On the road to systemic sustainability: How can cleantech facilitate the Finnish sustainability transition – a multi-layer perspective backcasting analysis

Jarno P. Laitinen

Jyväskylä University School of Business and Economics
Corporate environmental management

Master's thesis

November 2015

UNIVERSITY OF JYVÄSKYLÄ

- This page is left blank for 2-sided printing -

ABSTRACT

Author
Jarno P. Laitinen
Supervisor
Prof. Hanna-Leena Pesonen

Title
On the road to systemic sustainability: How can cleantech facilitate the Finnish sustainability transition – a multi-layer perspective backcasting analysis

Subject	**Type of work**
Corporate Environmental Management	Master's thesis
Time	**Number of pages**
November 2015	146

Abstract
Sustainable development has been a dominant theme in international debate since inception. During the last decades it has gained momentum due to pressing challenges in the domains of agriculture, energy, transportation, raw materials, water and ecosystems. Finland ranks highly on many sustainable development benchmarks, but the success is imbalanced. For constructing long-term redundant sustainability and well-being, Finland needs a transition affecting policy, people and businesses.

This study has an intertwined theoretical and applied objective, following a pragmatist approach. The theoretical objective is to develop a conceptual framework for analysing future oriented sustainability transition processes. The conceptual framework constructs sustainability as a property of complex systems and describes ontology of sustainable development through human-nature and socio-technical systems. Change is seen as a socio-technical transition process, and described through multi-layer perspective framework. The applied objective is to use normative fore- and backcasting scenario analysis within the framework for describing the present state of sustainable development within Finland and for envisaging a roadmap for the needed sustainability transition process from perspective of cleantech industry as a key facilitator.

The study validates both the conceptual framework and analytical methods for describing and analysing future oriented sustainability transitions. The analysis results in a description of a transition space and a roadmap for cleantech to facilitate the Finnish sustainability transition. As conclusions and summary of the analysis the study presents ten strategic 'clean-steps' to transition.

Keywords
sustainable development, sustainability transition, complex systems, multi-layer perspective, eco-innovation, cleantech, backcasting

Location
Jyväskylä University School of Business and Economics

- This page is left blank for 2-sided printing -

The difficulty lies, not in the new ideas, but in escaping from the old ones, which ramify, for those brought up as most of us have been, into every corner of our minds.

John Maynard Keynes (1936)

Dedicated to Lotta, Eelis and Lilian

- This page is left blank for 2-sided printing -

CONTENTS

- This page is left blank for 2-sided printing -

1 INTRODUCTION

1.1 Background

Historical development during the last two centuries has been predominantly towards a capitalistic, globalized, material and energy intensive regime - a progress we commonly call *modernization*. This development has arguably been one of the most amazing cultural and economic developments of humankind, having nurtured political liberty, value for science, industrial revolution and raised well-being globally thus reducing poverty and mortality. The flip-side of this development has been the objectification and commoditization of our natural world into a resource base, which has been ruthlessly and insatiably consumed for expansive and individualistic reasons (Mathews, 2011). This new human influenced epoch has already reached such magnitudes that it has deserved a geological nomenclature of its own, *Anthropocene*. According to many governmental and non-governmental reviews we have exceeded the sustainable level of living and as the human development in vast parts of the world will continue to increase it expected that by 2030 we will need two planets to sustain the development (EU, 2015; WWF, 2012; Rockström et al. 2009). There is an increasing support among policy-makers and researchers for the notion raised under the banner of *ecological modernization*, that clean technology and eco-innovation are key to create a win-win situation for maintaining and improving economic competitiveness, while securing and advancing ecological sustainability (Coenen & Lopez, 2010).

The complexity of ecological problems and their relation to our social structures, i.e. greenhouse gas emissions caused by traffic, have raised the question of how to facilitate a societal and industrial transformation towards more sustainable production and consumption (e.g. Geels, 2002, 2004; Coenen & Lopez, 2010; Fuenchillinger & Troffer, 2012). Under pressure for transition are especially sectors with pressing sustainability challenges in the domains of agriculture, energy, transportation, raw materials, water and ecosystems (EU, 2015). These domains are confronted with problems of resource scarcity and depletion, supply and access risks, climate change and air pollution, and increasing unpredictable extreme events. While most of these challenges are related to ecological and social problems, economic problems are likewise pressing. Existing infrastructure systems in many parts of the world are confronted with huge financial needs in terms of structural renewal and expansion. (Fuenshilling & Troffer, 2014; Markard et al. 2012).

The question what *sustainability* and *sustainable development* actually mean have been under debate since the 1970's and today a plurality of definitions exist (Wu, 2013). Through these debates the concepts have been mainstreamed and are today accepted as an ethical paradigm, as democracy or human-rights, constituting of a set of shared values and an approach for framing real-life problems (Hirvilammi, 2015). Though as with the definitions of democracy or human rights, the spatial-temporal variation requires that consensus of the terminology is the foundation for debate and actions. Some signs of consolidation are gathering behind the emergent discourse on *decent life* (well-being). Though the global affinity has grown 30-fold during the last century, majority of people feel less liberated. Economic wealth has not brought the quality of life that was expected. This has led people in the global north to (again) question whether social value can replace perceived material value. The accumulation of the "triple debt" is also reaching its social limits.

In the past decade, research on sustainability oriented innovation and technology studies has expanded rapidly to increase our understanding of the ways in which new technologies and social practices enable societies to become more sustainable. In particular, a new field dealing with *sustainability transitions* has gained ground and reached an output of 60–100 academic papers per year (Markard et al., 2012). Prominent contributions to the analysis of transitions has been made by the 'Dutch school of transition studies' with its focus on *socio-technical systems* and *multi-layer perspective* (Geels, 2002&2004; Jorgensen, 2012), which have been applied also in Finland to studying potential transitions in various sectors, e.g. transport, renewables and energy efficiency (Temmes et al., 2014; Wessberg et al. 2014). A key element of this *sustainability science* is understanding our world as *complex systems*. The complexity of human-nature interactions and the activities within modern societies poses a great difficulty in predicting what is sustainable in the long run. This *fundamental uncertainty* makes sustainable development a moving target (Sartorius, 2006).

It is widely accepted that a transition to a low carbon and resource wise economy, by *green economy, circular economy, green growth, de-growth* and/or *natural capitalism* is needed in the near future (e.g. Boons & Lüdeke-Fround, 2013; Coenen & Lopez, 2010; Geels, 2012; OECD, Mathews, 2011, 2009; UNEP, 2011). These new narrative promise to solve both ecological and economic problems, and frame increased ecological resilience and social change beneficial for business and thus for the economy and society at large (Geels, 2015). This introduces a new paradigm where sustainability is seen as an economic value added, rather than as an externality to be included in the production costs (Geels, 2015; Dolfsma & Seo, 2013; Sartorius, 2006). Fundamentally this paradigm change represents a shift away from the current neoclassical discourse which governs our global economy. The transition will require various gradual and radical changes, affecting social and regulatory institutions, sectoral composition, industrial networks, user practices and consumption (Gazheli, 2015; Geels, 2002, 2004; Markard & Truffer, 2008; Smith et al. 2010).

On the policy level Agenda 21 of the landmark United Nations 1992 Rio 'Earth Summit' calls on countries to adopt national strategies for sustainable development that should build upon and harmonize the various sectoral economic, social and environmental policies and plans that are operating in the country. Finland has been working to enhance the role of sustainable development in mainstream politics since the late 1980's, leading to the foundation of The Finnish National Commission on Sustainable Development in 1993 and to the first National Sustainable Development Strategy in 2006. The vision of the first strategy was to "*assure well-being within the limits of the carrying capacity of nature nationally and globally*". This strategy was revised in 2013 with a new vision of "*a prosperous Finland within the limits of the carrying capacity of nature.*" The new strategy moved beyond the government centric thinking to acknowledge that sustainable development is a joint vision of the future and for it to realize called for societal commitments from businesses, organizations and citizens. (PMO, 2006; FNCSD, 2013)

In economy, new *innovations* and *businesses* under the herald of '*cleantech*' have been amongst the key contributors to sustainability by developing and promoting new market solutions for eco-efficiency, -effectiveness and sustainability in various industries. In Finland these cleantech companies represent a significant part of the market, as the combined turnover of the Finnish cleantech companies in 2012 was 6,2% of the combined turnover of all Finnish companies, thought they amount only to 0,2% of the companies population (€24,8Bn/€394,9Bn; 768/322.184;) (CTF, 2015b; Tilastokeskus, 2015b; ETLA, 2015; Kotiranta et al., 2015). The Finnish government outlined in 2014 (TEM, 2014) as a country strategy to develop Finland a global cleantech superpower by 2020. The specific targets of the program are to double the cleantech sector turnover to €50Bn where 75% would be generated from export, while at the same time doubling the domestic market size to €20Bn. Also the amount of cleantech companies is targeted to increase from 2000 to 3000 and generate 40 000 new jobs within the sector. It goes without saying that the goals set for the next five years (2015-2020) are ambitious.

According to most metrics, Finland is amongst the most sustainable, innovative, competitive, business friendly, best in education, socially equal, corruption free, etc., and as all of us Finns would say, the best country to live in. One of the key questions is that do we want to be the best place to live also in the future and what, to us, being best means? In this thesis I acclaim that to fulfill this challenge we need to transition towards sustainability, a decent life, within a shared vision. This vision will only be realized through people - people who form the policy and science institutions and businesses. Though the vision must be a shared one, key champions will rise on this journey. To be sustainability champions globally and prosperous locally, especially cleantech businesses need to champion the race. As Neil Armstrong noted when he achieved what the whole nation with its politicians, scientists and industries had jointly fought for: "*that's one small step for man, one giant leap for mankind*". It needs to be understood, that facilitating a sustainable future has an even greater potential - *it would be the giant leap for mankind.*

1.2 Problem formulation and objective

Sustainability and sustainable development have permeated the modern debate on arenas of politics, business and peoples' lifestyles. The terms are used broadly and everyone agrees, though not on the content of the terms, that sustainable development is necessary for a future where well-being can sustain. In the past sustainable development was seen mainly as ecological conservation, poverty eradication or corporate sustainability, something that involved 'others'. Today, sustainable development is understood to also involve 'us'. It has become painstakingly clear that we cannot only be temporally sustainable, as the atrocities of war, inequality, poverty and injustice spread along the refugees filling our borders. Changes in magnitudes as required by sustainable development do not happen within a generation, such changes take lifetimes. The problem in this case is that time is not our friend.

This thesis has both a theoretical and an applied objective. The theoretical objective is to formulate a framework and terminology that can be applied to discussing sustainability and sustainable development related change processes. The applied objective is to use this framework and embedded theories for visualizing a transition process towards a sustainable future for Finland in a specific industry driven context. In this sense the research also aims to serve as an exploratory experiment to help determine most suitable frameworks, data collection methods and analytical methods for potential similar future works.

As specific objectives for this study, the following research questions are set. The research questions are set to both test the reliability and validity of the framework, methodologies and selected data. They also function as limiters for the scope of analysis and provide a certain perspective (point of view) for the context of analysis.

> **Q1.** *Can the selected theoretical framework and methodology be integrated in a coherent way to describe a change process?*
>
> **Q2.** *How is the Finnish national sustainable development policy 'The Finland we want by 2050' aligned with the emerging discourse of systemic sustainability and decent life paradigm?*
>
> **Q3**. *What can the (Finnish) cleantech industry do to facilitate the sustainability transition sustainable future - decent life for all (Finns)?*

1.3 Structure of the thesis

This thesis is structured in four different chapters, namely *framework*, *methodology*, and *analysis* and *discussions*. The first chapter describes the theoretical framework constructing the worldview and the research orientation. The second chapter defines the research methodology and the third chapter consists of the analysis. The last chapter includes the discussion and responses to the research questions.

The first chapter includes a broad discussion on sustainability – its background and present state. The reason for an overview on sustainability and sustainable development is to link it into the broader discussion and vision generation in the applied part of the research. The chapter also sets a background for the economic- , cleantech- and innovation -concepts, and acknowledges the importance of finance and policy in developing new technologies and businesses. The key theories presented in the chapter include complex systems theory and multi-layer perspective integral to sustainability science and transition research.

Methodology chapter consist of two themes, the research- and analytical methods. The former discusses and reasons the fundaments for the research paradigm and methodology, as well as the reliability and validity of them. It also presents the sources of data and their use. The latter presents the analytical methods, discusses their use and defines the specific methods applied in this thesis.

Analysis and discussion chapters are somewhat intertwined. The analysis consist of the scenario analysis. The aim of this chapter is to be descriptive and to act as an independent narrative. It withholds the baseline, vision and the backcasting analysis. The baseline presents data relevant to cleantech and the Finnish state and economy. The vision is aggregated on top of the existing national strategies from 2006 and 2013, with general considerations from the theoretical framework. The backcasting analysis is reported in a chart and discussed in the end of the chapter. The final chapter, discussions, includes responses to the original research questions and discusses potential items for future research.

2 THEORETICAL FRAMEWORK

This chapter first introduces, as an overview, the key concepts, terms and approach applied in this thesis. Following this brief introduction a more in-depth literature survey is presented to describe the key theories, the main topics, and the rationale for the approach on the theoretical framework. Finally the theoretical framework will be structured, conceptualized and defined.

The key definitions and approach that will be introduced include *sustainable development* and how it currently integrates to the larger prevailing *neoclassical economic synthesis.* The thesis argues that sustainability should be considered, instead of resource management view (*inter alia*), as a property of a *socio-technical systems* in the emerging *entrepreneurial economy.* For transitions of socio-technical systems towards sustainability (i.e. *sustainability transitions*) to actualize, the *systems'* total return needs to be positive. These transitions are generated and affected by various regime *actors.* In this thesis the key *network actors* are *eco-innovative SME's*, operating in the *cleantech* and other *smart-tech* sectors, facilitated by *venture capital* and governed by *public policy* and *institutions.*

2.1 Sustainable development as paradigm for decent life

Sustainability is a paradigm that has its roots in environmental movement and social equity. The fundaments, as the grand public perceives, have been to protect our common environment and care of social justice at local and global levels. It is in many ways a term that only a few comprehend similarly, though most have heard and used it. The first part of the theoretical framework is therefore dedicated to the ambiguous term *sustainability* and *sustainable development*, and to the history, purpose, theory and the modern scientific framework of sustainability science. The purpose of this chapter is to illustrate that sustainable development is not only a descendent of the environmental movement or a corporate catchword, but that it provides a *paradigm for decent life*.

2.1.1 Aspiration for sustainability

Sustainability is an age-old human aspiration and societal concept. It is today used so widely, that over a hundred definitions exists (Wu, 2013). Though much debated, it is today generally accepted as an ethical paradigm, as democracy or human-rights, constituting of a set of shared values and an approach for framing real-life problems (Hirvilammi, 2015). The socio-ethical roots of the concept lay in antique writings of good life and the techno-economic foundation in the debates concerning scarcities of water and land resources in pre-industrial[1] European nations (Hirvilammi, 2015; Spangenberg, 2008). Background for today's understanding of sustainability and sustainable development as a relationship between economic development, environmental degradation and social equality was brought to mainstream discussion only as late as 1960's and 70's by Rachel Carson's 'Silent Spring' (1962) and Club of Rome's 'Limits to Growth' (1972). Since then the growing concerns on deterioration of ecological conditions, population growth, increasing resource consumption and depletion of crucial resources have led to sustainability agenda gaining rapidly popularity. The concept and paradigm has in time evolved through series of international conferences and initiatives, culminating in the landmark United Nations 1992 Rio 'Earth Summit'. This conference laid the foundations for the political empowerment and global institutionalization of sustainable development (UN, 2010).

By its most common and well known definition sustainable development is, as depicted by the Bruntland Commission report 'Our Common Future' (WCED, 1987) "**development that meets the needs of the present without compromising the ability of future generations to meet their own needs.** It contains within it two key concepts: i) the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and ii) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs". The report also formulates that "sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development; and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations". The basic argument of the Bruntland Commission definition of sustainable development is one of welfare in the context of current and inter-generational equity (Kuhlman & Farrington, 2010), i.e. how to reconcile environment and development – needs vs. resources. Frequently also only the first part (**bold**) of the definition is quoted without emphasizing the world's poor; the social and environmental systems ability to sustain future needs; nor the need to orientate techno-economic development to maintain harmony in the need-resource axis. By quoting only the first part and being general in scope and vague in detail,

---

[1] Pre-industrial era refers to the period between 1600 - 1800 AD

more space has remained for various interpretations on sustainability (Lorek & Spangenber, 2014). This variety of interpretations has actually helped the definition to be adopted by a number of fields for various purposes, as it allows for various, and sometimes incompatible, interpretations (Wu, 2013).

Inspired by the Brundtland Report, John Elkington[2] popularized in 1994 the term *Triple Bottom Line* (or *People, Planet, Profit*) to emphasize that economic activities have important social and environmental consequences for which corporations must assume responsibility (Wu, 2013). This conceptualization has been integrated to the prevailing *Corporate Social Responsibility (CSR)* paradigm, which aims to embrace responsibility for corporate actions and to encourage a positive impact on the environment and stakeholders including consumers, employees, investors, communities, and others. This is done by advancing economic and social sustainability, material and resource sustainability, and environmental sustainability in compliance with the spirit of the law, ethical standards and international norms. (Holliday et al. 2002; Seuring, 2008). One of the hallmarks of corporate application of sustainability has been the development and publication *Social Responsibility* (SR) standard in 2010 by the International Standardization Organization (ISO) named *ISO 26000*.

Depending on the paradigm, sustainability has been commonly viewed either from anthropocentric[3] or eco-centric perspectives, leading to respective concepts of *weak* and *strong* sustainability (Hirvilammi, 2015). The prevailing *neoclassical economics* [4] have led traditional economists favoring the anthropocentric perspective to argue based on the Solow model[5] that a society using an exhaustible stock of resources could enjoy a constant stream of consumption over time if it invested all the rents from tapping on those resources (i.e. held the capital constant). This type of growth oriented sustainability is referred to as weak sustainability because it is based on the assumption of complete substitutability of man-made and natural capitals and does not acknowledge the ecological limits of the economy, nor address the primary social challenge of providing equally for needs of all. Strong sustainability on contrary is based on the eco centric perspective and is widely accepted by the environmental economists. It requires that substitutability has to be proven in each case rather than being simply assumed. It also

---

2 Chair from the Brittish business consultancy SustainAbility founded in 1987

3 Anthropocentrism is the belief that human beings are the central and most significant species on the planet. This worldview reduces nature to a resource and commodity base to be exploited for human development.

4 Neoclassical economics is a set of approaches to economics, developed in the 20th century. It rests on three key principles: 1) people are rational actors that 2) act independently on the basis of full and relevant information and that 3) individuals and firms goal is to maximize utility and profits. It has many fundamental differences to the Classical economics, e.g. in its' perception to the use and taxation of natural resources. Neoclassical economics dominates mainstream economics today and is the fundament of what we know as 'capitalism'.

5 The Solow-Model is a model of long-term economic growth set within the framework of neoclassical economics. It attempts to explain long-run economic growth by looking at capital accumulation, labor or population growth, and increases in productivity, commonly referred to as technological progress. It provides the basis for the hypotheses of 'infinite growth'

acknowledges the ecological limits of the economy and the necessity of ecological protection and reinforcement of social resilience and cohesion. (Sartorius, 2006; Lorek & Spangenberg, 2014).

Strong and weak sustainability are not necessarily exclusive and the distinction needs to be done on case-by-case level. Resources which cannot be substituted by capital (e.g. biodiversity) must mainly fall under the requirement of strong sustainability, while others which can be replaced with more sustainable options (now, or in the near future) could fall under the weak variety. A typical neoclassical approach has been to resolve such reversibility by determining shadow prices for those uses of nature, which cannot be effectively substituted. The depletion of fossil fuels, for instance, could be considered as an issue of weak sustainability with imposed ecological taxation, provided that related environmental and social concerns are observed and other sources of energy are developed in parallel (Kuhlman & Farrington, 2010). Thought this approach is tempting, it has often proved ineffective due to the difference in time horizons between human and nature processes and basic ignorance of the cause-effect relationships in nature (Sartorius, 2006). The question is anyhow not black and white, as well illustrated by Daly[6] (1995) noting that with "strong sustainability … no species could ever go extinct, nor any nonrenewable resource should ever be taken from the ground, no matter how many people are starving … absurdly strong sustainability is in fact absurd" (Wu, 2013).

To illustrate the differences and development of sustainable development and the concepts FIGURE 1 represents typical three pillars of sustainability or triple bottom line approach (A) and the weak (B) and strong (C) sustainability. The three situations in B are equally sustainable, because weak sustainability allows for the substitutability as long as the total capital remains does not decrease (Wu, 2013).

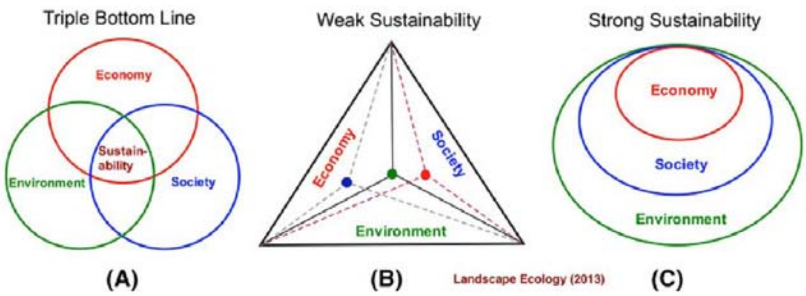


FIGURE 1. Illustration of different approaches to sustainability (Wu, 2013)

The debates on the intrinsic meaning of sustainable development on global scale have slowly externalized from original marginal position and reached the present scale and understanding. Though the diffusion and general acceptance of the concept has been rapid (30 - 60 years), the simultaneous underlying real-life developments have been more substantial and influential.

6 Herman Edward Daly (born 1938) is an American ecological economist that has been considered one of the pioneers in the field

The growing human influence on atmosphere, geology, hydrology, biosphere and other earth system processes have already led to a new human influenced geologic time period entitled Anthropocene[7] (Ambio, 2011; EoE, 2013), reflected by steep decrease in many ecosystem services[8] as climate, nutrient and water cycles, food and raw material production and reflecting also to cultural, spiritual and recreational values (MA, 2005). These pressing developments require coercive developments on our social and economic systems to limit unintended effects to earth systems. The inconvenient questions are: do we understand sustainability correctly, do we measure it correctly, are we ready to act upon it, and fundamentally do we really care about it?

2.1.2 Measuring development

Sustainable development is often described as three pillars: ecological, social and economic, and since the Earth Summit much has been also discussed of including culture as the fourth. Most national and international problem solving efforts focus on only one pillar at a time. For example, the United Nations Environmental Programme (UNEP) focus on the environmental pillar, the World Trade Organization (WTO) and the Organization for Economic Cooperation and Development (OECD) focus mostly on economic growth and the United Nations attempts to strengthen all three pillars, but focuses mostly on the economic pillar since economic growth is what most of its members want most. While this kind of thematic breakdown into pillars offers a good structure for developing more in depth understanding and potential indicators for each theme (e.g. for planetary ecological thresholds[9]) it simultaneously dissipates the interdependence and hierarchy of the dimensions (Sartorius, 2006). This is a perilous path, because hierarchy of the dimensions is from ecological to social to economic i.e. economy is a social construct of humans that are part of the global ecology – hence ecology does not need economy as is vice versa. There are a number of frameworks and indices for measuring sustainability at company, industry, region, policy, society or life quality levels (for excellent review, see Singh et al., 2009). This versatility serves its purpose in allowing industries, countries and other to benchmark themselves, and thereby stimulating decision-makers to try to improve the position in the rankings (Dahl, 2012). This versatility should anyhow not dim the holistic framing where

---

7 Anthropocene is a new term, proposed in 2000 by Nobel Prize winning scientist Paul Crutzen. It represents the geological epoch when human activities have had a significant global impact on the global ecosystem. As of April 2015, the term has been adopted formally as part of the official nomenclature of the geological field of study.

8 Though the role of ecosystems as a key factor sustaining life on Earth has been discussed since the beginnings of the environmental movement in 1950's, the concept of Ecosystem Services was popularized and defined by the Millenium Ecosystem Assesment (2005) as "the benefits people obtain from ecosystems."

9 Widely applied representation of ecological sustainability in the planetary context is "Planetary Boundaries" by Rockström et al. (2009 and 2015). The framework identifies nine global priority processes and systems that regulate the stability and resilience of the Earth System processes and relate to human-induced changes to the environment.

ecological-, social- (cultural-) and economic sustainability are parts of the same system, and where the whole is more than the sum of parts (Hirvilammi, 2015).

Interdependence and hierarchy of ecological impacts and economical- and technological development is often illustrated by the I=P×A×T equation. The model disaggregates ecological impact [I] into three components, population [P], affluence [A], and technology [T]. The equation describes that as long as population and wealth continue to grow and the technology used in production consumes resources or causes emissions, the ecological impacts will continue to grow (Hirvilammi, 2015; Lorek & Spangenberg, 2014). Kolbert (Ambio, 2011) illustrates the development of the global ecological impacts during the last decade within the IPAT equation by comparing the global population, GDP and patented technology (FIGURE 2) from 1900's to present. He calculates that increase of the ecological impact [I] factor from 1900 to 1950 was 10-fold whereas from 1950 to 2000 it was already 1450-fold. Especially the growth of affluence [A] and technology [T] in the latter half of the century have been manifold, and with the expected (and targeted) growth trends in population, affluence and technology, the ecological impact can only be expected to grow accordingly. To illustrate the difficulty of managing future ecological impacts only through technological efficiency Lorek and Spannenberg (2014) present the following calculation: If by 2050 the global population grows to the expected 9 billion, the global economy still grows 2 %/year and the global general income by 2050 reaches the level of EU, a 130 fold improvement of technological efficiency is needed to decarbonize our global environment to meet the IPCC's +2 degree Celsius thresholds in relation to mitigating most dramatic ecological impacts of climate change.

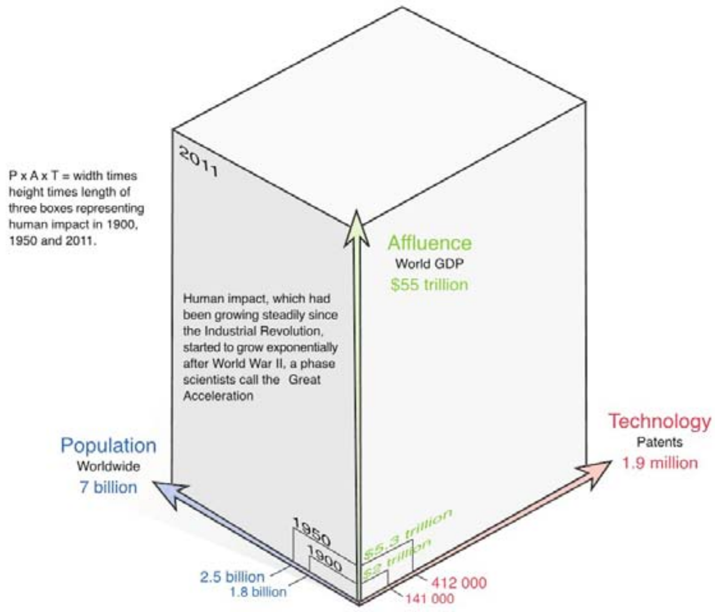


FIGURE 2. I=PAT identity at the global scale from 1900 to present (Ambio, 2013)

The world GDP per Population (A/P) has grown from 1000 USD/person in 1900's to 2000 USD/person in 1950's and 8000 USD/person in 2011. This growth is largely due to the transition to Fiat monetary system and the creation of the global banking system[10]. The distribution of this economic well-being has been highly unequal, whereas 10% of the global population control 90 % of the global wealth and 70 % of this wealth is located in Europe and America, 20 % in Asia-Pacific and only 10 %in China, Africa and Latin-America combined, which three latter constitute for 75 % of world population (CreditSuisse, 2014). Globally over 1500 million people are multi-dimensionally poor and if only economic factors were evaluated, over 2700 million people living with less than $ 2,5 a day could be considered poor (UNDP, 2014). On the apex of the global wealth pyramid, we have over 35 million USD-millionaires (CreditSuisse, 2014) and out of this group Oxfam (2013) calculated that the top 100 individuals globally added $ 240 000 million to their wealth in 2012, which would be sufficient to end the world poverty four times over. Like Gandhi said "the world has enough for everyone's need, but not enough for everyone's greed".

The material implications of this disproportionate distribution of population and affinity are clearly visible. Today's level of economic well-being is generated by using the equivalent of 1.5 planets to support human activities (WWF, 2012). In the EU states including Finland, total material consumption[11] (TMC) as cradle-to-cradle consumption per inhabitant and the ecological footprint[12] based on biocapacity are 40 - 50 tonnes/person/year and 4 - 8 global hectares/person/year respectively when the sustainable level of natural resource use taking into account an equal global distribution of natural resources and ensuring healthy ecosystems for future generations would amount to a maximum TMC of 8 tonnes/person/year and 1,8 global hectares/person/year respectively. FIGURE 3 illustrates the TMC reductions we need to achieve within the next generations in different categories of life to achieve the level of equal use and distribution off resources. This is not an easy task and it will require radical changes the way we live. In Finland, even the single households living in poverty [13] have TMC between 15 – 20 tonnes/person/year. When even our (*ibis*) 'poor' have a material living standard over double the equal global distribution, what is the working- and middle-class willing to give up? (Mont, 2014; Hirvimäki, 2015.)

---

[10] FIAT money is currency which derives its value from government regulation or law. It is the common form of money which is no more linked to any actual commodity, i.e. it's value is determined on free float markets. The banking system, connected with government, has the power to create money i.e. the question what is real wealth is ambiquous.

[11] Total material consumption is in this context calculated by the MIPS method (Material Input per Service Unit) which measures a products or services total material consumption during its lifecycle.

[12] Ecological footprint represents the amount of biologically productive land and sea area necessary to supply the resources a human population consumes, and to assimilate associated waste.

[13] Single family household, located in Southern Finland, age 25 - 65, unemployed, main source of income either unemployment support or national pension, and if granted, housing support. For more details see Hirvilammi (2015)

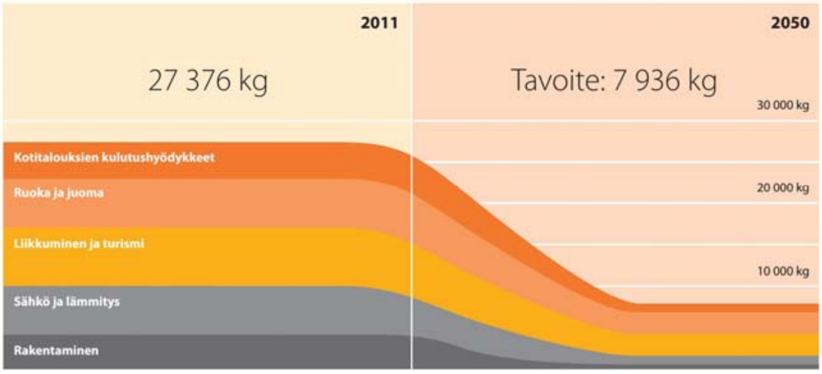


FIGURE 3. Average 2011 TMC for a European inhabitant and the level of changes needed for a global equal distribution (SITRA, 2013)

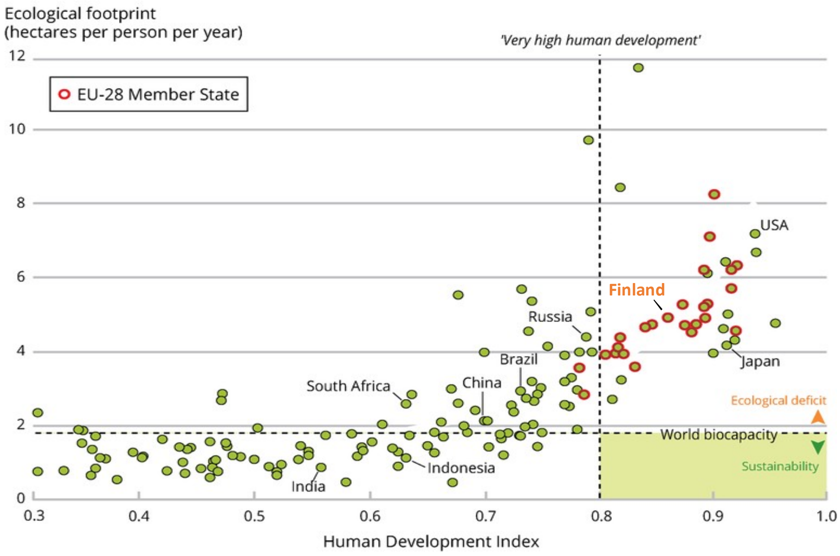
The questions imposed on sustainability in relation to economic equity and consumption are not only poverty or ethics. Accumulation of wealth is also socially divisive and politically corrosive as can be seen worldwide. Studies have also shown that wealth has a positive relation with individual's social class, education, quality of life and even health. In many countries participation to national politics also requires wealth, allowing for the few to have more say than the many. The culture of consumption has long term effects also to a significant number of current day global working- and lower-middle class[14] individuals. When more people progress from the bottom of the pyramid in regions as Asia and Africa, the center of gravity in the distribution of work and wealth will move away from Europe and America. Because most of the wealth in the working- and middle class is directed for consumption on basic needs, also the total global consumption will grow accordingly and lead to increased costs for basic goods everywhere.

