were introduced to the innovation development group. The Finnish innovation landscape is characterised with high R&D expertise, but there is a lack of marketing and commercial skills in many technology development programmes. This has resulted in well-designed products that will not reach the mass markets.

One of the most important aspects of the fresh innovation thinking is the role of the user. In many cases, users are regarded mainly as passive consumers, and researchers feel that the user would not bring additional value to the innovation process. However, the role of the user has also been found to be highly important in the very fresh innovation studies. For instance, the current trend is to invest in sustainable products and it is becoming increasingly important aspect in the buying behaviour. The user approach could enforce the adoption of low carbon innovations significantly because of the customers' increased knowledge of the product and its' benefits.

It will not be an easy task to shift the traditional linear innovation thinking to the open innovation and it faces resistance from some researchers. However, the evidence from the private sector shows that the user is one of the key aspects of successful product design. Until now, the governmental support mechanism for innovation does not include the user in any way in the innovation processes. However, the Finnish innovation institutes, such as Tekes could conduct a research on the ways that the customer could be included in technology and innovation development.

Even if the innovation system was enhanced with efficient policy measures, it is clear that the Finnish innovation system cannot produce all the innovations and technologies needed for efficient domestic climate change mitigation. Consequently, the government should promote, alongside with the innovation policies, efficient import policies for low carbon technologies and innovations. These policies could improve the domestic low carbon development in many ways, such as by improving the effectiveness of the domestic markets, increasing price competition and expanding the range of items available in the market. In addition, the innovation and technology imports could enhance the somewhat underdeveloped service sector in Finland.

Throughout this study, it has become evident that the policy consideration is a challenging task, and especially in the case of low carbon innovations. This study was not able to assess how the supportive governmental measures affect each other. Accordingly, these sorts of estimations are an important subject for the future studies, so that efficient policy measures could be implemented especially for the Finnish low carbon sector. Ultimately, the public mechanics would need to be designed in an integrated manner that allows barriers and gaps to be addressed at various stages of market development. Different policies have complicated consequences, and economic specialists, in co-operation with innovators would need to asses together the measures that would benefit the Finnish low carbon innovation landscape the most. As Finland has shown to be one of the model countries of research and development activities, the country should now show clear political will towards climate change mitigation and develop innovative measures to support the low carbon development. In other words - be a forerunner in the field.

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Appendix I

Questionnaire for the interviews

- Mitkä ovat merkittävimpiä esteitä ilmastoteknologioiden ja innovaatioiden kaupallistumiselle ja diffuusiolle Suomessa?

- Mitkä ovat suomalaisen innovaatioketjun merkittävimpiä pullonkauloja ja puutteita ilmastoteknologioiden ja – innovaatioiden näkökulmasta?

- Mitkä ovat sellaisia ohjauskeinoja ja toimia, joilla valtio voisi parantaa ja nopeuttaa ilmastoteknologioiden kaupallistamista ja käyttöönottoa?

- Mitkä ovat mielestäsi esimerkillisiä kansainvälisiä esimerkkejä toimista, joilla on saatu merkittävästi parannettua sekä nopeutettua päästöjä vähentävien teknologioiden kaupallistamista ja käyttöönottoa?

- Miten näistä voisi ottaa mallia Suomessa?

Appendix II
Interviews

Name	Organisation	Date
Jukka Uosukainen	Ministry of the Environment	28.1.2009
Petri Peltonen	The Ministry of Employment and the Economy	3.3.2009
Aleksi Neuvonen	Demos Helsinki	19.3.2009
Sami Tuhkanen (Juha-Pekka Hokkinen)	Sitra	25.3.2009
Eva Heiskanen	National Consumer Research Centre	3.4.2009
Janne Hukkinen	University of Helsinki	23.4.2009
Peter Lund	Helsinki University of Technology	20.5.2009
Tarja Teppo	Cleantech Invest Oy	14.4.2009
Timo Linnainmaa	Cleantech Invest Oy	14.4.2009
Vesa Harmaakorpi	Lappeenranta University of Technology, Lahti School of Innovation	6.5.2009

Appendix III
Attended seminars

Seminar	Date	Place	Organizer
Valorising the Experience of European support to Technology Transfer for the Enhancement of Technology Transfer System under the UN Climate Change Convention	4-5.2.2009	Maastricht, The Netherlands	European institute
YK:n ilmastoneuvottelut: mahdollisuudet suomalaiselle teknologiaviennille	27.2.2009	Technopolis Helsinki-Vantaa	Technopolis Ventures
Towards a New Climate Regime?	5.5.2009	The old auditorium, Government Helsinki	The Finnish Institute of International Affairs
Ilmasto ja yritykset	7.5.2009	Hotel President, Helsinki	WWF Finland/ ABB
Lahti Living Lab	12.5.2009	Felmanni, Lahti	LUT school of Innovation
ClimBus-seminar: Ilmastonmuutoksen hillinnän liiketoimintamahdollisuudet 2004-2008	9.6.2009 - 10.6.2009	Finlandia-talo, Helsinki	Tekes