



Jouko Myllyoja

Water business is not an island: assessing the market potential of environmental innovations

Creating a framework that integrates central variables of internationally successful environmental innovations

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Abstract

The main objective of this research is to develop a framework that integrates central variables of environmental innovations in an attempt to create internationally successful concepts. A special attention is being paid to water technologies, but the information will be treated in a way that enables results to cover other environmental sectors as well. The research supports the work of TESTNET (Towards European Sectorial Testing Networks for Environmentally sound Technologies) -project, which is one of the research and demonstration projects that the European Union has launched in the field of Environmental Technology Verification (ETV). The research will find answers for two main questions: 1) What are the central variables creating a basis for internationally successful environmental innovations? 2) Is it possible to develop a “fast and easy” -way to value the environmental and market potentiality of environmental innovations? As a method an approach can be described as a constructive research that produces constructions and tentative solutions for explicit problems. In this qualitative context of the research, theory will be treated both as a starting point and an objective of a research process. Referring to strong theoretical biases that the research adapts, fundamental idea is to strengthen the object theory gradually from different point of views. The following theoretical approaches are being utilized in achieving the research aims: 1) Innovation process 2) Special characteristics of environmental innovations 3) Environmental benefits in a context of new product development 4) Lead market thinking as market entrance procedure of environmental innovations. Answering the first research question, the Value Assessment Framework (VAF) will be presented. VAF is an attempt to integrate all central variables (e.g. environmental problems, market possibilities and restrictions, policies and regulations, company/sector reality) affecting the development of innovations in one frame and to reveal their

interconnections (see page 81). As a partial contribution of VAF, the Value Assessment Tool (VAT) will be presented. VAT will be further tested, completed and used in customer cases of VTT – the mandatory organization of this research. The second research question will be answered by presenting the results of attempt to build a “fast and easy” -way to value the market potential and environmental benefits of innovations. This trial quantitative method was created as a part of TESTNET-project related reporting. The empirical data of the research constituted of expert interviews, filled forms of Innovation Fact Sheets, and participations of different seminars and meetings.

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Avainsanat environmental innovation, cleaner production, water technologies, innovation process, new product development, lead market, sustainable development

Tiivistelmä

Työn keskeisin tavoite on muodostaa viitekehys, joka integroi keskeisimmät muuttujat kehitettäessä uusia, kansainvälisesti menestyksekkäitä ympäristöteknologisia innovaatioita. Tutkimuksessa tarkastellaan erityisesti suomalaista vesiteknologia-sektoria. Kaikkea tietoa käsitellään kuitenkin tasolla, joka mahdollistaa tulosten yleistettävyyden eri ympäristöteknologioihin yleensä. Tutkimus tukee osaltaan EU:n TESTNET (Towards European Sectorial Testing Networks for Environmentally sound Technologies) -projektia, jonka tavoitteena oli kartoittaa eurooppalaisten ympäristöteknologioiden verifiointijärjestelmän merkitystä ja mahdollisuuksia. Tutkimus hakee vastausta erityisesti kahteen seuraavaan kysymykseen: 1) Mitkä ovat keskeisimmät muuttujat, jotka tulee huomioida kehitettäessä uusia ympäristöteknologioita kansainvälisille markkinoille ja 2) Onko mahdollista kehittää ”nopeaa ja helppoa” tapaa arvioida innovaatioiden kansainvälistä ympäristö- ja markkinapotentiaalia? Tutkimusmenetelmältään työ on konstrukttiivinen. Teoreettisina viitekehyksinä käytetään seuraavia lähestymistapoja: 1) Innovaatioprosessi, 2) Ympäristöinnovaatioiden erityispiirteet, 3) Ympäristöhyötyjen merkitys kehitettäessä uusia tuotteita, 4) Lead market -ajattelu kehitettäessä kansainvälisesti menestyksekkäitä ympäristöteknologioita. Tutkimustuloksena esitetään viitekehys, joka pyrkii huomioimaan keskeisimmät ympäristöteknologisen innovaation menestykseen vaikuttavat tekijät. Viitekehuksesta johdettu, käytännön sovellettavuuteen pyrkivä työkalu esitetään liitteessä 2. Viitekehystä ja työkalua on tarkoitus edelleen kehittää tutkimuksen toimeksiantajan (VTT) asiakasprojekteissa. Jälkimmäiseen tutkimuskysymykseen vastataan esittämällä tuloksia markkinapotentiaalin ja ympäristöhyötöjen mittaamiseen kehitetystä kvantitatiivisesta menetelmästä. Tutkimuksen empiirinen aineisto koostuu asiantuntijahaastattelusta sekä TESTNET-projektin yhteydessä toteutetun kyselyn vastauksista. Osallistuminen seminaareihin sekä projekti-tapaamisiin olivat myös tärkeä osa tiedonjalostamisprosessia.

Contents

Abstract	3
Tiivistelmä	5
1. Introduction	9
1.1 General	9
1.2 Main objective.....	11
1.3 Research questions	11
1.4 Method.....	12
1.5 Structure	12
2. Definitions	15
2.1 Environmental technologies.....	15
2.2 Cleaner Production.....	17
2.3 Water technologies	19
2.4 Water quality monitoring.....	20
2.5 Future view of water technologies	22
2.6 Discussion	23
3. Innovation process	25
3.1 General description of an innovation process	25
3.2 Koen's model of front end of innovation	27
3.2.1 Influencing factors	28
3.2.2 The engine	29
3.2.3 Opportunity identification.....	30
3.2.4 Opportunity analysis.....	30
3.2.5 Idea generation and enrichment.....	31
3.2.6 Idea selection	32
3.2.7 Concept definition.....	33
3.3 New Product Development and innovation	34
3.3.1 Project level determinants	35
3.3.2 Organization level determinants.....	37
3.4 Characterizing environmental innovation	38
3.5 Guiding questions for structuring framework and tool	40
3.6 Discussion	45

4.	Analysing environmental innovation	47
4.1	Oltra & Maider's sectoral framework	48
4.1.1	Technological regime	49
4.1.2	Market demand conditions	50
4.1.3	Environmental and innovation policy	51
4.2	Product Ideas Tree diagram	52
4.3	Guiding questions for structuring framework and tool	54
4.4	Discussion	56
5.	Environmental benefits in a context of new product development	58
5.1	General	58
5.2	Life-cycle analysis.....	59
5.3	Generally applicable environmental indicators	60
5.4	Business specific indicators.....	61
5.5	Towards sustainable product design	62
5.6	Discussion	65
6.	Lead markets of an environmental innovation	67
6.1	General	67
6.2	Lead market factors	68
6.2.1	Price and cost advantage.....	68
6.2.2	Demand advantage.....	69
6.2.3	Transfer advantage	70
6.2.4	Export advantage	71
6.2.5	Market structure advantage.....	72
6.3	Applying lead market factors to environmental innovations	72
6.4	Guiding questions for structuring framework and tool	73
6.5	Discussion	75
7.	Forming and testing hypotheses – creating the Value Assessment Framework	77
7.1	Hypotheses.....	78
7.2	Reflecting hypotheses with empirical data	79
7.3	Water sector notions.....	82
7.4	Value Assessment Framework	83
8.	Conclusions.....	87
8.1	Key factors contributing the development of environmental innovations.....	87
8.2	Challenges and possibilities of Finland	89
8.3	An attempt to build a “fast and easy” way to value the potential	91
8.4	Concluding words	93
	References.....	95

Appendices

Appendix 1: Value Assessment Tool (VAT) – key topics conducted from categorization of VAF

Appendix 2: Innovation Fact Sheet. Environmentally Sound Technologies (ESTs) for cleaner production

Appendix 3: Empirical sources of information: Interviews, seminars, conferences and meetings

1. Introduction

1.1 General

New environmental technologies are facing many challenges, rapid changes and huge possibilities. Globalization and climate change are main macro forces contributing to the development of this turbulent field. Political decision making and legislation – with constantly living variety of new regulations, standards and recommendations – is another whole entity governing the development of environmental innovations.

Globalization is a vital part of the challenge. Along with an intensive competition, the markets now favor the solutions, which can contribute both environmental and economical benefits. (Ministry of the Environment 2007, 11) Environmental aspects should no longer be seen as something that have to be taken care of, but instead, something that can be a source of process enhancement, product quality improvement, material savings and competitive advantage etc. In other words, organizations should be/become convinced that cleaner production can make money (UNEP 2001). As a matter in fact, clean production technologies are often not only ecologically but also economically superior (Testnet 2008a).

When innovations are becoming increasingly hard to perform by one player (Hermansson 2007), globalization also means that making a breakthrough with innovation does not require just good engineering. It also requires innovative gross-boundary thinking between various actors such as complementary solution providers, vendors, financials, research institutes and competitors. Either can no country be the best in everything, whereat they should let other countries specialize in what they can't master themselves (Hermansson 2007). This requires clarified national strategies, and even largely, an own competition advantage analysis for such consortia such as Nordic countries and EU.

1. Introduction

Environmental policies have a crucial role by providing policy framework for the development and dissemination of new environmental technologies. Existing policies are meant to ensure that production meets the high environmental standards. An obligatory regulation has also been completed with different kind of market-based and voluntary instruments, such as eco-labelling and environmental management systems. (EC 2004, 5) As a matter in fact, tightening environmental legislation can be considered as the most significant factor for catalyzing the markets of environmental technologies (Sitra 2006, 17). However, it seems that literature on environmental innovations mainly focuses on the role of regulation as a stimulus for technological innovations while too little attention is paid to the innovation process itself – its features and determinants at the industry and company levels (Oltra & Maider, 2008).

Another essential challenge within the environmental business takes place in commercialization, commercialization for target markets and selling the environmental solutions. Similarly, utilizing the environmental information in product development and marketing in general are being found challenging. (Ministry of the Environment 2007, 18) On the other hand, a more comprehensive assessment of the environmental impacts of new technologies will require both collecting information and increased environmental know-how (Kivimaa & Mickwitsch 2006, 740).

From the point of view of R&D related activities there seem to be strong potential for mixing ecological and economic approaches to the systemic nature of innovation. This is due to the fact that typically such broad considerations have to be tied into the innovation already in the early stages of product related R&D. Thereby this kind of a broader approach would have the potential to affect products and processes on a more fundamental level. This in turn, could generate more information about environmental innovations in terms of critical and generalizable dimensions of an innovation. For example, the minimization of input streams (substances, materials, energy and water) over the whole life-cycle of the product may be argued to represent such a dimension. (Hellström 2007)

Finally, the operational environment of environmental innovations is very challenging, but at the same time opening huge possibilities especially in developing economies. At the same time with climate change, the general discussion has brought the discussion about sustainable development down to all levels. Without discussing the causes of climate change in this context in more detail, it must be stated, that beside the possibilities enabled by several positive market factors, the whole mental infrastructure – societal acceptance (see EU

2008) – for advancing environmentally sound technologies appears to be very favourable as well.

1.2 Main objective

The main objective of this research is to develop a framework that integrates central sources of an environmental innovation in a context of creating internationally successful concepts; in other words, the aim is to create a framework that offers a larger context for more detailed evaluations of market potential. Even though more attention is paid to Finnish water sector, the framework will be built in a way that it can assess environmental technologies in general.

Considering the informational background, the research supports the work of TESTNET (Towards European Sectorial Testing Networks for Environmentally Sound Technologies) project, which is one of the research and demonstration projects that the European Union has launched in the field of Environmental Technology Verification (ETV). TESTNET is a European project selected to design, develop and test an ETV system. TESTNET's aim is to develop an independent system to provide the market with credible performance data. (TESTNET 2007)

The objective of the ETV programmes is to accelerate market acceptance of innovative technologies by providing users with information about their performance. The overall strategic objective for a European system for ETV is to enhance the application of innovative Environmentally sound Technologies (EsT's) by purchasers and permittees, both inside and outside of Europe. (TESTNET 2007)

1.3 Research questions

Based on the main objective characterized above, this research will find answers for the following questions:

1. What are the central variables creating a basis for internationally successful environmental innovations?
2. Is it possible to develop a fast and easy way to value the environmental and market potential of environmental innovations?

1.4 Method

The research is constructive in its nature producing constructions and tentative solutions for explicit problems. Generally, constructivism can be seen as a form of applied research, the aim of which is to create new information in a form of new solution or some other specified aim. Essential part of the research process is to tie a practical problem to a previous knowledge, and to present that the suggested solution is new and functional compared to the original problem. The research process can roughly be divided to the following phases (Kasanen et al. 1991):

1. To find a relevant and interesting problem from the point view of research.
2. To achieve preliminary understanding of an objective of research.
3. Innovation phases. Constructing a model for solving a problem.
4. Testing solution in a practice – to prove that the construction is correct.
5. Showing theory bonds used in the solution. Proving scientific innovation value. Observing the scope of the solution for larger extensions.

It is useful to stress that functionality of constructions is a signal that created ideas that are valid. Another important focus is generalizing the solutions. This means in practice, that cases used are being observed in a general manner as well. In particular, attaching the observation to its theoretical background is needed. (Kasanen et al. 1991)

Constructive research can be characterized as a normative case study. Considering theoretical way of making conclusions, decision-making methodology is fairly close to a constructive method. With a similar interest of making a change, constructive research has common elements with action research as well. (Kasanen et al. 1991)

1.5 Structure

In the context of the qualitative nature of this research, theory will be treated both as a starting point and an objective of the research process. Referring to strong theoretical biases of the research, the fundamental idea is to strengthen the theory gradually (see Figure 1). Dashed lines are marked to present blurred boundaries of different phases, meaning, different parts cannot be strictly separated from each other. Instead, they are partly being constructed concurrently. In

particular this may be the case between the phases of data and theory 2, which is outlined using a back steered arrow.

The research will start with a theoretical part 1, in which preliminary elements of the framework will be explored and structured. This part will be composed of two background elements: literature review and examination of background data. Literature review includes reviewing relevant theories and concepts (Chapters 3–6). It is also based on VTT’s internal data documentation including e.g. TESTNET-related (2007; 2008a; 2008b) project material, especially the filled forms of Innovation Fact Sheets (see Appendix 2; Chapter 8.3).

The role of the data phase will especially take place in verifying, conditionally verifying or refuting the hypotheses (see Chapter 7.1) that are being created based on Theory 1. On the other hand, “the spirits” of empirical data will also be adapted to all following parts of the study. On the basis of reflecting hypothesis, the framework will be completed (Theory 2). By integrating the central variables in all together, forming the framework similarly answers the first research question. Finally, conclusions are being formed in Theory 3. As a partial contribution of the research – and similarly the second research question will be answered – the key notions of the report “Analysing the market potential and environmental benefits of ESTs” (Myllyoja 2008) will be reviewed in Chapter 8.3. The report is created by the author of this research.

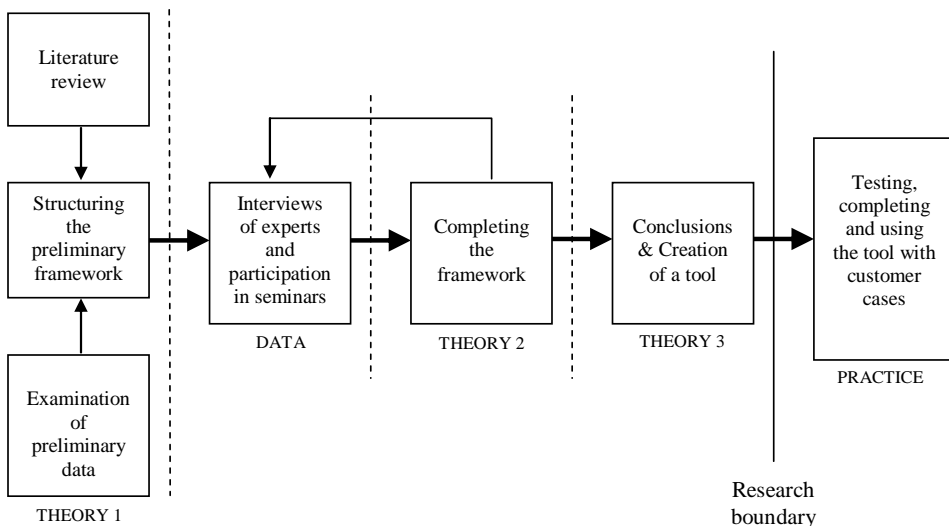


Figure 1. Process plan of the research.

1. Introduction

In sum, the primary objective of the research is to create a framework that offers the larger context for further potentiality evaluations. These further evaluations may concern either assessing the environmental, or market aspects. The bottom idea is however, that the born and success of an innovation is considered as a result of simultaneous key aspects, which are presented in the framework. Outside the core context of research a market potentiality tool will be formed that will be further tested and developed in practice. This practical use will take place for example in the NOWATECH-project (2008). If the use turns successful, the tool will be utilized in other customer projects as well.

2. Definitions

The aim of this chapter is to achieve understanding of the central concepts used in this research. This will be started by taking a look at different definitions of environmental technologies. Next, concept of Cleaner Production – one of the prevailing new strategies in the environmental sector – will be clarified. Cleaner Production is also one of the focus areas of the TESTNET (2007; 2008a; 2008b) project. The complex nature of this term will be explored by presenting a few definitions of it and comparing Cleaner Production to its near-concepts.

Among wide variety of different technologies in the environmental sector, water technologies form a specific field of interest as a sector. Thus, the concepts of water-treatment technologies and water quality monitoring are being viewed next. Also short overview of the major trends in the sector will be included. The aim of the water technologies reviews is not, however, to create profound understanding of technology specifications in the field, but instead, to create basic understanding of the sectoral concepts and trends. This disposal is meant to serve the research aim to create framework adaptable to environmental technologies in general.

2.1 Environmental technologies

It appears that there exists no specific answer to the question what exactly are environmental technologies (see Kuehr 2007). For example nanotechnology and biotechnology has a lot to do with environmental technologies as a whole, but still their relation to environmental technologies must be valued on a case-by-case basis. In this context, it is essential that their long term impacts will be assessed by using Life Cycle Analysis (LCA). Using nanotechnology and biotechnology still as an example, another issue is the problem of uncertainty. We don't know all relevant *risks* of them, which in turn, concerns for all technologies to a certain extent. Consequently, one should be careful using the

2. Definitions

label of eco-innovation as a denomination for broad technology classes. Instead, it should be used only for those innovations that have demonstrated environmental benefits in a long run. (Kemp & Foxon, 2007)

Kemp & Foxon (2007) define the term environmental technologies to refer to process technologies (including energy conversion technologies) and measurement technologies used for environmental purposes (to measure pollution or to identify toxics). They restrict the term environmental technologies to technologies that are more environmentally benign, falling the environmentally improved products into a category of their own – together with services innovations – and other innovations for which technology is not the primary thing. More generally, environmental technologies can be divided to integrated solutions and additive solutions, where additive solutions mean pollution treatment technology and systems of external recycling and waste disposal. (Kemp & Foxon, 2007)

The term “Environmentally sound Technologies (EsT)” is sometimes used synonymously to environmental technology (Kuehr 2007). However, it offers a slightly different way to approach environmental technologies. UN defines environmentally sound technologies in the following way (2005):

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

By shedding the multifilament nature of environmental technologies it is also useful to present Kuehr’s approach. He separates environmental technologies into four different categories (2007):

1. Measuring technologies on the environment. Consists of tools, instruments, machines and systems which measure and control or even harness the environment. Focus of this category takes place in understanding the environment and the containment of negative environmental impacts on mankind.

2. Cleansing technologies or end-of-pipe approaches. Concerns processes and materials that have been developed to minimize or neutralize harmful effects due to their use. Cleansing technology is mainly based on so called end-of-pipe solutions. Technologies in this category have an additive or repairing function as well as constituting the degree of aftercare with a transforming effect on emissions.
3. Cleaner technologies. Cleaner technologies offer modifications to processes minimizing or even eliminating harmful effect on the environment. These integrated technologies are designed to improve protection of the environment through a holistic reflection of the entire product cycle.
4. Clean technologies / Zero impact technologies. Comparing to cleaner technologies, clean technologies do not have any negative impacts on the environment. However, this kind of technologies does not exist, at least from holistic/life cycle point of view. Consequently its contribution is mostly in offering more or less ideal level where to reflect.

2.2 Cleaner Production

Cleaner Production can be considered as a rather fresh term and its theoretical background does not appear to be that solid yet. United Nations Environment Programme seems to have the most structured definition for it. UNEP describes cleaner production in the following way (2001):

Cleaner Production is the continuous application of an integrated preventive environmental strategy to processes, products, and services to increase overall efficiency, and reduce risks to humans and the environment. Cleaner Production can be applied to the processes used in any industry, to products themselves and to various services provided in society.

UNEP defines key elements of Cleaner Production as follows (2001):

- 1) Cleaner Production is a preventative approach to environmental management.
- 2) It refers to mentality of how goods and services are produced with the minimum environmental impact under present technological and economic limits.

2. Definitions

- 3) It does not deny growth; it only insists that growth is economically sustainable.
- 4) It is a win-win strategy. It protects the environment, the consumer and the worker while improving industrial efficiency, profitability and competitiveness.
- 5) It is forward-looking, “anticipate and prevent” philosophy.
- 6) Waste is considered as a “product” with negative economic value. Each action to reduce consumption of raw materials and energy, can increase productivity and bring financial benefits to enterprise.

Cleaner production has many close-concepts such as eco-efficiency, pollution prevention, waste minimization and industrial ecology/industrial metabolism. In order to clarify the characteristics of Cleaner Production itself, it is useful to take a look at these in more detailed.