Real progress on human development is not only a matter of economic- or environmental equity, but also enlarging people's critical choices and their ability to be educated, be healthy, have a reasonable standard of living, feel safe and be able to express themselves (UNDP, 2014). This understanding of well-being as key element of sustainable development has led to development of different indicators. Most known are the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI), Human Development Index (HDI) and Better Life Index (BLI) (Myötänen, 2015; OECD, 2013). One of the most widely applied, the UNDPs Human Development Index (HDI) measures the material condition and quality of life, constituting of (1) gross national income per capita, (2) life expectancy at birth, and (3) mean and (4) expected years of schooling. The HDI does not quantify or measure the sustainability of socio-economic or ecological systems, thought in its latest publications UNDP (2014) acknowledges that a key element of development is how secure achievements are and whether achieved conditions are sufficient for sustained human development (i.e. *vulnerability* and *resilience*). The UNDPs HDI metrics are

14 The terms relating to social class are used ambiguously in this context and do not refer to any established system of classifications. The classification consists of four classes: lower-, working-, middle-, and upper class.

fundamentally economic and social (i.e. education) development oriented, thought sustainability in the modern perspective requires taking into primary account also the ecological aspects. Finland has increased its HDI value for decades[15], but simultaneously decreased its overall position in the global ranking from 13th to 24th. This decrease in ranking is due to increases in life expectancy and GDP in many countries and Finland being left behind in mean and expected years of education in comparison to other top countries.

To depict the interrelation between economic- and social development (measured by HDI) and ecological impact (measured by ecological footprint) the correlation of the two indicators is often compared (FIGURE 4). In this comparison sustainable nations are perceived to be in the range of high or very high human development (HDI 0,7 and 0,8 respectively by UNDP classification) while having an ecological footprint below the estimated global sustainable bio-capacity of 1,8 global hectares/person/year. This comparison shows that a country which has achieved a high level of human development, has simultaneously increased its ecological footprint far above the global ecological bio-capacity. Such development leads to ecological deficit, and in the long term to sustained ecological debt. The 2012 UN Conference on Sustainable Development has called for better ways to monitor sustainability and address the connections between present and future sets of choices. In the Human Development Report 2013 UNDP outlined that "measures [to monitor sustainable development] should monitor the accumulation of economic and environmental debt based on the premise that every citizen on the planet, whether alive or not yet born, has an equal right to live a comfortable, fulfilling life. These measures should also highlight planetary boundaries or tipping points, recognizing that climate change, for example, already imposes substantial costs, with the brunt of them borne by poor countries and poor communities."



15 http://countryeconomy.com/hdi/finland [cited 30.6.2015]

FIGURE 4. Correlation of ecological footprint (2008) and the human development index (2012) (EU, 2015)

In the sense of global environmental and economic equity everyone should be allowed to live within our planets carrying capacity. Not everyone needs to live in the same way, but on average everyone must live within our system boundaries in order for a sustainable future to materialize (Mont, 2014). As a planetary population we have developed with such haste and not considered the direction of progress. This has caused our ethical paradigms and societal structures to be formulated around the anthropocentric, neoclassical, weak sustainability. Until today this *tragedy of commons*[16] has been managed by the high inequality in distribution of wellbeing, but when the bottom of the pyramid grows in wealth, reductions in the top will also become necessary for the whole to maintain within averages. Considering sustainable development, the only way to justify the current lifestyles exceeding our planetary carrying capacity and generating ecological, social and economic inequality is to focus aims more on developing a sustainable future for all.

2.1.3 Paradigm for decent life

Whereas economic and ecological sustainability can be calculated and measured, social sustainability is more ambiguous (Hirvilammi, 2015). This has undoubtedly directed the scientific community to traditionally focus more on the economic and ecological aspects of sustainability. Social sustainability provides a less discussed element for decoupling and managing the environmental impacts in connection to economic growth. Aristoteles has in the Nikomakhos ethics defined that moderation of wants is one of the human virtues (Hirvilammi, 2015), but today our perception of moderation is in many ways disproportionate to global sustainability. To achieve social sustainability and well-being our perception should not only reflect our connection to people and society surrounding us, but also to physical nature, global equity and the intrinsic attached values (MA, 2005; Hirvilammi, 2015).

The expansive discussion underneath moderation is related to what is decent life and whether social value can replace perceived material value. The ongoing research on human happiness has clearly indicated that the subjective well-being does not linearly correlate to the level of consumption, and that on contrary the adaptation of a more sustainable lifestyle and decreasing consumption can increase well-being (Hirvilammi, 2015; Epley, 2015). In high income countries non-material factors like safety, belongingness, social coherence, equity, and social relations, are of equal importance (compared to

16 The tragedy of the commons is a term, originally used by Garrett Hardin, to denote a situation where individuals acting independently and rationally according to each's self-interest behave contrary to the best interests of the whole group by depleting some common resource. Environmental movement has applied this term widely in relation to e.g. ozone depletion and climate change.

economic) for the wellbeing of humans and even more important than income after a certain minimum level of has been reached (Lorek & Spangenberg, 2014).

Research and discussion surrounding wellbeing and social sustainability originates more from philosophy, sociology and psychology than from economics and environmental science. Comprehensive frameworks for addressing the multi-dimensional aspects in defining decent life in relation to sustainable development have not been defined widely, but some good opening on the topic have been done (e.g. for review see Hirvilammi, 2015 and Wu, 2013). Original work by Hirvilammi (2015) presents and builds upon the capability theories by *Sen* and *Nussbaum,* and need theories by *Allard* and *Max-Neef* [17]a model where sustainability can be perceived through dimensions of ***having*** (food, water, housing, energy, and income), ***loving*** (work, education, and social participation), ***being*** (family, friends, community, future generations, and nature) and ***doing*** (presence, self-realization, physical and mental health). Similarly to the theories applied by Hirvilammi (2015), OECD's Better Life Initiative (OECD, 2013) has aimed at addressing the multidimensionality by identifying three categories for understanding and measuring people's well-being, namely (1) *material living conditions* which determines people's consumption possibilities and their command over resources; (2) *quality of life* which is defined as the set of non-monetary attributes of individuals that shapes their opportunities and life chances, and has intrinsic value under different cultures and contexts; (3) *the sustainability of the socio-economic and natural systems* where people live and work, which is important for well-being to last over time. Built upon these three categories OECD has also developed the Better Life Index which constitutes of 11 dimensions constituting of total 24 indicators within (OECD, 2015).

In addition to providing a comprehensive multidimensional framework and index, the Better Life initiative can be considered as genuine progress by an economic organization towards holistic management of sustainable development related issues. Both approaches, by Hirvilammi and OECD, contribute to the understanding of decent life and sustainable development. Neither providing a simple uniform approach to social sustainability, but instead underlining the complexity and the interrelation between the dimensions of sustainability. One perspective, applied by this study, into coupling the sustainable development and the decent life paradigm is illustrated in FIGURE 5. The viewpoint is that decent life (ie. the metaphysical notion) is bound to the individual human presence whereas the structural spheres of sustainability (environmental, social, cultural and economic) reflect more the existing nature-, human-nature - and soci-economic systems. The

---

[17] Amartya Sen (an Indian economist and philosopher) and Martha Nussbaum(an American philosophe (a American psychologist) have developed capabilities approach a predominant paradigm for policy debate in human development, Erik Allardt (a Finnish sociologist) and Manfred Max-Neef (a Chilean economist) have contributed to the understanding and classification of human needs and development, mainly based on the need theories originally induced by Abraham Maslow (an American psychologist)

linking factor and the core of the decent life paradigm is therefore people who experience the well-being – it is therefore not a built-in or parallel concept of sustainable development, but an interlinking concept model that allows to pin out the individual level implications of the more complex systems level causes and effects.

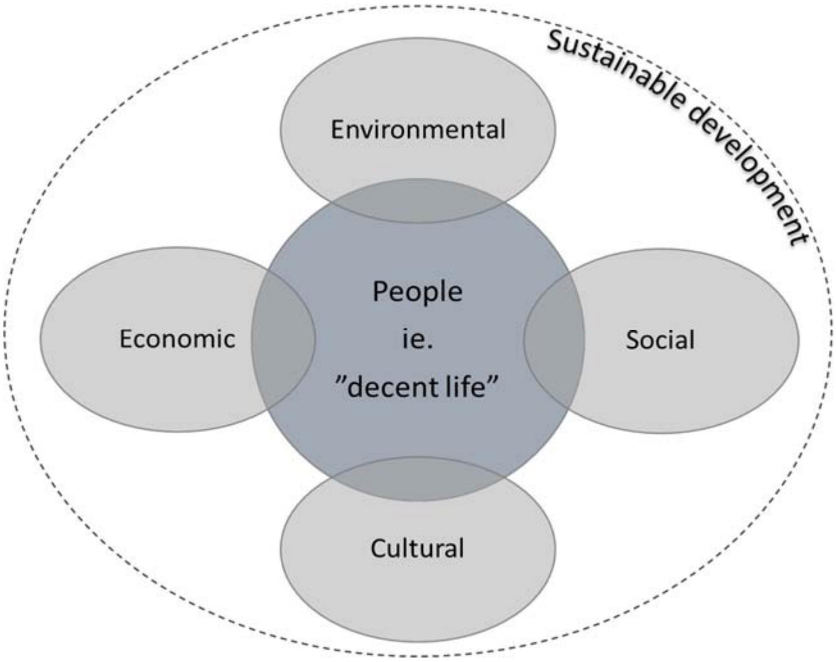


FIGURE 5. Linking the sustainable development and decent life paradigms (authors illustration)

2.1.4 Sustainability in complex systems

Meeting fundamental human needs while preserving Earth's life support systems requires an accelerated change toward sustainability. The difficulty of the task arises from the complexity of human-nature interactions, which poses a great difficulty in defining (and predicting) what is sustainable. Presently applied thematic division of sustainable development, lack of coherent definitions and abundance of strong long term narratives, causes the whole and the parts to be obscured. In the search for macro level sustainability, it also makes little sense to exclusively focus on the causes and solutions to specific sustainability issues, since they may be subject to considerable variation over time [18]. Especially the complexity of human-nature interactions and the complexity of activities within modern societies poses a great difficulty in predicting what is sustainable in the long run. This *fundamental uncertainty*

18 This is anyhow the approach applied still by many and serves as the fundament of frameworks such as PSR Pressure-State-Respose.

renders the ecological effects of activities in the ecological, social and economic regimes highly unpredictable (Sartorius, 2006).

To address this uncertainty, the research and paradigm development originating from the environmental movement of 1950's and the sustainable development agenda from 1970's has continued to evolve towards *transdisciplinary research*[19]. The common agenda has been since 2000's[20] outlined under the umbrella of *sustainability science* (FIGURE 6). This new field of sustainability research seeks to understand the dynamic relationships between nature, society and economy, at the local, regional and global levels – and help formulate a transformational agenda and related pathways for *change*.

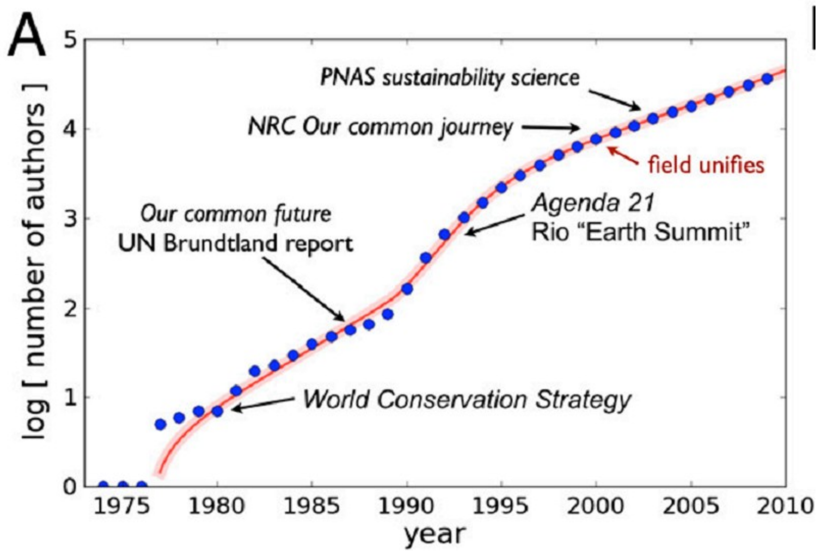


FIGURE 6. The number of unique authors vs. time and key events in the field of sustainability (science) (Bettencourt, 2011)

The field of study is highly complex. It is characterized by plurality of actors, fundamental uncertainties in human-nature interaction, spatial and temporal externalities and evolving policy objectives. Also, due to the transformational agenda, sustainability science is not only a theoretical field of study, but also has an applied approach for solving sustainability problems that require decisions on values. Such value formulation processes require civic

---

19 Transdisciplinary research is defined as research efforts conducted by investigators from different disciplines working jointly to create new conceptual, theoretical, methodological, and translational innovations that integrate and move beyond discipline-specific approaches to address a common problem. The research is based upon a conceptual model that links or integrates theoretical frameworks from those disciplines, uses study design and methodology that is not limited to any one field, and requires the use of perspectives and skills of the involved disciplines throughout multiple phases of the research process.

20 Sustainability science emerged as a new academic discipline in the beginning of 21st century. The new field of science was officially introduced with a "Birth Statement" at the World Congress "Challenges of a Changing Earth 2001" in Amsterdam organized by the International Council for Science (ICSU), the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change and the World Climate Research Programme (WCRP).

participation and the building of social legitimacy for proposed transition pathways. So whereas theoretical analysis is guided, explicitly or implicitly, by a normative agenda focused on change, the applied approach is guided by bridging the gap between theory, practice, and policy. (Bettencourt, 2011; Gazioluzy, 2015; Kates et al. 2001; Popa, 2015; Wu, 2013).

To overcome the problematic framing to finding solutions to specific problems in complex systems, sustainability should be viewed from a *systems perspective*. This approach acknowledges that ecological, social and economic sustainability are components of the same system where the whole is more than the sum of parts (Hirvilammi, 2015). Systems level view allows also to better understand the human-nature interactions, conceptualize them in more detailed level (Carrillo-Hermosilla et al. 2010) and address the fundamental uncertainty. In this context *sustainability should be viewed* not as a component, but *as a property of our socio-technical system as a whole to make agile responses to emerging pressures with reference to the systems state and capability, and to allow for the implementation of the most promising long term sustainable alternative* (Sartorius, 2006). Sustainable development should therefore not be seen as the three pillars or interlinking spheres, but as the activities in the interfaces of a nested hierarchy of institutions (the paradigms and institutions) that constitute the concept of sustainable development, and more importantly, considered as a property within the interfaces of system and its' sub-systems. (FIGURE 7). Some of the essential concepts within the sustainability science for defining the theoretical framework in relation to *systems thinking* are *capability, resilience, vulnerability, radicalism and long term orientation* (Bettencourt, 2011; Gazioluzy, 2015).

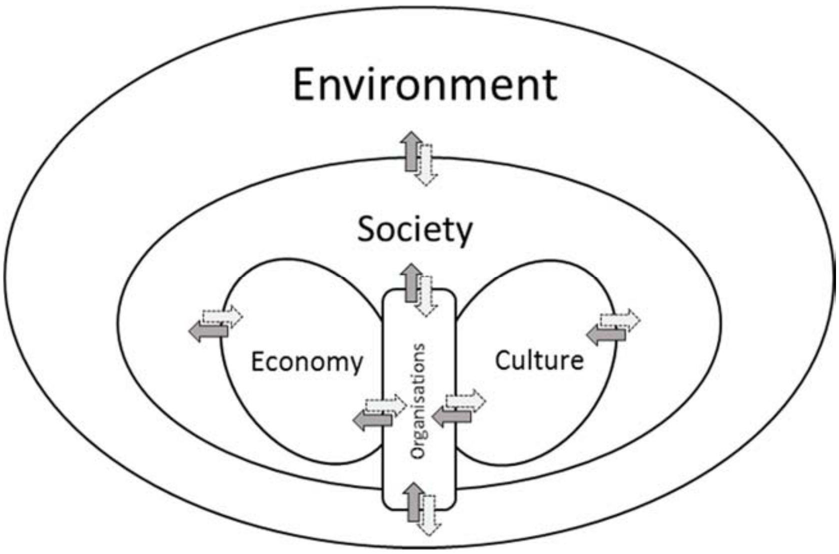


FIGURE 7. Structure of systemic sustainability

Capability has been only seldom accounted as a foundational theory for sustainability, though it is a crucial framework component within development science (which *inter alia* is at the core of sustainable development). Within sustainability science the concept has a many narratives. One fundamental narrative originates from the discussion of decent life, in which *capability refers to what individuals are able to do i.e. what are their real opportunities based on personal and social circumstance* (Burger et al., 2011; Hirvilammi, 2015). In the macro context of sustainability *capability refers to the resources, systems, structures and processes necessary to deliver – currently and in the future – the required level of performance in fulfilment of the mandated objectives* (a formulation selected from a review of definitions by Lindbom et al. 2015 which supports the selected definition of sustainability). By understanding capability in this scope of micro- and macro- level sustainability, of individual and systems level view, *capability fundamentally refers to the structural opportunities at the meta-sustainability level*.

Whereas capability refers to the forward enabling properties, resilience and vulnerability are more bound to the way systems maintain their equilibrium. During the past three decades resilience has emerged as a dominant paradigm in the study of socio ecological systems. By definition *resilience refers to systems' ability to respond to disturbance by resisting damage and adapting or recovering quickly*. The key concepts in resilience theory includes *latitude* (the maximum amount a system can be changed before it loses its ability to recover), *thresholds* or *precariousness* (tipping points), *alternate stable states* (regimes or domains), *resistance* (the ease or difficulty in changing system), *regime shifts* (phase transitions), *panarchy* (the structure in which systems are interlinked in continual adaptive cycles of growth, accumulation, restructuring, and renewal), and *transformability*. Thought sustainability and resilience are two different terms, some authors have treated them as contrasting by describing the former as a concept of equilibrium state and the latter as a concept of promoting change and *adaptive capacity*[21]. *Vulnerability* is a concept closely related to resilience and *refers to the systems' inability to withstand the effects of disturbance.* In general, highly resilient systems tend to be also less vulnerable, and *vice versa*. (Wu, 2013).

Since sustainability is about systemic transformations, the time frame of strategies involved should be *long term oriented*. Strategies should be informed by foresight covering the longest-term the system is subject to in planning, in order to be able to contextualize the sustainability potential and development direction from a vantage point. The vantage point for socio-technical transformations is around 50 years. The strategies should also understand that the required change for sustainability are not likely to happen through incremental efficiency gains achieved by redesigning existing products and technologies. There is a need for more *radical* thinking to shift design and innovation efforts from efficiency improvements to creating new ways of meeting societal needs. (Gazioluzy, 2015).

With respect to sustainability science, there is arguably no example in the history of science of a field that could span such distinct dimensions and achieve such ambitious and urgent goals of transdisciplinary scientific rigor and

---

21 Adaptive capacity is the capacity of a system to adapt if the environment where the system exists is changing. It confers resilience to perturbation, giving ecological and human social systems the ability to reconfigure themselves with minimum loss of function.

tangible socioeconomic impact that sustainability science is targeting (Bettencourt, 2011). The current development within the field has been a reflexive collaborative social processes of acknowledgement, critical deliberation and mutual learning on values, assumptions and understandings, which has enabled the generation of new meanings, new heuristics, and new stakeholder identities (Popa, 2015). From our current scientific and policy tools, sustainability science has the best potential to contribute to large scale sustainability transitions. To operationalize this in research and practice, however, the system properties, their interrelationships, and spatial and temporal scales must be further specified (Wu, 2013). Such work is imperative and urgent. The global environmental changes imposed by Anthropocene, growing inequality, cultural clashes between religions and regions, and the growing fragility of the global financial market require swift actions backed up by reliable scientific data. If we do not succeed in initiating these long term changes in due course, the resilience of our system is at stake.

2.1.5 New narratives

For advancing sustainable development new economic and social paradigms have been discussed to decouple economic growth and ecological impacts. These vision of *great transitions*[22] and popular socio-economic narratives range from communal and local economies of the *transition towns* movements to the *clean-* and *smart tech* drivers of *green economy, green growth, de-growth, circular economy* and *natural capitalism* (e.g. Bergh et al., 2011; Boons & Lüdeke-Fround, 2013; Coenen & Lopez, 2010; Geels, 2012; Mathews, 2011; OECD, 2009; UNEP, 2011) that promise to solve both environmental and economic problems (Geels, 2015). They frame environmental protection and social change beneficial for business and for the economy and society at large, rather than as an externality to be included in the production costs (Geels, 2015; Dolfsma & Seo, 2013; Sartorius, 2006). This framing allows for different green narratives built upon existing paradigms to be easily accepted by nations and industries. These '*green*' paradigms though represent only a partial shift away from the current neoclassical discourse of weak sustainability, as they depend on the promise of technological solutions, assume sufficient affordable energy supply without climate impacts through energy efficiency, and expect substitution ending the threat to biodiversity (Lorek & Spangenberg, 2014).

---

22 Great Transition was first introduced by Kenneth E. Boulding in 'The Meaning of the 20th Century - The Great Transition' (1964), considered a hallmark conception of systems thinking. The concept was popularized by the Global Scenario Group (GSG) which used it to describe a vision of a just and sustainable global future, concluding in a series of reports and a non-technical essay 'Great Transition: the Promise and Lure of the Times Ahead.' (2002). The original Great Transition vision included egalitarian social and ecological values, increased human interconnectedness, improved quality of life, a healthy planet, and an absence of poverty, war, and environmental destruction. The GSC potential future scenarios were Conventional Worlds, Barbarization, and Great Transitions to either Eco-communalism or to New Sustainability Paradigm.

It is important to note that for the general public, most often, sustainable development is still considered synonymous with environmentalism (or environmental sustainability). In today's research and in various global institutions though, as presented earlier, sustainable development is understood more widely as a continuum of ecological-, social- and economic- and cultural systems and the focus is towards understanding the more specific constituents, defining the limits, and guiding the progress towards *equal wellbeing to all within the global biophysical boundaries*. Under this framing, any new narratives aiming at 'sustainable growth' should take in account the current understanding of sustainable development and build upon a holistic narrative which aims at transforming the existing paradigms rather than supporting them, and understands that:

- Ecological sustainability refers to life within the limits of planetary natural capacity and resources; protecting biodiversity and ecosystems, reducing emissions to the level that ecosystems can manage them, using renewable resources only per their renewal rate, limiting the use of non-renewables and intensifying their existing use, considering the global equality in sharing natural resources and most importantly applying precautionary principle in all decisions to tackle the difference in time horizons between human and nature processes and the fundamental uncertainty of the cause-effect relationships in nature.
- Social sustainability refers to providing equally for the needs of all; maintaining resilience of social organizations, right to decent life (physical and mental health, education, work, income), to social equity (equality, gender) and participation (presence, self-realization) and affinity to society (democracy, cohesion).
- Economic sustainability refers to all above, as it mandates to hold in addition (and in connection) to the economic capital, also the ecological and social capital constant and growing for future generations to come.

For sustainable growth to actualize an approach based more on strong sustainability must be visualized. It should clearly focus on (1) understanding earth as a complex human-nature-society system, (2) target development of more efficient technologies and use of technology, (3) advance long term economic equity and changes in consumption patterns, and (4) introduce a clear discourse and mindset for what is decent life (e.g. Gazioluzy, 2015). Such significant changes from the existing paradigm would require a revolution in the way the world does business, and this would impact lifestyles and consumption patterns—especially so in developed countries, but also for the growing middle class in developing countries. Such changes are difficult, and have been thus far resisted in a world that has put economic growth over environmental and social issues, but sign of these are emerging from bottom up.

Real life expressions of the emergent transitions toward more sustainable paradigm as countermovement to the prevailing low efficiency material ownership are visible in many industries. Examples originate not only from the obvious optimization of- and reuse of raw materials to increase performance and reduce waste, but also from the emergence of new business models built upon natural systems (e.g. anaerobic digestion, biomaterials), innovative modes of service thinking (e.g. leasing, or service instead of ownership), and sharing and reuse of underused assets (e.g. home renting, second hand). Thought all of these business models are driven in part by financial gains, they are also advocated by stronger ecological sustainability and some carry within the underlying need for increased social sustainability, i.e. coherence in the *loving* and *being* dimensions. The Ellen MacArthur Foundation, a charity with the aim of accelerating the transition to a more sustainable, regenerative *circular economy*, has depicted a *ReSOLVE* framework (EMF, 2015) to describe how the fundaments of a more sustainable economy can translate to business actions, and how companies are already benefitting from this (FIGURE 8). Many of these businesses are already changing the way we live and perceive our surrounding eco- and social systems.

FIGURE 8. ReSOLVE framework of new business models (EMF, 2015)

2.2 Transition towards more sustainable systems

When sustainability is perceived as means to an end, not the end itself, the change becomes the focus of study. Sustainability science perceives this process of change as a *transition* process within our *socio technical system*, leading to alternate stable states in the *regimes* and ultimately also in the *landscape*. Whereas the theoretical analysis is focused on understanding and describing these systems and processes, in relation to present and *future technology*, the applied approach aims at bridging these *transition pathways* to practice and policy through tools such as *transition-* and *niche management*. This chapter introduces the prevailing models, frameworks, analytical- and applied tools within sustainability science used to study and facilitate *transitions towards more sustainable systems*.

2.2.1 Sustainability transitions

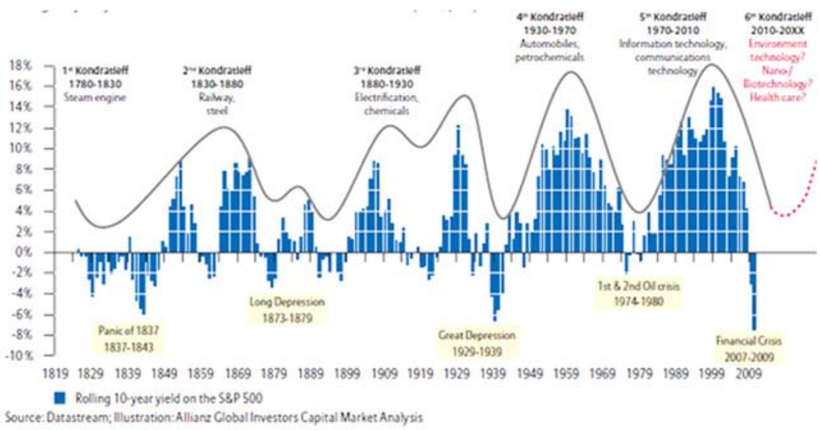
Transition by definition means a change from one state or condition to another. Neo-classical economics have traditionally conceptualized transitions as changes in the economic structure (e.g. the shift from labor to capital), which are driven by changing prices of production factors and outputs, in response to which firms change their investment strategies and consumers change their purchase decisions (Geels, 2010). Broader conceptualization of transitions in context of socio-technical systems has received increasing attention over the past 10–15 years (Bergh et al., 2011; Markard et al. 2012). The fundament of socio-technical transition studies is to better understand large systems like energy, transportation, agriculture or water supply as socio-technical systems consisting of networks of actors, institutions, artefacts and knowledge. The hope in the long term is to understand and affect fundamental transformation processes through which established socio-technical systems could shift to more sustainable modes of production and consumption. In the specific context of socio-technical systems transition towards sustainable development, it is often called in short *sustainability transition* to describe the large challenge within the aspects of sustainable development for a transition towards more sustainable system to actualize. (Bergh et al. 2010; Markard et al. 2012.)

Excellent reviews on the history and current state of research on sustainability transitions has been conducted by Bergh et al. (2011) and Markard et al. (2012). From both authors four frameworks have achieved quite some prominence in *transition studies*. These include *transition management* which combines the work on technological transitions with insights from complex systems theory and *strategic niche management* focusing on deliberate creation and support of technological niches to trigger off regime shifts (Bergh compiles both as 'complex systems'), *technological innovation systems* which is concerned with the emergence of novel technologies and the institutional and organizational changes that have to go hand in hand with technology development, and the *multi-level perspective* which is a heuristic framework to explain the pressures within socio technical systems causing different transition pathways to emerge.

The fundamental difference between socio-technical transitions and pure technological transitions is that the former also include changes in user practices, institutional structures, and typically encompass a series of complementary technological and non-technical innovations (Markard et al. 2012). A socio-technical transition is a set of processes that lead to far-reaching fundamental changes of technological, material, organizational, institutional, political, economic, and cultural institutions along different dimensions. These transitions involve a broad range of actors and typically unfold over considerable time-spans. In the course of such a transition, new products, services, business models, and organizations emerge, partly complementing and partly substituting for existing ones. Technological and institutional structures change fundamentally, as well as the perceptions of consumers regarding what constitutes a particular service (or technology). (Bergh et al., 2010; Geels and Kemp, 2010; Markard et al., 2012; Jorgensen, 2012.)

Human history is full of examples of technological and socio-technical transitions leading to increased prosperity. Movements over time from one state of being to another have always been inseparably intertwined with innovation (Diamond, 2010; Ruth et al., 2011). Innovations in the areas of energy, agriculture, transport, water management, urbanization and education, for example, have long been seen as ways to increase prosperity and overcome environmental constraints on socio-technical transition (Ruth et al., 2011). Commonly referred examples of past centuries technological transitions is given by Freeman and Perez (1988) (Bergh et al., 2011; Geels, 2002) and founded on the Kondratiev waves [23]. These transitions are based on wide scale adaptation of new technologies and methods leading to a change in the whole socio-technical landscape. These transitions (waves) are (1770-1830) mechanization and industrial revolution; (1830 - 1880) steam engine and railroads; (1880 - 1930) electrical and heavy engineering; (1930 - 1980) mass production and consumerism; and finally (1980 - …) information and communications technology.

The whole theme of sustainability transition is high on the agenda of many countries and international organizations. Many already state that developments towards these future landscapes is already in progress in different regions globally, and it is commonly understood that the next transition, whatever it may be, requires again a combination of technical, organizational, economic, institutional, social–cultural and political changes to take place (Bergh et al., 2011). It is worthwhile to note that the financial markets invests heavily that the future growth would originate from megatrends based on sustainability and green growth (FIGURE 9) (World Bank, 2015; Citi, 2015).



11

FIGURE 9. Rolling 10-year yield on S&P 500 and the Kondratiev waves (%, p.a.)

23 Kondratiev waves are a cycle-like phenomena in the modern world economy, introduced by Nikolai Kondratiev in his book 'The Major Economic Cycles' (1925). It claims that economy (inter alia) forms sectoral cycles of bust and boom. No statistical evidence demonstrates the existence of such events, though it is commonly applied in conceptualization of technology development.

(http://d-bits.com/wp-content/uploads/2010/10/Allianz-Kondratiev-Waves.jpg)

2.2.2 Socio technical systems

Systems in general are entities comprising of various interacting elements. By traditional ecological approach within sustainability science, earth ecosystems are understood as coupled *human-environment systems* or *socio ecological systems* (Sartorius, 2006; Wu, 2013). Geels & Kemp (2007) have listed a number of different kinds of systems models known in relevant literature, namely *large technical systems* for infrastructure, *sectoral systems* for industry sectors, *technological systems* for products and specific technologies, and *socio-technical systems* for clusters of elements, involving technology, science, regulation, user practices, markets, cultural meaning, infrastructure, production and supply networks. Whereas the first three are oriented more towards understanding how systems function, the latter is focused on how systems transition (change). These models share a common systems approach but are often positioned as different bodies of literature, having been developed for different analytical levels and targets. Large technical systems focus on innovation and change within systems such as electricity networks, the sectoral systems of innovation and technological innovation systems see innovation primarily as means for businesses and industries to achieve competitiveness and to show how technological innovation gives rise to economic growth. Socio-technical systems model is first and foremost interested in how new configurations around large socio-technical systems emerge and retain in society. (Bergh et al., 2011; Coenen & Lopez, 2010.)

Coenen & Lopez (2010) have compared backgrounds and approaches of these three systems models in detail. By citing them: "the pioneering work on technological innovation systems was carried out by Bo Carlsson and Rikard Stankiewicz (1991), who defined it as: network(s) of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion, and utilization of technology. Technological systems are defined in terms of knowledge or competence flows rather than flows of ordinary goods and services. They consist of dynamic knowledge and competence networks. … The most comprehensive and up-to-date sectoral systems definition is probably given by Malerba (2004, p. 16) in which a sectoral system of innovation and production is composed of a set of new and established products for specific uses, and a set of agents carrying out activities and market and non-market interactions for the creation, production and sale of those products. … Socio-technical systems encompass production, diffusion and use of technology in relation to so-called societal functions (e.g. transport, communication, energy, food). The elements of these systems, which in the above approaches are mainly constitutes of organizations, include for socio-technical systems also artefacts, knowledge, capital, labor, cultural meaning, etc. … Both technological- and sectoral systems can be regarded as firm-centered systems where the firm is the leading organizational unit responsible for innovation. … The socio-technical systems approach is critical of this neglect of other kinds of organizations beyond firms and calls for a broad range of actors to be considered in the system analysis. In lieu of bundles of resources, actors in the system are conceptualized as social groups based on strong coordination principles within the group."

The societal nature of the human environment and the strong role that institutions and policy play in regards to sustainable development render the sectoral systems of innovation and technological innovation systems inadequate for more rigorous application in this thesis. Though they hold the same roots as socio-technical systems do (Markard & Truffer, 2008), their application is more suited towards analyzing inter-organizational or technology centric innovation pathways. To analyze complex societal systems the approach needs to borrow insights from sociology of technology and institutional theories, innovation studies, science and technology studies, cultural studies and domestication studies (Geels, 2002). The structural problems modern societies face (e.g. traffic congestion, CO_2 emissions, pollution) are deeply rooted in societal structures and activities (Geels, 2004), and the advantage of approaching these problems from socio-technical systems perspective is that the co-evolution of technology and society, of form and function, becomes the focus of attention (Geels, 2007).

One of the key developer of the socio-technical systems theory is the Dutch School of Transition and Frank W. Geels who in his 2002 and 2004 articles defined the foundation for the model of socio-technical systems and for the transition framework entitled *multi-level perspective* (MLP). These model and framework consists of analytical and heuristic concepts to understand the complex dynamics of socio-technical systems and their change. According to Geels (2002, 2004) socio-technical systems encompasses of sub-functions, namely production, diffusion and use of technology, and the basic resources needed to fulfill these sub-functions (FIGURE 10). These systems do not function autonomously, but are the outcome of the activities of social actors (FIGURE 11) and the linkages between elements necessary to fulfil functions (like transport or communication). The relationship between sub-functions and resources on the one hand and social groups on the other hand is considered dynamic. The socio-technical system is thus a web consisting of the sub functions, resources to endorse them and interdependence of activities between actors.

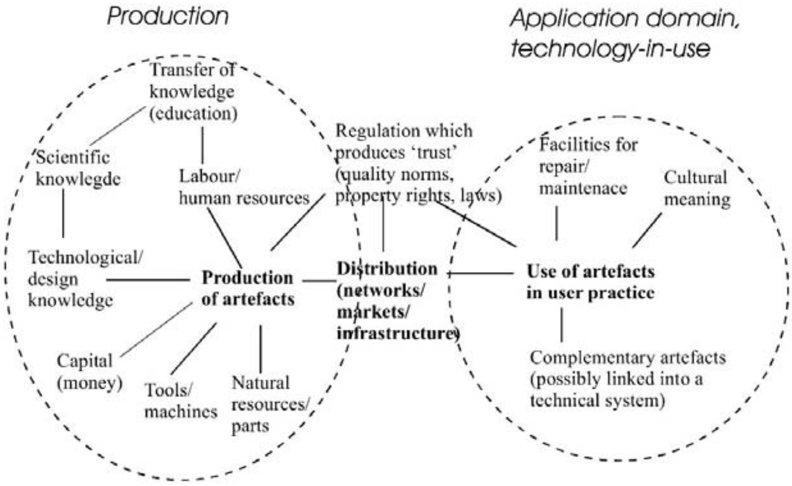


FIGURE 10. Basic elements and resources of socio-technical systems (Geels, 2004)

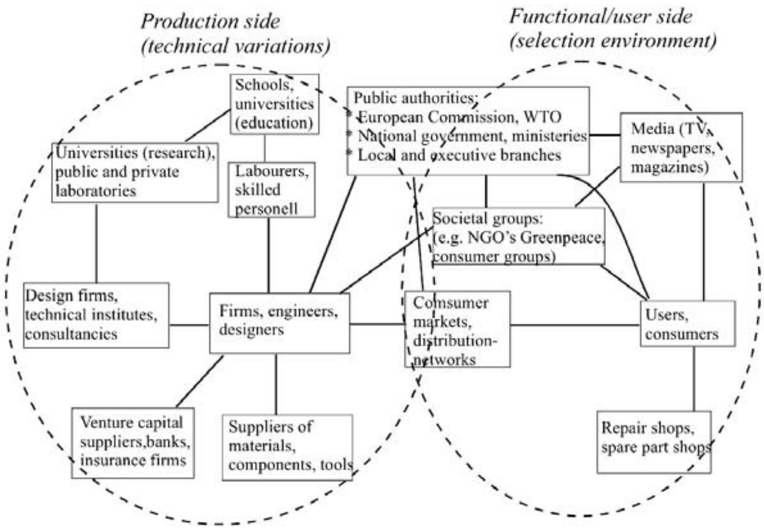


FIGURE 11. Social groups which carry and reproduce socio-technical systems (Geels, 2004)

Within socio-technical systems human actors are not completely free to act as they want. Their perceptions and activities are coordinated (but not pre-determined) by institutions and rules. For this reason the model presumes an analytical distinction between the socio-technical system, actors and institutions/rules, which guide the actors and interaction (FIGURE 12). (Geels, 2004).

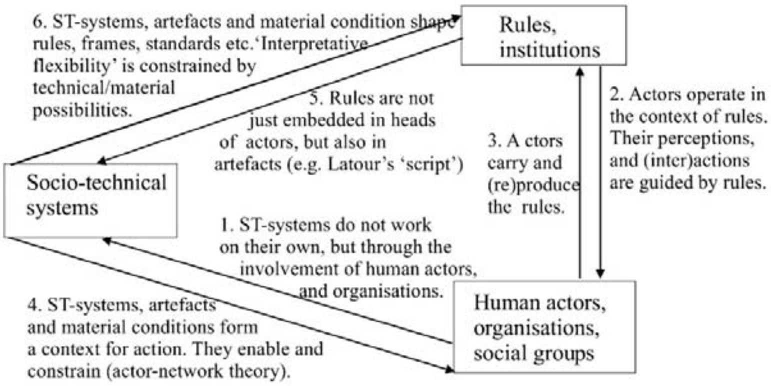


FIGURE 12. Three interrelated analytical dimensions and their interactions (Geels, 2004)

In socio technical systems, rules and social groups provide stability through different mechanisms, but they also face transition pressures and have other dependencies beyond the direct influence of actors. Material environments (cities, electric grids, etc.), environmental problems (climate change, pollution), shared values (sustainable development), and new technological trajectories (cleantech, smart-tech) form the external structure and context for interactions of actors (Geels, 2002). To address the issue of stability and change a complimentary multi-level perspective (MLP) framework has been suggested and widely applied to explain the stability and transition of socio-technical systems (Bergh et al. 2010; Geels, 2002 & 2004; Markard et al. 2012; Markard and Truffer, 2008; Jorgensen, 2012).

2.2.3 Multi-Layer Perspective

The multi-layer perspective (MPL) has been developed to explain the dynamics of socio technical systems and study long term transformative change. The MLP presents a systemic model of three inter-connected levels of socio technical systems that are defined by the metaphorical notions of '*landscape*', '*regime*' and '*niche*' which implicitly links between macro-, meso- and micro-level theories well known to economic and sociological definitions of hierarchy (Geel, 2002, 2004; Jorgensen, 2012). The relation between the three concepts can be understood as a nested hierarchy (FIGURE 13). The macro-level of landscape consists of slow changing external factors providing gradients for socio-technological trajectories (called landscape forces). The meso-level of regimes accounts for stability of existing technology, and the occurrence of trajectories. The micro-level of niches accounts for the generation and development of (radical) innovations. (Geels, 2002.) Landscape, regimes and niches can be differentiated by their degrees of structuration (very strong, strong and weak, respectively) and have therefore been called levels of structuration in the MLP framework (Fuenfschilling & Truffer, 2014).

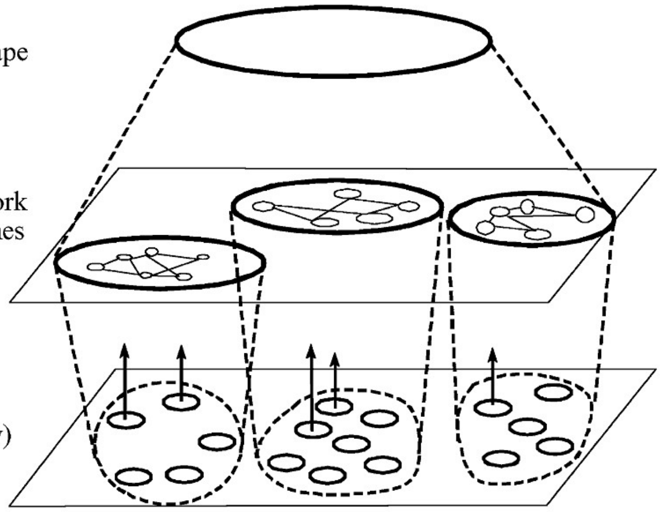


FIGURE 13. Multi-layer perspective and the nested hierarchy (Geels, 2002)

The landscape represents highly structural external environment of processes and factors that influence both regimes and niches (Markard & Truffer, 2008; Smith et al. 2010). Geels (2002) originally defined the landscape by the material context of society, e.g. the material and spatial arrangements of cities, factories, highways, and electricity infrastructures. Later this understanding of the socio-technical landscape (Geels, 2004, 2007) has been extended to include a large set of heterogeneous factors that span societal functions, such as oil prices, economic growth, wars, emigration, cultural and normative values and environmental problems. Landscape should be seen as an external structure or context for interactions of actors. Large technological trajectories are situated in this socio-technical landscape, consisting of a set of deep structural trends and their physical implementations. The growing awareness on the need for enforced sustainable development is a landscape process, which is confronting multiple regimes with new sustainability criteria which were never considered during their installation. (Smith et al. 2010).

The regime is formed by different social groups, that share a set of rules and configurations which establish them as the stable and dominant way of realizing a particular societal functions (Smith et al. 2010). The rules can roughly be divided to *regulative, normative* and *cognitive rules*. The regulative dimension refers to explicit, formal rules; normative to values, norms, role expectations, duties, rights and responsibilities; and cognitive rules constitute the nature of reality and the frames through which meaning or sense is made (e.g. words, concepts) (TABLE 1). As different groups share different rules (TABLE 2), different regimes may also be distinguished, e.g. technological or design regimes, policy regimes, science regimes, financial regimes and societal or user regimes (FIGURE 14). Socio-technical regimes can be understood as the 'deep structure' or grammar of socio-technical systems which are carried by the social groups. Socio-technical regimes do not encompass the entirety of other regimes, but only refer to those rules, which are aligned to each other. (Geels, 2002 & 2004).

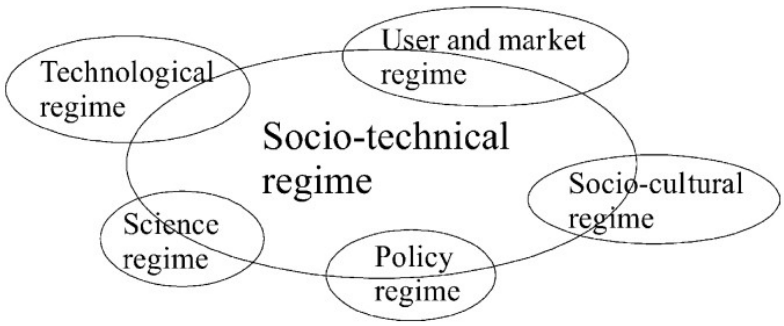


FIGURE 14. Meta-coordination through socio-technic regimes (Geels, 2004)

Niches represent the local level of innovation processes and are commonly referred to as the protected spaces (incubators) in which new technologies or socio-technical practices emerge and develop (Markard & Truffer, 2008). Protection is often provided in terms of subsidies, by public authorities or as strategic investments within companies (Geels, 2004). Geels (2002) describes niches as locations where it is possible to deviate from the rules in the existing regime. This is due that niches are less well-defined and stabilized than regimes, and therefore do not restrict actors to following rules in the same coherent and reproductive way. Based on the idea that niches provide the shelter for new innovations and present potentials for overthrowing existing regimes, attention to innovation policies nurturing niche developments has fostered the concept of *Strategic Niche Management* (SNM) as a central policy concept (Jorgensen, 2012).

One of the key functions of MLP is to model socio-technical transitions and regime shifts. MLP assumes that system transitions come about through the interplay between processes at different levels in different phases. In MLP, there is no simple cause or driver in transitions. For a transition to occur, dynamics at different levels should come together and reinforce each other. System changes are emergent outcomes of interactions between social groups with myopic views and differing interests. FIGURE 15 represents an illustration of the dynamics of change in socio-technical systems under the MLP framework. The important point of the illustration is that change is not only governed by processes within the niche, but also by developments at the level of the existing regime and the sociotechnical landscape. Likewise changes at the landscape level, for instance, may put pressure on the regime, and create possibilities for change. (Geels, 2002, 2004; Geels & Kemp, 2007.)

TABLE 1. Three kinds of rules/institutions (Geels, 2004)

	Regulative	Normative	Cognitive
Examples	Formal rules, laws, sanctions, incentive structures, reward and cost structures, governance systems, power systems, protocols, standards, procedures	Values, norms, role expectations, authority systems, duty, codes of conduct	Priorities, problem agendas, beliefs, bodies of knowledge (paradigms), models of reality, categories, classifications, jargon/language, search heuristics
Basis of compliance	Expedience	Social obligation	Taken for granted
Mechanisms	Coercive (force, punishments)	Normative pressure (social sanctions such as 'shaming')	Mimetic, learning, imitation
Logic	Instrumentality (creating stability, 'rules of the game')	Appropriateness, becoming part of the group ('how we do things')	Orthodoxy (shared ideas, concepts)
Basis of legitimacy	Legally sanctioned	Morally governed	Culturally supported, conceptually correct

TABLE 2. Examples of rules in different regimes (Geels, 2004)

	Formal/regulative	Normative	Cognitive
Technological and product regimes (research, development production)	Technical standards, product specifications (e.g. emissions, weight), functional requirements (articulated by customers or marketing departments), accounting rules to establish profitability for R&D projects (Christensen, 1997), expected capital return rate for investments, R&D subsidies.	Companies own sense of itself (what company are we? what business are we in?), authority structures in technical communities or firms, testing procedures.	Search heuristics, routines, exemplars) (Dosi, 1982; Nelson and Winter, 1982), guiding principles (Elzen et al., 1990), expectations (Van Lente, 1993; Van Lente and Rip, 1998), technological guideposts (Sahal, 1985), technical problem agenda, presumptive anomalies (Constant, 1980), problem solving strategies, technical recipes, 'user representations' (Akrich, 1995), interpretative flexibility and technological frame (Bijker, 1995), classifications (Bowker and Star, 2000).
Science regimes	Formal research programmes (in research groups, governments), professional boundaries, rules for government subsidies.	Review procedures for publication, norms for citation, academic values and norms (Merton, 1973).	Paradigms (Kuhn, 1962), exemplars, criteria and methods of knowledge production.
Policy regimes	Administrative regulations and procedures which structure the legislative process, formal regulations of technology (e.g. safety standards, emission norms), subsidy programs, procurement programs.	Policy goals, interaction patterns between industry and government (e.g. corporatism), institutional commitment to existing systems (Walker, 2000), role perceptions of government.	Ideas about the effectiveness of instruments, guiding principles (e.g. liberalisation), problem-agendas.
Socio-cultural regimes (societal groups, media)	Rules which structure the spread of information production of cultural symbols (e.g. media laws).	Cultural values in society or sectors, ways in which users interact with firms (Lundvall, 1988).	Symbolic meanings of technologies, ideas about impacts, cultural categories.
Users, markets and distribution networks	Construction of markets through laws and rules (Callon, 1998, 1999; Green, 1992; Spar, 2001); property rights, product quality laws, liability rules, market subsidies, tax credits to users, competition rules, safety requirements.	Interlocking role relationships between users and firms, mutual perceptions and expectations (White, 1981, 1988; Swedberg, 1994).	User practices, user preferences, user competencies, interpretation of functionalities of technologies, beliefs about the efficiency of (free)markets, perceptions of what 'the market' wants (i.e. selection criteria, user preferences).

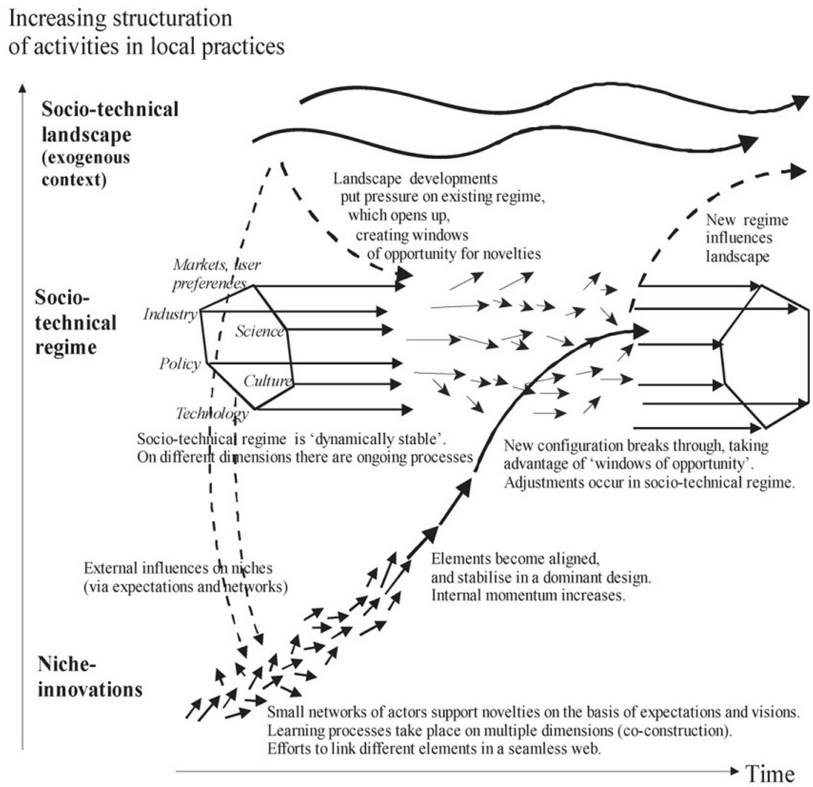


FIGURE 15. Dynamic multi-level perspective on socio-technical transitions (Geels, 2007)

Geels & Kemp (2007) point out that the regimes account for the stability of existing socio-technical systems, hence resisting the integration of new niche technologies and landscape pressures. The dominance of certain technologies and practices is not only a matter of economics but very much a matter of rules (TABLE 2). They continue describing that "established systems are stabilized by roles, routines, ways of thinking and of doing, and also by legally binding contracts. Systems are also stabilized because people have adapted their lifestyles to them, because favorable institutional arrangements and formal regulations have been created, and accompanying infrastructures are set up. Systems are further stabilized by social relationships, mutual role expectations and the organizational commitments and vested interests of existing organizations, finally the material aspects of socio-technical systems contribute to stability, because of sunk investments and the economics of use. Once artefacts and material networks are in place, they are not easily abandoned and acquire a logic of their own. The alignment between these heterogeneous elements leads to technological momentum, which is not easily broken."

As long as socio-technical regimes are stable and aligned, radical novelties have few chances and remain stuck in particular niches. If tensions and mismatches occur, however, in the activities of social groups and in socio-technical regimes, this creates 'windows of opportunity' for the breakthrough of radical novelties. There may be different reasons for such tensions and misalignment as shown by Geels and Kemp (2007):

- Changes on the landscape level may put pressure on the regime and cause internal restructuring
- Internal technical problems may trigger actors (e.g. firms, engineers) to explore and invest more in new technological directions.
- Negative externalities and effects on other systems (e.g. environmental impacts, health risks and concerns about safety) may lead to pressure on the regime.
- Changing user preferences may lead to tensions when established technologies have difficulties to meet them.
- Strategic and competitive games between firms may open up the regime.

If tensions exist, a radical innovation may take advantage and breakthrough in mass markets. It then enters competition with the existing system, and may eventually replace it. This will be accompanied by wider changes (e.g. policies, infrastructure, user practices). This is a period of flux, restructuring and Schumpeter's[24] *gales of creative destruction*. There may be entry and exit of new players in industry structures. Eventually a new system and regime is formed, carried by a network of social groups who create and maintain socio-technical systems. The new regime may eventually also influence wider landscape developments. (Geels, 2004.)

The socio-technical systems do not always change radically, but more often incrementally. To conceptualize the different levels of change, three kinds of processes are identified by Geels & Kemp (2007), *reproduction, transformation* and *transition*. In *reproduction* only dynamics at the regime level are affected, not at the landscape and niche level. Existing rules are reproduced by the relevant actors, and elements in the socio-technical system are refined. The orientation of dominant actors, key technology and knowledge remains but there is incremental and cumulative change along trajectories. In *transformation* there are interacting dynamics at the regime and landscape level, but little influence from niches. The basic mechanism is that changes at the landscape level create pressure on the regime, leading to re-orientation of the direction of innovative activities. The adjustment and re-orientation to external landscape pressure does not happen in a mechanical fashion, but through negotiations, power struggles and shifting coalitions of actors. Outsiders, public and regulatory pressure, or the entry of new actors may help to challenge previously held assumptions and place new issues on the problem agenda. The survival of incumbent regime actors is not threatened, and they are the ones to enact the redirection of the development trajectory of the existing system. In the transformation process, a new system may grow out of the old one, through cumulative adjustments in a new direction. A *transition* refers to a shift from

---

24 Joseph Schumpeter, considered the father of *evolutionary* and *innovation economics*, introduced innovation economics in his 1942 book Capitalism, Socialism and Democracy. Schumpeter contended that evolving institutions, entrepreneurs, and technological change were at the heart of economic growth, not independent forces that are largely unaffected by policy as in the neoclassical economic synthesis. He argued that creative destruction was crucial to capitalism.

one socio-technical system to another. It is not about the re-orientation of an existing trajectory, but about a shift to a new trajectory. This transition involved changes in the socio-technical system (e.g. technologies, knowledge base, infrastructure, regulations, user practices, and cultural preferences), social groups and regime rules. In a transition process, there are interactions between dynamics at landscape, regime and niche levels. Landscape developments create pressure on the regime, leading to major problems. Regime actors react with adjustments in the system (as in the transformation process), but they are not able to solve the problems. This creates a window of opportunity for new innovations, developed in niches and carried by a new network of social groups. If a new innovation breaks through and replaces the existing system, this will be accompanied by 'creative destruction' and the collapse of (some) incumbent actors. Once a transition has taken place, a new period of dynamic stability and reproduction sets in. TABLE 3 summarizes the differences between these change processes in terms of underlying mechanisms.

TABLE 3. Different mechanisms in change process (Geels & Kemp, 2007)

	Reproduction	Transformation	Transition
Levels involved	Regime dynamics	• Pressure from landscape • Adaptation and reorientation in regime	• Pressure from landscape • Increasing problems in regime, and attempts at re-orientation • New innovation in niches that eventually break through
Role of actors	Incumbent regime actors	• Pressure from outsiders • Incumbent regime actors respond through re-orienting innovative trajectories	• Pressure from outsiders • Incumbent actors fail to solve regime problems • Outsiders develop new innovations

2.3 Is entrepreneurial economy driving the change?

During the first three quarters of the last century, the prevailing belief was that economies of scale and scope present in production, distribution, management, and research and development of a firm led to increasing firm size. In addition, the growing but relatively low level of economic development and high price elasticity that were followed by price competition, favored large scale production. A major shift in the developed economies has been taking place: away from what has been characterized as the managed economy towards the *entrepreneurial economy*[25]. Multitude of factors have contributed to the change, ranging from the demise of the communist system, increased globalization, corporate reorganization, increased knowledge production and higher levels of prosperity. In particular technological change has been a fundamental catalyst underlying the shift from the managed to the entrepreneurial economy. (Myötänen, 2010; Thurik et al., 2013.) Entrepreneurship today is not only a preferred individual choice, thought much idealized by the surge of the start-up industry, but also an obligatory means of self-employment for many. The

[25] Bruce Kirchhoff's original formulation from (1989, p. 161) A good background on the development paths has been given in Thurik et al. 2013

change of 'work' has caused that more and more people are engaged in short term projects with limited employee rights, especially in the new industries.

The model of entrepreneurial economy is based on elements such as flexibility, turbulence, diversity, creativity and novelty, and new forms of linkages and clustering. Both the managed economy and the entrepreneurial economy models explain economic growth, but the foundations for the growth vary substantially between the two. In the managed economy, economies experience growth through stability, specialization, homogeneity, scale, certainty and predictably. On the contrary, in entrepreneurial economy, flexibility, turbulence, diversity, novelty, innovation, linkages and clustering drive the growth. Fundamental differences between the models in the specific context of this theses are the treatment of entrepreneurship and knowledge as the main source of comparative advantage. (Myötänen, 2010.)

2.3.1 SMEs and venturing

Since the last decade of the 20th century, *small and medium sized enterprises* (SMEs) and particularly new businesses have been the force driving economy. SMEs build a large group internationally. Figures for OECD economies show that SMEs make over 95% of the total number of enterprises (OECD, 2000). Also over the last 25 years, two thirds of new jobs and 95% of radical innovations have come from these entrepreneurial businesses (Chen, 2009). In addition, econometric evidence suggests that entrepreneurship is a vital determinant of economic growth and employment (Myötänen, 2010).

Since most radical innovations are borne in SME's, they should be considered as the key *niche* actors. The definition for SMEs varies between countries and regions, but commonly the distinction is done based on the number of employees and/or annual turnover (TEM, 2015; OECD 2000). In this study we will apply the EU recommended definition for SMEs (EU recommendation 2003/361), which includes the number of employees (<250) and either turnover (<50MEUR) or balance sheet total (<43MEUR) as main determining factors. (Myötänen, 2010; TEM, 2015.)

When discussing about businesses the focus is often on *entrepreneurship*[26]. Entrepreneurs are commonly defined as people who are the innovators, profit opportunity pursuers and risk takers (Myötänen, 2010). Much research is done on the personal qualities of entrepreneurs (Venesaar, 2014), but in the context of socio-technical systems where the dynamics span from social interlinkages, the beneficial unit of study is greater than the individual. Within this relation this study considers that a business is *a group of people and resources to achieve a specific goal.* It is also considered the lowest level of study, assuming it as an actor with a shared set of rules with inter-actor and –people linkages to other actors and people in the socio-technical niches and regimes.

[26] Originally depicted by Schumpeter "new combinations we call enterprise; the individuals whose function it is to carry them out we call entrepreneurs" (Schumpeter 1934; 74)

Businesses commercialize innovations mainly by *venturing* (Chen, 2009; Munoz and Dimov, 2014). Venture development is commonly understood as the economic development activity that is focused to help create venture and angel-capital-ready firms which have the promise to create significant economic wealth for a region, state or country including entrepreneurial wealth and jobs (Wikipedia: Venture Development). In business literature this understanding is extended, i.e. Munoz & Dimov (2014) define venture as a set of active exchange relationships that lies at the tail end of a development process that begins with an initial venture idea and is continuously shaped by action, social interaction and learning. They conclude that to study venturing process one needs to focus on the observable markers, namely the venture ideas (innovations) at their onset, the actions through which these ideas are expressed and set to motion and the interactions through which the ultimate exchange relationships are instituted. For the purpose of this study we define (according to Munoz & Dimov (2014) venturing as an *organizational innovation commercialization process, that is continuously shaped by action, social interaction and learning.* Another important concept in relation to venturing is *business model*, which we define as *a plan, which specify how a new venture can become profitable* (Boons & Lüdeke_fround, 2013).

2.3.2 Eco innovations

At the beginning of the 20th century, Joseph Schumpeter[27] stated that economic expansion is directly dependent on innovation (Medeiros et al. 2014). According to him, innovation can take the form of new products, new production processes or methods, new markets or even new sources of supply. In the past decade, research on innovations has expanded rapidly to increase our understanding of the ways in which new technologies and social practices transform our societies and enable to become more sustainable. The disciplines involved include innovation studies, evolutionary economics, environmental economics, environmental science, ecological economics, energy studies, geography, transport studies, management studies, science, technology studies and political science. (Bergh et al., 2011; Carrillo-Hermosilla et al., 2010; Medeiros et al., 2014.)

Key element in sustainability transition is *innovation*. It is important to note that the transition studies are in part descendants of innovation studies, originating from new technology/product development (NPD) research. *Sustainable innovation*, *environmental innovation* and *social innovation* are all new branches of research building upon the transition and NPD studies. The focus of these studies is to explore the processes involved, and also to understand how these *sustainable eco-innovations* contribute to the sustainability transition. (Bergh et al. 2010; Carrillo-Hermosilla et al. 2010; Pujari, 2006.)

An increasing number of researchers today are studying *eco-innovations* and *sustainable innovations*. Eco-innovations can be a relevant tool for wiring up

---

27 See footnote XXX

the innovation system. They may contribute to the renovation of whole socio-technical systems, taking into account social, ecological and economic aspects. The main difference between 'eco' and 'regular' innovations is the combination of an existing environmental problem that needs a solution but which is associated with external costs that do not enter the private costs of the polluter (Bergh et al., 2011). The long-term survival of the economic system depends on its ability to create and maintain sustainable economic processes, which do not involve short-term value creation at the expense of long-term wealth (Boons & Lüdeke-Freud, 2013; Carrillo-Hermosilla et al., 2010.) The spreading and diffusion of environmental innovation is often difficult compared to other technological innovation. This is due to the fact that environmental innovation is characterized by diffuse public benefits and concentrated private losses. Furthermore, successful environmental innovation is complicated as it tends to focus on factor saving rather than quality improvement (Gazheli, 2015).

Traditional definition of innovation reflects the definition used by the OECD (1997), which distinguishes *process innovations*, allowing to produce a given quantity of output with less input; *product innovations* which are characterized by the improvement of existing, or the development of new, goods or services; and *organizational innovations* including new forms of management (Sartorius, 2006). Innovations are commonly distinguished from inventions by the additional condition of successful market introduction (Boons & Lüdeke-Freund, 2013).

For defining eco-innovation multiple attempts and approaches exist. Carrillo-Hermosilla et al. (2010) have collected a number of definitions produced by both institutions and researchers. The definitions can be classified to either cover 'environmentally motivated innovations' or 'environmentally beneficial normal innovations'. For comparison with the traditional innovation presented in the previous chapter, view I will again present the OECD (2009) formulation. It states that eco-innovation is generally the same as other types of innovation but with two important distinctions: Eco-innovation represents innovation that results in a reduction of environmental impact, whether such an effect is intended or not; And the scope of eco-innovation may go beyond the conventional organizational boundaries of the innovating organization and involve broader social arrangements that trigger changes in existing socio-cultural norms and institutional structures (Carrillo-Hermosilla et al. 2010). When comparing the literary and connotative meanings of the OECD definitions of innovation and eco-innovation, the differences are the intended or not environmental impact and the broader socio-cultural regime effect. Many researchers point out the same conclusion, that eco- or sustainable innovations are designed to, or by incident, have larger implications to the socio-technical systems (landscapes and regimes) (Bergh et al., 2011; Carrillo-Hermosilla et al. 2010; Sartorious, 2006).

The discourse on eco- and sustainable innovation also acknowledges nuance differences between the terms and their definitions. Klewitz and Hansen (2014) have conducted a systematic review of sustainability oriented innovation including the background and terminology. They point out that the discussion on firms to create, redesign, adapt, and diffuse environmentally sound technologies already originated on the Bruntland report (WCED, 1987). This led to including the ecological factors to innovation and management research on the 1990's and in 2000's eco-innovation practices such as cleaner production, life cycle assessments, and eco-design found their way into firms. From this initially eco-innovation driven debate evolved a stream of research on *sustainability oriented innovations* (SOI) with a broader focus on environmental, social and, economic dimensions. Klewitz and Hansen (2014) see innovation for sustainability being about relative improvements in comparison to prior and define SOI as "a direction, which to follow requires the deliberate management of economic, social, and ecological aspects so that they become integrated into the design of new products, processes, and organizational structures". Key difference in comparison of the Klewitz and Hanzen formulation and the OECD definition of eco-innovation is deliberateness. A special characteristic of sustainable innovations that they have to fit from a technical or organizational point of view, be economical and contribute to solving sustainability problems (Boons & Lükede-Freund, 2013).

With such all-encompassing definitions to eco-innovation and sustainable innovation, both end to serve the same purpose. For a more generalized approach, I argue based on the premise of the definition of sustainability as a property of socio-technical systems, that due to the complexity of social interactions (and the fundamental uncertainty) that eco- or sustainable innovations represent: *innovations with deliberate ecological and socio technical aspects, that positively influence the sustainability transition.* Since the formulated definition is constructed analogous, and does not argue with the various accepted definitions, we shall apply it for the construction of the framework.