UNEP (2001) states, that concepts of eco-efficiency and Cleaner Production are almost synonyms. WBCSD (2000, 7) defines eco-efficiency as a broad term that is usually measured at the product or service level. As presented in a formula below, eco-efficiency measures environmental impact per unit of product or service value (WBCSD 2000, 3). $\text{Eco-efficiency} = \text{product or service value} / \text{environmental influence}$. The slight difference between them is that eco-efficiency starts from issues of economic efficiency which have positive environmental benefits, while Cleaner Production starts from issues of environmental efficiency which have positive economic benefits (UNEP 2001).

Hellström (2007) argues eco-efficiency quite differently. He claims that it is systemic in its nature and therefore focuses mainly on process and production improvements, not on product characteristics. Therefore the contribution of eco-efficiency is less instructive when it comes to ideating new products on the basis of environmental norms.

The Cleaner Production is often used interchangeably with the term pollution prevention and to some extent they also can be considered as synonyms. Even so, the difference between them is that the term pollution prevention is used in North America, while Cleaner Production is used in other parts of the world. From conceptual point of view, they both share focus on a strategy of continuously reducing pollution and environmental impact through source reduction, in other words, eliminating waste within the process rather than at the end-of-pipe. Pollution prevention is on its behalf often mixed with the term waste

minimization, whereas waste minimization can be considered as a broader term that in addition to source thinking also includes recycling and other means to reduce the amount of waste which must be treated or disposed of. (UNEP 2001)

Industrial ecology and industrial metabolism are closely related to Cleaner Production concept (UNEP 2001). The word metabolism is referring to change or transform, whereas industrial metabolism derives from the notion that industrial economies are like biological organisms or natural ecosystems, and thus can be understood as systems for material transformation with distinct metabolic pathways that evolve over time. Basic idea is to follow the “material flow” from its origin (e.g. mined ore) through the industrial processes used for its transformation, to the products and finally to its disposal or re-entry into the industrial system. Since 1960s, industrial metabolism has been used as a paradigm to describe the exchange of among industrial operations in a way analogous to the description of material and energy balances in natural and ecological systems. (Wernick 2001, 7331)

2.3 Water technologies

Water technologies concern drinking and process water, water reuse and waste water treatment. The application areas cover mainly industrial, municipal and agricultural use of water. (TESTNET 2008b)

Water treatment technologies can be categorized into different sections by considering their purpose of use. Firstly, water treatment technologies are needed to supply pure water especially for residential and industrial use, and secondly, they are utilized in the management of waste water. Third category is formed by water technologies which are used as an integrated part of the production systems of water-based industrial processes. (Könnölä & Eerola 2007, 22)

From the point of view of supplying pure water for residential and industrial use, water treatment processes can generally be divided in three stages (Könnölä & Eerola 2007, 22):

1. Primary treatment for collecting and screening including pumping and initial storage.
2. Secondary treatment for removal of fine solids and the majority of contaminants using filters, coagulation, flocculation and membranes.

2. Definitions

3. Tertiary treatment for polishing, pH adjustment, carbon treatment to remove taste and smells, disinfection, and temporary storage to allow the disinfecting agent to work.

Together with the sources of water – groundwater, surface water and storm water – the concept of waste water originates predominantly from water usage by residences and commercial and industrial establishments. Waste water flow is a result of multiple variations in water usage. These variables are e.g. climate, community size, living standards, dependability and quality of water supply, water conservation requirements, the extent of meter services, the degree of industrialization, cost of water and supply pressure. To remove contaminants from waste-water; physical, chemical and biological methods are being used. (UN 2003, 2–5)

Water saving and re-use is one way to approach water treatment technologies. As a descriptive example, a washing machine which accepts recovered water from the first washing cycle or which treat the effluent for direct re-use. Another example could be a recirculation shower system which could contribute to a reduction of the overall water demand in municipalities. Water saving aspect also includes a possibility to consider the equipments that does not use any water. A completely closed water cycle and almost zero water use may be possible in some sectors in a future as well. (WSSTP 2006, 10)

There are many thematic ways to handle water technologies. Called *civil engineering* solution, water stress can be tried to be solved in a way that water will be supplied from increasingly distant sources. Unfortunately, this method is rarely economically or politically accessible. The alternative *chemical engineering* solution means the way to use and treat the locally available water resources. Recently, more and more attention has been paid to *social engineering* approach, where public and private user communities are encouraged to conserve water and to improve the efficiency of water use. (WSSTP 2006, 5–6)

2.4 Water quality monitoring

As a term, “water quality” can be formed to express the suitability of water to sustain various uses or processes. Every use has certain requirements for the physical, chemical or biological characteristics of water. (Bartram & Balance 1996, 15)

Physical parameters include colour, odour, temperature and turbidity. Chemical parameters can be divided in organic and inorganic variables, where

organic parameters cover biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC) and total oxygen demand (TOD). Inorganic parameters include variables such as hardness, acidity and pH. Examples of biological parameters are coliforms and viruses. (UN 2003, 2–3)

The quality of water may be described in terms of concentration and state (dissolved or particulate) of the organic and inorganic material present in the water, together with certain physical characteristics of the water (Bartram & Balance 1996, 16). Both constituents and concentrations are varying based on time and local conditions. For example waste water can be classified as strong, medium or weak, depended on its contaminant concentration. (UN 2003, 3)

Water quality can also be defined by a range of variables which limits water use, meaning, each use have its own demand and influences on water quality. These demands can be divided to quantity and quality sections. Thus, meeting the requirements of different users is often compromising between the quality and quantity demands of them. (Bartram & Balance 1996, 15)

UNEP (2007) states that the primary objective of inland water quality monitoring is to provide safe water for human consumption. In this context a good quality of water depends on dissolved salts and minerals, because they are necessary components to help maintain the health and vitality of the organisms that rely on aquatic ecosystem services. Likewise, aquatic ecosystem and human health are dependent on the physical, chemical and biological composition of water. As a contributory notion to the ecosystem view, there is an increasing recognition that natural ecosystems have a legitimate place in the consideration of options for water quality management – concerning both for their intrinsic value and sensitiveness as indicators of changes of deterioration (Bartram & Balance 1996, 15).

Present water quality management is solidly connected to sustainability issues. For example Cagnon et al. finds that every good water-quality monitoring program contributes to environmental sustainability due to the following reasons (2007):

1. Its implementation makes necessary to identify if certain environmental thresholds are exceeded (when and to what extent).
2. It is the only way to assess the evolution of water quality from time perspective (the efficiency of actions or regulation compliance).
3. Monitoring is essential to ensure that natural capital is preserved effectively for future generations.

2. Definitions

Water quality is usually determined by in situ measurements and by examination of water samples in the laboratory (Bartram & Balance 1996, 16; see also future prospecting UNEP 2007, 13). Technologically, water quality monitoring is closely linked to sensor and measurement, modelling and simulation technologies, which are often used in a combination within comprehensive water monitoring, control and management systems (Testnet 2008a).

2.5 Future view of water technologies

Water quality is affected by a wide range of natural and human influences. Central natural influences are geological, hydrological and climatic; affecting both the quantity and the quality of water available. (Bartram & Balance 1996, 15) Constituting of both natural and human influences, the water sector is facing a dramatic evolution because of three major factors. These “drivers” of change are: (i) climate change, (ii) aging and deteriorating infrastructure and (iii) globalization, and population growth. (WSSTP 2006, 5)

It is forecasted that climate change will cause significant changes in both rain and temperature patterns, which have natural effects on the availability of water. Already now many areas suffer from water stress, and in the future it can occur in any geographical area where the demand exceeds the bearing capacity of water resources. Contemporarily, stress of water may be long term or seasonal, often acute and unpredictable. Usually water stress occurs in a form of quantity issue, but can also appear in a form of quality – or indirectly, it can be an unwanted result of unsuccessful water management. (WSSTP 2006, 5) It has to be emphasized that even though for many areas there may not be local concern about availability, it is increasingly costly to generate clean water, which on its behalf makes clean water as a very concrete global issue (WBCSD 2000, 18).

Considering water resources, a major challenge is to restrict the over-exploitation of groundwater. Meanwhile, it is also vital to minimize pollution threats to it, to integrate groundwater management concepts, and to increase water harvesting and groundwater recharge. Similarly, the development of cheaper and smarter technologies which are using alternative resources of water is seen important. This concerns new resources such as brackish water, karstic water, seawater, waste water and rainwater. Advances in membrane technology are expected to have a major role in the development of new methods of water treatment. (WSSTP 2006, 10)

The information on the quality of water is increasing due to the growth of water fit-for-purpose needs. In this context, the quality requirements of water should be matched with the needs of adequately treated water from upstream water users and suppliers. Consequently, research is needed on water quality demands for individual processes by modelling and simulating predictive process control tools to achieve sustainable water use in industry. As an own field of interest, the development of drought and salt resistant crops is an important part of this research. (WSSTP 2006, 10)

Urbanization is a rapidly increasing phenomenon, which in many cases is triggered by poverty resulting from large scale destruction of natural resources. Often urban areas suffer from old water infrastructures and consequently are very vulnerable to failure. Besides facing the increased demand of water, migration also raises questions about finding efficient solutions for waste water treatment and re-use, and for ensuring the water requirements of safe food supply. When urbanization can be characterized by unpredictability and by uncertainty of the rate of migration, there occurs an apparent need for smaller scale, adaptable, innovative and flexible water services solutions. (WSSTP 2006, 6–7)

2.6 Discussion

In order to avoid thematic contradiction of whether e.g. nanotechnology or biotechnology belongs to environmental technology, environmental technology will be understood here similarly than in Sitra's (2006, 13) report. This definition is based on EC's (2004, 2) description where environmental technologies are determined to encompass all technologies whose use is less environmentally harmful than relevant alternatives. In this context they cover technologies and processes to manage pollution, less polluting and less resource-intensive products and services, and ways to manage resources more efficiently. Consequently, environmental technologies are here seen to cover all economic activities and sectors where they cut costs and improve competitiveness by reducing energy and resource consumption creating fewer emissions and less waste (EC 2004, 2). Similarly, all these technologies can contribute to any innovation with an ecological effect so that eco-innovation can happen in all industrial sectors – also unintended (Testnet 2008a).

In line with the above definition of environmental technologies, the concept of Cleaner Production offers a creative way to approach environmental technologies. Especially in terms of innovations and eco-efficiency cleaner technologies have

2. Definitions

a huge potential in count of applications. There may be cases where neither the substance nor the standard equipment is environmental goods, but the particular production method has smaller environmental impact. (Testnet 2008a) Consequently, for seeing the environmental impacts as they fall in the nature Cleaner Production offers a holistic and useful concept. Even though the theoretical debate whether green can be competitive is far from solved, many practical examples suggest that Cleaner Production is widely applicable and generally delivers both environmental and competitive advantage (Howgrave-Graham & Berkel, 2007).

Water technologies represent wide variety of applications within environmental technologies. These applications occur e.g. in the fields of drinking water, process water, waste water treatment and monitoring. Due to many contemporary trends of globalization and consequences of climate change, water technologies are considered as one of the most prominent sector in terms of both environmental importance and increasing market value.

3. Innovation process

This chapter will create a description of an innovation process, which covers project-, service-, as well as process innovations. The chapter will start with a glance for generic characters of an innovation process. Different phases of an innovation process will be treated in more detailed by presenting Koen's et al. (2001; 2006) model concerning front end of innovation and taking look at the general characteristics of New Product Development (NPD). In order to identify the characteristics of environmental innovations in particular, generic description of environmental innovations related activities and information requirements will be conducted.

The term innovation is here understood similarly than Kettunen et al. (2007, 5) describe it. In their definition, an ordinary improvement is distinguished from a genuine innovation, where this "genuine" innovation should be related to creating something new in more profound sense of word. An innovation may be e.g. a solution to a problem that could not have been solved in the past. This novelty value may also arise from a new and useful combination of existing technologies and applications. Another essential element of an innovation is the benefit it should create; to qualify as an innovation it must create value for the customer and profits for its producer.

3.1 General description of an innovation process

Innovation process is generally understood as a process which covers the time span from exploring innovations to the birth of them. Consequently it covers the larger entity than traditional new product development or R&D process; including additional functions such as sales, marketing, after sales services and repairs services. (Apilo et al. 2007, 131–132) Consequently, seeing innovation as a process may contribute to (Kettunen et al. 2007, 89):

3. Innovation process

- identification of dependencies between various phases,
- specification of deliveries (input to the next phase),
- definition of objectives and performance measures, and
- operative management and development activities.

There are different kinds of descriptions of an innovation process (Kettunen et al. 2007, 90). Depending on the source it is typically divided in two or three distinctive phases. For example Koen et al. (2006, 5) finds three separable parts: the fuzzy front end, the new product development process, and commercialization. In Apilo's (2007, 131) description, innovation process contains the front end innovation phase and the realization phase. Although there are many definitions, they usually have a lot in common; new product development is preceded by some sort of opportunity and assessment section, and followed by a commercialization section (Kettunen et al. 2007, 90).

The first phase, considered here as the front end of innovation has traditionally been considered fuzzy or even chaotic. One reason for this may be the fact that front end of innovation cannot be divided in distinctive phases of discrete projects as it can be done in the latter parts of an innovation process. Instead, it can be rather characterized as a continuous process and interactions of various factors. However, this does not mean that the functions of it could not be recognized. For example, the tasks of front end of innovation can be classified in the following sections: identifying the possibilities, creating the ideas, developing the ideas and valuing the ideas. (Apilo et al. 2007, 131–134) Typically the front end is regarded as one of the greatest opportunities for improvements of the overall innovation process (Koen et al. 2006).

As the process proceeds, the degree of formality grows step by step. Unlike the front end of innovation, the latter part is typically more structured, purposeful and project oriented. It may include activities such as new product development and commercialization, see Figure 2. (Kettunen et al. 2007, 90)

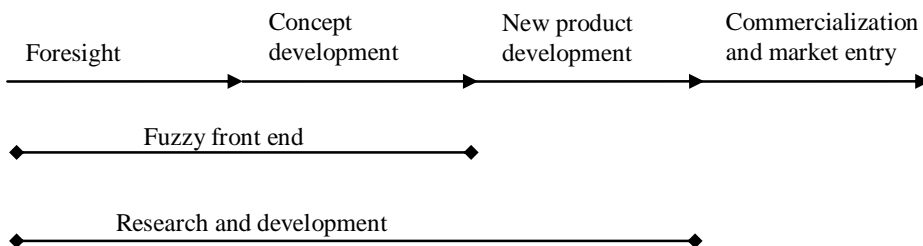


Figure 2. An innovation process model (Kettunen et al. 2007, 90).

As described in Figure 2, fuzzy front end is here referring to range of activities that typically take place before new product development. Fuzzy front end may also include such phases as foresight activities, scenario building and others that aim at better understanding of the development of the business environment. Research and development may cover different sorts of activities depending on the organization concerned. Typically “research” stands for supporting the new product development or market research. Especially in engineering companies, the “development” on its turn equals new product development. (Kettunen et al. 2007, 90) Herein, the focus of the research adapts the point of view of serving information needs of research and development activities, observing hence especially the concepts of front end of innovation and New Product Development (NPD).

3.2 Koen’s model of front end of innovation

While typical representations of the front end consist of a single ideation step, Koen et al. (2006) underlines the aspect of the actual fuzzy front end for being more iterative and complex. In order to clarify the complexity of sub-categories and wide variety of definitions used within them, they present a new concept development model (Figure 3).

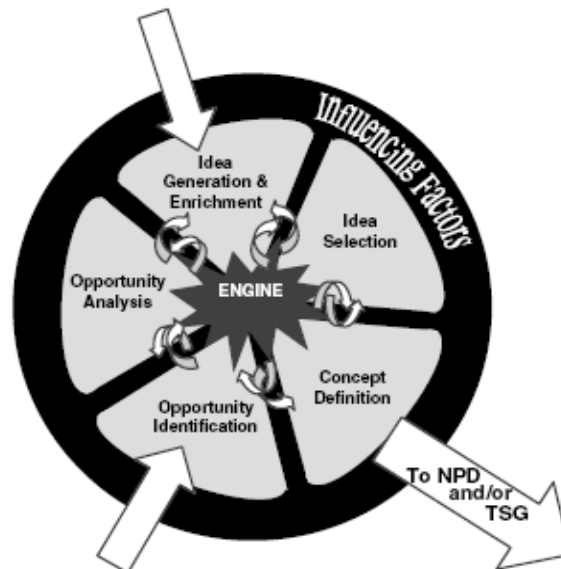


Figure 3. The new concept development model (Koen et al. 2001; Koen et al. 2006).

3. Innovation process

The above model consists of three key elements. First, the *engine* marks the leadership, culture and business strategy of the organization. Secondly, *inner spoke area* defines the five controllable activity elements: opportunity identification, opportunity analysis, idea generation and enrichment, idea selection, and concept definition. And thirdly, *influencing factors* consist of organizational capabilities, the outside world, and the internal and external enabling sciences that may be involved. Influencing factors are relatively uncontrollable by the corporation. (Koen et al. 2006)

The model has a circular shape to suggest that ideas are expected to flow, circulate and iterate between and among all the five elements. The flow may encompass the elements in any order or combination and may use one or more elements more than once. Looping arrows between different segments are pointing out the consequentially expected progression of these key elements. Further, interactions between the influencing factors, the key elements, and the engine are expected to occur continuously. (Koen et al. 2006)

3.2.1 Influencing factors

The fuzzy front end exists in an environment of influencing factors. These factors cover the organizational capabilities, customer and competitor influences, the outside world influences, and the depth and strength of enabling sciences and technology. (Koen et al. 2006)

Organizational capabilities determine how opportunities are identified and analyzed, how ideas are selected and generated, and how concepts and technologies are developed. Organizational capabilities can also include organized or structured efforts in acquiring external technology. These capabilities give the organization the ability to deal with the influencing factors. (Koen et al. 2006)

Enabling science and technology is another critical factor, since technology typically advances by building upon earlier achievements. Science and technology can be defined “enabling” when they are developed enough to build it into a manufactured product or regular service offering. Typically technologies become enabling early in their life cycle. (Koen et al. 2006)

The outside world covers variables such as government policy, environmental regulations, laws concerning patents and socioeconomic trends. Without discussing customer and competitor influences in this context more detailed, one additional actor should be added into this category, complementors. Complementors are not direct competitors, instead they are serving the growth of the same industry

(for example: Microsoft, Intel and Dell). It is the case that many of these outside world variables are largely uncontrollable by the organization itself. (Koen et al. 2006)

3.2.2 The engine

The elements of the engine – leadership, culture and business strategy – sets the environment for successful innovation. The number of successful innovation depends on the proficiency of this engine. This in turn, distinguishes highly innovative companies from less innovative ones. (Koen et al. 2006)

The continuous support of senior management has a critical role in an innovation process. This appears in a practice with a need to align the entire innovation process with business strategy, and hence to ensure a pipeline of new products and processes with value to the company. (Koen et al. 2006)

Organization culture aspects may be approached from a practical point of view. These descriptions of innovative companies are based on Zien & Bucklers (1997) studies. According to them, the innovative companies can be characterized as follows (ibid.):

- Leaders are demonstrating in every decision and action that innovation is important to the company.
- Employees are encouraged to try new things.
- The real relationships between marketing and technical people are being developed.
- Employees are encouraged to interact closely with customers.
- The whole organization is engaged to understand that innovation is the fundamental way that the company brings value to its customers.
- An individual is valued and environment is set to conduct high motivation.
- Reinforcing the principles and practices of innovation, the powerful stories are being told.

Prather (2000) has explored the characteristics of an innovative organization by identifying the dimensions that are typical for it. According to Prather the most important dimensions are: (Koen et al. 2006)

- A compelling challenge that commits people emotionally to projects.

3. Innovation process

- An environment that allows risk taking.
- Trust and openness that allow people to speak their minds and offer different opinions.
- Sufficient time for people to think ideas through before having to act.
- Availability of funding resources for new ideas.