Several typologies from the literature on innovation are relevant to characterize innovations, and to make a clear distinction between new and established technologies. The basic differentiation is done between *incremental* and *radical*, but innovations can also be distinguished in terms of the object of change at either organizational, sectoral, or business systems level, in discrete and complex product architectures (Boone et al., 2013). The radicalness of an innovation is important, though most innovations are incremental by nature (Carrillo-Hermosilla, 2010; Bergh et al. 2011; Sartorius, 2006; Klewitz & Hansen, 2014). Carrillo-Hermosilla (2010) define incremental and radical innovations by that incremental changes refer to gradual and continuous competence-enhancing modifications that preserve existing production systems and sustain the existing networks, creating added value added in the existing system in which innovations are rooted. Radical changes, in contrast, are competence-destroying, discontinuous changes that seek the replacement of existing components or entire systems and the creation of new networks, creating value added.

From the socio-technical perspective, incremental innovations are the continuous improvement of the production processes and established products within the socio-technical regimes by the current actors, and radical innovations are those that are creating new-markets and that are disruptive for both customers, manufacturers and other actors in the existing socio-technical regimes (Boons et al. 2013). (Markard & Truffer, 2008). While regimes usually generate incremental innovations, radical innovations are generated in niches (Geels, 2004). Originally the niche focus was on technical innovations in demonstration or market niches, the focus is now being broadened to consumer niches (e.g. vegetarians) and niches employing new business models (e.g. car sharing and other services) (Boons et al., 2013). Based on the concept off incremental and radical technological change and the degree of impacts to the socio-technical systems, Carrillo-Hermosilla et al. (2010) proposes three approaches to identify the role and impacts of eco-innovations (FIGURE 16).

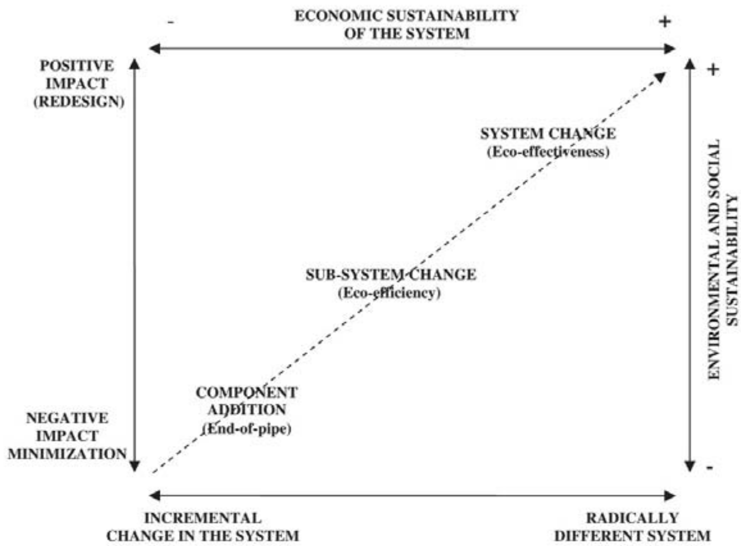


FIGURE 16. Typology of eco-innovations according to incremental/radical nature and the level of system impact (Carrillo-Hermosilla et al. 2010)

The first level in impact/transition typology identified by Carrillo-Hermosilla is component-addition which minimizes and repairs negative impacts without necessarily changing the process and system that generate those impacts in the first place. This type of innovation is incremental by type and has very low level of sustainability impact. Common examples of component addition are e.g. end-of-pipe filters. The second level is sub-system change, which reduces negative impacts by creating more goods and services while using fewer resources and generating less waste and pollution. This level of innovation can be best described as eco-efficiency. Sub-system change is still more an incremental innovation, but it effects sustainability, though it's often erased by subsequent growth. The third level is systems change, in which changes in the system, its sub-systems and components are designed with a view to promote sustainability transition. This approach builds upon the analogy of socio-technical systems and nature. These eco-effective innovations transition sustainability in a radical means, by i.e. shifting production from open systems to closed systems.

Geels & Kemp (2007) describe how radical innovations are introduced, and how innovations transform socio-technical systems. First radical innovations emerge in niches, often outside or on the fringe of the existing regime. There are no stable rules (e.g. dominant design), and actors improvise, and engage in experiments to work out the best design and find out what users want. The networks that carry and support the innovation are small and precarious. The innovations do not (yet) form a threat to the existing regime. In the second phase, the new innovation is used in small market niches, which provide resources for technical development and specialization. The new technology develops a technical trajectory of its own and rules begin to stabilize (e.g. a dominant design). But the innovation still forms no major threat to the regime, because it is used in specialized market niches. New technologies may remain stuck in these niches for a long time (decades), when they face a mismatch with the existing regime and landscape. The third phase is characterized by wider breakthrough of the new technology and competition with established regime, followed by a stabilization and new types of structuring.

As the example by Geels & Kemp above shows, innovations might remain stuck for long times in specialized market niches because they face mismatch with the existing regime and landscape. This is very technology centric view which needs to be extended towards a *business model concept* to link the individual firm (product/service) and the larger production, diffusion and use systems (Boons et al., 2013).

Boons and Lüdeke-Freund (2013) have analyzed from existing literature what are the business models for sustainable innovation. They define four generic models that provide a basic set of normative principles for business models which need to be fulfilled in order to contribute to successful marketing of sustainable innovations.: *Value proposition*, what measurable ecological and/or social value in concert with economic value is embedded in the product/service offered by the firm; *Supply chain*, how are upstream relationships with suppliers structured and managed; *Customer interface*, how are downstream relationships with customers structured and managed; and *Financial model*, costs and benefits from previous models and their distribution across business model stakeholders.

No matter of the business model, sustainable innovation like any other offering, has to be successfully marketed to unfold its sustainability potential, and the underlying business model has to operate according to certain principles to not contradict this potential.

2.3.3 Cleantech

In past decades new innovations that have contributed to eco-efficiency, -effectiveness and sustainability have been commercialized on various markets including *agriculture* and *bio-products, energy efficiency, smart grid* and *energy storage, renewables, transportation, water and waste management, information technology* and *energy efficient appliances*. The market for these 'new technologies' was established by the integrated pollution prevention and control directive IPPC (Directive 2008/1/EC) as an instance of market innovation. The directive heralded the development of a *cleantech* industry that has since attracted growing attention from entrepreneurs, investors and policy makers (Johnson & Suskewicz, 2009). The main innovation brought about by markets for clean technologies lies in the attempt to combine environmental and economic values (Doganova & Karnoe, 2014).

The transition from emerging technologies to new industries is a complex process and the development of a new industry may happen rapidly or it may take several decades. Evolution of a new market is typically modelled as an S-shaped curve over time (FIGURE 17). The rate of adoption begins slowly, speeds up, and eventually slows down. The fundamental assumption behind sigmoid curve is that there is an upper limit to the growth of a technology and the growth pattern follows a logistic path. According to this, each technology undergoes four different phases: learning, growth, saturation, and decline. However, the S-curve may not hold for all industries. For example, in the clean energy sector, the solar energy industry experienced its first boom-and-bust cycle in the early 1980s, only to return to the clean energy cycle almost 20 years later as an interesting investment area. (Balachandra et al. 2010; Teppo, 2006.)

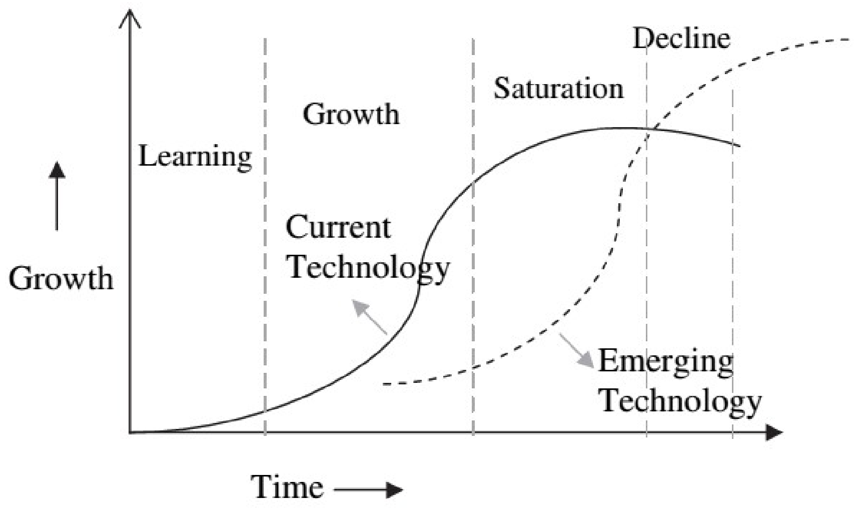


FIGURE 17. S-curve of technology diffusion (Balachandra et a., 2010)

Cleantech, as a term, is not specific to any particular industry, but it is a broader concept that can be applied to various industries (Teppo, 2006). At its' fundament, 'clean' combines the existing 'green' technologies and solutions and integrates them with 'smart' applications. 'Smart' on the other hand is something that has been used ambiguously for any electronic devices or systems that can be connected to the internet, used interactively and that extend some intelligence (e.g. smart phones, -meters, -tv's, -grids, -cities). Kotiranta et al. (2015) have reviewed a number of existing definitions for cleantech and note that the difficulty in providing an explicit definition for cleantech are inherent in its cross-industrial and -technological nature and in the diversity of companies' business lines operating in the value chain. They note that cleantech commonly combines three criteria by definition: It is technologies, products, services, processes, practices and investment classes that promote the sustainable development; and through efficiency gains or entirely novel alternatives it reduces the unsustainable exploitation of natural and societal resources in industry, business and consumption; and finally it provides industries, businesses and consumers with superior value propositions when compared to conventional solutions. In this thesis we will apply a modified definition including a balance of eco-eco and social factors, and also distinguishing between technology and business. In this framework cleantech *refers to technologies, services, and solutions that reduce the ecological impacts caused by human activity, save energy and natural resources, or improve social wellbeing. Cleantech businesses profit by solving ecologic or socio technical challenges with superior value compared to conventional solutions.*

Comparing the selected definition of cleantech with the earlier formulated definition for sustainable innovation, differences like similarities can be identified. The key difference between these two terms is that whereas the latter describes products and processes that transform the socio-technical systems, the former are actors within the system that produce and apply those innovations. In similar both definitions have the deliberate focus on ecological or socio technical problems and innovating (and profiting from) sustainability transition at their core. This allows to hypothesize that cleantech businesses, by definition, are organizations that potentially generate sustainable innovations, of incremental/radical nature, with different levels of socio-technical system impact. So, if innovations are the key drivers of systems transition, cleantech companies are amongst the key actors.

2.4 Role of private equity and public policy

An established financial market, with public and private participants is crucial for a functioning economy. SMEs with innovative technologies in new sectors like cleantech are often young companies with high R&D costs, low operational cash-flow and short financial history. Due to the high risk involved with young, *new-technology based firms* (NTBF), venture capital often plays a significant role in their financing (Bjornali & ellingsen, 2014). Research has also show a clear linkage between venture capital (*private equity*) funding and SME financial success and value added, in terms of employment growth (Croce et al. 2013; Paglia & Harjoto, 2014). These linkages make financial market actors likewise crucial for sustainability transitions. To a degree, the industry itself has also identified the earnings potential in the forward moving sustainability transition as the amount of green bonds and cleantech private equity investments have grown significantly in the 21st century (Worldbank, 2015; Citi, 2015).

2.4.1 Private equity

In several studies private equity, especially venture capital, has been shown important in the market introduction of new technology enterprises and venture development (Chen, 2009; Croce et al., 2013; Paglia & Harjoto, 2014; Teppo, 2006). Venture capital has also been shown empirically to increase company's revenues and employment growth rates in comparison to non-VC backed firms (Paglia & Harjoto, 2014). Bjornali & Ellingsen (2014) conducted a literature review on the factors affecting the development of *cleantech* start-ups. They found *only* 13 articles that were highly relevant in addressing the cleantech enterprises. A key finding in their study, likewise, was the potential positive relationship between VC and enterprise growth. There are only a few studies that have explored VC and investing in cleantech (Teppo, 2006). Thought the role of venture capital finance is not widely studied within the cleantech space, the general results on the effect of venture capital on new technology business firms (NTBF) and general SME success apply (Chen, 2009). Venture capital is typically applied in later stage technology development and scale-up phases (FIGURE 18) when there are more risks involved and the operations are not large enough to seek finance from public equity markets. (Geels, 2012).

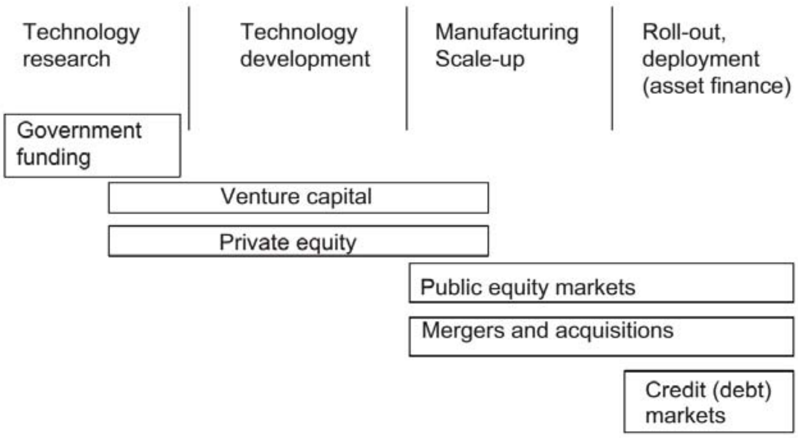


FIGURE 18. Types of finance in different development phases (Geels, 2012)

As a general introduction to the terminology, equity refers to any capital, invested in a company that is not debt. Companies listed on public exchange are considered public equity, whereas non-listed are private equity. In the investment context *Private equity* (PE) refers to risk capital being invested in companies, and *PE investors* are institutions, companies or high-net worth individuals operating with equity that is not listed on the public market. Academic literature and private equity firms recognize four subclasses of PE, namely venture capital (VC), mezzanine/growth capital, distressed and buyouts (Viitala, 2012). The key focus in this thesis is in the *venture capital*, which can be defined as *investment of long-term, risk equity finance by professional investors in new enterprises where the primary reward is eventual capital gain* (Teppo, 2006). Venture capital can be further divided into independent venture capital (IVC), government venture capital (GVC) which has been a common policy initiative in European countries to overcome funding gaps in the promotion of early-stage ventures, and corporate venture capital (CVC), a growing segment which is defined as investment of corporate funds directly in external start-up companies (Luukkonen, et al., 2013; Teppo, 2006). In this thesis when we refer to venture capital, we mean all types of venture capital not separating by source, thought it needs to be noted that all categories have differing weightings on their fundamental investment reasons (i.e. capital gains, employment growth, new market sector generation, technology sourcing, strategic venturing, etc.).

VC is usually organized in the form of limited partnerships, where the operational (fund) managers are called general partners (GP) and the passive investor's limited partners (LP). The typical structuring is a closed-end fund where GPs (i.e. private equity firms), sets up a fund and gathers investments from a variety of sources, provide a minority share of equity, and manage the funds and the funds' portfolio companies. LPs on the other hand provide the majority of equity capital for these funds, don't have managerial control, but are entitled for the majority of the returns. Since VC funds are closed-end funds with finite lives, the investors who commits to a fund cannot draw their funds out until the fund has reached its end. Funds have a clearly recorded focus and investment strategy, as well as defined size of the fund itself, levels of leverage and types of securities, used in investments (
FIGURE 19). (Teppo, 2006; Viitala 2012.)

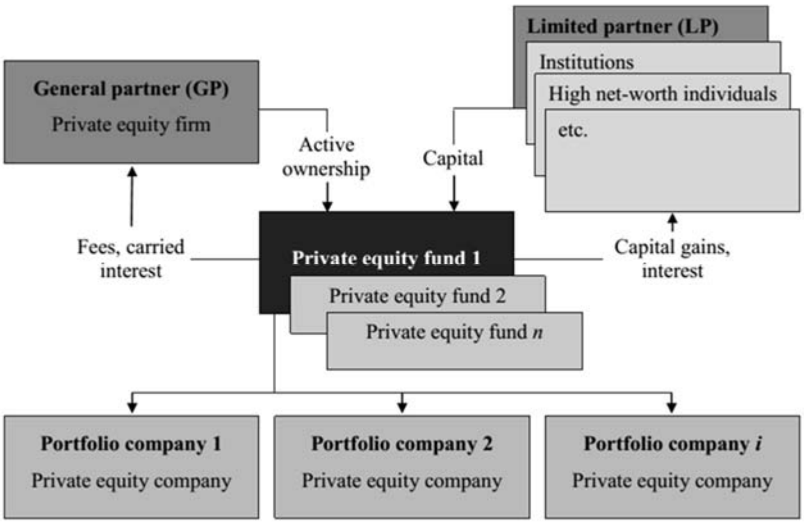


FIGURE 19. Private equity model structure (Viitala, 2012)

In addition to providing resources by means of financial capital to portfolio companies, VCs also take an active role in firm decision-making. This is due to the specific situation of new ventures, which are characterized by high levels of uncertainty and information asymmetries between insiders and outsiders. Therefore, VCs are typically highly specialized in identifying, investing in, and monitoring new firms in a specific sector and at a specific stage of development of a company. (Teppo, 2006). The value-adding activities professional VC investors provide for their portfolio companies include: 'coaching', that is providing them with financial, administrative, marketing, strategy and management support, which is especially lacking in young, innovative firms operating in high-tech industries; fosters the managerial 'professionalization' of young, innovative firms, facilitates access to specialized professional services and establishes alliances with third parties thus extending their social capital; and 'signal the quality' of the portfolio firms to third parties such as customers, alliance partners, skilled workers and other financial intermediaries (Luukkonen et al. 2013). Teppo (2006) also suggest that VC value-adding could be extended to sustainability and quotes O'Rourke (2004) who introduced four strategic levels of sustainable VC: (1) VC investments that target enterprises and technologies that deliver socially, financially, and environmentally sustainable returns and avoid investing in clearly unsustainable practices; (2) VC practices that guide companies in adding value but prevent the potential negative environmental and social impacts of new ventures; (3) VC work that aims to develop market and stakeholder support for sustainable products and services; and (4) VC activity that generates financially, socially, and environmentally sustainable rates of return on investment. (Croce et al., 2013; Paglia & Harjoto, 2014; Viitala, 2012).

In relation to socio-technical systems and sustainability transitions, the hypothesis is that VC plays a significant role. Transition is, above all, a challenge about investment. Which projects receive funding is a major question which can strongly influence the direction of change (Antal & Bergh, 2013). Addition to the resource (capital) directing function, VC functions as an actor in the ST-regime with constant interaction and linkages to other socio-technical regimes and niche actors. VC provides both access to established regimes and other niche actors, and also importantly access to their networks. As the functioning of socio-technical systems happens in the linkages and interaction between the various layers and actors, the VC role can be understood if not critical, beneficial. Also the capability of VCs to operate with uncertainty and information asymmetries and specialization in identifying, investing in, and monitoring new firms in a specific sector (Teppo, 2006) suggest that they are able to identify and develop potential technological trajectories from the niches to the regime and landscape.

A number of research on the process and criteria used by PE to make their investment decisions have been conducted (Hatton & Moorehead, 1997; Macmillan et al., 1985; Teppo, 2006; Tyebjee & Bruno, 1984; Zacharakis & Meyer, 1998). Much of the process and criteria research is based on the original work by Tyebjee and Bruno (1984). The publication presents the venture capitalist decision-making as a process consisting of five steps: deal origination; deal screening; deal structuring; deal evaluation; and post-investment activities. And identifies as five key criteria used in deal evaluation: entrepreneur's personality; entrepreneurs experience; characteristics of the product/service; characteristics of the market; and financial considerations. These decision criteria have been extended in other studies to also account for environment threats (Hatton & Moorehead, 1997). Teppo (2006) points out that number of researchers have expressed their doubt on the accuracy of describing the venture capitalist decision-making process as a flow of logical steps, because venture capitalists are as different from each other as are individuals. More recent policy capturing studies (Zacharakis & Meyer, 1998) have tested whether VC actually understand their decision process and concluded that they do not necessarily understand how they make their decision, but that they are very consistent in their decision-making process.

2.4.2 Policy and regulation

Lastly, one particularity of sustainability transitions is that guidance and governance often play a particular role (Smith et al., 2005) which leads to government and institutions being key actors in sustainability transitions. Economic studies show that the major part of reduction of emissions in the coming decades is unlikely to come from technological innovation but instead from environmental regulation that changes decisions about inputs and outputs by producers and consumers, which will alter the sector and demand structure of the economy (Jorgenson et al., 2009; Popp, 2001). These changes in behavior will of course involve changes in technology, but through new application of already existing technologies rather than innovation trajectories which generate new technologies (Markard et al., 2012).

Building on an improved understanding of socio-technical change processes, there is a growing interest in how policy initiatives can support transitions (Kern, 2012). Most scholars agree that policy and regulation play a particular role for sustainability transitions (Smith et al., 2005). According to the idea of managing or at least orchestrating transition processes, transition theory has been considered a form of reflexive governance; and as such, it is often described as a necessary development in response to the complexity of societal regulation and the limited resources and knowledge of government (Jorgensen, 2012).

Cleantech, though not a specific industry sector, is not immune to the adverse effect of the lack of policy and regulations on the pace of technology development and deployment (Erzurumlu, 2013). Policy and regulation are commonly formulated in the socio-technical policy regimes and identified as key stabilizing structures of the system. They form the regulative dimension of the socio-technical systems through e.g. government regulations which structure the economic processes at the national level (e.g. property rights, contracts, patent laws, tax structures, trade laws, legal systems). There are also normative and cognitive levels of policy and regulation such as policy goals, commitments and problem agendas. Governmental policies are slow in diffusion and often take years before they have substantial effects at the level of systems. (Geels, 2014). Key actors within the policy regime are: public and private organizations providing statistics, research, standards, norms and their verification; interest groups with influence; different level political organizations e.g. on city, municipality, national, and international; and multinational organizations such as OECD, IMF or UN. For the context of this thesis the focus will be mainly at the national governmental and public organization level.

Many policy theories assume governments to be exogenous to the economy and society, however, transitions thinking can gain explanatory power by regarding governments as players in the system (Gazheli et al., 2015). Gazheli et al. (2015) approached transition studies, especially the policy context, by implementing theories of bounded rationality, social interaction and learning. According to them governments are bounded rationally in the sense that they do not realize the full outcomes before they are actualized. Deviations from the rational goal of welfare maximization can be attributed to the bounded rationality of individuals in the government or the structure of governments that creates conflicts between collective and individual goals. Decisions of policy makers, supposedly serving governmental or social purposes, are not necessarily more rational than decisions of consumers or private companies.

A key result of Gazheli et al. (2015) is the three-part level division of potential transition policies (TABLE 4). The policies have been divided to niche, regime and landscape levels, and the stakeholders identified are belong to both the production and use sub functions of the socio-technical systems. The first set of policies in the table is aimed to support innovative niches. These measures try to create a network between producers, innovators, investors and the financial sector in order to help innovators get access to credit, for example. Other policies, which focus on the niche level, are those designed to stimulate local experiments and elevate these to a national level. Finally, measures that are on the border between the niche and regime level are policies stimulating escape from existing lock-in of regime-related technologies or practices. At the regime level we classify policies supporting the expansion of a whole sector, such as subsidies in favor of renewable energy options, which have a major effect on all the stakeholders. The last types of policies at a regime level treated are those supporting the development of a sector by pricing pollutants, for example CO2. Measures at the landscape level can be the promotion of civic debate. Consumers are affected since they are involved in the civic debate and producers because the measures may affect the way they produce or test their products. Another type of measure at a landscape level are policies creating informed debate – such as public participation in policy development – through mechanisms like meetings and round tables. Involving citizens in policy design may positively influence the likelihood of a sustainability transition.

TABLE 4. Transition policies in a multi-level perspective framework and stakeholders affected (Gizhali, 2015)

Level	Policy measure	Example	Consumers	Innovators	Producers	Investors	Financial Sector
Niche	Policies supporting niches	Grants for conversion to organic farming		X			
	Support for the creation of niche networks between various stakeholders	Fostering communication between stakeholders, fostering access to credit		X		X	X
	Stimulation of local experiments	Public co-funding of bottom-up initiatives		X		X	X
	Policies to escape lock-in	Reforming fossil fuel subsidies, setting strict long term environmental goals, creating infrastructure conditions for new technologies		X	X		
Regime	Support for the expansion of a sector through subsidies or price guarantees	Feed-in tariffs for renewable electricity	X	X	X	X	X
	Policies limiting the power of regimes	Limiting size of firms, no privileges or more frequent contacts with particular firms or representative organizations, transparency of lobbying processes		X	X		
	Promotion of technical or resource diversity	Public R&D investments and subsidizing private R&D		X	X		
	Regulating dirty activities	Pollution taxes or tradable permits, command-and-control of pollutive technologies and products	X	X	X	X	X
Landscape	Promotion of civic debate	Public participation in policy development (round tables).	X		X		
	Information provision	Informative campaigns for consumer behavior	X	X	X		
	Creation of informed debate	Supporting public participation in setting the policy agenda	X		X		
	Developing policy integration (technology, environment, consumers)	Making one ministry responsible for coordinating all initiatives and policies concerning long term sustainability transition	X	X	X		

As long as the regulatory framework reduces economic uncertainties, the innovation and adoption of sustainable technologies will be accelerated (Erzurumlu, 2013). Governance might for example set long-term goals that inform the direction of the targeted transition (Markard et al., 2012).

2.5 Conceptual framework of the study

As a conclusion and aggregate of the theoretical framework this chapter conceptualizes and defines the key concepts as definitions to be applied in this study. The conceptual framework presented in FIGURE 20 represents the structuration of the framework. The general theoretical structure is built upon the multi-layer framework, which serves as a hierarchical structure for analyzing socio technical systems. It should be noted, though the discourse is of sustainability, that the applied socio technical systems model does not withhold the ecosystems model. This is due to the selected perspective of the study and the complexity of including the human-nature interactions in a qualitative framework. Within context, the framework is used to model a transition process from the present state of affairs, towards a future of increased well-being. Sustainability in this framework is seen as a property of the system and sustainable development as a guided process towards increased well-being and systemic resilience. The presumptions are that sustainable development is a landscape force causing pressure on the regime and influencing changes in the respective institutions. At the same time these pressures facilitate development of niches within cleantech industry, which if favourable conditions exist in the mid-term, have the potential to break into the mainstream regime and eventually effect the landscape structures. The sustainable future is only a snapshot, not an ultimate goal, as within the framework sustainable development is an evolving concept – a moving target.

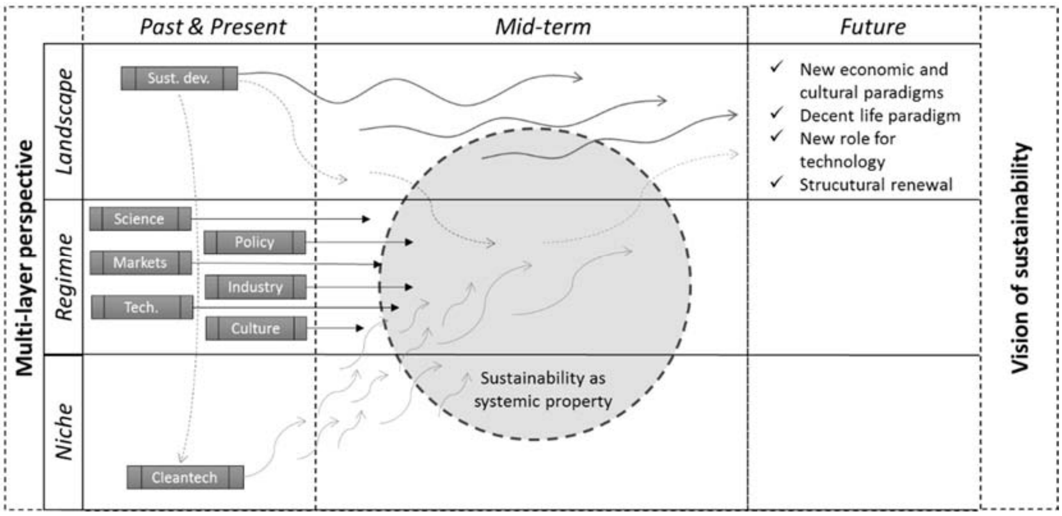


FIGURE 20. Conceptual framework of the research

Summary and definitions for the key concepts and terms applied in this thesis are listed below.

i. **Sustainability** *is a property of our socio-technical system as a whole to make agile responses to emerging pressures with reference to the systems state and capability, and to allow for the implementation of the most promising long term sustainable alternative*

ii. **Sustainable development** *is the continuum of ecological- and socio technical systems where the guided focus is towards providing equal wellbeing to all within the global biophysical boundaries, now and in the future, while increasing the systems resilience.*

iii. **Decent life** *is an interlinking concept that pins out the individual level implications on well-being of the more complex systems level causes and effects of sustainable development.*

iv. **Socio technical systems** *model the production, diffusion and use of technology in society as an outcome of the activities of social actors, elements necessary to fulfil these activities and constrains enforced by rules and institutions.*

v. **Multi layer perspective** *is a framework of nested hierarchy to explain the emergence and generation of transition pathways in socio technical systems. The macro-level of the framework 'landscape' consists of slow changing external factors, meso-level 'regimes' accounts for stability of existing system and micro-level 'niches' account for the generation and development of (radical) innovations.*

vi. **Sustainability transitions** *are processes where large socio technical system like energy, food or transportation, consisting of a broad range of actors, institutions, artefacts and knowledge, shift (over considerable time-spans) to more sustainable modes of production, diffusion and consumption.*

vii. **Transition management** *is a reflexive governance approach to guide the gradual, continuous process of sustainability transitions to a presupposed desired future (SD) by facilitating policies, governance structures and institutions necessary for this future with less inherent uncertainty and enhanced resilience.*

viii. **Backcasting** *It is a normative approach to foresight using desirable or so-called alternative futures, instead of likely or possible futures. It is applied by generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved.*

ix. **Eco-innovations** *represent innovations with deliberate ecological and socio technical aspects that positively influence the sustainability transition.*

x. **Cleantech** *refers to technologies, services, and solutions that reduce the ecological impacts caused by human activity, save energy and natural resources, or improve social wellbeing. <u>Cleantech businesses</u> profit by solving ecologic or socio technical challenges with superior value compared to conventional solutions.*

xi. **Business** *is a group of people and resources to achieve a specific goal.*

xii. **Business model** *is a plan, which specify how a new venture can become profitable.*

xiii. **Venturing** *is an organizational innovation commercialization process, that is continuously shaped by action, social interaction and learning.*

xiv. **Venture capital** *refers to investment of long-term, risk equity finance by professional investors in new businesses where the primary reward is eventual capital gain*

3 METHODOLOGY

The aim of this research is to integrate and narrow the question of sustainability transitions to individual industry level and ask the question that *how can a single industry help achieve the desired transition*. To do this, the theoretical framework was constructed to describe not only the theories, but also the ethical considerations of sustainable development and the emerging narratives which (in the authors view) make the selected actor potentially critical for such transitions. To discuss of ethics (ie. in relation to sustainability), one is always subjective and expresses individual values. Also when selecting desired narratives, -economic paradigms and pre-assuming critical actors one does this on the basis of inner perception (or wish). Sustainability science is by no means value ridden. It is a theoretical and applied transdisciplinary field that requires making assumptions to test '*what works best*' for finding the relevant answers. Due to this transdisciplinary nature of the research, the expansive theoretical framework and the value based choices also impose an effect on the research methods.

The following chapters are constructed to first describe the research paradigm and methodological choices employed in this thesis, and second to present the analytical methods applied.

3.1 Research methods

3.1.1 Paradigm

In transdisciplinary research, with a subjective and interpretive focus, objective and deterministic epistemologies provide limited approach on production and use of knowledge. Many researchers, especially in transdisciplinary research and sustainability science have found that constructionism and pragmatism provide apt epistemologies in such instances (Hirvilammi, 2015; Popa, 2015). Constructionism and especially social constructionism assume that reality is subjective and that all individuals construct their own or shared interpretation of it (Eriksson & Kovalainen, 2008). Ontologically this leads to reality being socially constructed between the actions and interactions of individuals, which constructionism assumes science can undercover. Pragmatism accepts that reality is subjective as constructionism, but at the same time acknowledges that there is a reality outside of our own social construct which can be solved by combining inductive and deductive thinking, measuring, observing and developing new meanings (Grimstad, 2008; Hirvilammi, 2015). Whereas social constructivists understand that knowledge is shaped by social dynamics, discourse and power relations, pragmatism conceives knowledge production as a continuous social process where credibility and legitimacy are defined within a community (Popa, 2015). Both paradigms have somewhat aligned epistemologies. The epistemological difference is that constructionism will try to uncover meaning from data, whereas pragmatists collect data in order to find solutions and solve problems (Grimstad, 2008).

The ontology in pragmatism is based on an interactive model, where the analytical results of 'how things really are and work' give clues of new or enhanced conceptions and definitions, leading to theories being 'analytical'. Similarly these new conceptions and definitions can *vice versa* guide new observations and actions, leading to analysis being 'theoretical'. This leads the research methodologies of pragmatism to be more real world problem oriented, whereas constructionism is more theory oriented. In terms of methodologies, both paradigms use quantitative and qualitative data, but pragmatism is more open to using mixed methods and research triangulation. Pragmatism also distances itself from both value neutrality and value relativism acknowledging that science is always rooted on certain values and choices done by the researcher. It does also not distinguish between logical analyses, empirical observations or the researchers own actions. (Grimstad, 2008; Hirvilammi, 2015).

The aim of the research, the theoretical framework, and the methodology and methods suggest that pragmatist paradigm provides the most suitable epistemological and ontological framework for this study. It allows for the researcher to construct a value based ontology which can then interactively be modified together with the analysis to form a more holistic description of, and generate a potential answer, to the real life question. This epistemology also allows for the use of the researchers own logical analyses and empirical observations as sources of knowledge, with the understanding that their validity and legitimacy is ultimately only accepted through community discourse.

3.1.2 Methodology

The methodology is selected to describe the socio technical environment, and the role and roadmap of a single industry influencing the long-term sustainability transition. The data used for analysis is compiled of public access information, both qualitative and quantitative at nature. The data includes information on the past developments, present situation, and long-term future expectations (visions). The focus of analysis is in the mid-term (0-35 years), where the gab is accordingly, and where the transition needs to occur. To allow for constructing a coherent description, a combinatory method for aggregating the theoretical framework, existing background data and the expected results into an independent narrative needs to be used. The chronological structure of this narrative is shown in FIGURE 21. Two typical streams of methodological approached have been identified in the relevant literature, namely transition studies, case studies and scenario analyses.

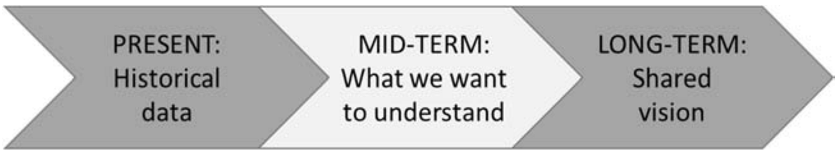


FIGURE 21. Chronological structure of the narrative in the methodology

Typical methods for addressing and analysing change in transition studies are *strategic niche management, transition management* and *socio technical scenario tool.* These methods have a wide range of applications and are well documented in the respective literature. All of the method are thought forecasting and policy guiding by nature. Strategic niche management is a process orientated approach with a focus on experimenting and learning in the niche level. Transition management is concerned with the dynamics of structural change in society, and when and how transformation can be initiated, facilitated, and shaped. The socio technical scenario tool describes possible future developments in terms of the multi-level interactions making use of historical research on transitions with regard to identified patterns and mechanisms. (Bergh et al., 2011; Robertson, 2015; Markard et al., 2012).

Case studies are a widely used research method especially in economics, and have a long background in qualitative tradition. Eriksson and Kovalainen (2008) define case studies as empirical inquiries that investigate contemporary phenomenon within real-life context. This type of research method allows for the researcher to gain (and convey in pragmatist manner) in-depth holistic knowledge of the subject being studied. Case studies are well suited to research problems which are context and actor bound by nature and cannot be generalized. This study has a high degree of such structuration, but the descriptions and causes of underlying concepts and phenomena can have some transferability. This suggests that the specific case approach can be classified as descriptive and explanatory. Descriptive case studies aim at describing concepts, processes and phenomena, while explanatory studies aim in examining and explaining causality or consequences of those concepts, processes and phenomena (Eriksson and Kovalainen, 2008).

Many researchers have also applied methods from future studies to sustainability issues, which has a vast array of approaches to similar problems (for references see e.g. Vergrat, 2011; Vangel, 2011). One of the most basic future studies methods is *scenario,* which can denote both descriptions of possible future states and descriptions of developments. One of the (today) most popularized application of this method in sustainable development context are the climate change forecasting scenarios by the International Panel on Climate Change (IPCC), predicting what could happen if the global average temperature would rise to different levels. There is no uniform classification of scenarios, but an emerging categorization (see e.g. Börjeson, 2006) in the relevant literature is done between *predictive*, *explorative* and *normative* scenarios, answering respectively to principal questions of '*what will happen?*', '*what can happen?*' and '*how can a specific target be reached?*'. The two former are forecasting by nature, and the latter backcasting. The forecasting scenarios accept the *status quo* and ask what will happen in the future if nothing (or something internal/external) changes. The backcasting scenarios typically ask, starting from the endpoint (vision), that '*what needs to change (now or during the process) to reach the target?*'. (Börjeson, 2006; Vergrat, 2011).

In conclusion, when the present and the endpoint (vision) in our research are fixed, and we want to understand and describe the mid-term scenarios fulfilling these targets, and identify actions that can be taken to actualize the vision, transforming normative scenario is best suited. The conceptual model of the selected research paradigm, theoretical framework and research methodology are illustrated in FIGURE 22. The figure illustrates how the framework consists of the key theories, concepts and descriptions crucial to discussing the topic, which in the methodology are integrated to allow for formulation of a normative scenario analysis. The methodological choices are somewhat experimental, since no precisely similar approaches were found applied in the literature reviews. This is partly due to the pragmatist paradigm applied on the transdisciplinary topic and the young nature of the research field, but more-so due to the setting of the research question in the MLP framework and the corresponding source data.

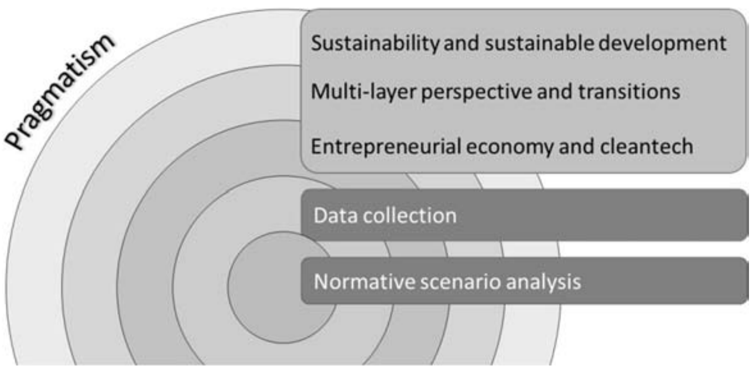


FIGURE 22. Conceptual model of the research methodology

3.1.3 Data sources

The theoretical framework provides an integral part of this thesis as it outlines and defines the concepts, theories and processes, as well as brings visible the authors own values related to the topics. The framework was constructed primarily by using peer reviewed academic journals. In some instances research and policy publications from international sources (OECD, UNDP, WorldBank, etc.) or think tanks (SITRA, etc.) have been used to bring forth also the 'real world' politicized view, which is more opaque than the purely scientific approach. Interestingly, the approaches by the scientific, policy and market institutions were mainly congruent. A good example of this alignment was the emergent discourse on the social aspects of sustainable development in the context of decent life (or well-being).

Whereas the theoretical framework is built upon widely accepted discourse the on the ethical, political, scientific and socio technical concepts, theories and processes involved in the study, the data sources used in describing the socio technical environment of the case and analysis are more policy and target oriented. Majority of the sources used for research data were governmental policy publications (laws, strategies, policy guidelines), national government related institute reports (ETLA, SITRA, TEM), on-line databases (Tilastokeskus, OECD, Pääministerin kanslia), doctoral dissertations and masters theses (with primary data), news, newspapers and online articles. In addition the researchers own knowledge and views of the respective topics and industry was applied to deduct possible flaws in the reported data or induct potential connections between topics that were not reported in public sources.

This study does not conduct primary empirical research, but follows the pragmatic paradigm 'from theory - to application - to theory' approach to data collection. This allows new ontological considerations to be synthesized in the epistemological discussion, which can then potentially open new paths of analysis. The problem arising from such an approach, not pre-limiting the data, is expansiveness of the knowledge. To not go too in-depth to the topics, the study provide references (and uses footnotes) to allow for follow up the discussion.

3.2 Analytical methods

The analytical methods applied for the data include, as described in the methodology chapter, a normative scenario analysis. The following chapter describes the fundaments of this analytical method and its use in sustainability research.

3.2.1 Scenario analysis

Futures studies is a transdisciplinary applied field research that consist of a vast range techniques used to gain insights into what the future may look like (Allwood et al. 2008; Börjeson et al. 2006). Pesonen et al. (2000) provides a glossary of definitions of such futures research methods, including scenario analysis and normative methods. There is no universal definition of scenario (Allwood et al. 2008), but according to Pesonen et al. (2000) the term refers to the setting of frame conditions or a description of the system to be modelled, and to either describing a snapshot in time or to a future developments.

The scenario typology applied in this thesis is originally presented by Börjeson et al. (2006), who introduced a framework for classifying scenario approaches based on the user's need to know *what will happen*, *what can happen*, and/or *how a predefined target can be achieved.* The scenario classification, methodologies, time frames and system structures are presented in more detail in TABLE 5. As explained earlier, the normative methods differ from traditional forecasting methods by having a different 'point of origin'. Whereas forecasting describes the present and develops future narratives based on this, normative scenarios develop a vision and 'backcast' the roadmap to the present. A good illustration (FIGURE 23) of the difference between forecasting and backcasting scenarios is given by Gaziolusyou et al. (2013). The illustration shows that when the point of origin for the analysis is in present, there is a '*sustainability gap*' in the future, and when the point of origin is in the future, there is a '*reality gap*' in the present. The research (*ibis*) also presents a very interesting approach to increasing accuracy of the modelling by suggesting a *double flow model* where both front- and backcasting are applied at the same time. In an iterative modelling process this would undoubtedly provide an interesting approach, whereas the outputs of one model could be used as inputs for the other, allowing to construct a non-linear optimization process.

TABLE 5. Summary of key aspects of scenario types (Börjeson, 2006)

Scenario category/type	Quantitative/qualitative	Time-frame	System structure	Focus on internal or external factors
PREDICTIVE—what will happen?				
Forecasts	Typically quantitative, sometimes qualitative	Often short	Typically one	Typically external
What-if	Typically quantitative, sometimes qualitative	Often short	One to several	External and, possibly, internal
EXPLORATIVE—what can happen?				
External	Typically qualitative, quantitatively possible	Often long	Often several	External
Strategic	Qualitative and quantitative	Often long	Often several	Internal under influence of the external
NORMATIVE—how can a certain target be reached?				
Preserving	Typically quantitative	Often long	One	Both external and internal
Transforming	Typically qualitative with quantitative elements	Often very long	Changing, can be several	Not applicable

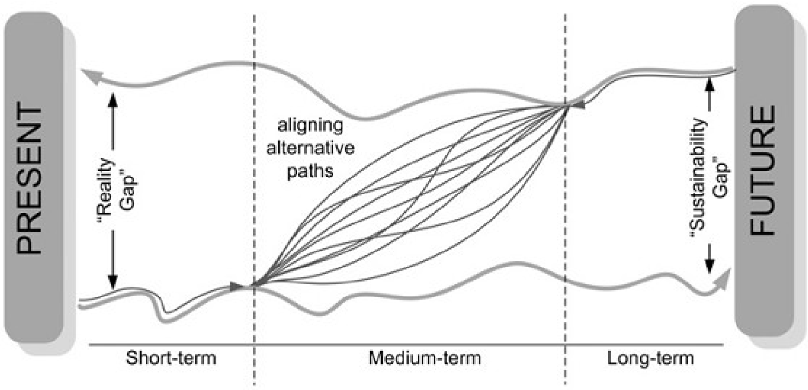


FIGURE 23. The 'reality gap' and 'sustainability gap' in fore- and backcasting (Gazioluzyou et al. 2013)

The typical structure of scenario development varies very much in the literature, and is related to the type of data applied. Pesonen et al. (2000) describe the development of qualitative scenarios with three stages: (1) *preparation*, where the scenario environment is defined and the key driving forces listed; (2) *development*, where key measures (e.g. economics, legislation) and event (e.g. technologies, crises) are defined; and (3) *reporting,* where the best documentation is in most cases a simple set of charts and narratives. This approach is elaborated by e.g. Börjeson et al. (2006), who points out that an integral element of scenarios is modelling, especially numerical. This is very much due to the typical question framing, e.g. '*how many Celsius will the global temperature rise if the CO_2 concentration continues to increase?*' or '*how much can we save on energy/raw materials/costs/… if we do x/y/z?*' This leads Börjeson et al. (2006) to define that quantitative scenario generation consist of (1) *generation* of ideas and gathering of data; (2) *integration* where parts are combined into wholes; and (3) *consistency* checking of the scenarios. Robertson (2015) in his article presents a four step framework built upon the multi-layer perspective for a qualitative-quantitive mixed data approach. It consists of (1) *framing* of long-term societal goals and associated targets; (2) *baselining* the current situation in relation to the societal goal; (3) *visioning* the future and transition seed identification and (4) *analysing* scenarios, strategies and transition policy recommendations.

3.2.2 Backcasting

The origin of backcasting (ie. normative scenario analysis) is in the 1970's when it was proposed as an alternative planning technique for electricity supply and demand. It was later in 1990's also applied to sustainability planning and to sustainable organizations. The focus of the early energy backcasting was on analysis and deriving policy goals, which was from early on expanded to account also for wider environmental and social responsibilities. (Quist 2006, 2009). Backcasting literally means looking back from the future. It can be defined according to Vergragt et al. (2011) as "generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved”. Backcasting is not an unambiguous concept, but has various different applications and methods. Wengel (2011) notes that the key differences are the (1) *relative emphasis on whether the image of the future needs to be developed as goal-fulfilling or not*; (2) *whether it is seen as crucial or optional to outline pathways of transition*; or (3) *whether this is something that should be avoided altogether*; (4) *whether the scenarios are developed mainly by experts or through stakeholder or citizen participation*; and (5) *the degree of participation in the backcasting study*. Based on these differences Wengel (2011) continues to outline a typology of backcasting methods (1) *target-oriented*, which focuses on developing and analysing target-fulfilling scenarios; (2) *pathway-oriented*, in which setting strict goals is considered less important and the focus is on change; (3) *action-oriented*, in which the main objective is to develop an action agenda, strategy or action plan; and (4) *participation oriented*, in which backcasting is used as a creative workshop tool. Quist (2009) notes that several types of backcasting methods can be combined within a single backcasting study and that the variety is even larger, as the term backcasting is both used for an overall approach, for a specific backwards-looking step, and a tool within a methodology.

A typical time horizon in many backcasting studies is 50 years, because it is both realistic and far enough away to allow major transitions to occur in technologies, lifestyles, and even cultural norms and values (Vergrat, 2011). In terms of sustainability and sustainable development, an integral characteristics is their systemic multidimensionality. Backcasting scenarios recognize the systemic nature of the challenges ahead, and often assume that systemic societal transitions are necessary in order to achieve desirable futures (Vergrat, 2011). According to the definitions (in the theoretical framework), sustainability and sustainable development should be seen as ‘moving targets’ which cannot be fully elaborated as they change and evolve through time. This imposes the fundamental uncertainty to backcasting analysis, likewise in all long-term, complex systems analysis.

The type of the backcasting analysis applied in this research is in the tradition of pathway- and action-oriented analysis. The specific process for the analysis follows the general scenario development structure outlined previously, but also takes example of Robertson (2015), Quist et al. (2009), Gaziolusyou (2013) and Allwood et al. (2008). The scenario process (illustrated in

FIGURE 24) includes (1) *baseline*, in which the scenario environment, concepts and key driving forces are listed and described in relation to the current situation; (2) *visioning*, in which the societal goals and targets are envisioned; (3) *backcasting*, in which the baseline is integrated to the vision by developing qualitative scenarios; and (4) *roadmapping*, in which the identified transition seeds, pathways and obstacles from the scenarios are transformed into a roadmap.

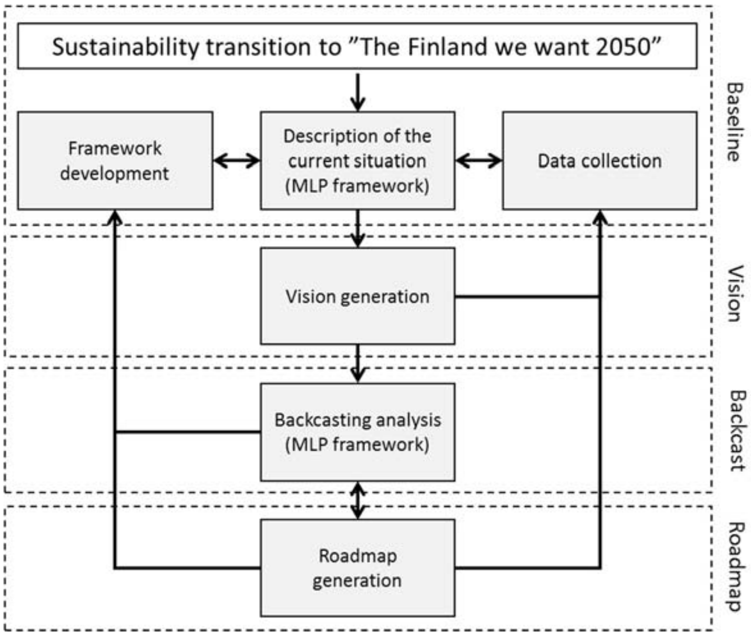


FIGURE 24. Analytical framework for the study

3.3 Reliability and validity

In this chapter both reliability and validity are addressed. Reliability refers to the ability to generate results that are aligned with the methodological choices of the research and validity to the consistency and applicability of the research methods in terms of accurately depicting the research subject (Hirsjärvi et al. 2001).

To ensure reliability, the research has attempted to explain the reasoning behind all assumptions and selections. This rigor includes also the ethical considerations within the topic of sustainable development. Though the overarching purpose is to minimize the impact of the researchers' independent view on the research subject, it has been difficult at times. Clearly the researcher's interests have affected the framing of the research, ethical considerations and selection of the data. Interestingly, the approaches by the scientific, policy and market institutions were mainly congruent, and also very much aligned with the researches personal views (is this a reason for selecting the data, or a result of the data?). Also within the selected data, especially within the analysis section, much of the data is gathered and compiled by government linked research institutes which are not forced to go through scientific rigor or community review. It is therefore probable that (also) these sources include some intrinsic agendas not obviously visible. However, the researcher has aimed for integrity and diligence in the analysis, to gain an aligned and truthful impression of the process and the results.

The validity of the research is more difficult to predict. According to the pragmatic tradition the researcher has selected methods that 'best fit' the framework and data. Though the research has tried to explain the wider perspective of the methodology and the rationale for methodological choices, I do admit that I am no expert on any of these analytical fields. The best way to assess the validity of this research will be through discussions and community reviews.

4 ANALYSIS

This chapter consist of the scenario analysis. It is structured to first describe the vision, then present the baseline situation and conclude in the roadmap illustrating and discussing the main findings of the backcasting analysis. The vision for a future of well-being is based the existing national Finnish sustainability strategy *The Finland we want by 2050* (ME, 2013), and elaborated by various industry specific strategies, discussion papers and the theoretical formulations of sustainability, sustainable development and decent life as defined in the theoretical formulations of this thesis. Also the scope of backcasting analysis is further defined according to the conceptual framework, to limit the baseline analysis.

The baseline for Finland in relation to sustainable development and decent life presents a qualitative and quantitative review of the *status quo*. It draws insight from the international benchmarks by OECD *Better Life* and SSI Foundations *Sustainable Society Index*. The purpose of this benchmarking is to understand Finland's strengths and weaknesses within the landscape level sustainable development paradigm and individual level paradigm of decent life. These benchmarks are then linked to the global and local developments supporting the sustainability transition, and to entrepreneurship, innovation and venture development by the cleantech sector acting as enablers in the transition.

The baseline analysis also describes and quantifies the relevant resources and capabilities Finland possesses. This includes the macroeconomic capabilities such as population, employment, education and industrial structure and the main actors, namely cleantech, as developer of sustainable innovators and independent- and governmental venture finance institutions enabling R&D and venture commercialization. The chapter concludes on presenting a roadmap of the result from the backcasting exercise. The roadmap is reported in a chart and discussed.

4.1 Vision: The Finland we want by 2050

4.1.1 Background of sustainable development policies in Finland

Finland has a long history of working towards environmental protection and sustainable development. Most active periods were in the change of 1970's and 1980's, which have been described to as the 'blooming era of the environmental movement'[28]. In 1987 a national *Environment and Development Committee* was formed with the aim of answering the challenges introduced in the Bruntland (WCED, 1987) report. In 1990, the government of the time prepared a memorandum for the parliament entitled *Sustainable Development and Finland* which was founded on the proposals submitted by the recently appointed committee and conclusions gathered from the first national multi-stakeholder environmental summit held in 1990 at Haikko[29]. After the Rio Summit in 1992, the Finnish environmental and sustainable development politics were also mainstreamed. In 1993 the *Finnish National Commission on Sustainable Development* was formed, which had the aim of providing political guidance for the execution of the Rio agenda and decisions. Finland joining the European Union in 1995 extended the international policy alignment also to environment and development issues. Following this period for nearly ten years the issues were not in the main scope of politics in Finland. In 2006 major reformations of both the EU and the Finnish national sustainable development strategy were published. The Finnish strategy was soon reviewed (in 2009), and partly due to the identified lacking execution, the formulation of a new strategy was initiated soon afterwards. In 2013 a new strategy was published, which was founded on 'societal commitment' model presented in the 2011 published *German Advisory Council on Global Change* flagship report *World in Transition – A Social Contract for Sustainability*. (Rouhinen, 2014).

The current Finnish sustainable development strategy is entitled *The Finland we want by 2050.* A good illustration of strategy is given by Sauli Rouhinen, who has recently published his doctoral dissertation (Rouhinen, 2014) on the topic of *On the Path Towards a Model Country? How Sustainable Development Took Root in Finland*. Rouhinen has been working for decades in the policy institutions related to the environment and development issues in the Finnish government and also acted as the Secretary General of the Finnish National Commission on Sustainable Development during the formulation and launch of the strategy. His (Rouhinen, 2014b) mind map illustration of the context and scope of the sustainability strategy presented in

FIGURE 25 shows how the strategy has a twofold approach: (1) *to clarify the idea of sustainable development and strengthen the policy coherence*, and (2) *to provide a political and implementation framework for executing sustainability driven initiatives*. (Rouhinen, 2014).

---

28 This period was described by the rise of social participation and environmental movements, ie. the Koijärvi-movement in 1979 which members were influential in the formation of Ministry of Environment in Finland in 1983 and in the formation of the Green Party in 1988.

29 "Aika on kypsä" environmental summit was held in Haikon Kartano 8.81990 with over 130 participants from the government, industry, science, unions, church, etc.

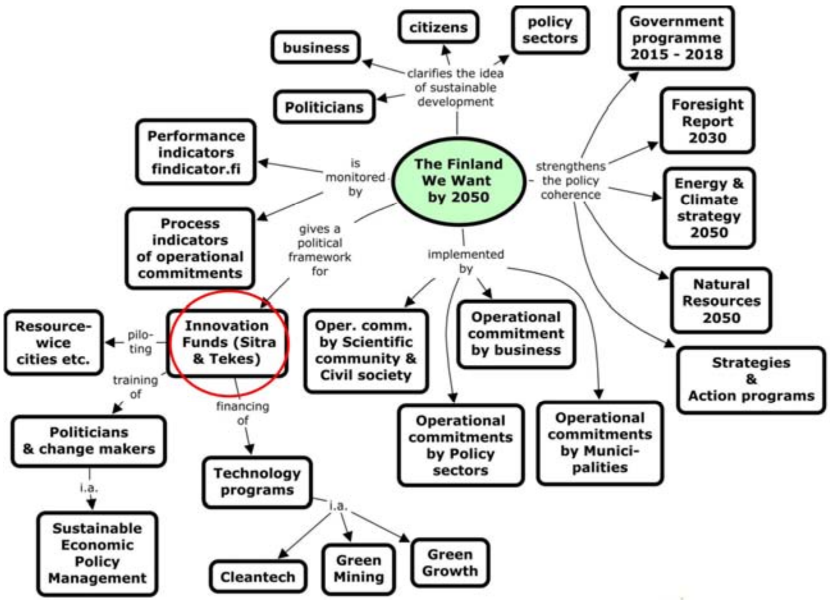


FIGURE 25. Mind map on the context and scope of the Finland we want by 2050 sustainability strategy (Rouhinen, 2014b)

The strategy reflects a transgovernance process, which is driven by long term vision generation where the scope of visioning is in the trans-generational future of 2050's, but the implementation is focusing on operational commitments and niche support from dominant regime actors with a 5+ year results framing. The new aspect in comparison to the past governance approach is the significantly longer term orientation. This allows for setting more visionary targets and formulations of the necessary transitions for a sustainable future to materialize, while justifying present investments for future landscape and regime structures in favor of existing (Rouhinen, 2014). The hindsight of the strategy framework is that whereas it boldly envisions a sustainable future and encourages regime transitions, it begins building niche support atop exinsting technology programs and policy structures. By building atop existing the niche generation and structuring programs can be initiated faster, but the risk of losing potential innovation trajectories due to existing regime dependencies and potential lock-ins is higher.

4.1.2 A breakdown of the present sustainable development strategy

Looking in-depth on the present strategy, it's built upon a vision that states (YM, 2013): "*in 2050, every person in Finland will be a valuable member of society. Finland will be an affluent society that lays the foundation for sustainability and provides its citizens, communities and companies with the conditions they need to operate sustainably. The carrying capacity of nature is not exceeded and natural resources are used in a sustainable manner. Finland will promote peace, equality and justice, and offer practical and sustainable solutions to the world's problems.*" The elaboration of this vision is structured by focusing on eight thematic objectives, namely (1) *equal prospects for well-being*; (2) *a participatory society for citizens;* (3)

sustainable work; (4) *sustainable local communities;* (5*) a carbon-neutral society;* (6) *an economy that is resource-wise;* (7) *lifestyles that respect the carrying capacity of nature;* (8) *decision-making that respects nature.* These objectives withhold a number of tasks and goals, ie. "*we will promote entrepreneurship and innovation and develop the service sector*" or "*our objective is a carbon-neutral society … by the year 2050*". The objectives are monitored through a number of performance indicators as *employment rate, R & D expenditure, consumption of natural resources, share of renewables, loss of species, etc.* The performance indicators are recorded and openly monitored through **findikaattori.fi** web site managed by the Statistics of Finland.

A breakdown of the themes, objectives and performance indicators is presented in TABLE 6. Inspection of the objectives within the themes shows that there are somewhat different weightings. Whereas some themes as 'an economy that is resource-wise' are mainly focused with economic factors, others are more focused on environmental or social factors. Majority of the objectives do interlink environmental, social, economic and cultural aspects of sustainable development, and connect to the decent life paradigm. Interestingly, there is a significant weighting on the social factors, especially within the social-democracy and well-being paradigms.

TABLE 6. Objectives and performance indicators divided by theme in the Finland we want 2050 -strategy

Theme	Key objectives	Performance indicators
Equal prospects for well-being	All members of society will be guaranteed equal prospects for health, education and employment.	Life expectancy
	We will hold to a high standard of education and general knowledge	Income differentials
	We will reduce inequality by ensuring an adequate livelihood and basic social security.	Those aged 17 - 24 not in education or training
	We will pay special attention to the well-being of children and young people.	Subjective well-being
	We will ensure equivalent welfare services and equal access to all welfare services.	Development co-operation
	We will support the recognition of cultural rights and we will strengthen cultural values that support sustainable development.	
	We will do what we can to eliminate extreme poverty and reduce inequality and discrimination in the world.	
	We will fulfil our development cooperation commitments.	
A participatory society for citizens	We will strengthen democracy and promote equal opportunities for all persons to influence their own lives and common issues.	Voting turnout
	We will especially support the participation of young people in the society.	Direct voting participation
	We will make administration more transparent: open and public information increases the trust of citizens and their chances of influencing societal issues.	Civil society
	We will promote cultural activity, diversity, equality and tolerance, so that all citizens, including different minorities, can fully take part in developing our society.	Trust towards institutions
	We will actively participate in international cooperation that promotes peace and security, human rights and sustainable development.	Corruption
Sustainable work	We will undertake to increase jobs and improve the productivity, profitability and quality of work.	Employment rate
	Our goal is a high employment rate.	Economic dependency ratio
	We will promote the creation of jobs in the green economy.	Government R&D funding per societal target groups
	We will develop our education and social security systems, in accordance with the need for new expertise, the needs of the employment market and the measures needed to secure an adequate livelihood.	Work absences due to sickness
	We will support the employment of young people, harness the expertise of immigrants and provide employment opportunities for those with a reduced capacity to work.	Work related accidents
	We will promote entrepreneurship and innovation and develop the service sector.	Possibilitiy to influence tasks, pace and allocation of work
	We will help the industrial sector in its regeneration process, aiming at more value-added and high productivity jobs.	
	We will improve the quality of employment by increasing the opportunities for employees to have an influence on their work and on developments in their work environments, and by providing opportunities for flexible working methods and schedules.	
Sustainable local communities	We will create sustainable and safe communities, where jobs, housing, comprehensive services, sustainable transport systems, the use of information and communication technology, and green areas support economic, social and cultural well-being, as well as the well-being of the environment.	Average commuting distance
	We will strengthen local communities by supporting an active civil society, and by developing meeting places, operating models and local decision-making that promote social learning and influence, so that citizens can create pleasant and healthy living environments for themselves.	Availability of services
	We will reduce the need for traffic, increase telecommuting arrangements and strengthen electronic services.	Broadband services
	We will prepare for changes in climate and water levels and promote local adaptation to climate change.	Transport modes
A carbon-neutral society	Our objective is a carbon-neutral society by the year 2050.	Energy consumption
	The central measures to be undertaken for reaching this objective are improving energy efficiency, increasing the share of renewable energy sources, and developing the low-carbon sectors of the economy.	Share of renewable energy in energy consumption
	We will develop intelligent and interconnected structures, such as transport and energy systems, that enable and promote the use of renewable energy sources and energy savings, while also encouraging people to reduce energy consumption.	Greenhouse gas emissions
	We will invest in the development of innovative energy technologies and forms of energy, as well as new businesses.	Greenhouse gas emissions / GDP
An economy that is resource-wise	Finland and Finns will promote and offer sustainable and competitive solutions, both nationally and globally.	Total consumption of natural resources
	We will increase resource efficiency, as well as create business models that boost the productivity of natural resources and test them.	Consumption of natural resources (TMR) and GDP
	Our companies will be globally respected for their socially responsible business operations.	Increment and drain of growing stock
	The wise utilization of resources and knowledge that is open to all will provide a competitive advantage to companies and communities and a basis for environmental business.	Renewable energy as a proportion of final energy consumption
	Finland will offer the best test market and operating environment in the world for environmental innovation and a sustainable economy.	
	We will invest, in particular, in clean technology, high-quality research, the bioeconomy and renewable energy, as well as in the development and production of non-material goods and services.	
	Finland will pioneer sustainable food production and forestry.	
Lifestyles that respect the carrying capacity of nature	We will do what we can to bring the global consumption of natural resources to an environmentally sustainable level by the year 2050.	Housing: Area, energy consumption and GHG emissions
	We will focus on encouraging both consumers and companies to reduce their ecological footprints.	Private transport: kilometers and emissions
	We will make it as easy and cost-effective as possible for consumers to make consumption choices that conserve natural resources in housing, transport and food.	Food: consumption of different categories
	We will encourage companies and communities to offer sustainably produced products and services to consumers.	Research and development
	We will strengthen attitudes that value sustainable choices in our operations.	Generation of waste
	We will support lifestyles based on non-material consumption and services that sustain such lifestyles.	
Decision-making that respects nature	We will foster people's respect for biodiversity and raise their awareness of its importance, so that administration, municipalities, companies and citizens will consider it in their own decision-making and actions.	Threatened species
	The goal is to stop the loss of biodiversity by 2020.	Bird populations: forest birds, mire birds, farmland birds
	We will strengthen guidance that promotes biodiversity and the sustainable use of natural resources and that respects proprietary rights.	Baltic sea: algea situation, visibility depth
	We will increase our understanding of the importance of ecosystem services for people's well-being.	Recreation in nature
	We will redirect environmentally harmful incentives, while considering social, economic and cultural conditions in a balanced manner.	Attitutdes towards biodiversity
	We will promote the use of scientific research data to support decision-making.	