3.2.3 Opportunity identification

In this element the organization identifies opportunities that it wants to pursue. A typically opportunity identification is driven by the business goals and the resources will be allocated to new areas of market growth, operating effectiveness, and efficiency. In this context, opportunity is understood as a possibility to capture competitive advantage, means to simplify operations, speed them up or to reduce their cost. It might also be a new product platform, a new manufacturing process, a new service offering, or a new marketing or sales approach. (Koen et al. 2006)

However, the emphasis in opportunity identification is that there have to be sources and methods to identify the opportunities. For example, the organization may have created a formal opportunity identification process aligned with influencing factors or it may have informal opportunity activities including ad hoc sessions, cyberbase discussions, individual insights, edicts from senior management etc. In many cases opportunity identification precedes idea generation and enrichment. There may also arise unanticipated notions of business or marketplace needs. (Koen et al. 2006)

3.2.4 Opportunity analysis

The meaning of opportunity analysis is to assess whether an opportunity is worth pursuing. In translating opportunity identification into specific business opportunity, additional information is needed. This involves both technology and market assessments. Opportunity analysis may be part of a formal process or it may occur iteratively. Business capability and competency are assessed in this element. Despite all the efforts, the keyword is *uncertainty* that concerns both technology and marketing aspects. (Koen et al. 2006)

Opportunity analysis utilizes many of the same tools than opportunity identification (roadmapping, technology trend analysis, competitive intelligence

analysis, customer trend analysis etc.) however, the difference is that opportunity analysis goes further. Herein considerably more resources are expended, providing more detail on the appropriateness and attractiveness of the selected opportunity. A typical analysis for a large-scale opportunity includes strategic framing, market segment assessment, competitor analysis and customer assessment. (Koen et al. 2006)

Typically in a large-scale opportunity analysis, a multifunctional team is assigned to perform the opportunity analysis. The team effort begins with a project charter that provides a clear set of expectations, committing resources and outlining the expected outcome. The team will also benefit from a clear analytical framework for assessing opportunities and the assistance of an experienced analyst. Example of an analytical framework for assessing technical opportunities is the context graph of historical performance, benchmarks, and theoretical and engineering limits. (Koen et al. 2006)

In some cases, the team work may loop back to opportunity identification to identify entirely new opportunities that were not envisioned at the start of the project. On the other hand, the team's work may in many cases loop back from the concept definition stage to the opportunity analysis by providing new features and constraints. (Koen et al. 2006)

3.2.5 Idea generation and enrichment

Idea generation and enrichment element concerns the birth, development and maturation of a concrete idea. Idea generation might be described as an evolutionary and iterative process where ideas are built up, torn down, combined, reshaped, modified etc. Linkages with other teams and contacts with customers and users as well as collaboration with other companies and institutions often enhance this activity. (Koen et al. 2006)

This phase may be a formal process, including brainstorming sessions and idea banks. A new idea may also emerge outside the bounds of any formality – a supplier offering a new material, or a user making an unusual request etc. Basically new ideas may be generated by anyone facing a certain problem, need, or situation. Once the idea is identified, many different techniques can be applied to generate it upon. Idea generation and enrichment may also feed opportunity identification. (Koen et al. 2006)

The most effective tools and techniques of idea generation and enrichment involve (Koen et al. 2006):

3. Innovation process

- Methods for identifying unarticulated customer needs. This may include usage of both ethnographic approaches and lead user methodology.
- Early involvement of customer views.
- Discovering the archetype of a customer.
- Increasing technology flow through internal and external linkages.
- An organizational culture that encourages employees to test and validate their own and other ideas.
- Variety of incentives to stimulate ideas.
- A web enabled idea bank.
- A formal role for someone to coordinate the idea development.
- A mechanism to handle ideas outside/across the scope of established business units.
- A limited number of simple, measurable goals to track idea generation and enrichment. (for example: number of ideas generated, number of ideas commercialized, number of ideas resulting in patents, number of ideas accepted by a business unit for development)
- Frequent job rotation to encourage knowledge sharing and extensive networking.
- Mechanisms for communicating core competencies, core capabilities, and shared technologies throughout the corporation.
- Inclusion of people with different kind of background in an idea enrichment team.

3.2.6 Idea selection

There is hardly ever a shortage of good ideas and the real problem is which ideas to pursue in order to achieve the most business value. Unfortunately there is no single process that will guarantee a good selection. Often an idea selection involves an iterative series of activities that include multiple passes through opportunity identification and analysis, idea generation and enrichment, often bringing new insights from influencing factors and new directives from the

engine. It is frequently a case that idea selection is based on individual's judgment, emotions or "gut". Financial analysis and estimates of future income at this early stage are typically only wild guesses. (Koen et al. 2006)

Despite the challenges there should be some formal decision process involved, otherwise there is a threat that most new ideas disappear into a "black hole". Most of these formal processes begin with some person or group looking at the idea in a light manner. If the idea is considered attractive, the next step is usually to acquire more information. Once this information has been gathered and analyzed, the idea usually goes through another decision process. Herein, the next step is to prioritize the best ones. It is notable that there significant differences have been observed when different persons with different kind of preferences for intuition and thinking are making selections (Stevens et al. 1998; 1999). (Koen et al. 2006)

Communicating to the originator about what is happening is critical to the continuity of the process. Otherwise they are less likely to submit any new ideas. Another important aspect is that decision makers need to have a positive attitude in order to avoid killing ideas that might have potentiality in another form. Instead, new ideas should rather be helped to move forward or modified for increasing their attractiveness. Nevertheless, the strategic guidelines must be kept in mind in order to avoid situation where new ideas may in the worst case destroy company's existing business. (Koen et al. 2006)

3.2.7 Concept definition

The concept definition stage provides only exit to new product development or technology stage gate. To pass this gate the investment case must fulfil certain criteria. These may address: (Koen et al. 2006)

- Objectives,
- Fit of the concept with corporate and/or divisional strategies,
- Size of opportunity,
- Market or customer need and benefits,
- A business plan that specifies a specific win-win value proposition for value chain participants,
- Commercial and technical risk factors,

3. Innovation process

- Environmental, health, and safety “showstoppers”,
- Sponsorship by receiving-group champion, and
- A project plan including resources and timing.

However, the information requirements and criteria vary depending on the nature and type of concept as well as the decision makers’ attitudes toward risk. Formality of the case varies because of several factors: nature of opportunity (e.g. market situation, new technology and/or new platform), level of resources, organizational requirements proceed to new product development, and business culture. (Koen et al. 2006)

The concept definition may be conducted through a formal goal deliberation process, where members of the cross-functional team define the business goals or outcomes of the proposed product, process, business, or technology management. The team will respond to questions regarding market, customers, competitors, technology, product, manufacturing, regulatory issues, supply chain, delivery, service and other related topics. It will also define boundary conditions that may result in project termination. These boundaries may include the range of technical approaches, cost ranges, timing and resource limits and other sources of technical and commercial risk that might affect the outcome. (Koen et al. 2006)

In the case of observed high potential of process or product innovation there could be use for a method where a further evaluation is conducted rapidly (see Smith et al. 1999). Another special case occurs when significant technical uncertainties are being faced. Herein some companies are using the technology stage-gate process (e.g. Eldred & McGrath, 1997). As a result of the technology stage-gate process, the technology related risk will be reduced to justify further investment, more resources will be utilized, and decisions will come more structured. (Koen et al. 2006)

3.3 New Product Development and innovation

New product development is conceived as a multidimensional construct. It can be viewed in market oriented terms (e.g. customer satisfaction and market share), or in strategic terms (e.g. extent to which the new product allows a firm to enter a new market). Determinants of success and failure are used to predict market success. They are divided into two fundamental groups (Berchicci & Bodewes, 2005): 1) Project level determinants, which are based on examining the specific compatibility of process activities, product characteristics and

market opportunities during the project, and 2) organizational level determinants, which are examining the compatibility of company practices and firm characteristics that may be important to the success of the project but are not apparent at the project level. (Berchicci & Bodewes, 2005)

3.3.1 Project level determinants

Montoya-Weiss & Calantone (1994) have presented a meta-analysis of published empirical research of new product performance. In their research they created an inventory of success/failure determinants of a product. The analysis proposes 18 factors divided into four main categories (strategic factors, market environment factors, development process factors, organizational factors). Main categories and success/failure determinants with brief descriptions are (Montoya-Weiss & Calantone, 1994):

1) Strategic factors

- Product advantage. Product advantage refers to the customer's perception of product superiority with respect to quality, cost-benefit ratio, or function relative to competitors.
- Technological synergy. Technological synergy represents a measure of the fit between the needs of the project and firm's resources and skills with respect to R&D or product development, engineering, and production.
- Marketing synergy. Marketing synergy represents the fit between the needs of the project and the firm's resources and skills with respect to the sales force, distribution, advertising, promotion, market research, and customer service.
- Company resources. Company resources represent the compatibility of the resource base of the firm with the requirements of the project.
- Strategy of product. Strategy indicates the strategic impetus for the development of a project (for example, reactive, defensive, imitative). Measures of product positioning strategy are included, as they are measures of "fit" between the new product and corporate strategy.

2) Development process factors

- Proficiency of technological activities. Proficiency of technological activities indicates proficiency of product development, inhouse testing of the product or prototype, pilot production, production start-up, and obtaining necessary technology.
- Proficiency of marketing activities. Proficiency of market related activities specifies proficiency of marketing research, customer tests of prototypes or samples, test markets/trial selling, service, advertising, distribution, and market launch.
- Proficiency of up-front activities. Proficiency of these predevelopment activities refers to proficiency of initial screening, preliminary market and technical assessment, detailed market study and market research, and preliminary business/financial analysis.
- Protocol (product definition). Protocol refers to the firm's knowledge and understanding of specific marketing and technical aspects prior to product development.
- Speed to market. Speed to market factor refers to the speed of the development process or launch effort.
- Financial/business analysis. Business analysis reflects the proficiency of ongoing financial and business analysis during development, prior to commercialization and full-scale launch.
- Top management support, control and skills. This factor refers to top management's commitment to the project, day-to-day involvement, guidance/direction, and control over the project development.
- Costs. Costs reflect project development cost, including measures of production, R&D, or marketing cost overruns or expenditures.

3) Market environment factors

- Market potential/size. Market potential is a measure of market size and growth, as well as an indication of customer need level for the product type. It also indicates the importance of the product to the customer.

- Market competitiveness. Market competitiveness reflects the intensity of competition in the marketplace in general and/or with respect to price, quality, service, or the sales force/distribution system.
- External environment. External environment refers to the general operating environment faced by the firm.

4) Organizational factors

- Internal/External communication. Communication factor refers to the coordination and cooperation within the firm and between firms. It may concern, for example, communication or information exchange between departments and external firms, cross-functional participation on projects, and degree of interaction.
- Organizational factors. Organizational factors refer to organizational structure of the firm, especially with respect to the new product project. It also includes measures of organizational climate, size, centralization, reward structure, and job design.

Product advantage, which refers to the customer's perception of a product's superiority with respect to specific attributes compared to competing products, is often considered as the most important predictors of new product success. This underlies the customer involvement in the NPD process. On the other hand, a good match between the resource requirements of the product and the firm's resources and skills – related to marketing and technological activities – increases the chance of success. (Berchicci & Bodewes, 2005)

3.3.2 Organization level determinants

One organizational requirement for the success of new product development is the creation of a dedicated project organization. Most importantly, people should be specifically assigned to the NPD team. Especially the project leader has an important role to play; she/he must have the necessary qualifications and sufficient know-how. The project leader should also have access to team members from other departments. The cross-functionality is an important factor because it encourages interfunctional communication and co-operation. Generally, the NPD team ought to have responsibility for the whole NPD process rather than just for parts of it. This fosters motivation and commitment, which, in turn, has a positive influence on the success of a new product. (Ernst 2002)

3. Innovation process

Senior management's recognition of the NPD programme seems to have a positive effect on the success of new products. Its support should appear for example in the resources allocation – resource allocation must go beyond the R&D budget, since expenditures for market research and market launch of the new product are important for the success of new product. Some Ernst's (2002) findings also point out the importance of a strategic framework which offers orientation to a single NPD projects. In this context, the NPD programme should have a long-term focus which also includes long-term NPD projects. (Ernst 2002)

Interconnections between organizational culture and NPD success has not been adequately surveyed so far. However, it can be concluded that personal engagement of specific people has an important influence on success. It also seems beneficial to support activities that encourage the emergence of individuality and creativity. (Ernst 2002)

3.4 Characterizing environmental innovation

According to Hellström (2007) the area of environmental innovations has been strongly influenced by eco-efficiency thinking, i.e. innovation is traditionally considered in a way that firms improve the efficiency of their production processes, in order to reduce environmental impacts as opposed to a product innovation, where environmental value is embodied in the commercial output of the firm. However, there has been shift in orientation from production processes to products (Magnusson 2003). Generally, this can be seen as a result of two main aspects. Firstly, firms gain advantage over their competitors by providing products with better environmental performance (Magnusson 2003). And secondly – partly due to previous factor – the environmental products and services are an enormous business itself today.

Approaching environmental innovation from business development perspective Oltra & Maider (2008) define environmental innovations to consist of new or modified processes, practices, systems and products which benefit the environment, and consequently contribute to environmental sustainability. Herein, innovation towards a sustainable society may be conceived on three broad levels: technological, social and institutional. It is commonly held that technological eco-innovation must be supported by a corresponding evolution of social arrangements and institutional support structures (Freeman 1996). Consequently, eco-innovation should be built on relevant social structures and, in some cases, the innovation should also be able to influence these structures as well.

However, it seems clear that only a minority of all technological development is geared towards change of this type in practice. (Hellström 2007)

An important theme in the context of sustainability is also that instead for developing reactive style solutions, there should be a direction towards anticipating solutions. Again, environmental innovation differs from a regular innovation in that it addresses the needs of a broader society. Hence it depends on translation of societal interests into product requirements and consequently the society can be seen as the primary beneficiary of improvements in environmental performance (Magnusson 2003).

Even though it is acknowledged that environmental regulation may be a driver of technological change, environmental innovations cannot be considered as a simple and systematic response to regulatory pressure. For example, knowledge bases, technological opportunities and appropriative conditions, and demand related issues influence the technological responses of firms. (Oltra & Maider, 2008) In this respect, Magnusson's (2003) statement that nowadays it has become difficult to distinguish between what is driven by perceived user needs and what is driven by regulatory demands – feels important. He finds the reason behind this integration to be the move towards preventive and product-oriented environmental management.

Most of innovations place in the incremental mode, and eco-innovation makes no exception. However it has been said that in order to achieve the emissions targets implied in a truly sustainable manner, it will not be enough to improve existing technologies only gradually. This has raised a need to reconstruct environmental products and systems significantly, which has lead the term of radical innovation to be raised (Huesemann 2003). In comparison with incremental innovation, this distinction refers to the newness of innovation. In other words, a technology or process can be either significantly or only marginally different from its predecessors/alternatives (Freeman & Soete, 1997). When the emphasis has been taken place on process innovation and efficiency gains, the orientation has turned to incremental rather than radical innovation. (Hellström 2007)

The partition can also be made between architectural and component innovation. Component innovation takes place when one or more modules within a larger system are replaced, while the system stays intact itself. An architectural innovation instead, changes the overall system design and hence the way that the parts interact with each other. It may sometimes be difficult to define whether it concerns componential or architectural changes. This is due to the issue of defining the system boundaries. For example, the introduction of a

new component may radically change the other components in a system and thereby lead to architectural change as well. Typically the component innovation is more likely to result from incremental and process improvements, but answering the question whether a certain component represents a product or a process innovation is also matter of perspective. (Hellström 2007)

3.5 Guiding questions for structuring framework and tool

Contribution of this chapter will be first presented in the form of question patterns erased from characterization of an innovation process and environmental innovation. A fundamental idea is to perceive frames for the following chapters. These guidelines will be crystallized in the distinct discussion section of this chapter. The significance of themes and questions below will be also tested in the following empirical parts (interviews) of the research. Hence the contribution of this chapter will occur in three different roles: steering the research process forward, being part of empirically tested material, and being part of the final outcome (framework and tool).

- Influencing factors. Following questions are created based on the characterization of influencing factors presented in Chapter 3.2.1 (based on Koen et al. 2006):
 - Is an external factor controllable by an organization, and if is, to what extent?
 - What kind of tools are used for gathering, organizing and utilizing external information?
 - Are present technologies enabling the development of an innovation? If not, what does it require and when would it be possible?
 - What kind of co-operation is required? Can the present partners provide the required elements or will it require establishing new alliances and partnerships?
 - Are customer needs being explored properly?
 - What kind of market entrance barriers exists?
 - Are competitive threats being explored properly, what is their assumed effect?

- The engine. Following questions are created based on the characterization of engine presented in Chapter 3.2.2 (based on Koen et al. 2006):
 - Is senior management committed to support creation of innovations?
 - Can the company be described as an innovative company? – see also Zien & Buckler’s (1997) characterization and Prather (2000) dimensions. Koen et al. (2006, 14) refers to Creative Problem Solving Groups’s approach which measures climate for innovation with nine variables: challenge and involvement, freedom, idea time, idea support, openness, and risk taking. An important element is also enabling creativity in an organization. The KEYS (developed by the Center for Creative Leadership) dimensions for creativity are: organizational encouragement, supervisory encouragement, work group supports, resource availability, challenging work, and freedom. (Koen et al. 2006, 14)
 - How innovations fit in the company’s vision, strategy and product portfolio?
- Opportunity identification. Following questions are created based on the characterization of opportunity identification presented in Chapter 3.2.3 (based on Koen et al. 2006):
 - What is the core of the improvement aimed? Is it e.g. simplifying operations, speeding them up or reducing their cost?
 - How opportunity identification is conducted? Important thing is that there exist formal/informal processes/occasions for opportunities to arise.
 - How the uncertainty of future is analyzed? (e.g. roadmapping, technology trend analysis and forecasting, competitive intelligence analysis, customer trend analysis, market research, scenario planning. The mapping process for example provides a forum for sharing the collective wisdom of the project team resources, capabilities, and skills (Koen et al. 2006, 16).
- Opportunity analysis. Following questions are created based on the characterization of opportunity analysis presented in Chapter 3.2.4 (based on Koen et al. 2006):
 - How the opportunity fits in the company’s market and technology strengths, gaps and threats?

3. Innovation process

- Why this particular opportunity represents a great opportunity? Answering this question includes a detailed description of the market segment, where factors that impact market segment are also evaluated (economic, cultural, demographic, technological, and regulatory factors).
 - Who are the major competitors in the identified market segment? What do we know about competitor's strategies and capabilities? Do they have recent patents in this area?
 - What are the major customer needs that are not being met by present products?
- Idea generation and enrichment. Following questions are created based on the characterization of influencing factors presented in Chapter 3.2.5 (based on Koen et al. 2006):
 - How are the customer needs explored? What do we know about them? What do we need to find out more?
 - How our customers can be categorized?
 - How are the customer perspectives taken into account when creating ideas?
 - How has the information flow concerning new technology solutions and new ideas flow been arranged? This concerns both internal and external sources.
 - Is it enabled for employees to test and develop their ideas? Has this process been stimulated in some way? What kind of technical tools are in use to support this process (e.g. web bank of ideas)?
 - Is idea enrichment process being structured? Who manages it?
 - Is there any data to track the idea generation and enrichment (number of patents vs. ideas etc.)?
 - Is the job rotation been arranged in a company?
 - How the discussion concerning core competencies and core capabilities is being arranged (throughout the whole organization)?
 - How are different views taken into account in the enrichment process?

- Idea selection. Following questions are created based on the characterization of idea selection presented in Chapter 3.2.6 (based on Koen et al. 2006):
 - Is there a formal process to value the ideas?
 - Is the idea valued properly from the strategic point of view?
 - What is the potentiality of an idea to be technically successful?
 - How are the ideas valued financially? What kind of issues of uncertainty are related to these calculations? What is the potentiality of an idea to be commercially successful?
 - Are the most suitable persons conducting the task of an idea selection?
 - Are the inventors of the ideas informed and rewarded?
- Concept definition. Following questions are created based on the characterization of concept definition presented in Chapter 3.2.7 (based on Koen et al. 2006):
 - Have the goals and outcomes of the project been defined properly?
 - Have the criteria been created to describe whether a project is attractive or not? This may include many variables (e.g. market, competency, technology, and financial factors).
 - If a high market potential for an innovation is been observed, how does it changes the process? For example, is there an immediate possibility to place more resources for further development of a concept?
 - Have the capability limits of the technology being covered properly? Would it make sense of acquiring new partners outside the core competences?
 - Are customers tied to real project tests?
- New product development. Following questions are created based on the characterization of new product development presented in Chapter 3.3 (based on Ernst 2002; Berchicci & Bodewes, 2005; Montoya-Weiss & Calantone, 1994):
 - Have all the product determinants (strategic, development process, market environment, organizational factor) been taken properly into account?

3. Innovation process

- Concerning teams; are they cross-functional, do they have a skilled, respected and motivated leader?
 - Is intensive communication enabled both horizontally and vertically?
 - Is internal entrepreneurial spirit supported?
 - Has the NPD program a clear strategy and focus?
 - Has the NPD been fed with the proper amount and quality of market information?
 - Are users / potential users involved in the development process?
- Environmental innovation. Following questions are created based on the characterization of environmental innovation presented in Chapter 3.4 (based on Hellström 2007; Freeman 1996; Huesemann 2003; Magnusson 2003; Oltra & Maider, 2008):
 - Is environmental innovation understood and approached in its large context? Is the purpose of innovation to create new/improved processes, practices, systems or products? Or do some of these occur simultaneously? What are the systemic boundaries for the observation? Has a life-cycle analysis been conducted for an innovation?
 - Are innovations developed on reactive or on anticipate basis?
 - Can the enabling factor of an innovation be specified (is it market or regulatory driven)?
 - How the courses of regulation occur in the development process of innovations? What is the significance of regulation in comparison with knowledge bases, technological opportunities, appropriative conditions, and demand related issues?
 - Is there potentiality for radical environmental innovations? How are they approached and treated?
 - Have all the different dimensions of sustainable product design – environmental, ethical and social (Jones et al. 2001) – been taken into account?
 - How the system boundaries of an innovation have been defined? Is the innovation about architectural and/or component innovation?

3.6 Discussion

Even a distinct potential of an innovation is usually hard to predict in the early stages of innovation process, yet environmental innovations rarely occur fully accidentally. Although the front end of innovation is sometimes described as “fuzzy”, the information needs of the front end can be supported by different kind of information, methods and tools. However, in these early phases of innovation process, the information required is often more qualitative than quantitative in its nature. Or to put in another way, the qualitative information has a decisive role and the quantitative information has a supportable role in the front end of innovation. This is due to the wide variety of ideas, information sources and different micro-, and macro variables making the amount of combinations extensive. The role of information is a vital topic in another way as well: combining the existing information in a new way may not only enable new, acute business opportunities, but also may create valuable information that could be useful in other time and/or place.