Following the research task of this thesis to understand the cleantech sector as a key actor in facilitating sustainability transitions and the role (and roadmap) it plays in these transitions, the industry needs to be connected to the sustainability vision. In the strategy the Finland we want 2050 a number of objectives are directly linked to the industrial transformation process towards a green economy with value added generation from high-quality research and new business models in clean technology, bio economy and renewable energy. Examples the objectives (some listed below a - l) can be found from all thematic groups within the strategy and they share a common ground in targeting: (1) *industrial transformation generating high productivity employment and leading to economic value added*; (2) *high quality R&D supporting sustainable innovation and 'born global' entrepreneurship*; (3) *supporting lifestyles that sustain and/or businesses that develop resource efficient and/or non-material goods and services solutions*; (4) *making Finland world best test and operating environment for sustainable innovations;* (5) *stopping the loss of biodiversity by 2020;* and (5) *achieving a carbon neutral nation at par with the global resource equity by 2050*.

a. We will promote the creation of jobs in the green economy.
b. We will promote entrepreneurship and innovation and develop the service sector.
c. We will help the industrial sector in its regeneration process, aiming at more value-added and high productivity jobs.
d. We will invest in the development of innovative energy technologies and forms of energy, as well as new businesses.
e. We will invest, in particular, in clean technology, high-quality research, the bio economy and renewable energy, as well as in the development and production of non-material goods and services.
f. We will increase resource efficiency, as well as create business models that boost the productivity of natural resources and test them.
g. Finland will offer the best test market and operating environment in the world for environmental innovation and a sustainable economy.
h. The wise utilization of resources and knowledge that is open to all will provide a competitive advantage to companies and communities and a basis for environmental business.
i. We will support lifestyles based on non-material consumption and services that sustain such lifestyles.
j. We will make it as easy and cost-effective as possible for consumers to make consumption choices that conserve natural resources in housing, transport and food.
k. Our objective is a carbon-neutral society by the year 2050. The central measures to be undertaken for reaching this objective are improving energy efficiency, increasing the share of renewable energy sources, and developing the low-carbon sectors of the economy.

l. We will do what we can to bring the global consumption of natural resources to an environmentally sustainable level by the year 2050.

Thought the strategy widely addresses emerging pressures to sustaining well-being, it lacks in its global perspectives of extending this well-being by simply acknowledging that "*we will do what we can to eliminate extreme poverty and reduce inequality and discrimination in the world*", "*we will fulfil our development cooperation commitments*" and that "*we will actively participate in international cooperation that promotes peace and security, human rights and sustainable development*". In this sense the strategy does not fulfill the primary targets in the original Bruntland definition of sustainable definition, particularly "*the essential needs of the world's poor, to which overriding priority should be given and the … environment's ability to meet present and future needs*". The dilemma here is the prioritization of the global equity perspective. Whereas sustainable development is a process for the humanity, the strategy Finland we want by 2050 is aimed at increasing national competitiveness in the global arena to maintain national well-being of its inhabitants.

One additional view from the sustainability level to the sustainable Finland vision was depicted by an international research group led by Mr. Pekka Himanen, which published in 2013 under the Prime Minister's Office a future survey entitled *Model for sustainable Growth.* The publication listed as conclusions three major future policy challenges for Finland, namely: (1) *transition from an industrial era welfare state to and information era welfare state*; (2) *transition to an information era ecological economy*; and (3) *a spiritual culture that supports 1-2 – from learning, to culture, to political leadership*. The report also discussed the ethical nature of development and the relating purpose of state. The conclusion brings together the concepts of capabilities and worthiness, elaborating that the ultimate developmental goal and cultural framework is decent life, which brings together the societal sustainable growth in ecological, social, cultural and economic sense.

Agreeing that a wide political, scientific and societal consensus exists on the presumptions underlying the Finland we want by 2050 -strategy, it serves as an excellent endpoint (vision) for the backcasting exercise in this thesis. It provides a well-defined overarching target for the transforming the Finnish society and industry towards sustainability driven entrepreneurial economy, with emphasis on sustaining and advancing decent life within its inhabitants. Other visionary foresight documents and national strategies relevant to this thesis are the *Europe 2020 strategy – Finland national program* (MF, 2012), the foresight report for 2030 *Government Report on the Future: well-being through sustainable growth* (VNK, 2013), the *Energy and climate roadmap 2050* (MEE, 2014b), *Finland as the path setter for natural resources economy in 2050* (MEE, 2014), the *National climate and energy strategy* (MEE, 2013) and the strategy for industrial renewal *Government Strategy to Promote Cleantech Business in Finland* (MEE, 2014c). These documents share the framing and targets of the sustainability strategy, but set more precise policy and macroeconomic targets. These targets will be brought up in the relevant contexts of the baseline.

4.1.3 Focus and scope of the analysis

The vision underlying the Finland we want by 2050 strategy is broad, interconnected and ambiguous. The focus of this study is on cleantech as a facilitator in sustainability transitions. To clarify and simplify the focus and scope of the analysis, the following '*Great Transition*' objectives are derived from the vision to be further analysed: (1) *Finland will be a globally leading country of the green economy*; and (2) *Finland will achieve carbon- and resource neutrality by 2050*. These derived and summarizing objectives will form the core of analysis as they are integrally connected to industry, innovation, entrepreneurship and cleantech. Though the objectives (1-2) are in line with the key national strategies, they do not represent a holistic structuring for sustainable future and decent life to materialize. The objectives are founded, as is the Finnish sustainable development strategy, on the need for developing sustainable long term national competitiveness in the changing global economy, which is mandatory for sustaining high level of human wellbeing. This leaves the highly important questions of e.g. social equity and biodiversity out of analysis.

Typical timeframe for transition research is long term oriented. Since the question is about systemic transformations, the vantage point is around 50 years. This is a timeframe that is both realistic and far enough to allow major transitions to occur in technologies, lifestyles, and even cultural norms and values (Vergrat, 2011). In the sustainable development strategy the Finland we want by 2050 the same long term orientation is applied, though not quite as far, but 35 years to the future. Other more close term objectives have been set in other strategy documents, mainly targeting the year 2020 (MF, 2012; MEE, 2013, 2014, 2014b, 2014c). This study will focus on the 2015 – 2050 timeframe of 35 years, during which many predict that e.g. the de-carbonization of energy systems on a global level is feasible, both from a technical and an economic point of view (WBGU, 2011).

At the core of the analysis is the sustainability transition process. It has the measurable objectives of carbon and resource neutrality, and the growth of the green economy, but it also has theory encoded immeasurable objective of integrating sustainability as a systemic property. The latter is an important objective as it underlines that sustainable development is a moving target. Whether we have goals today that we reach tomorrow, the fundamental uncertainty states that futures will always expose new pressures that increase our vulnerability. Sustainability encoded in the socio technical regime will enhance resilience and allow to integrate long term perspective in decision making. The transformation to a green economy and carbon/resource neutrality is primarily driven by emerging sustainable innovations and key enabling technologies (KET) from the cleantech sector niches. Additionally, the existing national strategies lay the foundation for the policy regime and necessary regime changes, and the landscape exerts pressures from the sustainable development discourse and other emerging trends. Together these transformative forces allow for potential new pathways emerge, either for technological or social trajectories. This framing of the backcasting study is illustrated in

FIGURE 26. The approach of this backcasting analysis is primarily qualitative by nature, but quantitative indicators are also used in describing the

magnitude of change. The quantitative objectives relating to the carbon and resource neutrality are in the range of global equity, not zero.

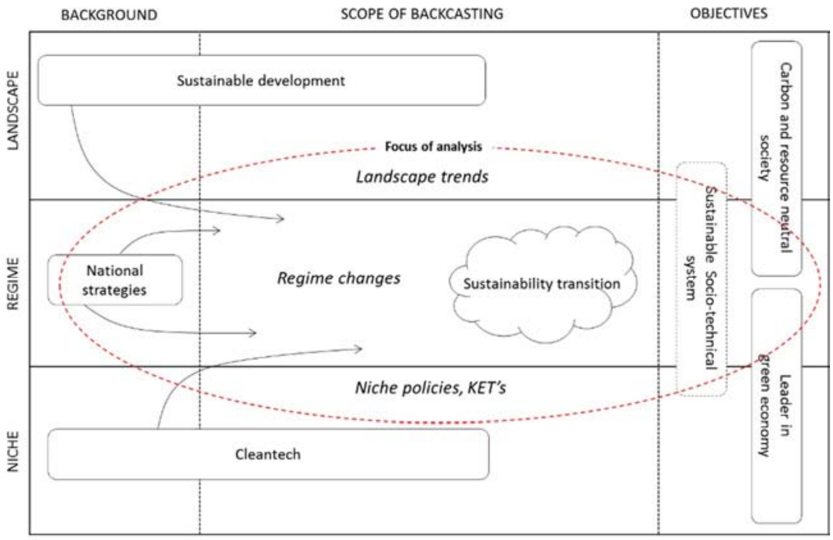


FIGURE 26. Scope of backcasting

As a concluding note, a sustainability transition to a carbon- and resource neutral society and the greening of a national economy requires more widespread changes in the socio-technical regimes and landscape then can be easily monitored with present day metrics. The interlinkages between different actors in a socio-technical transition are highly complex, especially when the focus is as wide as set in this thesis. Carbon- and resource neutrality interlink with everything in the food-energy-transport nexus and green economy affects the whole societal education and employment structure. It is outside of the level of this thesis is take into consideration all the causes and effects of such transitions. Instead, this research is satisfied to experiment with the multi-layer perspective and backcasting of nationwide and industry driven sustainability transitions to bring forth the understanding of the complexity of the actors and interactions.

4.2 Baseline: Equal society with clean environment

Finland has been long seen as a global leader in the development of environmental and social sustainability, and the Finnish industry has a good representation in the global sustainability indices. By most benchmarks Finland can be perceived to be amongst the best countries in the world, especially on the categories that Finns themselves value. This chapter has a two purposes: (1) *discussing the baseline of sustainable development and decent life Finland within a local and global perspective*; (2) *analysing the current state of the society, economy and industry in relation to the cleantech sector;* and (3) *linking the current state of development with the sustainability transition paradigm.*

4.2.1 Sustainable development and decent life in Finland

Sustainability can be measured by many metrics, as described in the chapter *measuring development* in the theoretical framework. These measurements are typically focused either on environmental, economic or social indicators, but seldom combined. In this chapter we will review how Finland benchmarks against other industrialized countries by applying the Sustainable Society Foundations indicators (SSI, 2012) and the OECD Better Life initiatives indicators (OECD, 2012). Both indicator sets aim to include the environmental, economic, social and cultural indicators with a wide perspective.

According to the OECD and SSI (and others[30]) Finland is a leading country in *education*, *environmental quality, health* and *subjective well-being* (FIGURE 27). In addition to ranking based on statistics, the OECD Better Life initiative also records what actually matters to people most (FIGURE 28). Interestingly, the topics most valued by Finns are the same as where they excel: *health, education* and *environment*. The fundaments for achieving so well and valuing so much these categories has been much discussed, and debated. Education for example has succeeded well in the past, by providing equal basic, and even university, education for all. This was the way to go in the past, as noted by the SITRA report *Maa jossa kaikki rakastavat oppimista* (2015) but no more. Today unemployment effects all no matter of the educational level, and the capability to continue to learn and evolve is becoming more important than official degrees. As for our environmental quality, it should be noted that the population density in Finland is only 16 inhabitants per square kilometre, which is only 5 % compared to the 250+ habitation density of equal (or smaller) sized Germany and UK. Also, the Finnish industrial history spans not half as far as the latter mentioned countries. It would be a wonder if Finns could have spoiled the environment with such small available 'human resources'. The same reason that has helped preserve our nature, has also help sustain a strong human-nature relationship. This helps maintain respect of nature and to sustain the environmental quality. (OECD, 2015; SSI, 2012).

In comparison with the peer group, Finland does not do poorly in any category. The weakest results from the OECD and SSI indexes are in the categories of *employment*, *income*, *consumption* and *energy* (renewable). When again compared against what matters most to people, they correlate to a degree with least valued attributes being: *civic engagement, community coherence, income, housing* and *jobs*. The lack of interest in civic engagement in Finland can be seen e.g. in the voting turnouts, where the turnout ration in the 2015 parliamentary elections was 66 %, which is 15 % below its Scandinavian peers (IDEA, 2015). Interestingly also income and jobs are amongst the least valued category topics for Finns, and in these categories Finland succeeds below average compared to its peer group. The 2010 value research by *Finnish Business and Policy Forum* EVA (EVA, 2010) noted that work for Finns mean above all income, social

---

30 For a good listing of rankings during the last decade see: https://fi.wikipedia.org/wiki/Suomi_kansainv%C3%A4lisiss%C3%A4_vertailuissa

connections and self-identity. According to the study work today has less intrinsic meaning and it is no longer seen as a civic duty.

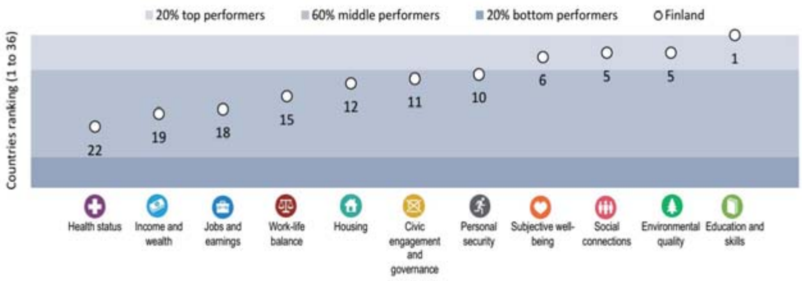


FIGURE 27. Finland's well-being compared to other OECD countries and major economies by category (Source: OECD, 2015)

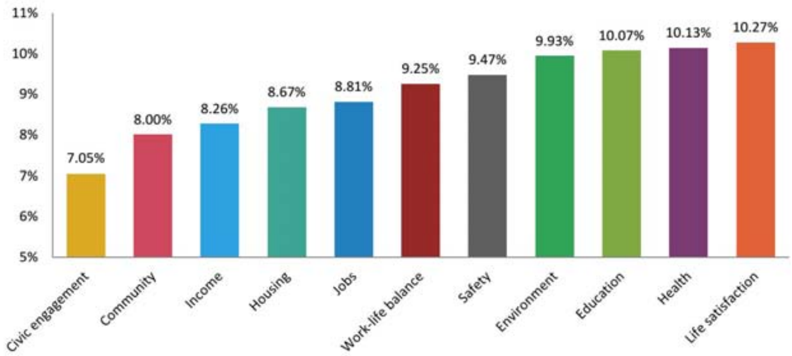


FIGURE 28. What matters most to people in Finland by category (Source: OECD, 2015)

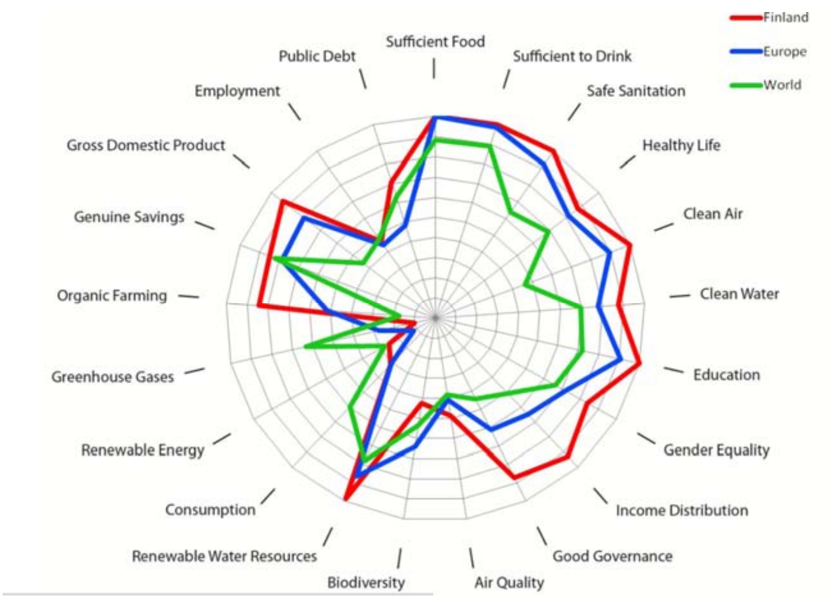


FIGURE 29. Finland's sustainability compared to other European and global countries (Source: SSI, 2012)

Based on the OECD and SSI metrics Finland can be said to be a country of clean and healthy environment and coherent society that provides equal opportunities for education, health and security. If we analyse this perceived and actual level of sustainable development and decent life in Finland through the hierarchical structure of sustainable development and the individual decent life theorem presented in the theoretical framework we can observe an imbalance in the emphasis. I will explain the imbalance in more detail in the coming chapters.

The typical hierarchy of sustainable development is from environmental to social, economic and cultural. This is something that we have commonly accepted and founded our sustainable development paradigms and strategies on. This has directed the main focus in global efforts to advance sustainable development to environmental protection and social equity. When it comes to economic sustainability, we have generally accepted based on the neoclassical approach that markets are able to self-regulate, which has manifested in CSR programs and the development of triple bottom line thinking. Cultural aspects are only a minor nuance in the sustainability agenda, though we have for long been in a progress of homogenizing our global cultures. Even in Finland the indigenous minorities of Sami people live under stress from the main culture to sustain their heritage.

Concerning decent life and individual well-being, the hierarchy of individual needs is commonly structured[31] to basic needs, social needs and self-realization needs. At the bottom is commonly the basic needs as food, water and shelter, which extend as the fundamental needs are fulfilled to employment, education, friendship, nature and self-realization. Finland is undoubtedly a welfare state. We are so well provided by the society that we no longer have to concern ourselves on fulfilling the fundamental needs of food and shelter. Housing and consumption do interest us, but with land and resource abundance we have the benefit of choice for selecting how we wish to life and consume. This leaves us little concern for making choices based on necessity. As for the need for education as a pathway to employment, or even employment and the adjoining income, both have become less important (EVA, 2010). Finland is already one of the most equal countries in terms of education and income differences (OECD, 2015). It seems that we have developed to such high well-being, that abstract values as life satisfaction and self-realization mean more to us than shelter, income or even community coherence.

There is a commonly known concept of *diminishing marginal gain* in the psychological *prospect theory*[32] (Kahneman, 2012), that provides a behavioural explanation to the lock-in on the psychological well-being compared to the physical basic needs. The concept of diminishing marginal gain states that if you already have abundance, a little more does not give the same psychological reward. In addition the prospect theory integrates two relevant concepts, *loss aversion* and *reference point*. These mean that people tend to weight losses more than gains, and that the psychological effect of the loss (or win) is based on the current status or other reference point. Behaviourally these theories describe

[31] Here I refer to Abraham Maslow's need hierarchy, which serves as a foundation to Max-Neef for elaborating his need theorem, again serving as the primary foundation for the approach formulated by Hirvilammi (2015) and applied here.

[32] For further considerations see *game theory*

that if you have an abundance, losing little is more mentally influential then gaining little, but if your reference point is not abundance, but nothing, then gaining and losing little are more likely equally attractive. As an anecdote one could say that in the Finnish society we have all climbed high on the now inverted ‘development pyramid’ (FIGURE 30). The additional value from climbing higher is minimal, but no-one wants to move downwards due to the fear of losing the little what they have gained. This means that the structure becomes more and more weighted from the middle and top, and if there is not enough support at the bottom, it will collapse.

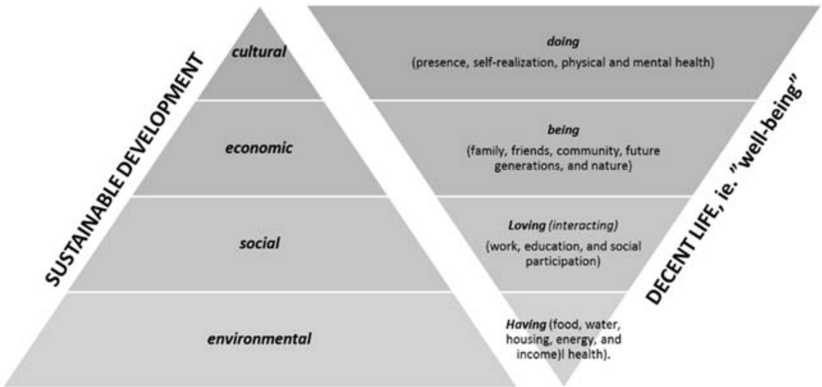


FIGURE 30. Hierarchy and proportional focus we put on sustainable development and our individual well-being (authors illustration)

The imbalance in Finland between global and individual levels of sustainable development arise from the emphasis on the socio-environmental levels of sustainable development contradicting the emphasis on being and doing level individual decent life. This imbalance leaves the economic-cultural and the having and loving aspects underweighted. The development is due to multiple reasons, as the globally prevailing *sustainability paradigm* and individual level lock-ins due to *loss aversion*. The problem with this imbalance arises from the foresight that a high social and psychological well-being can only be sustained with a sufficiently strong fulfilment of basic needs. If we wish to continue to focus on the *doing* and *being* levels of decent life, we must construct sustainable and efficient *having* and *loving* levels. This means that we must also focus on the *economic* and *cultural* sustainability, which are tightly bound to the material level of the socio-technical environment where production, use and consumption happen. *Environmental* and *social* sustainability and equity are unquestionably most important in the global perspective. In Finland these are anyhow something that we excel at national level, hence the marginal gain of advancing them is diminishing. What Finland is lacking on, is a sustainable culture and an economy that supports it, and people that are motivated also on the having and loving levels of decent life. Re-enforcing these requires strong social and political cohesion, new innovations, and ventures that create stories inspiring people to work and participate in the economy, society and community.

4.2.2 Global development trends

There are two main viewpoints towards global and development trends prevailing in the discussions today. One view is based on the discourse of strong sustainability and focusing on environmental degradation (biodiversity, climate change) and social equity, whereas the other is based more on the weak discourse and focused on resource scarcity and depletion, supply and access risks and economic sustainability. Both approaches share much in common and acknowledge each other's importance, hence both serve as important foundation for outlining the developmental trends.

Looking at the post-2015 sustainable development goals, the advance unedited agenda *Transforming our world: the 2030 Agenda for Sustainable Development* (UN, 2015) which will be discussed later this year in September in New York in the *United Nations Summit to adopt the post-2015 development agenda* list in addition to environmental and social equity based goals targets that are aligned with the green economy, and energy and resource neutrality. The relevant goals include *'access to affordable, reliable, sustainable and modern energy for all', 'promotion of sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all', 'building resilient infrastructure, promoting inclusive and sustainable industrialization and foster innovation', 'making cities and human settlements inclusive, safe, resilient and sustainable'* and *'Ensuring sustainable consumption and production patterns'*. These goals reflect the need to change the socio-technical system in relation to its *infrastructure, industries, buildings, energy, economic growth* and *sustainable consumption*. They also represent a paradigm change in the SDGs towards multi-stakeholder approach where industry and consumers are also seen as key actors. This is what the scientific community has also widely acknowledged. Excluding the social and environmental development issues, the most urgent needs are in the energy and infrastructure systems and that changes in the industry and production-consumption patterns need to emerge.

Looking backwards towards pre-2015 era, the OECD's 2015 publication *Towards Green Growth?* lists developments of the last years at national levels towards facilitating green growth agendas. The report lists as key problematic themes in facilitating green growth at national levels *carbon pricing, tax and subsidy management*, and *building innovation systems*. Based on these problems OECD (2015) reformulated the green growth policy framework guidance. The essential policy frameworks that OECD suggest to develop in the future include *linking environmental objectives with economic reform policies, addressing the constraints to green investment, development of regulation to provide incentives for green growth (emission standards, energy efficiency), subsidies to promote clean technologies/products/practices, pricing instruments (tradable permit systems, taxes)*, and *labour market and skill policies to transition workers to new sectors* amongst others. In relation to Finland OECD found that especially the carbon pricing and environment related subsidies have been most problematic, though it also needs to be noted that Finland had not reviewed the relevant green growth problems.

4.2.3 Resources and capabilities for transition

The following chapter presents and analyses the Finnish macroeconomic environment in relation to its population and employment structure, industry, education, entrepreneurship, innovations, and cleantech. The aim qualitatively describe the environment and to provide analysis based on quantitative data and applied forecasting. The approach follows the double flow model presented by Gaziolusyou et al. (2013) (and in methodology section) where forecasting is used to generate future narratives that can be used to frame the backcasting scenario structuring.

4.2.3.1 Population and employment

The population in Finland is projected to grow from the current (2015) 5,4 million to 6,1 million in 2050 (OSF, 2015) (FIGURE 31). In terms of population dynamics, whereas in 2011 we had almost an equal amount of children 16,5% (887 000) and pensioners 17,5% (941 000), and a working age population that accounted for 66% (3 547 000) of the population, it is estimated that in 2050 the corresponding numbers will be 15,5% (941 000) children, 27% (1 639 000) pensioner and the working age population will be only 58% (3 516 000) (FIGURE 32). When the absolute birth rates slowly decline and the expected lifetime increases for both male and female, Finland will end up an aging society. Economically this means that with the same amount of working age population we will have to supply for an equal amount of children as today, and almost double the pensioners.

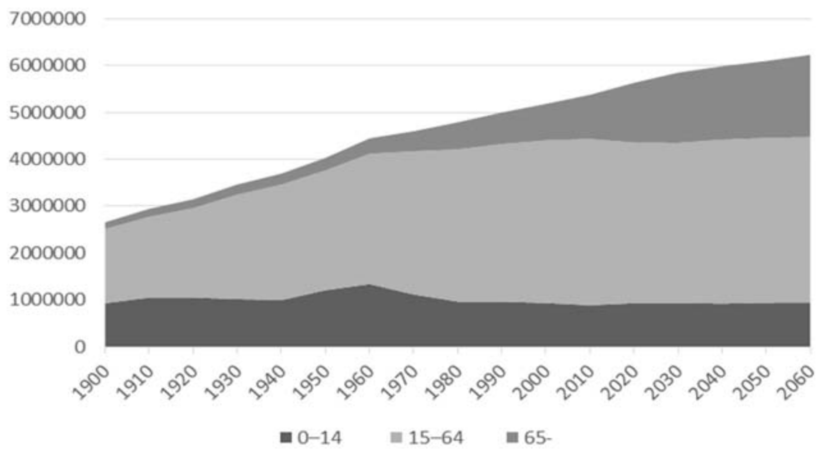


FIGURE 31. Population growth by age from 1900-2060 (2020-2060 projection) (Source: OSF, 2015 - Population statistics)

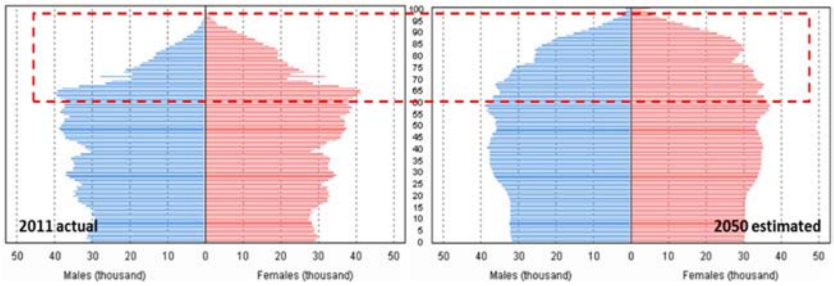


FIGURE 32. Population demography in 2011 and 2050 (projected) (Source: OSF, 2015 - Population statistics)

When the population is going to age and the birth rates decline, the question is how to maintain a sufficient labor force. FIGURE 33 represents a model where population growth (based on population projections by Statistic of Finland) is linked with *labor force participation*, *employment* and *unemployment*[33]. The basic assumptions for the model are that (1) *labor force participation increases from the current 74% to 80% by 2050.* The fundament for the presumption is that if the labor force participation increases too high, it will affect the social well-being of people and ultimately also industry. (2) *employment-% increases from the current 68% to 75%.* The Finnish EU 2020 target for employment rate is 75 %, which is at the range of other Nordic countries current rate (which ranges from 70…85%). (3) *Unemployment decreases from the current 9% to 6%.*

In simple numbers: During the period 2010-2050 total projected population will grow 12%, but the working age population decreases by -1%. This decrease in the working age population (14-65) will have an effect of -30 000 people on the employable population. The decrease in the unemployment rate will contrarily increase employment by adding 50 000 jobs. These summed and the increase of the labour force participation would move 220 000 people from outside labour force (from studying, parental leave, …) into employment, assuming that there is work. If we would wish to achieve an increase of 12% or more in the amount of employed people (at rate with population growth), we would need an employment rate of 80%, which is already very high in global comparison. To take the example further, if we would wish to maintain similar *demographic (employment) dependency ratio* both 2015 and in 2050, it would mean that in 2050 both the labour force participation and the employment rate would both need to be 100 %.

---

33 *Labor force* = economically active people aged 15-65, excl. homemakers, students, …
Labor force participation rate (%) = labor force / people aged 15-65
Employment rate (%) = Employed people / People aged 15-65
Unemployment rate (%) = unemployed people / labor force
Demographic (employment) dependency ratio = (Children + Pensioners) / employed people

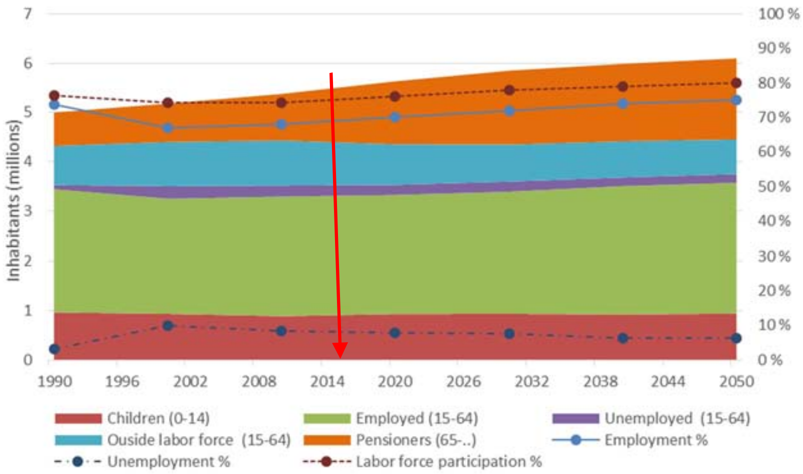


FIGURE 33. Population, economic activity and work model [PEW] (data: OSF, 2015; NSI, 2015; 2010-2050 authors projection)

The modelled scenario is by no means an optimal scenario, but possible due to the conservative estimates and long time frame. 220 000 new jobs in 35 years is a significant amount, but it could be more. Divided to annual new jobs generated, it would account to 6200 jobs/annum from 2014 onwards whereas during 2000-2015 the increment in Finland was 7500 jobs/annum (OSF – Työssäkäyntitilastot, 2015). There are global pressures and risks thought. The global trend on labour force participation and employment rate is declining. In the latest World Employment and Social Outlook 2015 publication the International Labour Organisation (ILO, 2015) predicted that the global labour force participation rate will continue to decline at least until 2030 and that the global employment growth rate has declined to a degree that by 2020 a total 280 million new jobs would need to be created to suffice the need of new labour market entrants.

In terms of sustainable development and decent life the population demography development brings forth a potential problem. To continue focus on the individual doing and being levels of decent life, we must construct sustainable levels for needs in having and loving. We are facing a situation where more people are pressured to enter the labour market, earlier, with less pre-work education, and to stay there longer. At the same time, we are facing the need to have an innovative, high tech industry providing high value added. The latter cannot happen without world class education and R&D.

How about the generations to come. Should we address the population dynamics in terms of encouraging fertility (which contradicts high labour market participation) or increase immigration? Finland is already open to any world class specialists as immigrants, but so is every other country in the world. Due to their high education and skills, also Finns are globally sought after employees. In 2013 a total of 9 653 Finns moved away from the country, majority aged between 15-35, while 8 068 Finns moved back into the country, majority aged between 45-70 (KSLM, 2015). Most people moving away are in their best working age, when they don't yet have a family restricting their moving, and most moving back to Finland are pensioners returning to their home-regions. In neighbouring Nordic countries majority of the population growth is already due to immigration and post-immigrant child births. Finland likewise could utilize this as a potential for rebalancing population dynamics.

The systemic nature of sustainability and the principles of sustainable development require that we do not only try to only solve current problems, but to construct systems that are resilient to the fundamental uncertainty surrounding us. It is clear that we need a sustainable economy and culture to maintain our well-being, but to do this we need a population that motivated to participate in the society, community and economy, while skilled enough to compete in the global arena. In terms of stagnating population and employment the interesting question is that can we de-link employment and well-being.

Key factors and emergent questions affecting the Finnish sustainability transition which arise from the previous paragraph include:

- How does the **population dynamics** affect future **employment**?
- What are the **long term policies and strategies** for a sustainable green macroeconomic environment?
- Is it even viable to consider a sustainable future without **re-designing work** to accommodate new forms of **entrepreneurship** and **smart employment**?
- To sustain the growth of well-being, we need redefined goals for **work-life balance**, **decent life** and to **de-link work and income.**
- These **re-organisations of socio-technical functions** will drive large scale changes in the **transportation** and **building** sectors, facilitated by **innovation**, **entrepreneurship** and **cleantech** especially in **consumer niches**.