The aspects taking place in NPD phase are more concrete in their character. The transition from front end of innovation to new product development could actually be described as a shift from planning to an action. The concrete form of NPD raises many practical issues. This concerns new questions such as participants of a project team, potential customer involvement in the process and availability of more precise market information etc. As a matter of fact, it can be argued that the information requirements will simultaneously take a shift towards more quantitative requirements. On the other hand, the whole innovation process itself could also be described as a project of managing the risk; there are factors that are hard to be observed in the first place, there are factors which cannot be assessed quantitatively, or the relevance of data is inadequate, and there are factors that are totally out the firms influence such as development of international economics.

In a narrow context, the term environmental innovation (or eco-innovation) is sometimes used to mean innovations which are reducing environmental impacts through waste minimization. Adapting the idea of environmental innovation in a context of sustainability, the applications are significantly much wider. An environmental innovation may for example involve completely new products with net reduction of environmental impact, or a product that improves human life factors apart from minimizing waste, e.g. safety and other quality of life aspects. (Hellström 2007) Hence, an environmental innovation is here understood

3. Innovation process

widely to consist of new or modified processes, practices, systems and products which benefit the environment, and consequently contributing to environmental sustainability (Oltra & Maider, 2008). In this respect, the innovation process links closely to the term sustainable product design, which is one part of a global movement towards sustainable development. It requires the balancing of economic, environmental, ethical and social issues as a part of innovation activities. In addition, sustainable product design should lean on participation of many different actors such as policy makers, business strategists, managers, designers, engineers, marketing managers and customers. This term will be discussed in more detail in Chapter 5.5.

4. Analysing environmental innovation

There have been made earlier attempts to create tools that will prompt designers to explore and build environmental criteria into their design concepts. Tools such as Life-cycle Design Strategy and Eco-compass have been used to crystallize key environmental dimensions of an environmental innovation. The environmental dimensions provided by these tools are potential sources of innovation relating to both processes and products. For example aspects concerning the manufacturing process (e.g. reduction of material in the product, number of parts in the product and number of different materials in the product), product usage (e.g. reduction of water, energy or detergents), end-of-life (e.g. design for longer life, re-use of components and design for upgradeability, recyclability/ease of separation) and function redesign (e.g. redesigning of an activity). These dimensions cannot only be used to respond existing problems, but also to be used more pro-actively to ideate new products or processes, also radical ones. (Hellström 2007)

The major challenge appears to be an issue that former empirical research has revealed; the involvement of additional interests and actors during early stages of technology commercialization will further add the complexity of an already uncertain process. Hence, a technology producer whose aim is to gain competitive advantage through providing products with integrated environmental features may face multiple disparate drivers in its attempts. Assumptions of demand, market acceptance, and definition of new product concepts will be increasingly complicated. (Magnusson 2003) Relatively little research has been done on the idea generation process within environmental innovation as well (Jones et al. 2001).

The challenging task of developing new useful patterns for the environmental innovation process is approached here by using two different frameworks. Consisting of three main building blocks (technological regime, market demand, environmental and innovation policy), the aim of using Oltra & Mair's (2008)

4. Analysing environmental innovation

model is to provide larger, operational environment frames for an innovation process. The Jones et al. (2001) model on its behalf is more focused on supporting idea generation process itself. Another advantage of it is that it involves sustainable aspects in the environmental product design. Hence, the idea for selecting these two diverging models is: 1) to complete each other, 2) to give larger frames for front end of innovation process, 3) to strengthen the ties between environmental innovation and the phase of general front end of an innovation.

4.1 Oltra & Maider's sectoral framework

Environmental innovation, as any innovation, results from a dynamic and interactive process of knowledge creation and diffusion. Sectoral system approaches provide framework for an integrated and dynamic analysis of environmental and innovation policy. This approach adapts the idea of an innovation as a result of interplay between technological regimes, market demand conditions and environmental and innovation policy (see Figure 4). (Oltra & Maider, 2008)

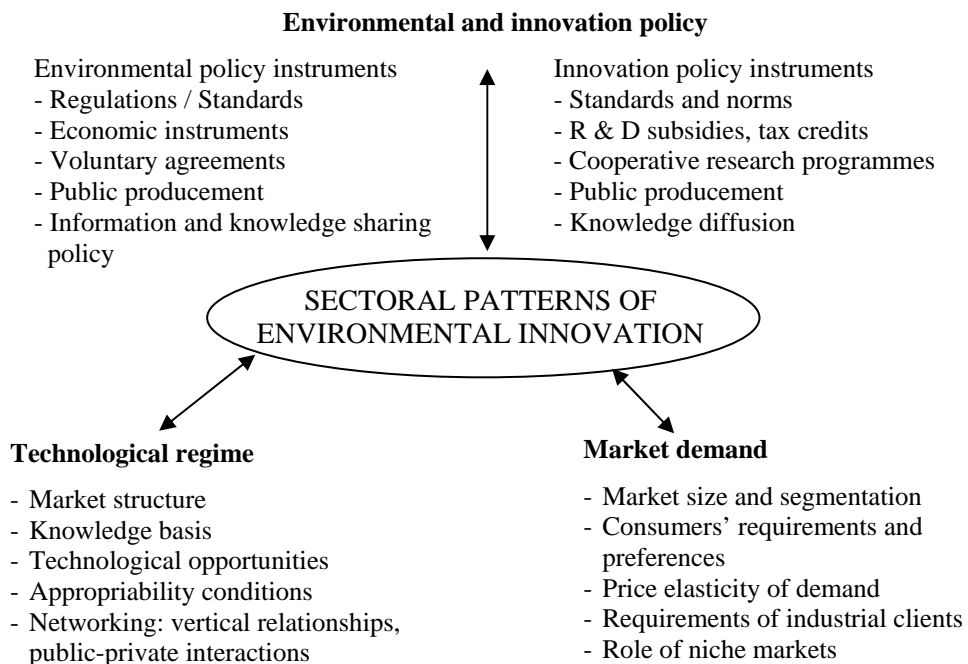


Figure 4. Framework for the analysis of sectoral patterns of environmental innovation (Oltra & Maider, 2008).

4.1.1 Technological regime

As a concept, the technological regime refers to a technological environment in which industrial firms operate. It identifies the properties of learning processes, sources of knowledge and nature of knowledge bases that are associated with the innovation processes of firms active in distinct sets of production activities. Malerba & Orsenigo (1995) have defined a technological regime as a combination of four factors: knowledge bases, technological opportunities, appropriability conditions and cumulativeness. In their study they showed how these factors shape the innovative patterns and the industrial dynamics. Here the authors have used the patent data and observed that patterns of innovative activities differ systematically across technological fields. Simultaneously they found remarkable similarities emerging across different countries for each technological field. (Oltra & Maïder, 2008)

Based on the Schumpeterian tradition, two types of technological regimes can be distinguished: Entrepreneurial regime that can be characterized by an innovative base which is continuously enlarging through the entry of new innovators and by the erosion of the competitive and technological advantages present in the industry. The routinised regime is based on the dominance of a few established firms which are continuously innovative through the accumulation of technological capabilities. (Winter 1984) These two types of patterns can largely be seen as a result of technical regime conditions. (Oltra & Maïder, 2008)

The above taxonomy can also be approached from the point view of technological barriers to enter. Based on Marsili's (2001) research, there can be five different industrial technological regimes distinguished: science-based, fundamental processes, complex systems, product engineering, and continuous processes. Each of these regimes is defined by a specific combination of technological opportunities, technological entry barriers, inter-firm diversity in the rate and directions of innovation, diversification of the knowledge base, external sources of knowledge, links with academic research, and nature of innovation. Each regime has its own characteristics which means that the regime gives insights on the patterns of innovative activities in the industry. (Oltra & Maïder, 2008)

4.1.2 Market demand conditions

A large proportion of work on technological change and innovation is concentrated on the “supply” side dynamics. This Schumpeterian perspective tends to assign a passive role to demand and to consumers in the innovation process. Considerable body of research focuses on the role of demand conditions and heterogeneity of consumers’ preferences in the process of technology diffusion and adoption. This research can be split into two types of literature: research on technological competition and network externalities, and industry life cycle analysis. (Oltra & Maïder, 2008)

Research on technological competition and network externalities concern rival variants of the same technology. Arthur (1988) has identified five sources of increasing returns to adaptation which may lead to a monopoly of one technology: learning by using, network externalities, scale economies in production, informational increasing returns and technological interrelatedness. The technological interrelatedness is linked to the development of sub-technologies and infrastructures, which go together with the adoption of a given technology. It considers that if some new technology is less adopted, it may lack the requisite infrastructure or it may require a partial dismantling of the more widespread technology’s infrastructure. (Oltra & Maïder, 2008)

From the point of view of industry life cycle analysis, the focus is on the evolution of industry structure and on the emergence of a dominant design. Once the dominant design has emerged, an era of incremental change takes place in which organizations focus on incremental improvements of the dominant design. Recently, versions of theories have occurred that stress the dynamics of the demand side. In this new approach, the industry stabilization is not reached only because a particular technological pattern is being found, but rather because of bandwagon effects on the demand side. (Oltra & Maïder, 2008)

Disruptive technology is a powerful term concerning the role of demand (see Christensen 1997). It means new technologies that represent different performance package from mainstream technologies. Even these new technologies are considered inferior to mainstream ones, the technology disruption may happen in a form where some new technology displaces the mainstream technology from the mainstream market. One reason for this is the phenomenon called performance oversupply, which means a situation where customers’ requirements for a specific functional attributes are met and evaluation shifts to place greater emphasis on attributes that were initially considered secondary. (Oltra & Maïder, 2008)

The above topics can be approached from the aspect of competitive dynamics as well. Adner (2002) has explored the influence of the demand structure which is defined in terms of heterogeneity in customers' requirements and preferences. Herein the essential aspect of disruption is the consumers decreasing marginal utility (performance go beyond requirements), leading to decreasing willingness to pay for improvements. Hence technology disruption is likely to occur when customers are willing to accept a worse price / performance ratio because the absolute price of the new option is sufficiently low. (Oltra & Mäider, 2008)

Windrum & Birchenhall (2005) have also found concepts useful here: technological substitution and technological succession. In technological succession, the new technology offers one or more new service characteristics that were previously unavailable when using the old technology. In occurrence of successions they seem to make most relevance when the gain in direct utility from new technology is high. In addition, the entrance of new firms and technology seem refreshing in a way that they stimulate old technology firms to innovate and improve the quality of products. Hence, the probability of a succession depends on the relative rates at which new and old technology firms innovate. (Oltra & Mäider, 2008)

4.1.3 Environmental and innovation policy

The literature on environmental innovations shares the idea that regulation may be a driver of technological change depending on the type of instruments used (command and control versus market-based instruments) and the context in which they are applied (Oltra & Mäider, 2008). Economic instruments such as taxes and tradable permits tend to be more cost effective than regulation and seem to provide incentives for firms to adopt new technology continuously. However, it has been shown that regulatory design is a key factor that may influence firms' innovative response. In particular, this concerns its stringency, flexibility and limiting uncertainty. Stringency means the absolute reduction of environmental impacts, but it also relates to the compliance using some new technology with an existing technology – which may be either not possible, or too costly. Despite increasing stringency of regulation, environmental regulation is most often incremental. This in turn, supports the incremental innovation and technological diffusion as well. (Oltra & Mäider, 2008)

Industry covenants are industry specific voluntary commitments. In achieving environmental goals they can give more flexibility for a firm. However, there

4. Analysing environmental innovation

may occur future threats such as product boycotts and potential stricter regulation. There may also appear other additional incentives regarding monitoring, penalties and inspections. (Oltra & Mäider, 2008).

Current environmental policy can also shape the market conditions by utilizing different demand-oriented measures. These may promote new information and knowledge sharing measures such as eco-labels and environmental management systems. Furthermore, public procurement can play a major role by creating niche markets for environmental technologies by allowing feedbacks between experimental users and the emerging technology users. (Oltra & Mäider, 2008)

The set of instruments defines an environmental policy mix, the purpose of which is to promote more sustainable systems of production and consumption. This policy mix determines some of the environmental priorities and objectives in terms of emissions, quality of inputs or products, but it also has a role by shaping market conditions and interactions among others. Properly designed regulation/policy mix can thus strengthen both technology push and market pull effects. (Oltra & Mäider, 2008)

The term “double externality” problem of effects of environmental innovations seems important. It means the two types of positive externalities that environmental innovations produce: knowledge externalities in the innovation phase and externalities in the diffusion phase due to the positive effect upon environment. Hence, the beneficial environmental impact makes their diffusion always socially desirable. (Oltra & Mäider, 2008)

4.2 Product Ideas Tree diagram

The aim of Product Ideas Tree (PIT) diagram (see Figure 5) is to help structure generation activities and the outcomes of them. The specific advantage of PIT is in overcoming communication problems between the different stakeholders at the early stages of the Eco-Innovation process. One of the key issues is to structure ideas output from chaotic brainstorming sessions by mapping these ideas into surface. The PIT diagram combines some key starting points for eco-innovation, hierarchical structure for ideas, and the mind mapping technique to produce valuable documentation in the form of maps. It can be argued that the use of PIT diagram would produce more ideas, more environmentally relevant ideas, and would facilitate creative sessions to enable preceding issues to happen. (Jones et al. 2001)

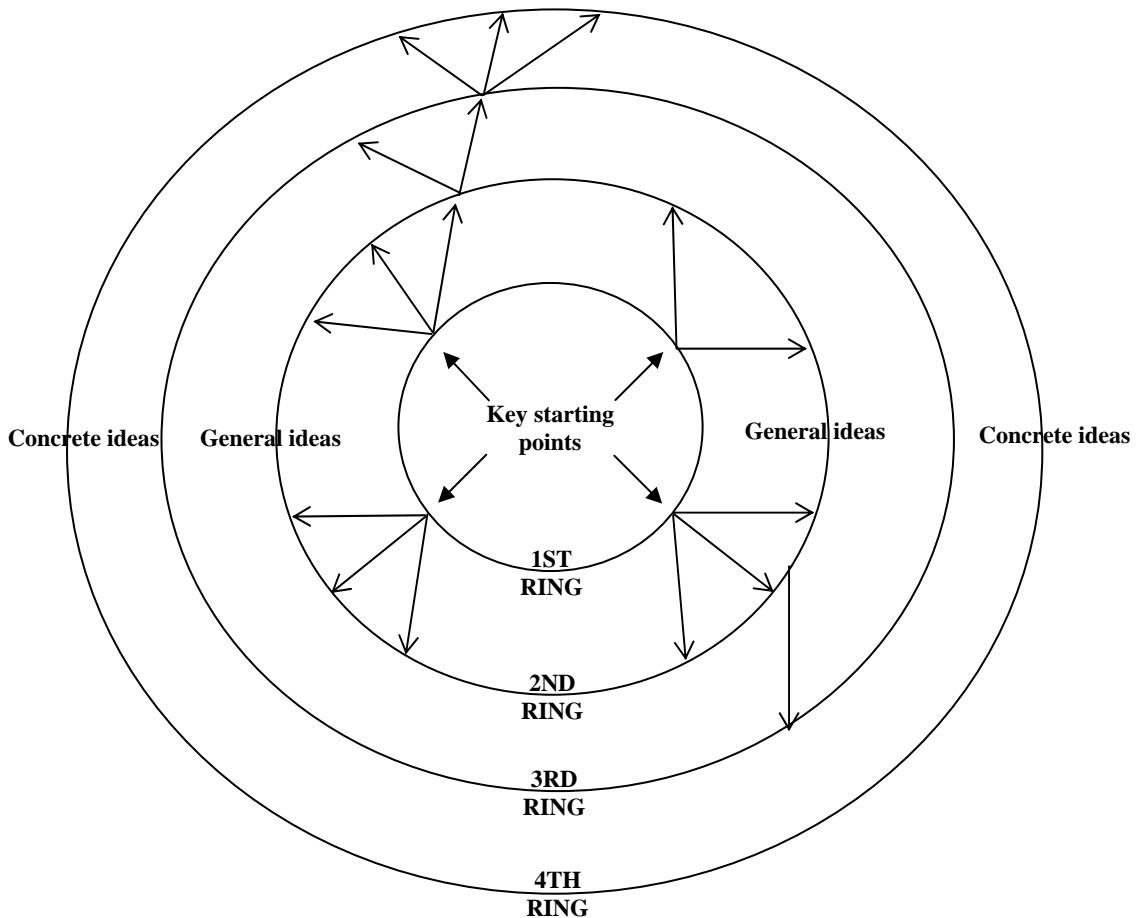


Figure 5. PIT Diagram (Jones et al. 2001).

Taking a place in the first ring, to start using the PIT diagram requires that the key starting points are being set first. They may be categories such as product usage, product manufacture, function redesign or end-of life. These starting points may also be called as the headings, working as an upper concept for sub headings conducted from them. The sub heading will be located in the second ring. Example of this dissembling may look like as presented in Figure 6. Example concerns planning a new environmental friendly washing machine.

4. Analysing environmental innovation

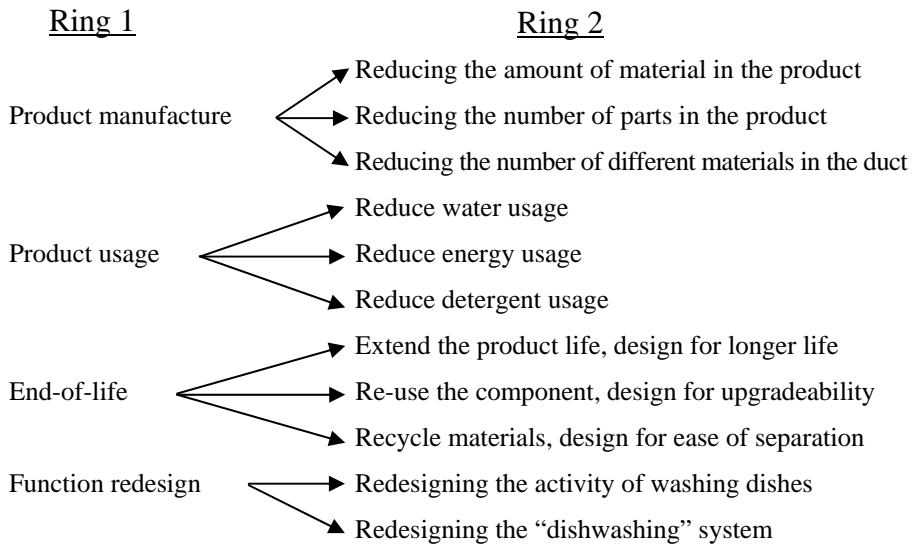


Figure 6. Disassembling headings to sub headings (Jones et al. 2001).

Each of ring 2 ideas can be then exploited further to generate spin-off ideas. Even the number of ideas may not be the most appropriate data to collect, the spectrum of ideas could be more useful. Different rings may also work horizontally: By moving in a ring it is possible to assure that all relevant areas of design have been taken into account. When moving vertically towards outermost ring, the ideas should become gradually more concrete. (Jones et al. 2001)

4.3 Guiding questions for structuring framework and tool

As in section 3.5, the contribution of this chapter will be presented in a form of question patterns first. Hence, the following questions will appear in three roles: steering the research process forward, being part of empirically tested material, and being part of the final outcome (framework and tool).

- Technological regime. Following questions are created based on the characterization of technological regime presented in Chapter 4.1.1 (based on Malerba & Orsenigo, 1995; Marsili's 2001; Oltra & Maider, 2008; Winter 1984):
 - The properties of the knowledge base. How could the nature of knowledge to be characterized? What kind of generic knowledge is required in the field? What kind of specific knowledge is required in an application level?

- Technological opportunities. How the opportunity conditions act in the course of the evolution of an industry? Is there a danger that the technological opportunities would become depleted in some run? What is the influence of firms' R& D functions – Are opportunities in the field being regenerated by firms' innovative activities?
 - Appropriability of innovations. How are the innovations being protected from imitation (high or low appropriability)? High appropriability means the existence of ways to protect innovation from imitation successfully. Low appropriability conditions mean an economic environment characterized by the widespread existence of externalities.
 - Cumulativeness of technical advances – Knowledge and innovations today are building blocks of tomorrow's competitiveness. Are innovations being generated continuously? Is there a systematic method to document what kind of new information an innovation has provided?
 - Can the technological regime be described as entrepreneurial or routinised one? What does it mean from the point of view of industrial dynamics?
 - What kind of technological barriers exist to enter the market?
- Market demand conditions. Following questions are created based on the characterization of market demand conditions presented in Chapter 4.1.2 (based on Adner 2002; Christensen 1997; Oltra & Maider, 2008; Windrum & Birchenhall, 2005):
 - Are customer requirements and preferences in knowledge? Is there large heterogeneity in them? How is this information acquired? How is this information utilized?
 - What kind of dominant factors can be characterized in the markets? What kind of incremental changes are presumable to enable by these factors? How dominant can they be considered to be? What will be the next dominant factor(s)? To what extent are the firms imitating each other?
 - What kind of minor technologies exists in the markets that could become the next major technology in the field?

4. Analysing environmental innovation

- What kind of consequences the new minor/major new technology has? Will it substitute the old technology as a whole? Will it enable some new incremental improvements to be added to the old technology that were earlier impossible to realize?
- How the contribution of new firms is being followed up? How the competitor analysis is being executed in general?
- How is the competitive pool of an own network to be followed up, documented and developed?
- Environmental and innovation policy. Following questions are created based on the characterization of environmental and innovation policy presented in Chapter 4.1.3 (based on Oltra & Maïder, 2008):
 - What kind of policy mix is steering the development in the field? How does it affect the innovation activities of a firm?
 - What is the significance of policy mix vs. market demand factors as a driving force in the field?
 - What is the degree of stringency of regulation in the field? Does it enable enough flexibility for the companies to innovate? What kind of uncertainty factors exist?
 - Is company involved in any voluntary commitments? What are the benefits/disadvantages of them?
 - Is there any demand oriented policy measures (e.g. eco-labels or environmental management systems) contributing the development in the field? What are the benefits/disadvantages of them?
 - Is company aware of assumed future development of environmental policies? What kind of effects they might have?
 - Is company involved in any co-operative organs affecting the development of policy tools in the field?

4.4 Discussion

It appears that there is no single best instrument to foster environmental innovation and the most common response of firms is incremental innovation and adoption of technologies with short-term paybacks. Market based tools are

not substitutes, and sufficient to induce innovation alone, either can environmental innovations be considered as a simple and systematic response to a regulatory pressure. (Oltra & Maïder, 2008) Consequently, it seems apparent that firms have to adapt the abilities to foresight and respond to both market demand and policy mix factors concurrently. In the context of this research, it means that the model and tool to be developed should adapt elements of both. The key question, however, is which factors to be emphasized and to what extent? The technological regime may offer one way to approach this question fruitfully but, assumingly, the variation in the emphasis of these factors may occur within a field as well, even in a product level.

The notion of differences between different industrial sectors is important. The same policy instrument may have different impacts on innovation according to industrial sectors. This emphasizes the significance of technological regime – depending on the nature of knowledge bases and the conditions of technological opportunity and appropriability, firms may experience more or less favourable conditions for environmental innovations. In other words, the impact of environmental policy instruments is dependent on the features of technological regime. (Oltra & Maïder, 2008)

As a consequence, it appears to be vital to clarify the characteristic of the technological regime dominating in the field. However, from the point view of view of an external consultant issuing this task, it seems obvious that there is no “fast and easy” -method to assess information of this kind. Instead, becoming an expert on most relevant characters of a certain technological regime requires either having strong previous experience on the field, or acquires setting up qualitative sessions with persons who possess the best knowledge of technological development.

Considering the role of technologies outside the mainstream, called here as minor technologies, changes in the policy mix or in market circumstances may open possibilities for finding a niche market for a specific product or service. This enables fast movers, most often small and medium sized companies, to respond the changes in the short run, and, therefore gain competitive advantage. These minor players have also a vital part in industry dynamics. They create incremental improvements for prevailing major technologies. They combine information of unique kind. Sometimes niche markets may turn out to be a source for the next dominating factor in the field.

5. Environmental benefits in a context of new product development

5.1 General

Referring to the concept of an innovation process discussed in Chapter 3, it is notable that eco-innovation considers environmental aspects of the product in the early stages of the product development process. The ever emerging discussion is also tying the sustainable product design issues into product development. (Jones 2001) Taking a generic look first, it seems that environmental performance data need to be normalized against some meaningful indicator of business activity. Typically this means the use of intensity indicators, expressed as net environmental impact per unit of production or sales. Alternatively, efficiency ratios can also be measured, i.e. the economic value created per net unit of environmental impact caused. Even though variables such as pollution intensity and eco-efficiency can be regarded as best Cleaner Production measurement practices, they cannot capture trade-offs. Trade-offs mean situations where one environmental impact category improves at the expense of another (e.g. waste water vs. energy usage), or where chemicals with different environmental impacts are being substituted (e.g. ecosystem toxicity vs. human toxicity). In principle, life cycle analysis can be a way to assess these trade-off situations. (Howgrave-Graham & Berkel, 2007)

Most commonly, measuring company's environmental performance happens by comparing data before and after implementation of a Cleaner Production project. It should be noted that even though Cleaner Production project might reduce or even eliminate a specific waste stream, it does not necessarily show up in the company's overall environmental performance. For example, this may be the case when a waste stream in question represents only a small portion of the total waste stream. From this perspective, tracking trends of the company's

environmental performance remains as the most desirable Cleaner Production quantification. (Howgrave-Graham & Berkel, 2007)

The above themes reveal only a small part of the problems that valuing environmental benefits faces. This is due to the wide complexity of defining both central variables and systemic boundaries of the assessment. For example, the situation is quite different whether approaching the environmental benefits from the point of view of outcomes of the producer; product, project, process, or management system, etc. – or whether assessing the environmental impacts of them; energy usage, toxic emissions, social or health contribution etc. Here the level of analysis tried to set in a level that it reveals the central environmental topics and indicators affecting the judgment of how environmental friendly a certain innovation is, however, in the research context the measurement methods of them are excluded. The aim is aspired to achieve by reviewing life-cycle analysis, general environmental indicators, business specific indicators and concept of sustainable product design.

5.2 Life-cycle analysis

UNEP (2001) states that the objective of environmental evaluation is to determine the positive and negative impacts for the environment, however, the whole life-cycle of a product or service must be taken into account. Life Cycle Assessment (LCA) is a way to approach environmental aspects of a product or service through all stages of its life cycle. It identifies and quantifies the environmental loads involved, such as energy and raw materials consumed, and emissions and wastes generated. After the identifying phase, LCA then evaluates the potential environmental impacts of these loads and assesses the options available for reducing environmental impacts. (Rorarius 2007)

According to UNEP (2001), life-cycle analysis can essentially be divided into qualitative and quantitative analyses. The qualitative approach involves forming a matrix of environmental issues vs. stages of life cycle. The quantitative way involves developing a set of criteria against which the environmental impact of a product or a service can be measured and then actually measuring it against these criteria. Criteria can be developed using parameters such as: the cost of energy used at all stages in the life cycle, cost of disposal of the wastes at all stages in the life-cycle etc. The qualitative method, instead, involves drawing up a matrix of environmental issues versus life cycle stages.

5. Environmental benefits in a context of new product development

LCA is widely considered as one of the best tools for environmental assessment of a wide range of products and processes. However, it is best suited to primary or secondary industrial processes. It can namely suffer from a number of limitations. The most significant of these is the incompleteness and lack of reliability associated with current inventory data sources, including both process and input-output data. In order to assess the life-cycle environmental loadings from the manufacturer of a particular product, a greater level of more complete data where input and output flows are quantified is needed. (Crawford 2008)

Also Johns et al. (2008) underlines the above problems by stating that environmental costs have difficulties in assigning their costs to individual products from multi-product processes. Similarly, problem occurs in assigning costs to streams that are partly reused and partly sent to waste. As a solution they represent a model, where the whole production network of inter-linked products and processes is considered in an integrated way. Basic idea is to accumulate environmental costs process by process.

5.3 Generally applicable environmental indicators

General environmental indicators, which are independent from business area, will restrict the amount of indicators to few. In addition to being relevant to all business sectors, another common aspect to all of these is that they all share a global perspective, and they have an agreed measurement method and definition. These indicators are following: Energy consumption, water consumption, material consumption, greenhouse gas emissions and ozone depleting substance emissions. WBCSD (2000, 17–18)

Energy consumption means the formula where the total energy consumed equals energy purchased minus energy sold to others. Energy use could also be further elaborated breaking it down into different types of energy sources, e.g. identifying the use of renewable energy. As a special case, electricity companies can also be taken into account by reporting the purchased energy and subtracting the energy sold. Their generation and transfer losses would be kept as part of their consumption. (WBCSD 2000, 17–18)

Water consumption is an aggregate of all fresh water obtained from a water supplier, or straight from surface or ground water sources. Fresh water covers also water used for cooling purposes even there is no physical contact to process materials. Sea water is excluded. (WBCSD 2000, 17–18)

Material consumption is the sum of weight of all materials purchased or obtained from other sources. This includes raw materials for conversion, other process materials (catalysts, solvents etc.), and pre- or semi-manufactured goods, parts and modules. This section excludes water and fuels, which are located in a different category. Packaging is important especially in consumer industries, but there is lack of generally applicable criteria, neither is an agreement on measurement methodology, so it will be dealt with a business specific indicator instead. (WBCSD 2000, 17–18)

Greenhouse gas emissions cover emissions from fuel combustion, process reactions and treatment processes. Defined in the Kyoto Protocol, these are the gases behind the climate change. The “boundary fence” is an important concept for this indicator. It means that an indicator in question covers only emissions from direct corporate activities. Another group of gases concern Ozone depleting substance emissions, which were originally defined in the Montreal Protocol. The amount of the most dangerous gases has been strongly reduced though and less harmful alternatives introduced. (WBCSD 2000, 17–18)

5.4 Business specific indicators

Each business has its own characteristics, which apparently make the comparisons in the context of all life-cycle very challenging. However, according to WBCSD environmental business specific indicators can be identified at least in the following areas (2000, 33):

1. Indicators on emissions of individual or groups of gases and metals to air or water.
2. Environmental burden/effect indicators. They are summary indicators for different gases or effluent substances that contribute to the same environment burden or effect (e.g. human toxicity). For some indicators certain weighting factors have been developed. These weighting factors measure how individual gases or effluent substances contribute to environmental effects.
3. Summary parameters for water effluents (e.g. Chemical oxygen demand). Water effluent substances are not relevant for all type businesses and there is also a lack of aggregate parameters. For businesses which this indicator is relevant will then have to choose between alternative parameters and measurement methods.

5. Environmental benefits in a context of new product development

4. Indicators on particular fractions of waste or non-product output (e.g. wastes from processes, treatments and packaging disposed of by landfill).
5. Product use indicator (e.g. product packaging, energy consumption during product use).
6. Indicators on aspects of upstream impacts emerging at operations of suppliers.

5.5 Towards sustainable product design

Sustainable product design appears to integrate many of the above mentioned aspects. It also reveals some new variables into consideration. The objectives that the approach of sustainable product design (SPD) must meet are based on the idea of creating more stakeholder and customer value with less environmental impact by (James 1997): 1) increasing resource productivity so that more is obtained from less energy and raw material inputs, 2) creating new goods and services which maintain or increase customer value but use fewer resources or create less pollution. (James 1997)

One of the challenges of the SPD is to translate complex LCA data into simple concepts and criteria which can be used by product designers and developers. Eco-points and Eco-compass are such evaluation schemes that are worth taking a closer look at. When using Eco-points software (called Eco-Scan), the user selects appropriate materials, processes, usage, and transportation details – covering all life cycle stages of a product. The software then calculates an eco-score for each of these elements. The value of this approach is that it can provide quick analysis of the overall environmental effect of products and how different elements of the design contribute to this. The main disadvantage of this tool is that it creates subjective weightings of different environmental effects that are not always transparent to other users. Hence, its primary contribution takes place in identifying areas for attention and exploring choices between different alternatives. (James 1997)

Eco-compass is based on the indicators developed by WBCSD. It consists of six “poles”: energy intensity, mass intensity, environmental and health risk potential, sustainability of resource usage, extent of revalorization (reuse, remanufacturing and recycling) and service intensity. Like the previous tool, it measures all these variables across the whole life cycle. Its advantages takes place in comparing and making choices between product and product variants,

and with some restrictions in communicating environmental effects to customers and other parties. The disadvantages in turn are; 1) It requires reasonably complete LCA data. 2) Some of its elements include qualitative elements which may be difficult to measure. (James 1997)

With a guidance of previous observation there seem to be a need for a tool that can 1) Encompass both qualitative and quantitative information, 2) Present information in terms of a few states rather than in highly complex forms or ones which are summarized in single number, 3) Take the social dimensions of sustainability into account. James model represents an example of such. It is structured into four rings: customer value, physical environmental impacts, product attributes and social impacts. (see Figure 7; James 1997)

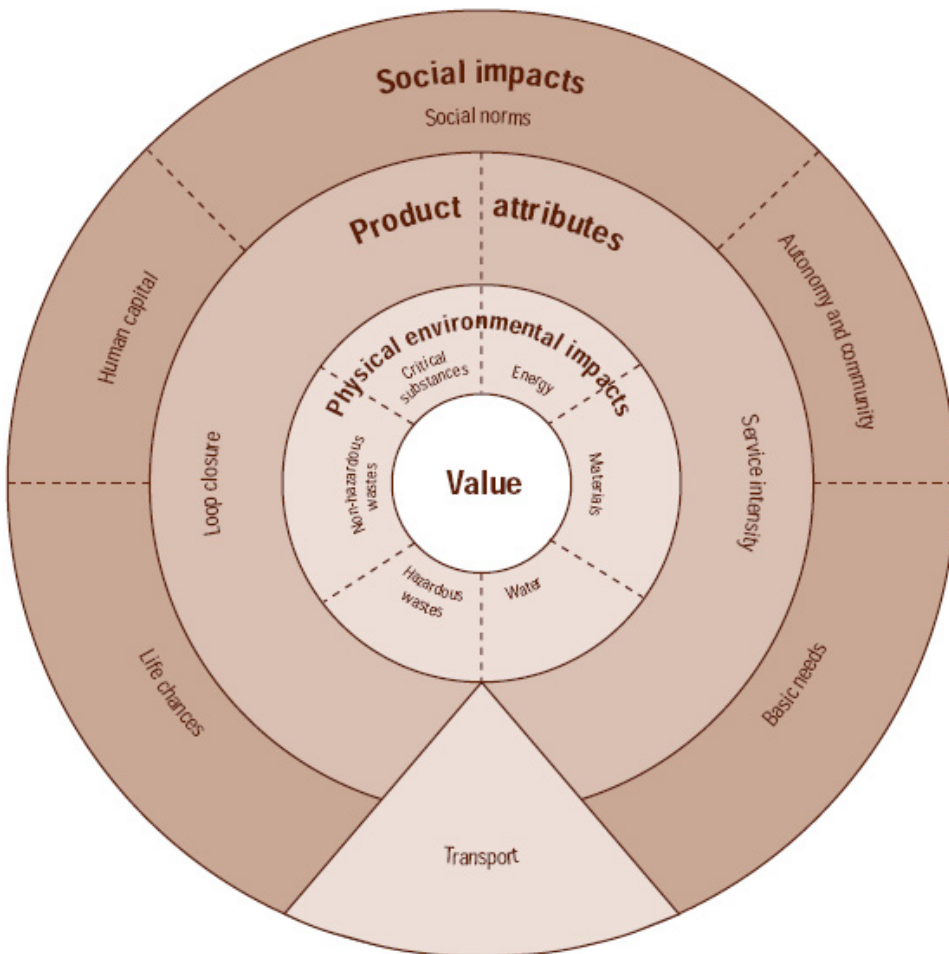


Figure 7. The sustainability circle (James 1997).

5. Environmental benefits in a context of new product development

As a central aim of product development, the customer value takes place at the centre of the circle. Often the environmental impacts are presumed to deliver value creation of environmental product; however, there are often opportunities to develop new sources of customer value through the whole eco-innovation process. Hence, it is important to consider opportunities to do this when all elements of the wheel are being considered. (James 1997)

The second layer concerns primary/physical environmental impacts that can be quantified through the use of LCA techniques. These are divided to inputs and outputs. Inputs are energy, material and water. Outputs cover hazardous substances and radiation, non-hazardous wastes and environmentally critical substances. (James 1997)

The third layer concerns the product attributes determining the physical environmental impacts of the product. These attributes can be identified in the following areas (James 1997): 1) Transport; the total use of transportation over the life cycle. 2) Revalorization/Loop closure; the extent to which the product can be recycled. 3) Service intensity; Additional services to customers which reduce environmental impacts. These are for example product substitution, intensity of use, life extension, product augmentation (addition of new features to facilitate a service), multi-functionality and product integration. (James 1997)

In addition to gaining nature related environmental benefits, sustainable development also ties the social aspects in the product development. However, dealing with them at the design level is difficult. This is often due to the lack of knowledge about social impacts, which may be complex and often occur some time in the future. This means that the quantified data may be difficult or even impossible to obtain. In addition, products are designed in specific contexts and it may be inappropriate to assess them against universal criteria. Sometimes the assessment may be only about whether there are violations of the social conditions for sustainability. Quite often the complexity of many different points of view involved mean that there is no single right answer and the main objective takes place is simply recognizing these different aspects. (James 1997)

Consequently, assessing the social issues in the context of new product development is difficult. However, five key elements can be identified five key elements to cover most aspects (James 1997):

1. Basic needs. More than billion people have inadequate food, shelter and other necessities of life. The reality in richer countries is often such that these aspects can be considered in quite restricted manner.

However, some positive experiences exist, which shows that innovative actions are sometimes possible.

2. Life chances. This element is basically about answering the question whether a product accentuates existing disparities of life chances.
3. Social norms. A new product can create emotional reactions that may challenge or impinge the existing norms. Hence, the considerations of the ways that the product might challenge or change societal norms.
4. Human capital. On one hand, new products and processes normally require less human labour to operate than previous versions. On the other hand, they may create new forms of employment elsewhere. The key indicator is, however, what is the overall effect of the product on knowledge, skills and other dimensions of human capital.
5. Autonomy and community. New products may have the effect in an individual level that they threaten his or her freedom and/or local community. Hence, it seems important to check these effects as well.

5.6 Discussion

As noted in Chapter 5.1, the idea is not to form criteria how to measure different environmental impacts, but to *reveal* the central variables which should be measured. Hence, this aim supports the final outcome of the research in a form of building a tool. The idea of sustainability circle on its turn was to give frames for the assessment; simultaneously it brought up some other aspects into consideration. Here the central environmental variables are first briefly reviewed, and then the contribution of LCA and sustainability circle is summarized in a way that supports the work of structuring the final framework.

Taking a look at the general environmental indicators that WBCSD (2000) presents there appears to be five major categories that need to be assessed: energy consumption, water consumption, material consumption, greenhouse gas emissions and ozone depleting substance emissions. From the business specific point of view, the following environmental indicators are seen as vital: Indicators on emissions of individual or groups of gases and metals to air or water, environmental burden / effect indicators of gases or effluent substances contributing to the same environment burden or effect, summary parameters for water effluents, indicators on particular fractions of waste or non-product output,

5. Environmental benefits in a context of new product development

product use indicator, upstream impacts indicators. In the context of sustainability circle, the environmental indicators were divided to inputs and outputs, where inputs covered energy, material and water – similar to WBCSD categorization. Outputs covered hazardous substances and radiation, non-hazardous wastes and environmentally critical substances.

Looking at the contribution of LCA, it seems important to notice that sometimes it is useful to apply a full LCA, sometimes LCA may be more appropriate to be conducted in a lighter manner. Another useful observation takes place in the field of application on the objectives that it shares with the research; LCA is suitable for utilization in new product development and it also contributes to the basis of many eco-labelling schemes. In addition, LCA has two potential ways to approach systems: qualitative and quantitative way. In the context of the research, LCA thus appears as a method to provide a holistic way to approach the environmental themes in a qualitative way: 1) to reveal the most significant environmental variables over the whole life cycle of the product, 2) to create general understanding of their relative significance.

The presented sustainability circle includes many useful techniques and aspects. Assumingly, what makes it practical is the way it sets customer value at the centre of the circle – by applying the idea widely; unless the total value is not being created any other layers will lose their significance. The second layer concerns environmental impacts that can be quantified through the use of LCA techniques, discussed above. Adapting also the aspect of LCA, the third layer concern the product attributes determining the physical environmental impacts of the product (Transport, revalorization/loop closure, service intensity). Social dimensions are widely discussed lately, but the key question remains unsolved; how to tie the social factors more solidly into companies real actions. Generally, it could be stated that social dimensions are not the highest priority in firms' new product development; however, they could be seen as secondary factors that in some cases could facilitate the favourable development of a new product.

6. Lead markets of an environmental innovation

There would be various ways to approach the environmental innovation from the point of view of market factors. Basically, this task could be issued by utilizing the demand factors, buying behaviour, competition, segmenting, or some other basic market theories constructed from these (customer relationship management- or b-to-b marketing theories, theories of network etc.). Still, even though all of these approaches would apparently enlighten some angles of an environmental innovation; there seem to be a shortage of theories that perceive the context of an environmental innovation in a holistic way.

However, the theories of lead markets appear to make a positive exception. This is due to the reason that all lead market factors (price advantages, demand advantages, transfer advantages, export advantages and strict regulation) appear to be relevant for environmental innovations (Beise & Rennings, 2003). Consisting of many multifilament variables, an applicable lead market theory can thus be considered more as an eclectic theory than a mono-causal model focusing on a presumed main international system (Beise 2004).

6.1 General

Taking a closer look at the diffusion of a globally successful innovation, that is to say that many innovations have become internationally successful after they have been preferred and adapted in a single country. Another useful contribution of lead market approach is that it integrates the public good character of environmental benefits and the role of regulations into general lead market model. (Beise & Rennings, 2003) The Porter effect is an important part of the Beise & Renning's model. It refers to Porter's (Porter 1991; Porter & van der Linde, 1995) idea that environmental regulation should promote the creation of innovations that are both environment-friendly and competitive.

6. Lead markets of an environmental innovation

The term of lead markets follows the definition of Bartlett & Ghoshal (1990) who characterize these as geographical markets that induce global innovations by local demand preferences and local environmental conditions. Beise (2004) has additionally approached this definition with the term of lag markets. However, fundamentally it does not refer to a market area where innovation design will be adopted later, instead, it refers to a market area that adapts the dominant design factor later. One example of these dominant factors is GSM that was originally only European cellular mobile standard, but nowadays adapted worldwide. Another descriptive case is anti-lock braking system (ABS) that faced resistance in many countries initially, but after achieving market approval in Germany, reached the acceptance world-wide. In sum, lead markets can be considered as geographic markets, based on characteristics of product of process innovations designed to fit local demand preferences and local conditions, but that can subsequently be introduced successfully in other geographic markets without many modifications (Beise et al. 2003).