4.2.3.2 The role of education

Looking at how the work in the future is structured, and skills required, the global trend in new jobs generated seems to be towards non routine cognitive operations, while at the same time work in non-routine manual operations is decreasing (FIGURE 34). This same development has been visible in Finland in the employment of people in different educational levels (FIGURE 35). The employment rates for people with lower or higher level university education are in the range of 70-80% respectively and for people with basic or upper secondary education in the range of 20-40%. At the same time (1990-2010) the amount of employees with lower or higher university degree has doubled and the amount of employees with basic education has decreased to a third. (OSF Työssäkäyntitilasto, 2015). One of the phenomenon related to this is *de-skilling*. This process results from decreasing demand, when highly educated workers move downwards in labor structure and push the mid-level educated people to works requiring basic level education hence forcing the basic level educated out of employment (T&Y, 2014).

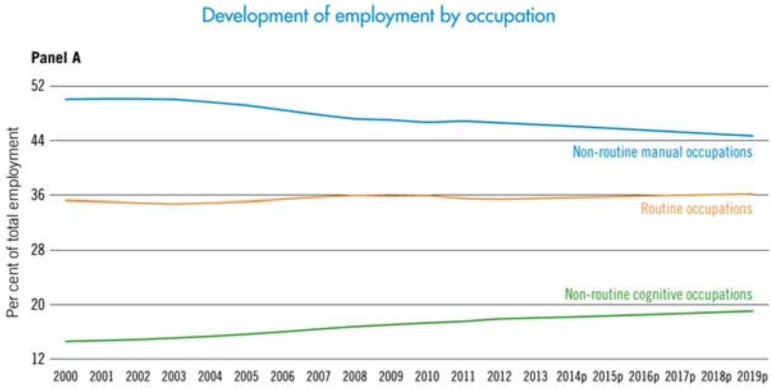


FIGURE 34. Development of global employment by occupation (Source: ILO, 2015)

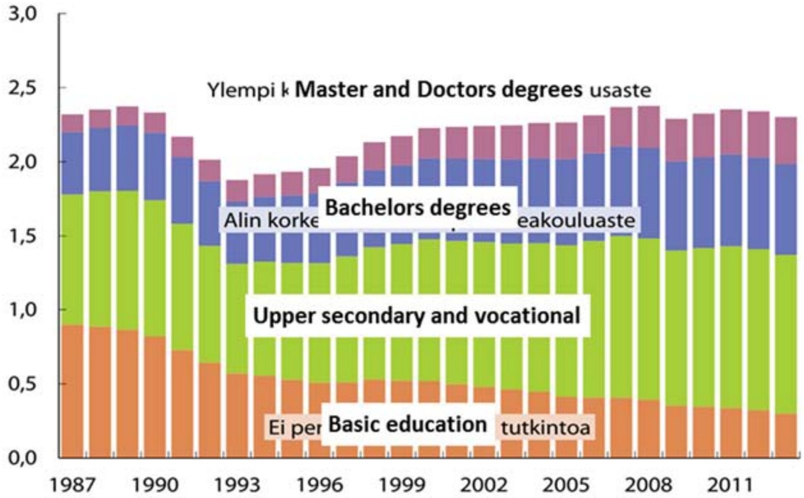


FIGURE 35. Employees by educational status in Finland (source: EVA, 2015)

With the trend in new jobs generated and educational skills required, it is fair to say that future global high value added work requires high level university education as the basis. FIGURE 36 represents a model which reflects the Finnish situation in terms of *population*, *combined gross enrolment ration*[34] and *educational structure of the population*. The model projects on conservative estimations where (1) *combined gross enrolment ratio grows from current 83% by a percent per decade reaching 87% by 2050*. This is already a very high enrolment ratio, as there are always people in the total population (i.e. children < 7a.). Other estimations are based on the change of work, where more people require high level education compared to basic education. These assumption set targets where (2) *the amount of employees with vocational or lower/higher university education grows on average 50% by 2050*; (3) *the amount of people with upper secondary education grows 12% (at par with population) by 2050*; and (4) *the amount of people with only basic education decreases 20% by 2050*.

34 *Combined Gross Enrolment Ratio CGER* = number of students enrolled at all levels of education / number of total population

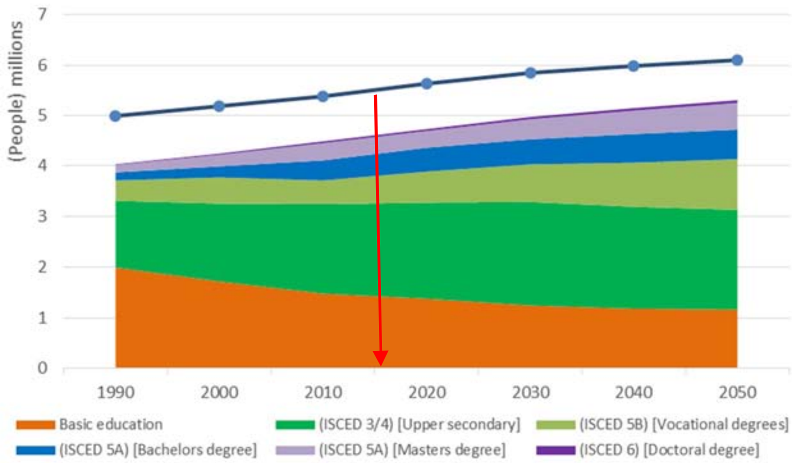


FIGURE 36. Educational model (data: OSF, 2015; 2010-2050 authors' projection)

The effects of increasing the combined gross enrolment ratio and the growing population means that we will need a high number of additional educational capacity at all levels, especially at the university level. In the earlier population and economic activity model (FIGURE 33) we estimated that by 2050 Finland would have an employment rate of 75%, which deducted by the structural unemployment of 6% leaves a 20% outside labour force population (appx. 700 000 people in 2050). In our education model the increase of CGER and the amount of higher level education means that especially people aged 15-25 will be outside of labour force due to university education. The estimated total population between ages 15-25 in 2050 is approximately 700 000, corresponding to the outside labour force population, but leaving no room for other reasons to be excluded from labour force besides education (OSF Työssäkäyntitilastot, 2015). This is not viable, but if we are to generate new cleantech jobs, we will need enough educated employees to fill those jobs.

The implication of sustainability and sustainable development dictates that we must facilitate personal and social growth, not forgetting the environmental and economic aspects. Education is one of the fundamental rights and a means for self-realization in the doing level of decent life. It also allows us to develop better understanding on the complexities of human-nature interactions and develop the necessary *key enabling technologies* for sustainability transitions. Again we face the paradox of stagnating labour force and the need for higher skillsets and innovation capacity. By perceiving the problem through the sustainable systems perspective, the orientation changes towards the question "*how can we achieve an employment rate necessary for sustaining well-being, while educating our people with the skills necessary for developing a globally competitive green economy?*" As earlier discussed, sustainability by definition is a moving target and hence planning for fixed targets and points in time is arbitrary if it is perceived as a systemic property. The system needs to be structured so that it can sustainably self-manage the future vulnerabilities in relation to changing needs in education, employment requirements, new technologies, work-life balance and global competition. What are the other ways to help people in educate themselves and share knowledge within the society, while at the same time providing employment for industry and maintaining a high level of well-being?

Key factors and emergent questions affecting the Finnish sustainability transition which arise from the previous paragraph include:

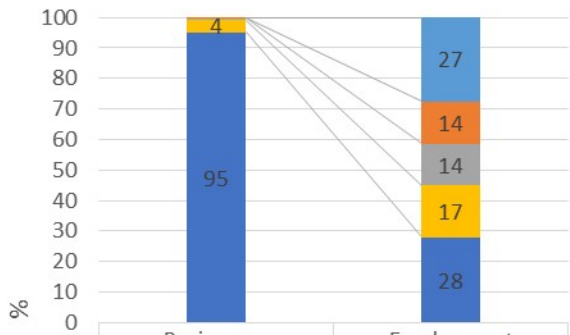
- Can **cleantech** develop solutions to **education**?
- **Education and R&D** should be more integrated. Manufacturing sector cleantech businesses could train labour in apprenticeship and more masters and doctors programs could be industry driven?
- Education builds an important foundation for **social participation**, which is the cornerstone for democracy.
- Education should have also a strategic focus on the **paradigm force** topics of **sustainable development**, **green** and **circular economy.**

4.2.3.3 Industrial structure

Majority of Finnish private sector businesses are SME's (mainly micro-businesses), and they provide for 60% of the total employment in the private sector (FIGURE 37). The amount of large companies (>250 employees) and giant companies (> 1000 employees) is diminishingly small, only around 1,5% but they provide for 40% of the total employment. When looking at the longer term trends (FIGURE 38) the SME's have grown in numbers since 2000 by 131 000 new businesses and generated 175 000 new jobs and EUR 85 000 million in new turnover. During the same period only 28 companies have grown into the large companies category and while reducing over 5 000 employees[35] and increasing turnover by EUR 49 500 million. These trends fall very well with the globally rising increase of self-employment and SME businesses. (OSF - Yritys ja toimipaikkatilastot, 2015; OECD, 2015c).

---

[35] In 2014 and 2015 there has been a significant number of YT processes, which have according to SAK led to approximately 18 000 jobs being lost (https://www.sak.fi/aineistot/tilastot/yt-ja-irtisanomistilastot/yt-neuvottelujen-kuukausivertailut-20142015-2015-02-02)



	Businesses	Employment
> 1 000 employees	0,04	27
250–999 employees	0,1	14
50–249 employees	1	14
10–49 employees	4	17
< 10 employees	95	28

FIGURE 37. Size and employment distribution of private sector businesses in Finland (source: OSF – Yritys ja toimipaikkatilastot, 2015)

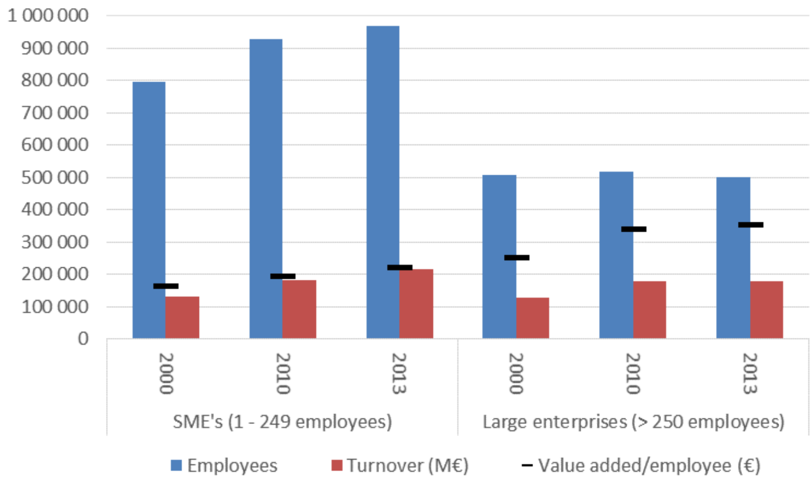


FIGURE 38. Development of employees, turnover and value added/employee in the Finnish SMEs and large businesses 2000-2013 (source: OSF – Yritys ja toimipaikkatilastot, 2015)

Most SMEs though are operating mainly in the domestic market and the majority of Finnish export is done by the few large companies (FIGURE 39). The top 100 companies in Finland account for 68% of all exports and top 1000 companies for 90%. In total Finland has only 13 000 export companies. Export accounts for 40% of the Finnish GDP generation. Majority of exports are products which account for 75%, whereas export of services accounts for 25%. Service exports are mainly internal trade by the multinational companies operating in Finland. Five main Finnish export products are paper and cardboard (12,5%), raffinated mineral oils (10,7%), steel plates (4,5%), phones and components (2,7%) and pulp (2,4%). If we look from the global perspective, Finland is amongst the top producers for global trade in fur (14,7%), paper machines (8,3%), paper and cardboard (8,2%), metal coins (7,8%), steel plates

(5,3%). (EVA, 2014). The global decline of the commodities markets and the Finnish ICT industry has had a clear effect on the national exports since 2007, leading to a negative trade balance the last years (FIGURE 40).

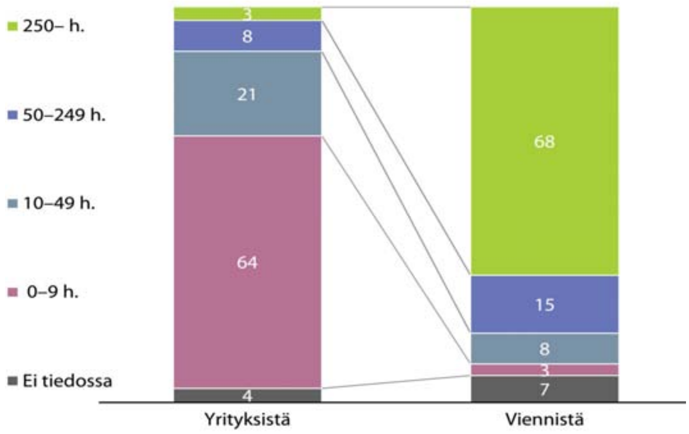


FIGURE 39. Export and company size (source: EVA, 2014)

FIGURE 40. Finnish import (red line), export (blue line) and trade balance (bars) (source: Customs of Finland)

The Finnish industry structure is very much dominated by raw materials production and a few large multinational corporations. In the context of sustainable development we have earlier noted that Finland needs a sustainable economy to maintain well-being. The strategy and likewise goal is to transform the economy to a green economy, which is carbon and resource neutral. Analysing the current Finnish industry structure we can see that a large number of the export related value added is generated from carbon and resource intensive industries in petroleum and minerals industries. What are the other export opportunities that Finnish industry has? Are there emerging industries in the cleantech sector? Are there SMEs that have the potential to grow with sustainable green economy solutions?

In term of sustainability a redundant economy would be an optimal environment for businesses to manage the continuous systemic changes in technologies and needs globally. The current industrial structure where large businesses account for a significant portion of employment, EVA and majority of export is not optimal in this sense. The large companies do anyhow provide the backbone for the Finnish industry and cleantech should be able to build upon this and to grow SMEs into international level sub-contractors and to other value chain actors while piggy packing the large businesses.

Key factors and emergent questions affecting the Finnish sustainability transition which arise from the previous paragraph include:

- Cleantech SMEs can help large businesses to be winners in the global **industrial** and **structural renewal**
- Cleantech is one of the most encouraging fields for **entrepreneurship** and **venture capita**l, leading to increased growth in **innovation** and **start-ups**.
- The sustainability paradigms of **green** and **circular economy** drive an **industrial change** in **energy**, **transportation** and **agriculture.**
- The need for industrial renewal also opens opportunities in the **industrial niche** for new **key enabling technologies**, **dematerialization** and circular economy **ReSOLVE** solutions.
- A key driver in the national renewal would also be the construction of a **domestic market for innovative green economy solutions**.

4.2.3.4 Entrepreneurship

Finland has been amongst the countries that have been successful in achieving rapid structural change and technological development. In the times after the world wars pre-1960s was the trigger for investment driven industrialization in Finland. Central role was played by the forest industries which until the 1950's accounted for 80-90% of the export earnings. Finland's war reparations to the Soviet Union, which amounted 300 million gold dollars during 1944-1952 were a key event that helped to create new forms of important industrial pillars and competencies for the Finnish economy for decades to come. This contributed greatly to the transition of the economic structure from agriculture towards industrialization and urbanization. Afterwards in 1960s and 1970s the Finnish science and technology developed and diversified. In 1980 the financial markets were liberated and new venture capital actors emerged that increased the development rate of the Finnish industry. This led to wide based success during the 1980s and 1990s. In this process, the traditionally strong forest and metal industries were the primary economic drivers. In 1990s Finland entered into recession, but rapidly recovered and established its position as one of the top countries in different innovation- and competence-related rankings. The ICT industry started to grow, spearheaded mainly by Nokia and its global success. Most new young professionals were employed by the large multinational businesses, because they were able to provide a competitive quality of life compared to entrepreneurship. In 2000s the global ICT market suffered from a dramatic 'dot-com' bubble and simultaneously a change in the global pulp and paper markets emerged. During the early years of 2000s the Finnish ICT eventually lost its global leadership status in consumer solutions as new global actors entered the arena. By 2010s the global changes in pulp and paper industry and the minerals industry, and the dramatic decline of Nokia had profoundly affected the state of Finnish economy. (Sipola, 2015).

Against this background it is clearer why Finnish SME's, especially new SMEs, have been the dominant force driving economic development in the last decade. Entrepreneurship has not only been the preferred choice, but a necessity for some global experts (i.e. because of unemployment). It is interesting to note that the entrepreneurs in the top performing countries (Sweden, Switzerland, Canada and USA), are less driven by 'necessity motives' for starting a business, but rather are inspired by the intrinsic value of entrepreneurship – the perceived opportunity for a better income and/or independence. Therefore, what makes these countries 'top performers', is that they have been diligently investing in making entrepreneurship attractive, both by giving individuals the necessary training, advice, or connections to ensure their success, and also by greatly rewarding them for their endeavours.

To make entrepreneurship attractive requires a clearly aligned and institutionalized view of winner generation. Data collected by Sakari Sipola (2015) for his doctoral dissertation on the *start-up industries and experimental winner generation in Finland, Israel and Silicon Valley* show that unsuccessful attempts to resolve the failures of the early stage venture capital market and the long-standing dominant role of public actors have cumulated in a multi-voiced and contradictory perception of a winner in Finland. The institutional criteria for perceived winner is set in the different financial instruments i.e. public grants, loans, subsidies and development projects, of which 54 alone existed in 2005. The criteria used by market actors as business angels and venture capitalists iscontrarily based on strict investment readiness. The difference is illustrated most clearly by the indicators used by the actors. Whereas the target for the Finnish entrepreneurship support system has historically been the generation of new businesses (measured by new Business Identification Codes) and adjoining potential jobs, the target for the venture industry has been the generation of stock listings through Initial Public Offerings IPOs. (Sipola, 2015).

In the past years there has been a strong emerging start-up industry in Finland, with a clear ambition to be winners in the broad global sense. These actors are undoubtedly partly born due to necessity, but many also originate from universities and incubators, seeing entrepreneurship as a viable option for income and independence. These new industry actors are still though operating in protected niche environments where their technologies are not yet facing the harsh global competition.

In terms of sustainability, entrepreneurship should be favoured as a systemic mechanism to allow new employment to be generated and innovations commercialised in line with needs of time. In terms of decent life, entrepreneurship provides individuals more freedom (and responsibility) of their own independence and income. For some this can be a factor of well-being, as in many countries ex-Finland (OECD, 2015). Entrepreneurship can also contribute to the sustainable development through sustainable businesses. As the present regime actors are locked-in on the existing infrastructure and technological dependencies, niche actors (as entrepreneurs) are needed to facilitate as change agents.

Key factors and emergent questions affecting the Finnish sustainability transition which arise from the previous paragraph include:

- The entrepreneurial **winner generation** must be advanced and a joint definition accepted.
- The critical role of the **change agents** ie. **Entrepreneurs**, **start-ups** and **venture capital** must be acknowledged in national **strategies**.
- Entrepreneurship has a significant role in the **industrial renewal** from the past economic paradigm to **entrepreneurial economy**.
- Entrepreneurship has a key role in developing **consumer niche** solutions for **sharing economy**, **connectivity**, **optimising**, and **products-as-service** systems.

4.2.3.5 Eco-innovations and R&D

According to the *Cleantech Innovation Index* published by WWF and the Cleantech Group (WWF, 2014) Finland ranks as the world's second best performing country when it comes to cleantech. The ranking is based on the nation's innovation drivers and evidence of emerging innovation, which can be illustrated by the strong general innovation inputs, cluster development and human capital and supported by high profile cleantech companies and new environmental patents. Where Finland lacks according to the survey, is commercializing cleantech innovations. This low level of commercialization is illustrated by average company revenues and only few M&A and IPOs of the sector. (WWF, 2014)

Finnish innovation is driven by high level education and R&D. Majority of the R&D funding is originating from the companies themselves. The amount for public finance of R&D investments by businesses in Finland is below 5% and majority of this funding is directed through the Finnish Funding Agency for Innovation TEKES. Development of R&D expenditure by source is presented in FIGURE 41. Finnish businesses are amongst the highest R&D spenders globally. In 2013, the amount of R&D expenditure in Finland accounted for 3,3% of the total national GDP. In Euros, this 3,3% still is very small in the global comparison. (OSF – Findikaattori.fi, 2015)

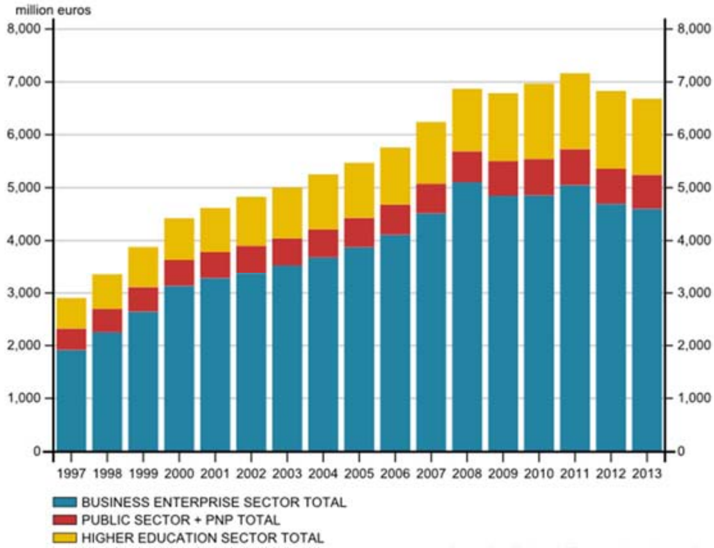


FIGURE 41. R&D expenditure by source (Source: OSF – R&D, 2015)

When looking at the patenting activity in Finland based on the OECD statistics on total and environmental technology related patents applications filed under the PCT (FIGURE 42) the total amount of patents has grown in 2000-2010 only 12% (171 application) but the environmental technology related patents have grown 440% (121 applications). Majority of the increase in the total patent applications from Finland is therefore due to environmental technology related applications. Most applications are from the main groups of *general environmental management, energy generation from renewable non-fossil sources* and *emission abatement and fuel efficiency in transportation.* If we compare the Finnish patent activity to Sweden, Norway or Denmark, we at par with the peer group (excl. Danish activity on renewables which is manifold compared to others). The proportional amount of environmental patent applications compared to total patent applications is also very (12%) exceeding clearly the majority of industrialized countries. Also the total amount of patents/inhabitant is approximately in the same range as in the leading industrial countries as Germany.

According to the EU *Innovation Union Scoreboard 2011,* measuring innovativeness by 25 indicators, Finland is amongst the top leading countries with Sweden, Denmark in innovation (T&T, 2012). The aforementioned, all top cleantech countries, have demonstrated large gaps between 'evidence of emerging cleantech innovation' and 'evidence of commercialised cleantech innovation,' perhaps because companies in these geographies have not yet reached full maturity or are having trouble scaling up efficiently (WWF, 2014). Innovation and patenting is only one part of the process. Commercialization is the necessity for any business to have impact.

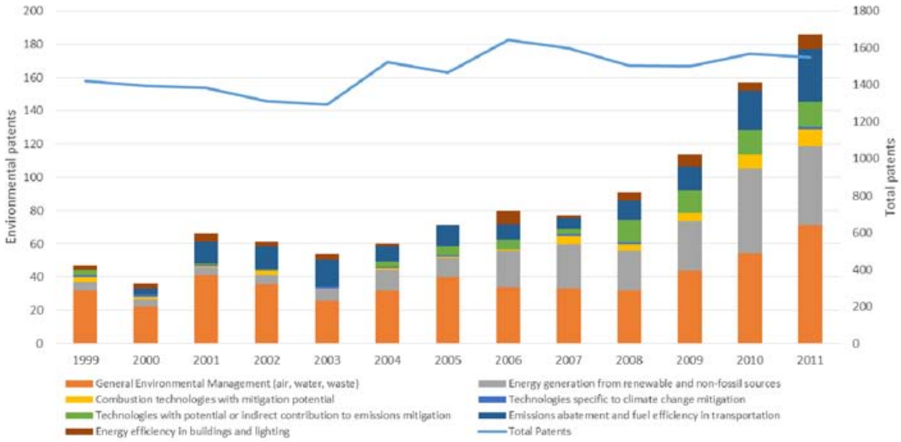


FIGURE 42. Environmental and total patent applications filed under the PCT (Source: OECD.Stat, 2015)

The amount of innovations and especially environment related innovations shows that Finland has a good background for green economy solutions. Besides greening the existing products, many of the patented innovations can also be translated into new businesses and ventures. There is though a large underused potential. Cleantech as an industry has the possibility of commercializing these innovations. Most of the innovations fall under categories which support the large landscape infrastructures such as energy systems, and water- and waste infrastructure. Cleantech has the potential to address the issues of sustainable development and decent life also on other levels. It can provide innovations that address the emerging consumer cleantech niches of the sharing economy, re- and up-cycling or products-service systems. In the best case, it can also facilitate the necessary industrial and societal structural renewal leading to de-materialization and de-consumerism.

Key factors and emergent questions affecting the Finnish sustainability transition which arise from the previous paragraph include:

- Finland is one of the most innovative countries in the world and one of the most eco-innovative countries. This needs to be nurtured and advanced though **national innovation strategies**.
- Developing innovation in the present complex and fast paced economy requires **international participation** to both **basic research** and **R&D**.
- Finland should also understand the benefits (and problems) linked to its **Nordic location** in relation to global innovation.

4.2.3.6 Finnish cleantech

The Finnish cleantech industry has been just recently analysed in-depth by Kotiranta et al. (2015) in a report by The Research Institute of the Finnish Economy of publication *From Cleantech to Cleanweb – The Finnish Cleantech Space* *in Transition*. I will summarize the key findings of the report to build more in-depth grounds for understanding the construct of the 'industry sector' in Finland.

The enterprise data for the report was collected and compiled from central governmental and non-governmental economic development organizations such as Cleantech Finland, Confederation of Finnish Industries, Ministry for Employment and the Economy, the Finnish Funding Agency for Innovation, Centre for Environment and Energy, and Lahti Region Development. The original unedited data consisted of 1800 enterprises active in the cleantech space, from which 200 recently deactivated were removed. The remaining enterprises were manually screened and categorized to thematic cleantech sectors such as *smart grids, recycling and waste management, etc.*, and classified according to their cleantech intensity meaning how central their role was (1-5 scale, peripheral role - dedicated pure player) in the cleantech ecosystem. From the total population 13% received the intensity value of 5 and 48 % received intensity values from 3 – 5. Enterprises operating at the fringe of the cleantech space (intensity values 1-2) were filtered and remaining were selected to the study (762 enterprises representing 21 thematic sectors).

The size distribution of the cleantech enterprises according to the study was that micro enterprises constituted 41 % of the cleantech population, whereas the other groups were SMEs 36 %, large enterprises 23 % (>250 employees) and giant enterprises <1 % (>1000 employees, turnover >1 Bln. EUR). The giants in the population were: Wärtsilä Oyj, Neste Oil Oyj, Nokia Oyj, UPM-Kymmene Oyj, Stora Enso Oyj and non-listed ABB Oy. If we compare these figures against the national statistical distribution of companies (Toimialaonline) we can note that only 0,1 % of the micro enterprises registered in Finland operate on cleantech, thought they amount (in 2012) for 95 % of all enterprises. Out of the total amount of SME registered in Finland 1,5 % operate in cleantech and amount for 5 % of the total enterprises. The interesting statistics originates from the segment of large enterprises, where 30 % of the enterprises registered in Finland operate in cleantech, while they only account for 0,2 % of the total enterprises. It is also notable that the proportion of SME's, large and giant enterprises in the cleantech sector is significantly larger than in the total national enterprise population. The researchers Kotiranta et al. had also recorded the total employment by the cleantech sector to be over 83 360 individuals which is approximately 6 % of the total amount of employed within the private sector. The Finnish cleantech sector consists mainly of privately owned, domestic companies. Roughly 83 % of the cleantech companies are private and in domestic ownership and municipalities own three percent and the government one percent of the companies. 12% of the enterprises are in foreign ownership. Without a doubt cleantech by ETLA definition is a significant employer in Finland and is especially strong within the large companies.

Traditional industry classifications do not disclose well companies activities within the cleantech space as many cleantech companies operate as added value producers within traditional industry sectors or interlink multiple sectors. To bring more clarity to as which fields of operation the cleantech companies act in, the cleantech population was analyzed both by conventional industry classification (European industrial activity classification, NACE) and in addition divided in 34 thematic sectors. These categorizations are shown in FIGURE 43 and FIGURE 44. These statistics show that the Finnish cleantech space is very much manufacturing driven (by NACE classification) and that cleantech in Finland is largely understood and defined as an engineering-related activity. In a more detailed breakdown to thematic sectors renewables (combined solar, wind, biomass, hydro and geothermal) (12%), water and wastewater treatment (11%), biofuels and bio-chemicals (10%), energy efficiency (9%), as well as recycling and waste treatment (9%) are the common sectors in Finland. The sector 'other cleantech' includes sectors such as mining, hydro and marine power, fuel cells and hydrogen, metals, electronics and environmental services.

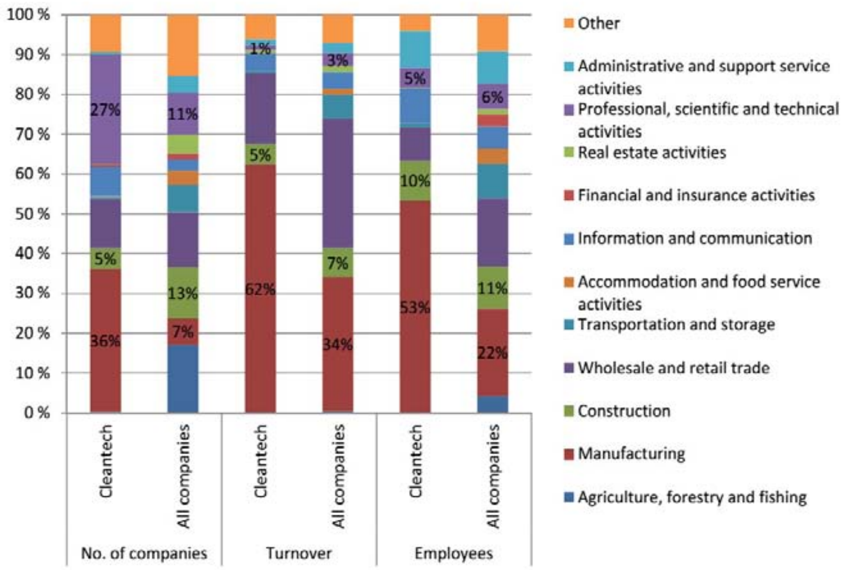


FIGURE 43. Breakdown of the cleantech population data by NACE industry classification

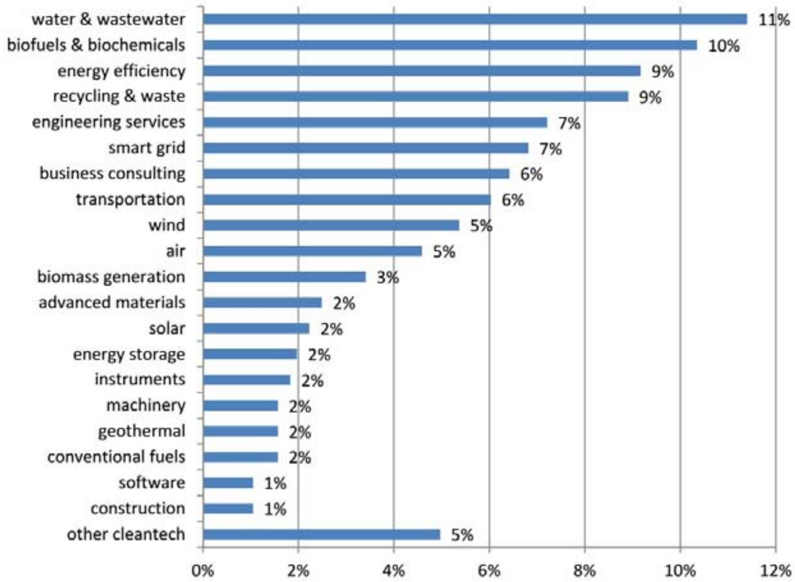


FIGURE 44. Breakdown of the cleantech population data by thematic sectors

From the economic and financial metrics the research analyzed both the economic value added and financial performance of the cleantech sector. The value added measures the total value added produced by the various factors of production in an establishment's actual operating activities. In more operational terms, the value added is calculated as the sum of labor costs, depreciation and amortization, rents, and profits, reflecting the costs of production within the company. The value added can be also harnessed to determine the productivity of employment – i.e. the value added per employee The value added is an important measure for the purposes of economic development because, by definition, it quantifies the net volume of local, regional, or national production. The financial performance of the companies was measured with a number of weighted average value indicators, namely: return on assets (ROA), return on equity (ROE), earnings before interests and taxes (EBIT), and the profit margin. The value added by cleantech sector and employee productivity by company size are presented in FIGURE 45 and FIGURE 46, and financial performance analyses by cleantech sector and by company size in FIGURE 47 and TABLE 7.