6.2 Lead market factors

Nation-specific characteristics can be classified into five groups of lead market factors. The idea is to integrate all possible international mechanisms, allowing easily comprehensible system for innovations. The groups can be described as homogenous within but not necessarily between. Another character is that they can correlate with each other either positively or negatively. Furthermore, if a company is strong in one area, smaller amount of additional advantage may be needed. For example, if a company has developed an innovation that can easily be used in other countries (export advantage), less attention may be needed to be paid to other lead market factors. (Beise 2004)

6.2.1 Price and cost advantage

A price advantage arises from either the relative price reduction of a nationally preferred innovation design (compared to designs preferred in other countries), or an anticipation of international price changes. Most often the relative price reductions are based on economies of scale of mass production. This gives the country with the biggest market at an early phase of the technology life cycle a cost advantage. Hence, if a mass market emerges first in a market area, a relatively small country can achieve a cost advantage as well. Small country may

also be attempting market for specialized high-tech products with few applications. In addition, high market growth increases the early market size. The growth affects positively also through lower cost of new technology and reduced risks in investing it. (Beise 2004; Beise & Rennings, 2003)

Prices of input factors and complementary goods are variables affecting the cost of an innovation. However, the input factor prices are only an advantage when a country stays at the forefront of an international price trend. A cost advantage may result from either increasing or decreasing factor prices. Obviously, global price decline of a factor that is used to produce particular innovation, or that is complementary to the innovation, enhance the international diffusion of the innovation. Increasing factor costs affect on their behalf by finding new alternatives. For example, since the labour costs have increased everywhere, countries with the highest relative labour costs have become lead markets for automating machinery. (Beise 2004)

In sum, the price advantage can be one of the most significant lead market factors. The advantage may be enabled by large price reductions or shifts in global input factor costs. Good example of this is the Internet, development of which was paved by the reduced price on its way to become a global success story. (Beise 2004)

6.2.2 Demand advantage

A demand advantage refers to national environmental conditions that increase the demand for an innovation and that emerge over time in other countries as well. Earlier, the dominant global demand trend that explained a lead market was increasing income. However, nowadays when differences in income per capita have become marginal, other global trends are mainly responsible for the global diffusion of innovations. These trends can occur in economical, ecological, social and environmental contexts. Innovations responding to these trends are first adopted in countries that are most advanced in them. (Beise 2004)

The availability of so called complementary assets can also be a demand advantage in the case that the creation of them is not a direct response to the introduction of innovations but follows a global trend. As an example, the countries in which credit cards are more common have a lead in the adaptation of e-commerce services. However, quite often the recognition of a global trend that is responsible for the international diffusion of an innovation is difficult and demand advantage is therefore expected to be a less significant variable for lead markets. (Beise 2004)

6.2.3 Transfer advantage

The transfer advantage means a country's ability to shape the customer preferences in other countries. The perceived benefit of an innovation is being increased if the country will be able to lower the associated uncertainty of an innovation in another country. This concerns for example the usability and reliability issues of an innovation. Communication ties between customers in different countries may play an important role in some cases. Another transfer advantage may also happen when an innovation is actively transferred to another country by e.g. businessmen and tourists. Similarly, the firms with foreign manufacturing units have an incentive to use standardized equipment; typically this technology flow happens from headquarters to subsidiaries. (Beise 2004)

The question of patents is important, and it can be noted that proprietary innovations are often disadvantaged in international diffusion against non-proprietary innovations. This is due to the fact that non-proprietary standards can be imitated by other companies, which in turn enables dissemination on a larger scale. Since open designs can be more easily improved by many producers and users, proprietary standards are expected to improve less over time than non-proprietary. Additionally, nations are often reluctant to support a standard that is seen as a property of a foreign company. (Beise 2004)

Network externalities (the concept of externality is also touched upon in Chapter 4), are another factors that may increase the adaptation of innovations. As a matter of fact, externalities are a major force when considering the adaptation of many high-tech products. Quite often they are, however, more common within countries than between them. Hence, a strong interaction between actors of different countries is required. (Beise 2004) In short, the network externality can be defined as a change in benefit, or surplus that a user derives from a good when the number of other users consuming the same kind of good changes. For example, as fax machines increased in popularity, the fax machine became increasingly valuable for the single users of it. The value received may also be separated into two distinct parts. One component, can be labelled as an autarky value, which is the value generated by the product even if there are no other users. The second component, which may be called as a synchronization value, is the additional value that is derived from user being able to interact with other users of the product. (Liebowitz & Margolis, 1998) Some Internet located applications could be used as a present example of

network externalities. For example, Facebook creates more value to its single user when the total amount of users is larger.

6.2.4 Export advantage

Local innovations are more likely to become international if the local market conditions increase the exportability of innovation design. Three factors can be identified in delivering the export advantage (Beise 2004): 1) Similarity of local market conditions compared to foreign market conditions, 2) Domestic demand that is sensitive to the problems and needs of foreign countries, 3) Local network putting pressure on companies to develop exportable products. (Beise 2004)

Based on early suggestion of Vernon (1979), the higher the similarity of cultural, social and economical factors between two countries, the greater the likelihood that innovation will be adopted in another country as well (Beise & Rennings, 2003). To put it in another way, an innovation of which specifications are less different from those demanded in other countries, is most likely to become globally accepted (Beise 2004).

Considering the second factor, sensitivity of domestic demand for problems and needs, there may be a situation where domestic users can be more sensitive to global problems and needs than potential adopters in countries where the *problem* instead is more acute. This local sensitivity of demand on its turn may push the domestic companies into global markets before companies in other countries. For instance, the markets may be sensitive for the matter of climatic change in some country even if the domestic environment itself would not be affected as much as in other countries. (Beise 2004)

Pressure for export may come from many local users such as suppliers, financiers and national institutions. Customers may put pressure on producers to develop globally successful solutions for an innovation that can be exported. A theme can be approached larger as well: A strong export orientation of some region shapes the political, social and cultural system of it. These export-oriented regions also have an important role as communications centers between several large economies. This is due to their high-level intelligence gathering capability in identifying world trends. (Beise 2004)

6.2.5 Market structure advantage

Competition in domestic markets increases the likelihood that the local markets will identify preferences and innovation design that is competitive also globally. This concerns technical superiority and practicability issues as well as the cost-benefit relation. Simultaneously, competition pushes the costs down and makes a technology more price competitive against other innovations and technologies. (Beise 2004)

Consequently, the *degree* of competition in local markets is an attribute of lead markets. One traditional indicator is the concentration in a market, for example, the number of independent buyers can create pressure for a reduction of process and an improvement in product performance. Another used indicator is the fluctuation of market share over time, in a competitive market a company can turn any technological advantage into a market share. In addition, the absence of barriers to entry the market is essential in innovation intensive industries. Greater openness to enter a market allows users to find the most suitable solution for their problem. (Beise 2004)

Beise & Rennings (2003) argues that market structure advantage shall include the “Porter effect”. The Porter effect considers here especially the problem of double externalities, discusses earlier in this chapter. Conducted from there, the environmental problems cannot be solved simply by deregulation strategies, since the negative external effects require regulatory measures correcting these market failures. Hence, the Porter effect can be understood as a strict regulation for the respective environmental problems in a lead country. This strict regulation in its turn may induce environmental innovations in a lead country.

6.3 Applying lead market factors to environmental innovations

The firms that are producing eco-innovations are facing a problem of double externalities. It means a situation where the company is creating benefits for both user and, at least to some degree, to a society. An example of this could be a biological food providing healthier food for the benefit of an individual, and more environmental friendly production method instead creates benefits (less pesticides) for the whole society. An example of electricity appoints the significance of externalities quite differently – the electricity that the user gets to the household is similar regardless of the way of producing it. Hence, producing

the electricity from renewable sources does not provide any additional benefit for the user, which in turn reduces the firms willingness to invest in eco-innovations, and the competition between environmental and non-environmental stays distorted as long as markets do not punish environmentally harmful impacts and reward environmental improvements. Therefore, there exists a distinctive need for an innovation policy to support the adaptation of new environmental technologies both locally and internationally. (Rennings 2000; Beise & Rennings, 2003)

One of the main drivers for the international diffusion of environmental innovations is adaptation of national regulations by other countries. Hence, it is important to clarify, when and why environmental regulations are being adapted by other countries. One process of policy convergence is the cross-national diffusion of successive new policies. It is also a question of solving uncertainty: both social problems and policy instruments intended to ease these problems are surrounded by uncertainty. Different countries, in turn, tend to adopt foreign policies that have proved to be effective in solving problems in this complex context of uncertainty. (Rennings 2000; Beise & Rennings, 2003)

Policy communities, different international organizations (e.g. OECD and WTO) and transnational professional organizations (different NGOs for instance) have an incentive to harmonize policies among countries. International organizations can also apply pressure to governments to adopt a specific policy. On the other hand, the multinational firms themselves have an incentive to standardize their technology within their global network instead of employing different technologies from country to country. Hence, they also try to push the policy makers to accept (or wait) the international agreements on environmental regulations. (Rennings 2000; Beise & Rennings, 2003)

6.4 Guiding questions for structuring framework and tool

As in sections 3.5 and 4.3, the contribution of this chapter will be presented in a form of question patterns first. Hence, the following questions will appear in three roles: steering the research process forward, being part of empirically tested material, and being part of the final outcome (framework and tool).

- Price and cost advantage. Following questions are created based on the characterization of price and cost advantage presented in Chapter 6.2.1 (based on Beise 2004; Beise & Rennings, 2003):

6. Lead markets of an environmental innovation

- Is price advantage based on relative price decreases of a nationally preferred innovation design (e.g. advantage of mass market) or an anticipation of international price changes? Or is the product very specialized with only few applications on the markets?
 - What is the rate of market growth in the domestic markets? How does it differ from rates elsewhere?
 - What is the significance of prices of input factors and complementary goods and services in relation with the total price of an innovation?
 - What are the lead country's possibilities to stay in the forefront of price trend in producing the innovation (including the labour costs etc.)?
 - What is the global trend in different factor prices? What are the consequences of increase or decrease of different factor prices?
- Demand advantage. Following questions are created based on the characterization of demand advantage presented in Chapter 6.2.2 (based on Beise 2004):
 - What kind of economical, ecological, social or environmental circumstances in a country are alike to become prevailing factors also internationally? How are these trends being followed?
 - In what areas a country has a good availability in complementary assets? What is the global trend that they lean on?
- Transfer advantage. Following questions are created based on the characterization of transfer advantage presented in Chapter 6.2.3 (based on Beise 2004):
 - What kind of uncertainty is prevailing among customer in other countries? How the preferences of customers are meant to be influenced?
 - How the dynamics of patenting work in the field? What kind of product strategies this dynamics enables/requires?
 - Can any network externalities be identified – if amount of users increases (within or between the countries), what kind of consequences does it have?
- Export advantage. Following questions are created based on the characterization of export advantage presented in Chapter 6.2.4 (based on Beise 2004; Beise & Rennings, 2003):

- What are the similarities and differences of local market conditions compared to foreign market conditions? How the domestic demand is linked to the problems and needs of foreign countries? Is local network putting pressure on companies to develop exportable products?
- What kind of similarities can be found on cultural, social and economical factors of lead market vs. target markets?
- What kind of regional exporting activities can be found (main actors, power structures, fields of interests etc.)? How can these activities be exploited?
- Market structure advantage. Following questions are created based on the characterization of market structure advantage presented in Chapter 6.2.5 (based on Beise 2004; Beise & Rennings, 2003):
 - Is there competition in the domestic market? How do the competitive circumstances differ from the target markets?
 - How the market shares have been acting earlier in relation to new technological advantages?
 - What kinds of barriers exist to enter the market?
 - What kind of environmental problems exist in the lead market? Does it mean a strict regulation in these areas? Has this regulation been a source of an environmental innovation? Have these new innovations made breakthrough in other market areas?

6.5 Discussion

All presented central factors of lead markets seem to have relevance with environmental innovations. In any case, the rate and extent of the significance of different variables seem to vary. Assumingly, this variation may occur depending on the technological regime in question, even on the case by case - basis within a certain regime. Here few key notions of the lead market approach are being brought up.

Firstly, the price and cost advantage is an apparent part of the general innovation design. The element that ties this factor in *environmental* innovation design in particular is the issue of double externalities; when adapting the principles of sustainable product design, an innovator is creating benefits for

6. Lead markets of an environmental innovation

both customers and to the society. Even there might hypothetically be a positive situation where innovation creates the most comprehensive environmental benefits in a most competitive price, the normal situation would be the one where gaining more environmental benefits included in the same product would essentially mean raised production cost and end price.

Considering demand advantage, the larger focus seem to take place in following the international trends, in other words, companies should find out which local economical, ecological, social or environmental circumstances are alike to become prevailing factors also internationally. In this respect, the availability of complementary assets may also play a significant role in some cases.

In addition to basic elements of lead markets, there are also some other factors to consider in this context. One key issue is to take an international perspective in a first place. This is due to the issue that *environmental innovations are providing marketable solutions to global environmental problems* (Beise et al. 2003). Consequently, from the point of view of innovation design, it can be concluded that being aware and forecasting the global environmental problems should also take place in an innovation process. Another issue to consider is that the pioneer market can also send out signals to the supply side beyond the domestic market (Beise et al. 2003). It may for example signal companies in other countries that the new technology has reached the level where similar solutions might have market potential. This logic works on the other way as well; Companies should follow the development in other countries in order to track the prevailing technological trends and impacts of infrastructure changes, to mention few.

7. Forming and testing hypotheses – creating the Value Assessment Framework

This chapter will first summarize the contribution of previous chapters in a form of key hypotheses. These hypotheses are meant to cover central attributes raised from presented theory in order to provide fundamental information to structure the framework. The hypotheses are first formed theoretically, and then tested in practice by reflecting them with the acquired empirical data. The hypotheses concern the environmental technologies in general. The role of sectoral qualities / technological regime will be treated separately under the title “Water sector notions”.

The contribution of empirical data may be divided roughly into two categories: 1) Data, the main focus of which is to verify the validity and significance of different hypotheses about environmental innovations in general. 2) Data, where water technologies was used as a concrete topic to approach environmental innovations. Hence, in a methodological context, water technologies are being utilized as a test field of an interest and the aim is that a model and a tool could be implemented in other sectors of environmental technologies as well. This aim was taken into account in discussions concerning water technologies. Discussions were kept in a quite high level, enabling the generalizations to environmental technologies as a whole.

The interviews were conducted in a manner where was no strict form to handle issues, instead, the discussion was let to live more or less freely. However, before each interview, the list of key themes was being written down. Since the assumed knowledge base of interviewees was slightly different, the designed topics varied from interview to another. On the other hand, the understanding of the researcher also developed through the information acquisition and hence the key themes were transforming during the process. The hypotheses presented below, and questions patterns that were created in Chapters 3, 4 and 6 created an implicit base for discussions. Even though the empirical data is in its most

visible form in the issuance of hypotheses (Chapter 7.2) and in the description of Finnish water sector (Chapter 7.3), it also has contributed to all information processing of Chapters 7 and 8. Interviews took from 1 to 3 hours, they were recorded and transcribed. After conducting all interviews, a common summary of the outcome of interviews was created. The summary became 10 pages in its length.

The seminars took place in an “Environmental Technology -08” -Fairs in Helsinki Fair Centre on September 11th 2008. Written notes and seminar handouts were used as a contribution of this data source. Likewise, participation in conference of “Boosting Environmental Technologies by Verification” and project meetings created wide range of topics-related information in a form of written notes and handouts.

As a final result of this chapter, the Value Assessment Framework (VAF) of environmental innovation will be presented. VAF will integrate the results of hypothesis in the same frame. Consequently its aim is to clarify the interconnections and contribution of these different aspects in all together. On the other hand, the framework will also work as a primary source for utilization a Value Assessment Tool (VAT) of environmental innovation, which will be presented outside the core context of the research (Appendix 1). This is due to the reason that the tool cannot be described as a final version yet. To complete this tool requires testing with the real cases first, this work will be conducted in another time frame of the NOWATECH-project.

7.1 Hypotheses

The hypotheses below are being formed based on the theoretical observations of the research. Hence, they could be described as key notions raised from theory. Different hypotheses can be verified, conditionally verified or refuted. By doing this, the aim is to structure the interconnections of key themes and to reveal the significance of central contents of them. The hypotheses are following:

Hypothesis 1: Environmental benefits are feasible as a key starting point of an innovation process.

Hypothesis 2: Environmental innovation is inherently linked with legislation.

Hypothesis 3: SMEs’ flexibility to adapt to target market needs is a key success factor in the international markets.

Hypothesis 4: The theory of lead markets offers a beneficial way to approach environmental innovations.

7.2 Reflecting hypotheses with empirical data

The above hypotheses are reflected with the empirical data. The primary data utilized here consists of the data acquired in the interviews. Some citations of the interviews are being used in connection with each hypothesis. From the point of view of acquired data, the hypotheses may potentially be verified, conditionally verified or refuted.

Hypothesis 1 is conditionally verified. In an attempt to structure a functional model for larger use, it essentially seems that environmental benefits are not something that could be set alone as a starting point of an innovation. This is due to several reasons, but especially because an innovation is a result of market possibilities and restrictions. To try to compress this wide thematic in short, there might for example be a situation where the customer does not see the environmental benefits as a primary product quality, or adapting the solution in question would require too expensive other investments etc. From the producers point of view this could be viewed by proposing questions such as: What are the key product attributes in customer's preferences? In which spot do environmental issues take place in this hierarchy? Or more fundamentally, what is the value that the company creates for the customer?

There are many drivers in the environmental business; one of them is legislation. (Interview citation)

Born of innovations could be considered as a value chain that consist of research/developers of technology, producers of solution, and the customer. The whole chain has to make co-operation. And the public sector is also involved in many ways. It is a complex formula. (Interview citation)

The hierarchy of environmental benefits themselves is another issue to consider. Approaches such as sustainable product design and LCA reveal a wide variety of environmental benefits on what basis an innovation could be built on. However, these sources of innovations are very diverging in their characteristics. The estimated usage of raw material can be assessed much easier than potential effects on quality of life of local people, for example. Not to talk about estimation challenges, that will be faced when taking the whole life cycle of the product into account.

However, there is no elementary objection why environmental benefits could not be set as a starting point of an innovation process. There could be a

functional way to set certain environmental problem in the center of the PIT type of diagram and then to split it down into different subcategories such as: how to respond these problems technologically, what are the potential environmental benefits of a solution, what are the potential profits etc. As environmental issues are becoming an evident part of any company's action, another potential advantage of this kind of approach could take place in offering an alternative way to structure and value different ideas alongside the traditional models and methods. This kind of parallel method might for example reveal potential situations where the same final technological and financial outcome could be received with less environmental impacts caused.

Hypothesis 2 is verified. Taking a look at the course of development, it seems that similarly than innovations are often based on existing technologies and thus develop incrementally, as are the environmental policies often based on earlier constructs and their improvements. Mainly due to globalization, another prevailing trend is that regulation is becoming more coherent. It also seems that regulation is developing towards market driven voluntary arrangements such as ETV. BAT (Best Available Techniques) and BREF (Best Available Technology Reference Document) arrangements are important as well. Most often company faces BAT practice when applying environmental permissions; when it has to present an own assessment how to adjust BAT in its own action. On the EU level, BAT information is being exchanged, as a result of which BREF documents are being formed. BREFs in turn will work as a comparative basis when valuing the success of BATs. In addition for their direct effects on markets, BAT and BREFs also have effects on the development of regulation; as a better technology becomes mainstream, regulation has a tendency to tighten. In sum, it is apparent that regulation – and largely, all actions of public sector – do have significant role as a promoter of innovations. However, from being decisive partner, this role is changing towards enabling and supportive actor.

Legislation is a key factor in all environmental business. (Interview citation)

Traditionally, environmental business has been dominated by public sector and legislation. This is why the development has been quite steady and the environmental sector has not be seen that interesting business area. Climate change and energy related issues have changed the situation so that the environment has become a factor that affects on all business activities. (Interview citation)

Hypothesis 3 is conditionally verified. The reality of SME is often restricted by resources: time, money and skills. SMEs have, however, one traditional advantage in a comparison with bigger companies. They can respond to changes in the operational environment faster. This may be the case in creating some service due to some change in regulations, or focusing on a creation of some specific solution to be marketed in niche markets. Most importantly, this hypothesis raises question of organizational possibilities and capabilities, which concerns the companies of any size. The company has to be aware what it can do, what it could do by acquiring more resources, and what it cannot/does not want to do in any circumstances. This concerns both the technological and organizational (culture, skills etc.) aspects. Obviously, these are the factors that the company vision and strategy should define. One of the prevailing trends in the international markets of environmental technologies seems to be that customers are looking for concepts rather than only narrow solutions. In such a situation, there is an apparent need for both horizontal and vertical co-operation in the field. Consequently, it can be concluded that flexibility to adapt to target market needs is one key success factor that SMEs have, but this capability cannot be observed alone. It is required that the flexibility of SMEs mapped in the context of technological and organizational capabilities, possibilities and restrictions.

Small companies do not have resources for marketing. Another restriction is that their products and services often solve only small parts of the customer's total need. (Interview citation)

Hypothesis 4 is verified. The lead market approach does have quite a lot of the dynamics prevailing in the field of environmental technologies. This is mainly due to the reason that environmental innovations are likely to start from one pioneer country and then to expand elsewhere. The key word behind this trend is the environmental problem that the solution relates to. In this respect country specific problems can be seen as a cogent reason to create innovations of many kinds. And as is, two primary conclusions can be formed: 1) The local environmental problems should be reflected with the international ones. 2) The local market circumstances should be reflected with the international ones.

Denmark had nothing (energy resources). That is why they had to develop wind power. Now they are selling they plants around the globe. (Interview citation)

Finland is a model actor as a water country. We have saved our lakes from environmental catastrophe, we have enormous clean water resources and we can offer plenty of clean water to all of our inhabitants. We also have a good reputation as a clean technology's country. The problem is that we cannot sell. (Interview citation)

7.3 Water sector notions

The water sector could be described stagnant in Finland. From the point of view of customer segments it can be roughly divided into communal and industrial segments. Water supply and sewerage systems are mainly managed by the public sector. The R&D investments have been quite small so far and the motivation to go for the international market can be considered rather low. (Summary of interviews 2008)

The value chain of the water sector can be divided roughly into three different parts. The first one concerns the research and development of the technology. Design offices often solidly take place in this phase. The second phase consists of industry that produces a product or the service. It may be for example equipment manufacturer or in a service sector a company that produces management systems. The third component of the chain is the customer (communal sector or industry). Probably the most significant contribution of this approach takes place in considering the customer value; in order to create it, the co-operation is required from all parts of the chain. Another characteristic concerns the foundations of the phases; the previous phase must be taken care until the next step in possible to conduct successfully. (Summary of interviews 2008)

Looking at the companies in the sector, approximately a couple of hundred of firms could be listed, most of them SMEs. And even though there are some middle sized companies (especially consulting groups and other field supportive actors), the sector could still be roughly divided into two groups: Kemira and the others. This strongly biased structure is an obvious problem, but it is also a possibility. An immediate need could thus be seen in getting more water technology companies in the medium sized companies' category. (Summary of interviews 2008)

From the international market point of view, creation of holistic concepts, instead of single and narrow solutions, appears to be a key issue. To enable the birth of these new competitive concepts, it would, however, require actions to improve information exchange and networking between SMEs. Especially co-

ordination would be needed more. In this respect the expectations for Tekes Water Programme 2008–2012 seem to be relatively high in the field (see Tekes 2008). (Summary of interviews 2008)

There would be a need for integrating the other actors in the field as well. It appears to be challenging to get the traditional communal organizations activated; still or therefore, new organizational and operational patterns should be explored more. By possessing the accomplished infrastructure their role would take place especially in offering a piloting base for new concepts. Another important theme would be to tie the supportive branches' companies into the concept development as well (ICT, metal, plastic etc.). A participation of research organizations is another necessity. (Summary of interviews 2008)

Centre of expertise in the water industry cluster (CEWIC) has been founded to rise to the preceding challenges. CEWIC's aim is to unite the Finnish water and waste water processing fields and to create a cluster that connects education and research and the needs of business life. Consequently, CEWIC's aim is to act as a network for all the Finnish actors in the field. As a result of the activities of CEWIC, services and business models that are based on solid Finnish know-how will be sold to the world markets. (see Osaamiskeskusohjelma 2007; Thule Institute) International strategy of water sector of Finland (Ministry for Foreign Affairs of Finland 2008) and Water Program of Finland 2008–2013 (Vahala & Klöve) are useful sources in search for additional information on the course of water sector development in Finland.

7.4 Value Assessment Framework

Value assessment framework (VAF) integrates the variables that have the most relevance in potentiality considerations of environmental innovations (Figure 8). This approach would be the most applicable in the use of SMEs which are willing to internationalize their businesses, but which are there not yet. By leaving two boxes concerning the international issues out, it might also be utilized in companies which are not primarily steering for international markets. Time span is another factor worth noticing of. The developed use of the framework would require integration of past, present, future -considerations. Herein, certain forecasting methods and tools would assumingly improve the efficient use of it.

7. Forming and testing hypotheses – creating the Value Assessment Framework

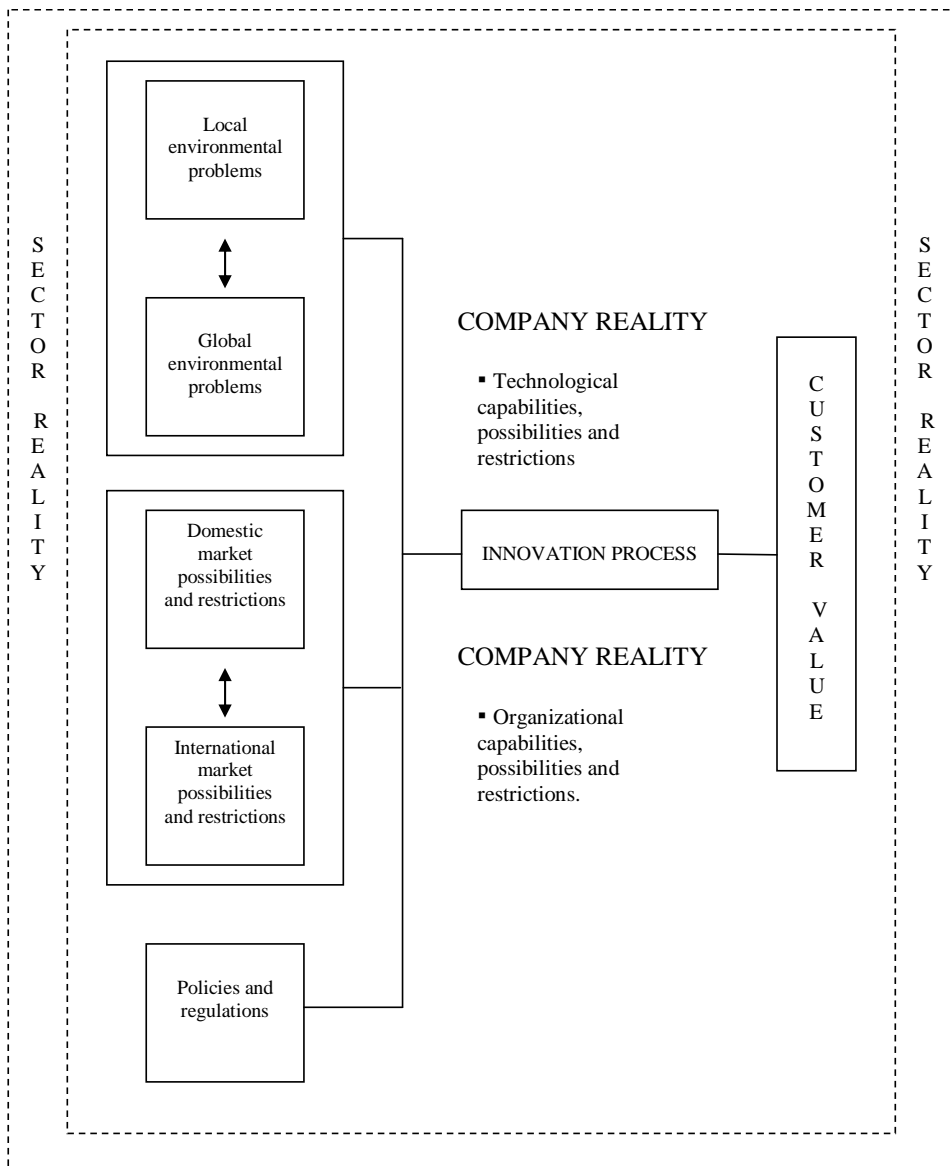


Figure 8. Value Assessment Framework.

The outer frame. The outer frame is named as the *sector reality*. It concerns the operational environmental of a company. Hence, it covers the prevailing society, other companies, research institutes etc. – basically all constituencies and circumstances having effect on company decisions and actions.

The inner frame. The inner frame is named as the *company reality*. The prevailing circumstances are defined to be dominated by technological and organizational capabilities, possibilities and restrictions. The lines between the boxes describe the value chain from sources of innovation to final aim of the process – value creation for a customer. No arrows are used to describe directions or preferences. This is firstly due to the reason of interaction, different factors have to aware of the existence of all others and they also do have effects on each other. Secondly, the final outcome is also seen as a result on the circumstances in question; sometimes the specific environmental problem may be higher in the hierarchy of product qualities, sometimes competitive factors may have bigger importance etc. It should be addressed that the inner frame has many *connections* across the organization's boundaries, and not only in the relation to customers, but also in the relation to financiers and other technology-, and co-operative partners. In this sense the company reality can also be seen as a multifilament and unique *network of value creation*.

Innovation process. Innovation process is here seen as an integrative *compressor of knowledge*. It is vital that this compressor gets the information from both directions. It also works as a supplier of information, to inside and outside the organization. It has to have effective methods and tools in all of its information management tasks. This wide area of different actions includes utilization and compression of both qualitative and quantitative information. It is notable that the information also has a role in decreasing the *uncertainty* of creating the exceptional customer value. High degree of uncertainty is prevailing in early phases of innovation process, whereas due to progressive information compression, the uncertainty factor should have the tendency to decrease during the process.

Local vs. global environmental problems. Matching the local and international environmental problems may be the key element for a company that is aiming for international markets. In addition for looking for “full matches”, the creativity is needed when considering which are the other problems that company's innovation could solve. Even by conducting some minor technical adjustments may create totally new areas of applications, for example.

Domestic vs. target market similarities and differences. Market structures and practices may differ significantly in different countries. Similarly than observing the environmental problems, there might be market areas which are alike with the domestic markets. They may be similar in terms of customer

amount and profile, competition situation, economical circumstances, and in terms of many other factors to consider. In addition to tracking similarities that may make another market area far more approachable – in which respect the cultural and lingual similarities are apparently the most attempting factors – the differences between the areas may be the key issue as well. Totally different kind of situation could also be a possibility, which may be a case for example when home markets are under extreme competition, but the target markets are not. By reflecting the similarities and differences between the market areas, the description of target market possibilities and threats will be formed.

Policies and regulations. The role of policies and regulations can be seen as *enabling, restrictive, disabling or primary* in their relation for innovation development. First three describes the level of effect for an innovation: enabling means that they do not restrict the development of an innovation, restrictive mean that they have some effects on the development, disabling means that they make an innovation impossible to realize under circumstances. Primary means that a *change* in policies or regulations works as a distinct break impulse for starting a new product development, which may be the case especially concerning some niche solution. Policies and the regulation box might also include a similar kind of regional analysis as was used in issuance of market and environmental problem sections, wherein the categorization of disabling in some market area may turn into restrictive in another, for example.

8. Conclusions

Internationally competitive companies are not those with the cheapest inputs or the largest scale, but those with the capacity to improve and innovate continuously (Porter & Linde, 1995). This statement concerns the companies operating in the environmental sector as well. What is crucial is that the company makes innovations activities visible and matches them with the possibilities that both the internal and external operational environment offers. This task also requires appropriate methods and tools and the research has been an attempt to contribute this challenge by creating larger framework for assessment of an innovation (presented in Chapter 7.4). This final chapter summarizes the key topics of the framework. It also presents geographical view of generic challenges of Finland. In addition, an example of a trial quantitative method of assessing the potentiality will be presented. Outside the core context of the research, the Value Assessment Tool (VAT) will be formed. It will be tested and further developed in practise of the NOWATECH (2008) -project.

8.1 Key factors contributing the development of environmental innovations

The problem based thinking is one way to approach the environmental challenges. It can be observed, that many of the local problems are global as well. This is the case concerning pollution of waterways, increasing amount of waste, the price and availability of energy etc. It means that if even a small country, for example, which has faced and solved a certain local problem which has significance in a global perspective, can essentially create innovations for the international markets. From the commercializing point of view it means, however, that the country has to be able to identify these pools of skills, to create marketable concepts of them and to find the most suitable channels and partners to export

8. Conclusions

them. There could also be discussion about the hierarchy of problems, in which respect the society in large focuses on solving the most topic challenge each time in question. This hierarchy could be roughly divided into three groups: 1) the health related environmental problems, 2) the consequences that production causes, and 3) the causes that create environmental problem in the first place. In this respect the development varies globally quite a lot; when most of the western societies are able to emphasize the solutions that focus on minimizing the generation of environmental problems (by utilizing approaches such as LCA), there is a large amount of economies which still are to struggle with the critical problems related to human health, the very fundamental starting point of this problem continuum.

The technology does have a crucial role in responding the challenge of sustainability, but its role is not as one-idea as it may have generally being thought. Traditionally, the role of technology has been considered as a provider of “end-of-pipe” -type solutions responding the changes in environmental regulations. Even as today there are some countries where these factors are the most critical environmental issues to solve first, the role of technology is changing. The technology has become as a part of the wider problematic relating to climate change, which its turn has been the main driver for the exponential growth of using the concept sustainability. Today the customers are not only expecting the technology to solve their problems but they are increasingly asking about the environmental performance. This is due to two things: i) Customers see environmental technologies as a source of achieve savings, e.g. less energy used and emissions released have immediate consequences in a form of financial outcomes. ii) Environmental aspects have an increasing image value for the company. Furthermore, corporate responsibility is one thing to consider in this respect as well; companies are a part of the society and its values, which means that sustainable development will come more visible in a relation to the changes in perceptions of decision makers.

In the end, the buyer of a product or service has the final power to influence by deciding what items to purchase. Since a purchase decision is usually a complex combination of many economical, functional, imaginal and social factors etc., there is one simple thing to be emphasized: The environmental solution must be better. It must be better in terms of how customer experiences the overall benefits (called as a customer value in VAF) when comparing it to alternative solutions. These overall benefits may be a combination of expensive but extensive improvements which will be profitable in a longer run, or they

may be a combination of aggressively marketed simple solution providing minor environmental enhancement – or they may be something else. The bottom line is that customer preferences are being surveyed properly, they are being understood correctly, and they are being responded in a way that suits for both customer's needs and provider's own strategy.

Furthermore, the “Society” could be added in the most outer frame in VAF. As it has been noted, the producer of environmental innovations has a double role in creating benefits for both customers and the society as a whole, the society itself should take many synchronous roles in supporting the innovation activities. Firstly, it should continue to support the creation of environmental innovations through existing mechanisms similar to ones that support the creation of any other innovation with increasing global potential. Secondly, it should take actions to support the creation of environmental innovations with the field specific arrangements (through regulations and subsidies etc.). Thirdly, it should support different kind of research attempts to build methods to understand and structure the ties between sustainable development and innovation design; by making them more visible they simultaneously increase the interest of producers to adapt these arising benefits into action as well. And fourthly, it should act as an example by taking the state-of-the-art green technology in its usage.

8.2 Challenges and possibilities of Finland

In certain sectors, the Finnish companies have been able to create world-class niche solutions, but horizontally the environmental sector could not be described as a strong one. Partly this is due to low networking level, especially among SMEs. In this respect, one key issue is the development of platforms for exchanging the information, skills and technologies. This may, for example, take a form as pilot projects gathering both public and private actors together with an aim to create larger concepts for international markets. This kind of projects can also take place outside the country's boundaries; participation in St. Petersburg's water purification plant project, for example, has a huge reference value in an attempt to access the whole Russian markets.

Another thing to consider is Finland's image as high-tech's and clean environment's country, which in together with Finnish companies' reputation as a reliable partner creates advantageous foundation for developing international environmental business. However, so far these factors haven't been utilized in

8. Conclusions

the international sales attempts in an adequate way, wherein all promotional actions such as Cleantech Finland brand intention can be seen highly supportive. In this respect the lack of sales promotion activities in European legislative forums is also noteworthy. Considering the development of BAT and BREF systems, for example, due to the Finnish reputation and expertise, there would be much larger possibilities to influence on the course of development than Finland's size would directly allow. Furthermore, considering the sales actions of SMEs themselves, there probably should be executed some sort of shift from technology stuck thinking towards more holistic business development thinking; technological solution and details have their place and time, but proposing financial statements, regional market growth rates assessments or partner network description etc. may in some circumstances have much more relevance.

There also raises a question of suitable co-operative near-regional partners; how to develop the Baltic, European, Nordic and Russian co-operation simultaneously. Due to existing bonds in terms of politics, business, social structures, cultures and environmental characteristics, each of these collaborations have their natural place, time, significance and potential – and depending on the context, they must all be developed continuously. However, the most important issue to stress is the fact that environmental problems occur across boundaries and so should the solutions and actions too. On the other hand, for a small country such as Finland, the cross-boundary incentives are not only about looking for the growth, but due to restricted size of domestic markets, they are often necessities for the existence of the business in the first place. Furthermore, deeper co-operation between the countries also crystallizes the common aims of them, which in turn may reflect in a form of stronger, common influence on development of European regulations.

Generalizing roughly, Finland does have the required know-how, technologies and resources. Also our image as a clean country is extremely good. Therefore it could be expected that environmental business would be one of the cornerstones of the Finnish competence. As a matter in fact, the whole problematic can be expressed with a short example: the water that drains from faucets in Finland is better in its quality than many bottled waters in shops. In conclusion, Finland must improve in observing what it already has, it must improve in creation of networks and concepts around those factors, and it must improve in marketing and sales actions of these concepts.

8.3 An attempt to build a “fast and easy” way to value the potential

This research was partly creating information to support the potential establishment of ETV system in Europe (see Chapter 1.2). As a part of this task, an attempt was conducted to build a “fast and easy” way to value the new candidates entering the verification process. The filled forms of cleaner production Innovation Fact sheets (IFS; Appendix 2) were approached by using a simple trial quantitative method. First, all question groups (A–H) were roughly divided into two groups: those containing relevant information for assessing the environmental benefits (see Figure 9) and those relevant for assessing the market potential. Next, the scale was defined to all questions. Lower the scale was, lower was the contribution to either environmental benefits or market potential. Lowest scale reached the value of one and highest the value of five. When the specific question was assessed to have potential negative effects, the scale was enabled to reach negative values as well. Next, the parameter of “Co-efficient” was established. It could reach the values from 0,0 to 1,0. Values of co-efficient were determined based on the answers given. For example, if the answer indicated that the innovation could have a great market potential, the co-efficient value of 0,8 or 1,0 was given. If the potentiality was considered very insignificant – or if there was no answer at all – the value of 0 was given. Finally, the “Value” parameter was established as a result of formula: Value = Coefficient * Scale. (Myllyoja 2008)

This trial method was tested in practice by assessing seven CP test cases in it. As a conclusion this method created an environmental index (sum C2, C3, F), market index (sum A, B, C1, D, E, G, H) and a total potentiality score (Environmental index + Market Index). Maximum potential score achieved for environmental index was 146, for market Index 104 and for total score 250. Results for environmental index varied between the scores of 11.0 and 41.6 and between the scores of 13.0 and 48.2 for market index. Lowest total score was 20.0 and the highest 89.8. (Myllyoja 2008)

8. Conclusions

<u>Question group</u>	<u>Question</u>	<u>Scale</u>	<u>Co-efficient</u>	<u>Value</u>
F. EST impacts	Water and raw-material savings	5	0	0
	Energy savings	5	0,4	2
	Reduced use of harmful substances	5	0	0
	Enables recycling/re-use of water, raw material and or energy	5	0	0
	Enables use of renewable materials and or renewable energy	5	0	0
	Reduces emission/pollution	5	0,8	4
	Positive impacts on human health and quality of life	3	0	0
	Improves performance characteristics, cost efficiency, durability of techn. process, product or service	5	0	0
	Creates new employment	5	0	0
	Fosters social equity	3	0	0
	Other environmental and or societal impacts, what?	5	0	0
	Drawbacks from environmental perspective*	5	-0,4	-2
	Drawbacks from economic perspective*	5	0	0
	Drawbacks from societal perspective*	5	0	0

* Scale may include negative values

Positive scale co-efficient can get values from 0.0 to 1.0
 Negative scale co-efficient can get values from -1.0 to 1.0

Figure 9. Sample of a trial quantitative method.

Even though the results revealed quite significant variation between the cases, this method faces two fundamental problems. Firstly, the forms were filled in quite differently especially considering the column “Developers and vendors claims”, meaning, some IFSs included much more extensive information than others (partly because of confidentiality issues and lack of time devoted to the IFSs by the key informants). The information was thus relatively incomplete in most cases. Another problem related to the lack of an expertise in assessing cases from such wide variety of fields and applications. Deep involvement of a variety of experts would be needed to carry out well-grounded and comparable analyses under these circumstances. (Myllyoja 2008)

Despite the problems that the quantitative method faced, the test showed that the quantitative method could be one option to assess the potentiality of new environmental technologies. By simplifying, the development of it would require the development of three key factors. Firstly, more statistical research and development of appropriate indicators is needed to build and test such a system.

Secondly – in order to create comparable data – exact instructions are needed for filling the forms (or alternatively the forms are filled in cooperation between an ETV expert and developers/vendors/appliers). Thirdly, cooperation between field specific experts would be required to value the answers in a comparable way. (Myllyoja 2008)

In the end, in order to develop a “fast and easy” – or as light and easy as possible – way for assessing the market potential and environmental benefits of an EST, IFS *kind* of solutions can be considered as tools for gathering relevant background information. This information must, however, be complemented with other types of information gathering methods and information sources. (Myllyoja 2008)

8.4 Concluding words

The born and success of an innovation can be considered as a result of simultaneous key aspects, which were presented in VAF. The applications of VAF may appear in a form of building consulting tools for the use of organizations developing environmental innovations. As the environmental aspects have rising significance for any innovations and organizations, VAF may offer parallel way to approach innovation actions in some other contexts as well, to say, where company is acknowledging environmental benefits as a competitive advantage and mapping the alternatives to turn potential environmental benefits as a part of its offering. Largely, with some adjustments, VAF might also offer alternative approach when constructing national strategies. Assumingly, this kind of observation would have relevance especially in a prevailing global economy where different nations and regions are increasingly motivated to consider their competencies in a relation to other countries and regions. Approaching national competencies in a lead market context, conceptualizing and commercializing environmental innovations may also result following major positive development paths to occur: 1) Local environmental problems solved may enable similar problems to be solved elsewhere 2) Lead market-Target market -array may turn as a genuine bilateral relationship, where learning and born of innovations are supported in both regions, and where business increases reciprocally – also outside the original environmental business field. 3) Experiences on bilateral partnership may encourage developing new bilateral relationships, which on their behalf, may turn as

8. Conclusions

multilateral networks of solving environmental problems and making diversified international business concurrently.

Explicitly, whether approaching environmental issues from economical, political, national, organizational view etc., it is useful to remind that the elementary particle of environmental change is an individual person. Hence, it feels applicable to close the research by approaching the term Sustainable Consumption. Similarly as its concept of origin – Cleaner Production – but having the focus on individual person instead of organization, it could be defined as following: Sustainable Consumption is a continuous way of thinking and acting in an environmentally friendly manner. It does not necessarily require bargaining about the standard of living, it may even be a way for better one. Through a mental leap where environment is taken into account as one decisive variable among others, the Sustainable Consumption enables realization of sustainable development from thought to action. It gradually emerges in all of our every day actions and offers an increasing personal possibility to carry responsibility of very fundamental source of our and our progeny well being, the environment.

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Appendix 1: Value Assessment Tool (VAT) – key topics conducted from categorization of VAF

STRATEGIC SECTION

Sector reality

- Generic description of the business area
- Description of key actors in the sector
- Description of dynamics in the sector
- Description of technologic know-how of different actors

Regulations

- Prevailing regulations in the field and their role as a contributor for a business
- Anticipated course of regulations
- Differences between the market areas

Company reality

- Company generic description (vision, strategy, employees, financial development...)
- Product portfolio, profits / product groups.
- Organizational capabilities, possibilities and restrictions
- Technological capabilities, possibilities and restrictions
- Company's network

Customer value

- Customer portfolio
- Value created by segments

Local versus global environmental problems

- Local environmental problems that has been solved
- Local environmental problems that could be solved
- Global environmental problems that the company's know-how could be matched

Domestic versus global market possibilities and restrictions

- Domestic competition
- Global competition

- Characteristics of different market areas
- Matching the entering requirements of different market areas to company's possibilities

Innovation process

- Description of born and sources of innovations
- Analyzing methods of the future development

PRODUCT SPECIFIC SECTION

Customer value

- Components of the exceptional value created

Product qualities

- General description of a solution
- Estimated price and profit
- Product qualities versus competitive solutions

Local versus global environmental problems

- Local environmental problem(s) that the solution solves
- Local environmental problems that solution could solve with minor changes
- Global environmental problems that the solution could be matched as is, or by making minor changes

Domestic versus global market possibilities and restrictions

- Customer segments and their requirements in domestic markets
- Customer segments and their requirement in target markets
- Competition environment in domestic market
- Competition environment in target markets
- Growth rate of the business between the countries
- Role of the public sector between the countries
- Barriers to entry the target markets
- Creation of wider product/service concepts to be considered

Innovation process

- Additional physical resources required
- Additional know-how required
- Additional market information required
- Building the co-operative network
- Building the co-operative team
- Customer involvement in the process
- Assuring the horizontal and vertical information flow

Appendix 2: Innovation Fact Sheet. Environmentally Sound Technologies (ESTs) for cleaner production

(ESTs) for cleaner production

A	Data gathering and information sources	Response field	Explanation
1	Project partner(s) responsible for information:		Name(s) and organisation
2	Date(s) of information gathering and updating:		Periods of initial data gathering & important updates
3	Information source(s) used:		Incl. documents, websites and personal contacts

B	EST candidate profile	Response field	Explanation
1	Name of the EST candidate:		Name/type/code with the help of which the specific EST candidate can be identified
2	Brief description of the EST candidate:		Describe the EST solution and application area with a few sentences
3	Developer(s) and their contact information:		Organisations, contact persons and their contact details (address, phone, email)
4	Vendor(s) and their contact information:		Organisations, contact persons and their contact details (address, phone, email)
5	Applier(s)/user(s) and their contact information:		Organisations, contact persons and their contact details (address, phone, email)

C	Contribution area	Yes (X)	No (X)	Description of application/contribution/technology areas	Explanation to the question
1	Industrial application sectors of this EST: - Agriculture and/or fishing				Select yes or no. Indicate all potential application sectors on the basis of your knowledge of the EST candidate. Please also specify the primary application areas and sub-areas in the description field

Appendix 2: Innovation Fact Sheet. Environmentally Sound Technologies (ESTs) for cleaner production

C	Contribution area	Yes (X)	No (X)	Description of application/contribution/technology areas	Explanation to the question
	- Mining and/or quarrying				
	- Manufacturing				
	- Construction				
	- energy/power generation				
	- Other, what?				
2	The EST contributes to cleaner production through: - end-of-pipe solution				Please answer 'yes' or 'no' on the basis of your knowledge of the EST (see also the definitions in the end of the fact sheet). You can further specify the contribution in the description field.
	- eco-efficiency solution				
	- eco-effectiveness solution				
	- subsystem improvement/optimisation				
	- system redesign				
	- better monitoring of the process and/or emissions				
	- some other way, how?				
3	New technology included in this EST: - improvement of traditional production technology				Select yes or no. Please indicate all technology areas that contribute to the innovative solution. On the basis of your knowledge of the EST candidate, you can further specify the technology of the EST in the description field.
	- new biotechnology				
	- new material technology				
	- new sensor technology				
	- new ICT technology				
	- nanotechnology				
	- new type of process control /management system				
	- substitution of materials, chemicals, energy...				
	- other, what? (incl. for instance new technologies for industrial power generation)				

D	Character of innovation	Yes (X)	No (X)	Description of the new/improved characteristics	Explanation to the question
1	The EST consists of a new or better process				Select yes or no. If 'yes', give also a brief description of the type of process, its new feature(s) and application areas.
2	The EST consists of a new or better service				Select yes or no. If 'yes', give also a brief description of the type of service, its new feature(s) and application areas.

Appendix 2: Innovation Fact Sheet. Environmentally Sound Technologies (ESTs) for cleaner production

D	Character of innovation	Yes (X)	No (X)	Description of the new/improved characteristics	Explanation to the question
3	The EST consists of a new or better product				Select yes or no. If 'yes', give also a brief description of the type of product and its new feature(s) and application areas.
4	The EST replaces traditional technology				Select yes or no. If 'yes', give also a brief description of the technology/ies replaced and feasible conditions for this.
5	The EST complements or improves existing/ traditional technology				Select yes or no. If 'yes', give also a brief description of the technology/ies complemented and feasible conditions for this.
6	The EST integrates existing technologies in a new way				Select yes or no. If 'yes', give also a brief description of the technology/ies integrated.

E	Phase of innovation	Yes (X)	No (X)	Description of the present state and future plans	Explanation to the question
1	The EST is already in markets or in use				Select yes or no. Please, include information on market introduction and present state and future plans in view of the diffusion in the markets.
2	A prototype of the EST exists, is piloted/ experimented				Select yes or no. Please, include information on the timing of introducing the proto type as well as present state and future plans in view of the prototype development.
3	First prototype of the EST is under development				Select yes or no. Please, include information on the present state and future plans of the prototype development.
4	The EST or parts of it are patented / brand marked?				Select yes or no. Please, include information on the present state of the patent / brand mark.
5	Potential markets of the EST have been examined/ a market study has been carried out?				Select yes or no. Please, include information on the time horizon and geographical/sectoral coverage of the market study and its main results (incl. estimated breakthroughs etc.).

F	EST impacts	Yes (X)	No (X)	Developers' and vendors' claims	Explanation to the question
1	Water and raw-material savings				Select yes or no. Please, include information on what type of water and material savings are claimed, to what extent and by whom. Clearly specify the range of savings claimed (e.g. water savings are 30–50% compared to technology X according to vendor Y).
2	Energy savings				Select yes or no. Please, include information on what types of energy savings are claimed, to what extent and by whom. Clearly specify the claimed range of savings (e.g. energy savings are 30–50% compared to technology X according to vendor Y).

Appendix 2: Innovation Fact Sheet. Environmentally Sound Technologies (ESTs) for cleaner production

F	EST impacts	Yes (X)	No (X)	Developers' and vendors' claims	Explanation to the question
3	Reduced use of harmful substances				Select yes or no. Please indicate which harmful substances can be avoided, to what extent and according to whom. Clearly specify the claimed range of reduction (e.g. the use of compound X is reduced by 30–50% compared to uses by technology Y acc. to vendor Z).
4	Enables recycling/re-use of water, raw-materials and/or energy				Select yes or no. Please, include information on the type of water/raw-material/energy that can be re-used and their possible re-uses. Clearly specify the claimed range of re-use (e.g. 30–50% of raw-material X can be re-used according to vendor Y; recycling and re-use defined in the end of the fact sheet)
5	Enables use of renewable materials and/or renewable energy				Select yes or no. Please, include information on what renewable energy forms can be used, to what extent and according to whom, incl. the estimated increase in the use of renewable materials and/or energy. (Renewable materials/energy are defined in the end of the fact sheet.)
6	Reduces emissions / pollution				Select yes or no. Please, include information on what type of emissions/pollution, to what extent and according to whom. (Emissions and pollution are defined in the end of the fact sheet.)
7	Positive impacts on human health and quality of life				Select yes or no. Please, include information on what type of impacts, for whom, how significant and according to whom (e.g. reduced exposure to compound X in work place/in neighbourhood/among consumers).
8	Improves performance, characteristics, cost efficiency, durability of the technological process, product or service				Select yes or no. Please, include information on what type of performance characteristic, to what extent and according to whom. (For instance increased detection limits, less interference, changes in monetary and non-monetary costs, extended maintenance intervals etc.)
9	Creates new employment				Select yes or no. Please, include information on what type of employment, to what extent and according to whom.
10	Fosters social equity				Select yes or no. Please, include information on what type of impacts, to what extent and according to whom.
11	Other environmental and/or societal impacts, what kind of?				Select yes or no. Please, include information on what type of impacts, to what extent and according to whom.
12	Drawbacks from environmental perspective				Select yes or no. Please, include information on what type of drawbacks, to what extent and according to whom (i.e. compromises due to the use of this EST).
13	Drawbacks from economic perspective				Select yes or no. Please, include information on what type of drawbacks, to what extent and according to whom (i.e. compromises due to the use of this EST).

Appendix 2: Innovation Fact Sheet. Environmentally Sound Technologies (ESTs) for cleaner production

F	EST impacts	Yes (X)	No (X)	Developers' and vendors' claims	Explanation to the question
14	Drawbacks from societal perspective (incl. health issues)				Select yes or no. Please, include information on what type of drawbacks, to what extent and according to whom (i.e. compromises due to the use of this EST)

G	Factors affecting the diffusion of innovation	Yes (X)	No (X)	Description of the barrier	Explanation to the question
1	High investment costs create barriers to diffusion				Select yes or no. Please, include information on what type of investments, to what extent and according to whom.
2	High operational costs create barriers to diffusion				Select yes or no. Please, include information on what type of operational costs, to what extent and according to whom.
3	Diffusion is constrained by regulatory and policy actions				Select yes or no. If 'Yes', please, include information on what type of regulatory and policy actions, how and to what extent.
4	Diffusion is facilitated by regulatory and policy actions				Select yes or no. If 'Yes', please, include information on what type of regulatory and policy actions, how and to what extent.
5	Diffusion requires new infrastructures				Select yes or no. If 'Yes', please, include information on what type of infrastructure, why and to what extent.
6	Diffusion requires training and new professionals				Select yes or no. Please, include information on what type of training and professionals and to what extent.
7	Deployment requires organizational changes				Select yes or no. Please, include information on what type of changes, why and to what extent.
8	Diffusion requires structural changes in economy				Select yes or no. If 'Yes', please, include information on what type of changes, why and to what extent.
9	Other issues affecting the diffusion of innovation, which?				Identify and describe additional important factors if any. Please add rows if needed.

Appendix 2: Innovation Fact Sheet. Environmentally Sound Technologies (ESTs) for cleaner production

H	Role & importance of verification	Yes (X)	No (x)	Description of the system & its role and impacts	Explanation to the question
1	Earlier verification by an existing verification system				Select yes or no. Please also indicate what characteristics of the specific EST have been verified, by which system and when.
2	Impacts of earlier verification on market entrance and/or diffusion				Select yes or no. If yes, describe even the impacts of verification on market entrance and diffusion.
3	European ETV system would facilitate market entrance and/or diffusion				Select yes or no. Please include also reasons stated by the informants (why, how, with what conditions, according to whom?)
4	European ETV system would slow down market entrance and/or diffusion				Select yes or no. Please include also reasons stated by the informants (why, how, with what conditions, according to whom?)

Further comments: Please feel free to take up any relevant issues in the yellow field on the right	
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Appendix 3: Empirical sources of information: Interviews, seminars, conferences and meetings

Date	Interviewee	Organization	Title	Primary contribution
26.8.2008	Jarmo Muurman	Ministry of the Environment	Senior Adviser	Producing and reporting environmental information, environmental indicators.
27.8.2008	Jukka Noponen	Sitra, the Finnish Innovation Fund	Executive Director, Energy Programme	Commercializing environmental and water technologies.
11.9.2008	Eero Huttunen	Technopolis Oyj / The Centre of Expertise Programme (OSKE)	Program director	Commercializing water technologies.
24.9.2008	Johanna Kilpi-Koski	Lahti Science and Business Park Ltd / Finnish Cleantech Cluster	Project manager	Commercializing environmental technologies.

Appendix 3: Empirical sources of information: Interviews, seminars, conferences and meetings

Date	Seminar	Speaker/ Organization	Title	Primary contribution
11.9.2008	Cleantech Finland -workshop: Support for Finnish SME's to carry out environmental business in China; FECC – Finnish Environmental Cluster for China	Yu Wang / The Centre of Expertise Programme (OSKE)	Project Manager (China)	Exporting challenges of Finnish Environmental SME's.
11.9.2008	Cleantech Finland -workshop: Export promotion in Asia and other parts of the world.	Manu Virtamo / Ministry for Foreign Affairs of Finland	Ambassador	Exporting challenges of Finnish environmental companies.
11.9.2008	Future challenges and views of water technologies	Kari Larjava / VTT Technical Research Centre of Finland	Technology Director	Commercializing water technologies.

Date	Location	Conference subject	Participants	Primary contribution
15.9.2008 – 16.9.2008	Brussels, Belgium.	Boosting Environmental Technologies by Verification. Final meeting.	All European project partners.	Significance of European verification system of environmental technologies. http://www.est-testnet.net

Date	Location	Meeting subject	Participants	Primary contribution
15.9.2008	Brussels, Belgium.	Steering committee meeting 4 of NOWATECH project.	All Nordic project partners.	Commercializing Nordic water technologies. http://www.etvnord.org/



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Author(s) Jouko Myllyoja		
Title Water business is not an island: assessing the market potential of environmental innovations Creating a framework that integrates central variables of internationally successful environmental innovations		
Abstract The main objective of this research is to develop a framework that integrates central variables of environmental innovations in an attempt to create internationally successful concepts. A special attention is being paid to water technologies, but the information will be treated in a way that enables results to cover other environmental sectors as well. The research supports the work of TESTNET (Towards European Sectorial Testing Networks for Environmentally sound Technologies) -project, which is one of the research and demonstration projects that the European Union has launched in the field of Environmental Technology Verification (ETV). The research will find answers for two main questions: 1) What are the central variables creating a basis for internationally successful environmental innovations? 2) Is it possible to develop a "fast and easy" -way to value the environmental and market potentiality of environmental innovations? As a method an approach can be described as a constructive research that produces constructions and tentative solutions for explicit problems. In this qualitative context of the research, theory will be treated both as a starting point and an objective of a research process. Referring to strong theoretical biases that the research adapts, fundamental idea is to strengthen the object theory gradually from different point of views. The following theoretical approaches are being utilized in achieving the research aims: 1) Innovation process 2) Special characteristics of environmental innovations 3) Environmental benefits in a context of new product development 4) Lead market thinking as market entrance procedure of environmental innovations. Answering the first research question, the Value Assessment Framework (VAF) will be presented. VAF is an attempt to integrate all central variables (e.g. environmental problems, market possibilities and restrictions, policies and regulations, company/sector reality) affecting the development of innovations in one frame and to reveal their interconnections (see page 81). As a partial contribution of VAF, the Value Assessment Tool (VAT) will be presented. VAT will be further tested, completed and used in customer cases of VTT – the mandatory organization of this research. The second research question will be answered by presenting the results of attempt to build a "fast and easy" -way to value the market potential and environmental benefits of innovations. This trial quantitative method was created as a part of TESTNET-project related reporting. The empirical data of the research constituted of expert interviews, filled forms of Innovation Fact Sheets, and participations of different seminars and meetings.		
ISBN 978-951-38-7359-2 (soft back ed.) 978-951-38-7360-8 (URL: http://www.vtt.fi/publications/index.jsp)		
Series title and ISSN VTT Publications 1235-0621 (soft back ed.) 1455-0849 (URL: http://www.vtt.fi/publications/index.jsp)		Project number
Date October 2009	Language English, Finnish abstr.	Pages 100 p. + app. 10 p.
Name of project		Commissioned by
Keywords environmental innovation, cleaner production, water technologies, innovation process, new product development, lead market, sustainable development		Publisher VTT Technical Research Centre of Finland P.O. Box 1000, FI-02044 VTT, Finland Phone internat. +358 20 722 4520 Fax +358 20 722 4374

Tekijä(t) Jouko Myllyoja		
Nimeke Ympäristötekniologioiden markkinapotentiaalin arviointi		
Tiivistelmä Työn keskeisin tavoite on muodostaa viitekehys, joka integroi keskeisimmät muuttujat kehitettäessä uusia, kansainvälisesti menestyksekkäitä ympäristöteknologisia innovaatioita. Tutkimuksessa tarkastellaan erityisesti suomalaista vesiteknologia-sektoria. Kaikkea tietoa käsitellään kuitenkin tasolla, joka mahdollistaa tulosten yleistettävyyden eri ympäristöteknologioihin yleensä. Tutkimus tukee osaltaan EU:n TESTNET (Towards European Sectorial Testing Networks for Environmentally sound Technologies) -projektia, jonka tavoitteena oli kartoittaa eurooppalaisten ympäristöteknologioiden verifiointijärjestelmän merkitystä ja mahdollisuuksia. Tutkimus hakee vastausta erityisesti kahteen seuraavaan kysymykseen: 1) Mitkä ovat keskeisimmät muuttujat, jotka tulee huomioida kehitettäessä uusia ympäristöteknologioita kansainvälisille markkinoille ja 2) Onko mahdollista kehittää "nopeaa ja helppoa" tapaa arvioida innovaatioiden kansainvälistä ympäristö- ja markkinapotentiaalia? Tutkimusmenetelmältään työ on konstruktivinen. Teoreettisina viitekehysinä käytetään seuraavia lähestymistapoja: 1) Innovaatioprosessi, 2) Ympäristöinnovaatioiden erityispiirteet 3) Ympäristöhyötyjen merkitys kehitettäessä uusia tuotteita, 4) Lead market -ajattelu kehitettäessä kansainvälisesti menestyksekkäitä ympäristöteknologioita. Tutkimustuloksena esitetään viitekehys, joka pyrkii huomioimaan keskeisimmät ympäristöteknologisen innovaation menestykseen vaikuttavat tekijät. Viitekehuksesta johdettu, käytännön sovellettavuuteen pyrkivä työkalu esitetään liitteessä 2. Viitekehystä ja työkalua on tarkoitus edelleen kehittää tutkimuksen toimeksiantajan (VTT) asiakasprojekteissa. Jälkimmäiseen tutkimuskysymykseen vastataan esittämällä tuloksia markkinapotentiaalin ja ympäristöhyötyjen mittaamiseen kehitetystä kvantitatiivisesta menetelmästä. Tutkimuksen empiirinen aineisto koostuu asiantuntija-haastatteluista sekä TESTNET-projektin yhteydessä toteutetun kyselyn vastauksista. Osallistuminen seminaareihin sekä projektitapaamisiin olivat myös tärkeä osa tiedonjalostamisprosessia.		
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Avainnimeke ja ISSN VTT Publications 1235-0621 (nid.) 1455-0849 (URL: http://www.vtt.fi/publications/index.jsp)		Projektinumero
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Projektin nimi		Toimeksiantaja(t)
Avainsanat environmental innovation, cleaner production, water technologies, innovation process, new product development, lead market, sustainable development		Julkaisija VTT PL 1000, 02044 VTT Puh. 020 722 4520 Faksi 020 722 4374

The purpose of this research was to develop a framework that integrates central sources of environmental innovations in the context of creating internationally successful concepts.

The work is a constructive study, producing constructions and tentative solutions for explicit problems in the field of environmental engineering. It gives answers to the following questions: how internationally successful environmental innovations are created, and how market and environmental potentiality of environmental innovations can be valued. The work presents a Value Assessment Framework and builds a “fast and easy” way to value the potential benefits.

The subject of the research was challenging and Jouko Myllyoja has responded to this challenge excellently and has produced a work of high scientific quality. The work is well organized, and brings new scientific knowledge, with potential of practical applicability.