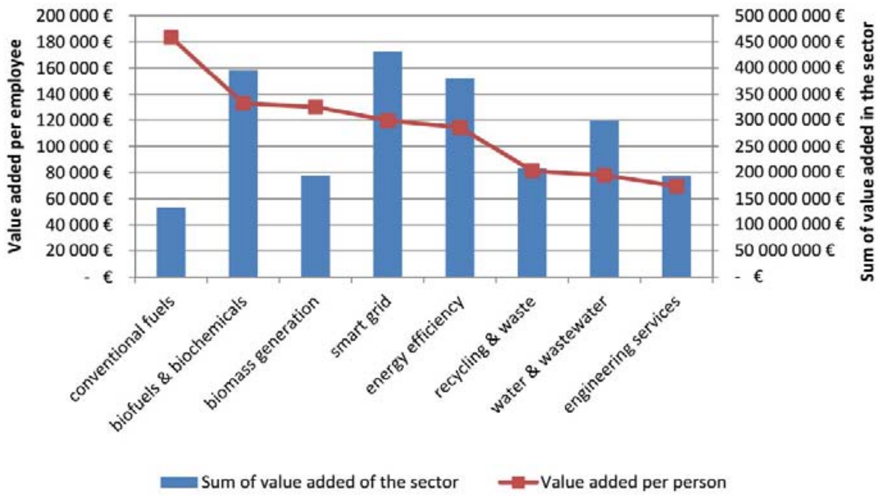


FIGURE 45. Value added by cleantech sector (Kotiranta et al. 2015)

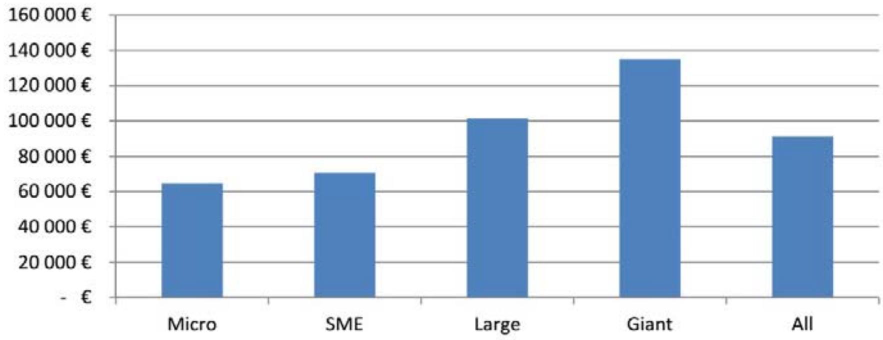


FIGURE 46. Average value added per employee by enterprise size (Kotiranta et al. 2015)

Figure FIGURE 45 reveals that in absolute volumes, the smart grid (€431M), biofuels and biochemical (€396M) as well as energy efficiency (€380M) -sectors generate the most value added in the Finnish cleantech space and the top eight sectors depicted in the figure produce nearly 75% of the value added of the whole cleantech population (note, giants excluded). The highest value added per employee originates from the conventional fuels, biofuels and biomass sectors, where the average productivity (value added) per employee is between €130 000 - €180 000 which are approximately twice the amount generated in recycling & waste, and water & wastewater sectors and of the national average of €64 900 (toimialatonline:2012). The value added per employee by enterprise size (FIGURE 46) reveals that most productive are the large and giant enterprises, where the value added per employee in giant enterprises is double what it is in the micro and SME companies.

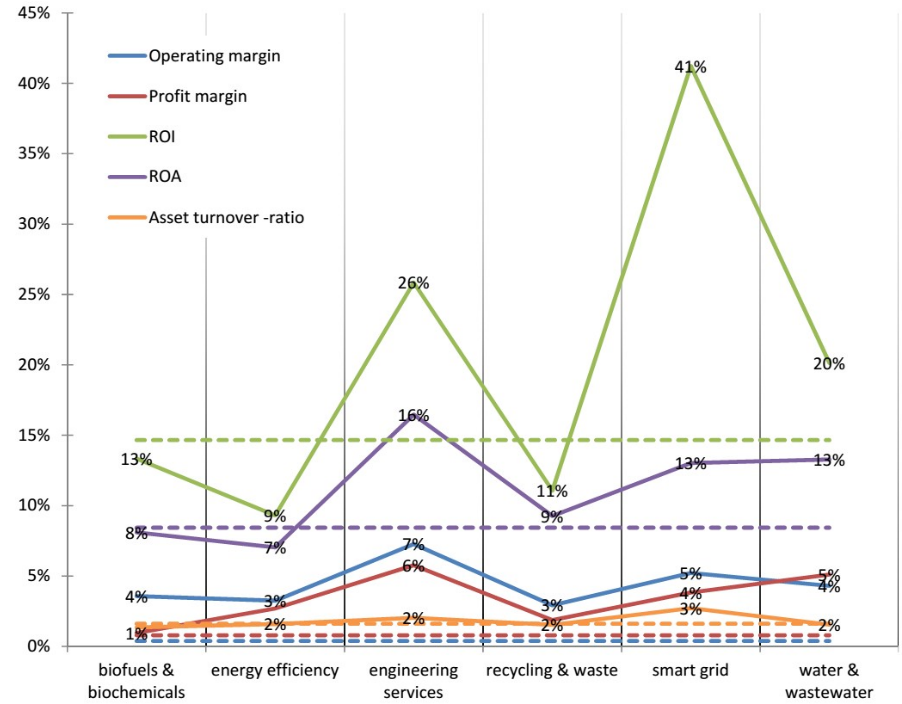


FIGURE 47. Financial performance by cleantech sector (Kotiranta et al. 2015)

TABLE 7. Financial performance by enterprise size (Kotiranta et al. 2015)

	Micro	SME	Large	Giant	All cleantech
Operating margin	-42 %	-7 %	4 %	2 %	0 %
Profit margin	-46 %	-10 %	5 %	6 %	1 %
ROI	0 %	12 %	16 %	16 %	14 %
ROA	1 %	7 %	9 %	9 %	8 %
Asset turnover ratio	2 %	2 %	2 %	1 %	2 %

FIGURE 47 illustrates the financial performance of cleantech for the six largest sectors as measured by value added. The figure reveals that majority of the companies in these sectors financially outperform the rest of the cleantech population on average (averages shown in dashed lines). The financial performance by enterprise size (TABLE 7) reveals that the poorest performers are micro- and SME companies which have negative operating and profit margins. This poor performance of the smaller companies was explained by the study to a degree by the operational phase of the companies, whereas many might be in start-up / pre-commercial (FIGURE 48) (in the data there was a positive correlation with a 95% confidence level between company age and size). The average Return on Assets (ROA) and Return on Investment (ROI) percentages of the Finnish industry in 2012 were 5,4 % and 14 % respectively (Kotiranta et al. 2015), and the operating margin-% and net profit margin-% in 2012 were 6% and 2,6% respectively (Toimialaonlin:2012). The cleantech populations below industry operating margin-% and profit margin-% combined with above industry ROA/ROI suggest that thought the returns have been smaller, they have been generated with lower assets and capital inputs. The researchers interpret the results by stating that the cleantech space is undercapitalized but has capital-efficient companies. The intrinsically efficient companies generate smaller profits simply because they have been unable to tap into large enough pools of resources or unwilling to invest into growth.

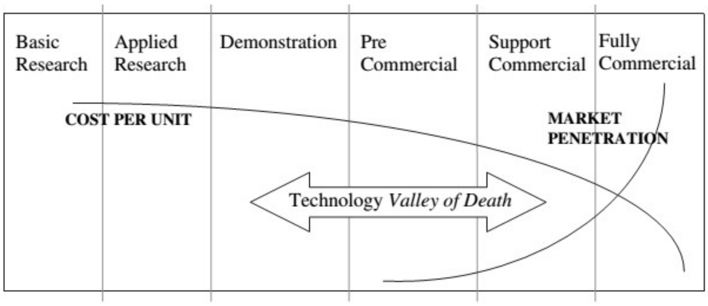


FIGURE 48. Technology valley of death (Balachandra et a., 2010)

Key factors and emergent questions affecting the Finnish sustainability transition which arise from the previous paragraph include:

- Finnish cleantech is **characterized** by a few dominant **large scale businesses** which do not contribute (in relation to their turnover) significantly to pure-play cleantech.
- Majority of companies, personnel and turnover is in the manufacturing and retail businesses, which are simultaneously facing most pressures for **structural renewal**.
- Finland needs a **domestic market for green economy** and an **investment platform** that support the growth of the emergent **niche cleantech businesses** in novel sectors.

4.2.3.7 Comparison with the Swedish industry

In addition to the Finnish cleantech industry, also Sweden has an active cleantech orientation. For comparison: Vallförs (2006) analysed the cleantech market actors and financing in her thesis “Den svenska CleanTech-marknaden – aktörer och finansiering”. In her thesis she identified 798 cleantech companies operating in the market (based on Cleantech Network ™ dataset). The industry categorization and time of formation are shown in the figure FIGURE 49.

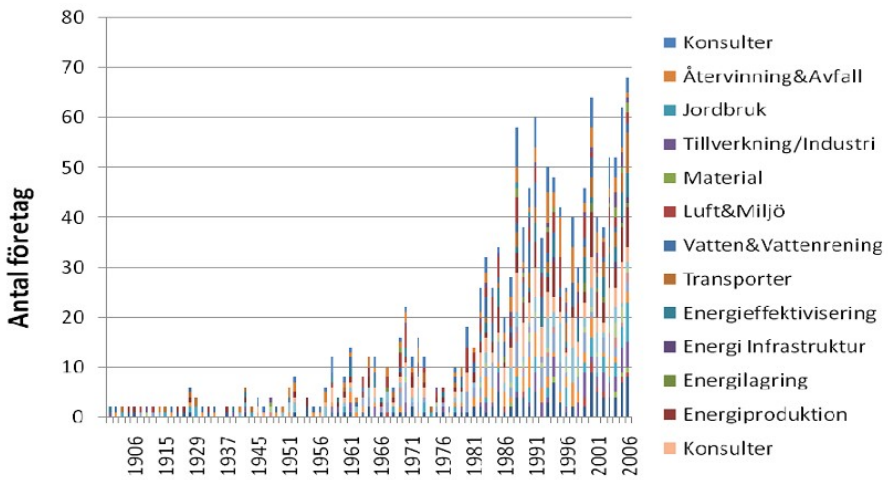


FIGURE 49. Swedish cleantech companies by sector and year of formation (Vallförs, 2006)

Compared by size, the companies were categorized as micro companies (turnover < SEK20M, small (turnover SEK <20M>100M), medium (turnover SEK <100M>500M) and large companies (turnover >SEK500M). Only 7% of the companies were categorized as large, within the group were companies like Vattenfall, SAAB and RagnSells. The turnovers and net results of the enterprises are shown in FIGURE 50 and FIGURE 51, both constituting of the same data but with different axis scales to bring out more clearly the main group, micro and small enterprises, constituting over 80% of the population.

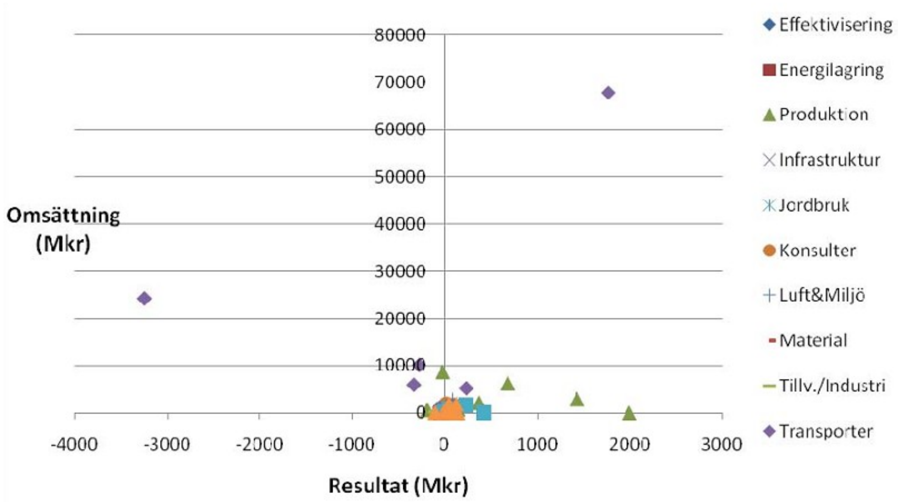


FIGURE 50. Swedish cleantech companies net profit vs. turnover (MSEK) (Vallförs, 2006)

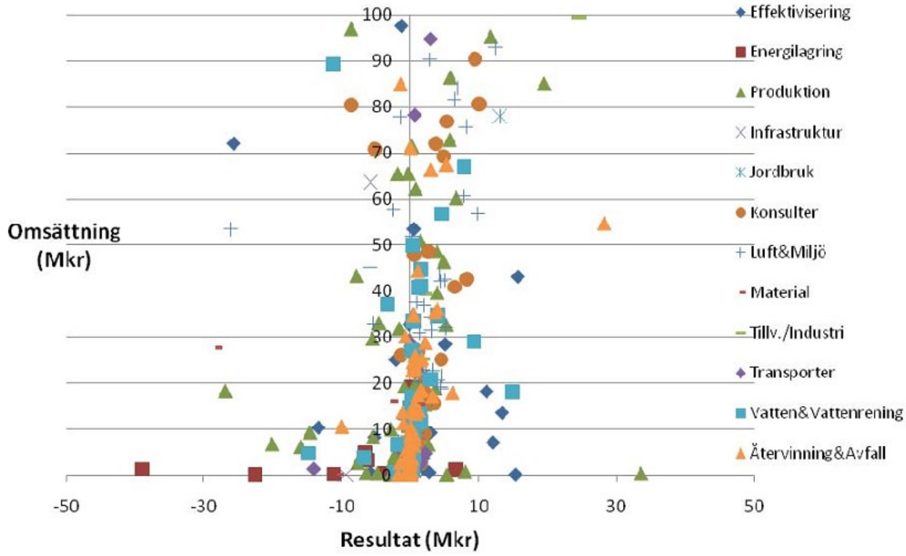


FIGURE 51. Swedish cleantech micro and small companies net profit vs. turnover (MSEK) (Vallförs, 2006)

The interest within the study by Vallförs was mainly in describing the constituents of the local cleantech sector and understanding the incentives and decision criteria of "risk capital" invested into the sector. Her study was elaborated in 2013 by Yang & Sollen who focused more on the investment side and private equity strategies.

Key factors and emergent questions affecting the Finnish sustainability transition which arise from the previous paragraph include:

- The Swedish cleantech business profile differs from the Finnish in relation to the company sizes and industries. Sweden has more consumer level energy, agriculture and environment businesses than Finland, which has more industrial recycling, biofuels and efficiency driven businesses.
- Sweden is undoubtedly one of Finland biggest competitors, but simultaneously the **best global testbed** for Finnish consumer cleantech innovations.

4.2.3.8 Venture finance in the cleantech sector

Recent Finnish employment and economic studies by Kotiranta et al. (2015) and TEM (2015) show that many of Finnish SMEs (including cleantech sector) are capitals stressed which hinders their growth. As outlined in the theoretical framework, venture capitals plays an important intermediary role especially in new technology business development (Paglia & Harjoto, 2014).

Considering the size of the cleantech VC market, according to the Cleantech Group (Knowles et al., 2013) (FIGURE 52 & FIGURE 53) the global venture and growth investments grew in volume globally until 2008 crisis, declined dramatically in 2009, and have since recovered until declining again in 2013. The European venture and growth investment volumes on the other hand grew constantly until 2010, after which they have declined almost -40% from the all-time-high. Also the deal count has been declining both globally and in Europe. When comparing the European cleantech with total VC investment (FIGURE 55), the %-proportion of investments to cleantech in comparison to total VC investments has not been as volatile, signalling that the cleantech investors are not as prone to market turbulence. Historically majority of the cleantech investments by thematic sector (FIGURE 54) have been to energy and renewables and energy efficiency and storage, but lately other sectors as agriculture, waste, recycling, water and transportation have been increasing.

The global fundraising to pure-play[36] cleantech funds (FIGURE 56) shows similarly a significant decline of over -50% from peak years. Cleantech has lately had a bad reputation within the investment community. The VC community discovered energy and cleantech around 2003/2004 and growing investments were based on the idea that VC would transform energy like it computers, Internet and ICT. But some years down the line venture capitalists are learning that energy is quite different from the digital world. This trending lead billions being raised in North America and Europe between 2006 and 2009, majority of which were put into failed clean energy big bets (FIGURE 58) (Geels, 2012; Knowles et al., 2014). Today, Chrysalix EVC2, one of the longest standing venture capital firms in the cleantech space, estimates that the total addressable market in cleantech will grow to a size anywhere between three and four trillion USD by 2020; an eight-fold increase since 2005. In 2013, global investments (including all forms of finance) into green energy alone exceeded $200Bn, whereas in comparison current investments into fossil-fuel-based power generation top out at $270Bn. (Kotiranta, 2015.)

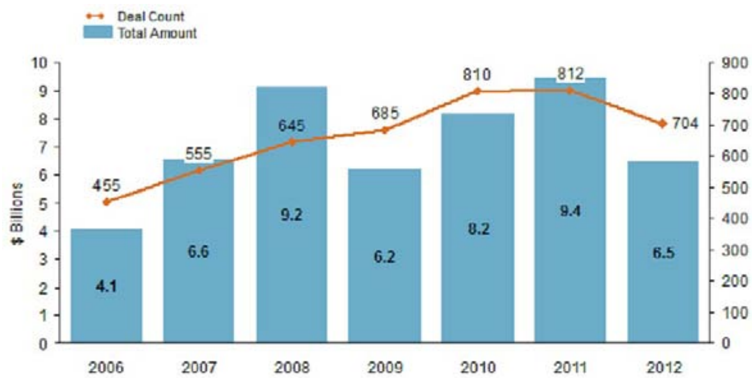


FIGURE 52. Global venture & growth investment in cleantech by year (Cleantech Group, 2014)

[36] In this context > 50 % of the funds investments are in pure play cleantech companies, referring to companies that actually operate with dedicated cleantech issues.

FIGURE 53. European venture & growth investment in cleantech by year (Cleantech Group, 2014)

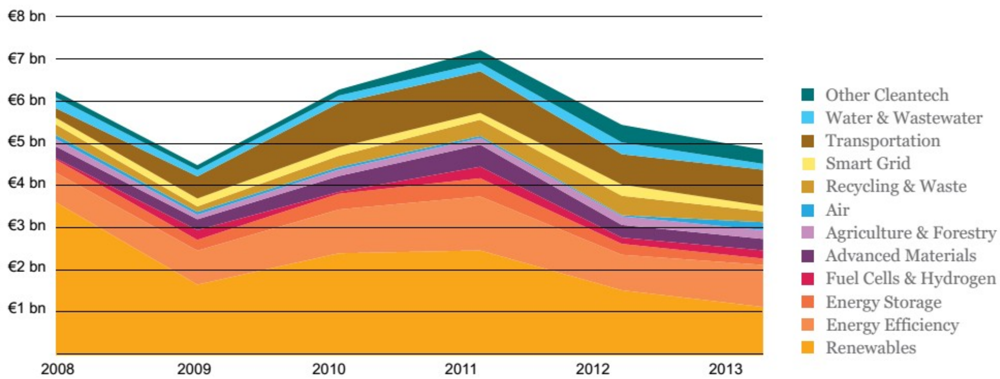


FIGURE 54. Global venture & growth investment in cleantech by thematic sector (source: WWF, 2014)

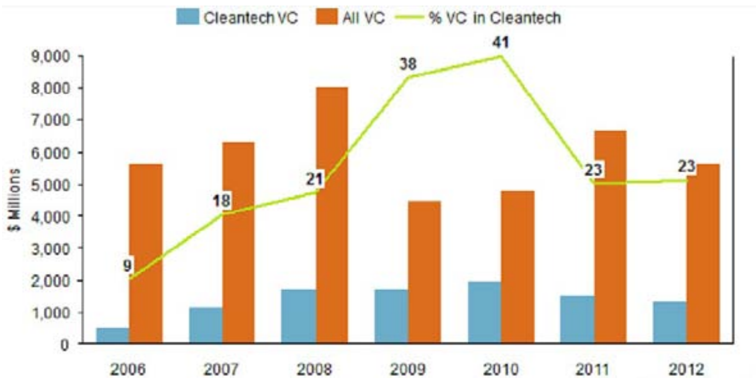


FIGURE 55. Venture capital total and cleantech investments in Europe (Cleantech Group, 2014)

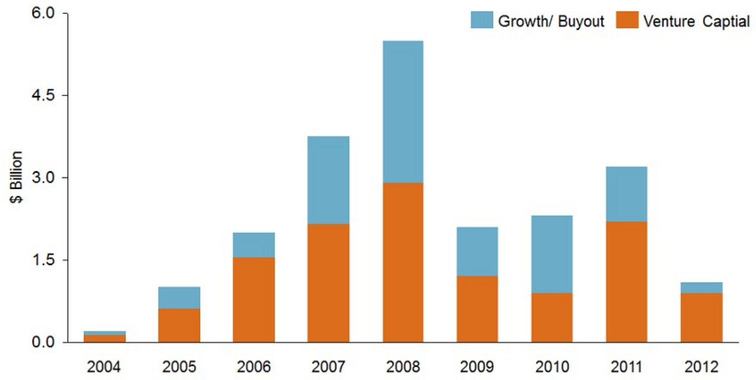


FIGURE 56. Global cleantech pureplay VC/PE fundraising (Cleantech Group, 2014)

When considering the size of the global and local cleantech venture capital markets, existing international data can be found from trustworthy sources, but no dedicated public recordings for the Finnish cleantech investments exists (thought a monitoring tool was planned already in 2006 (ETLA, 2006)). Thought there is no comparable data on the Finnish cleantech investments, *per se*, the Finnish Venture capital Association follows the national private equity market in good detail with the PEREP Analytics private equity database. In their 2015 report (FCVA, 2015) no similar declines in general VC activity can be identified, but year-on-year variance is visible (figure FIGURE 57).

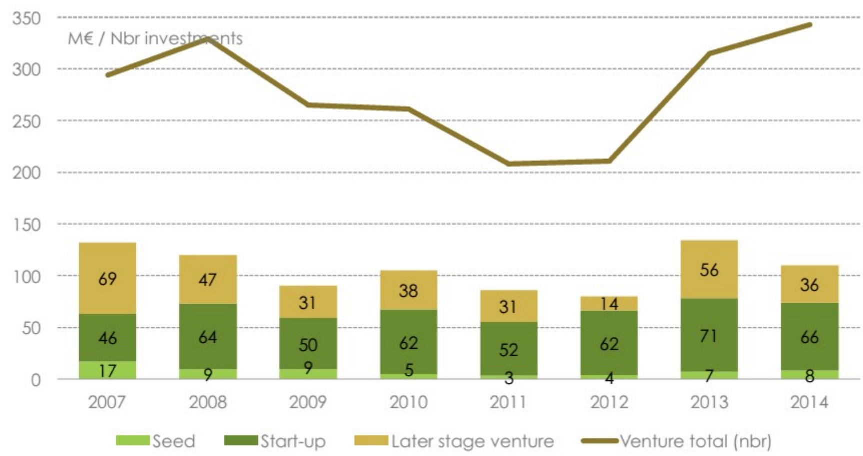


FIGURE 57. Annual VC investments made in Finnish portfolio companies (FVCA, 2015)

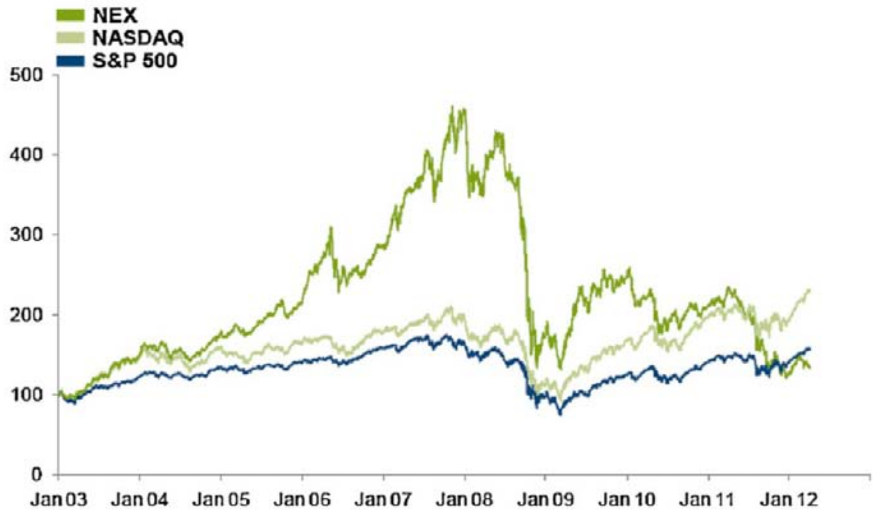


FIGURE 58. Performance of renewable energy stocks (NEX) compared to other indices (Geels, 2012)

Key factors and emergent questions affecting the Finnish sustainability transition which arise from the previous paragraph include:

- Finland has a semi **functioning venture capital market**, which needs to be **reinforced** especially at **seed and start-up stage cleantech businesses**.
- Government cannot be responsible for **winner selection**, but it can de-leverage the private sector risk. New **green investment platforms** could do this.

4.2.3.9 Policies supporting transition

Specific targets for developing the cleantech industry have been laid out in the Government Strategy to Promote Cleantech Business in Finland (MEE, 2014c). It outlines as numerical goals for the strategic program by 2020 that (1) *cleantech companies' turnover needs to be increased from € 25 000 million to € 50 000 million, of which exports account for over* 75; (2) *double the cleantech home market to about € 20 000 million*; (3) *raise the number of cleantech companies from 2000 to about 3000*; and (4) *create at least 40,000 jobs in clean technology in Finland*. To achieve these targets the strategy outlines as priority actions (a) *making cleantech the spearhead theme of the country brand*; (b) *promoting cleantech investments*; (c) *creating cleantech demonstration environments*; and (d) *establishing the Cleantech Finland Board, which transcends the boundaries of administration*. These targets are aligned with the Finland we want by 2050 strategy and elaborate with numbers the short term target for the direction and speed of the industrial transformation. The cleantech business strategy also outlines some governance tools for achieving the targets, mainly within the actions of promoting cleantech investments and creating cleantech demonstration environments.

4.3 Roadmap: Cleantech as a foundation for future economy

As described and defined in the earlier chapters, Finland has a number of national strategies, and is a signee of a number of international strategies, agreements and conventions, focusing on transforming our nation and global societies towards sustainable development. As shown in the baseline analysis, Finland is doing well on many of these targets, being ranked as one of the best in the world. There are shadows looming though. The national macroeconomic developments and global recessions during the last decade have pinpointed a significant imbalance between individual and global levels of decent life and sustainable development. The Finnish industry is doing poorly and in a need for structural reformations to continue support the welfare society.

The following chapter describes a roadmap for the national sustainability transition towards a carbon and resource neutral society which is a global leader in the green economy. The roadmap is constructed by using backcasting. First the chapter introduces the sustainability transition space in the multi-layer perspective and identifies a number of actions, actors, risks and opportunities (hereinafter *key factors*) at niche, regime and landscape levels. In the next step a transition pathway is backcasted and the key factors matched in a timewise strategic timeline to describe a potential pathway. The chapter concludes in describing the transition through potential actions constituting the key factors.

4.3.1 Setting the sustainability transition space

The sustainability transition space is a theoretical and conceptual framework which combines the: (1) *the research questions*; (2) *the theory of socio-technical sustainability transitions and the multi-layer perspective*; (3) *methodology of backcasting scenarios*; (4) *the focus, scope and objectives of the analysis*; and (5) *identified key factors affecting the transition in connection to cleantech*. The sustainability transition space framework is presented in FIGURE 59.

The key factors in landscape and niche are divided thematically. In the landscape the affective key factors arise from the *paradigm forces* such as sustainable development or circular economy, from *global pressures* such as population growth or urbanisation, from national *macroeconomic* factors such as population dynamics and competitiveness and from potential *lock-in*s such as the Nordic location of the country or sunk costs in infrastructure. In the niche level the key factors are divided into *socio-technical systems* such as energy or transportation, *change agents* as entrepreneurs or venture capital, *consumer niche* including sharing economy, products-as-service and *industrial niche* including key enabling technologies (KET) and dematerialization. In the regime level the key factors are not at divided thematically, though the factors include political, industrial, economic and socio-cultural themes. Majority of the landscape and niche key factors have been identified in the theoretical framework, during the vision generation and the baseline analysis.

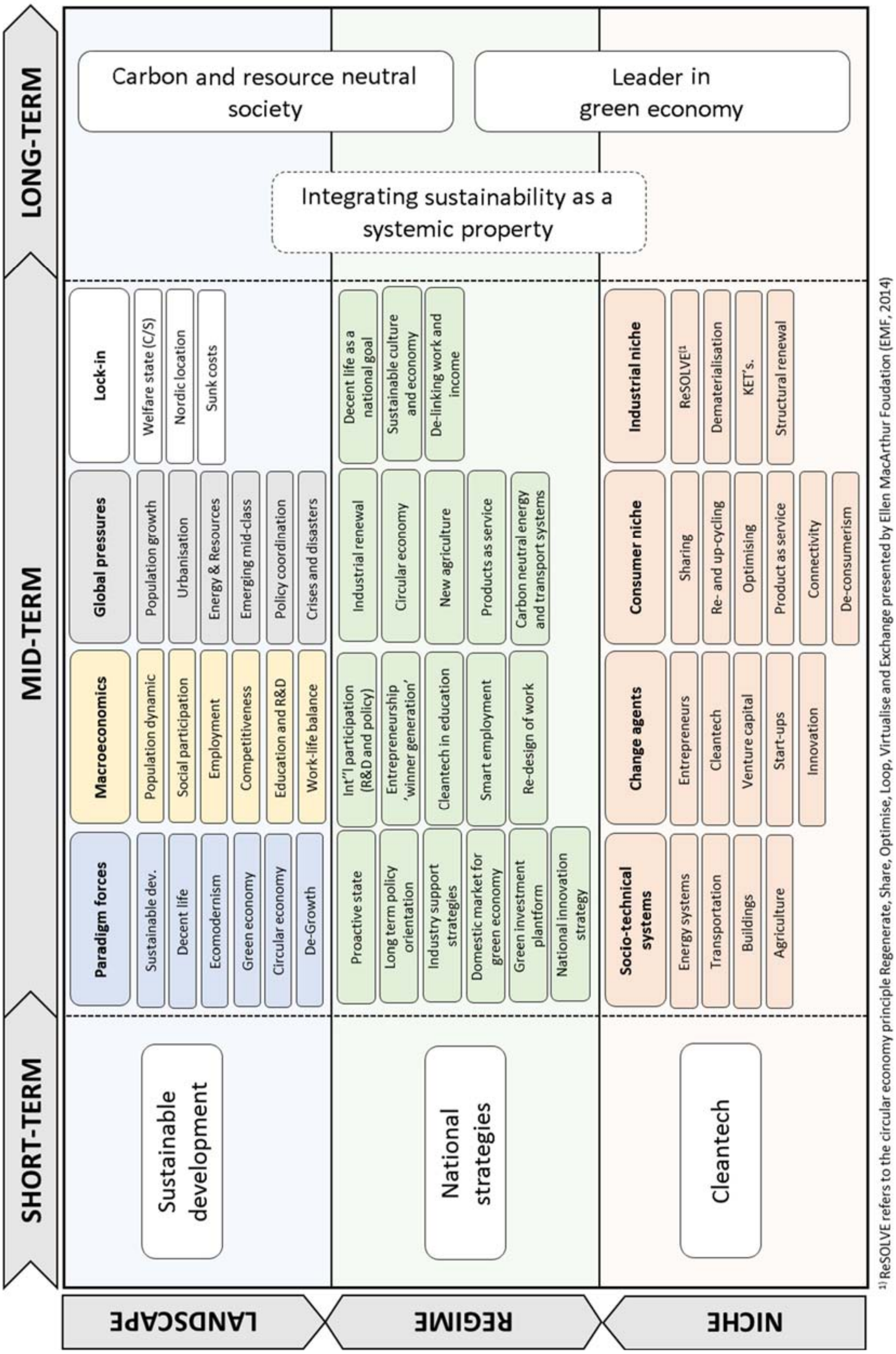


FIGURE 59. The sustainability transition space with identified mid-term actions, actors, risks and opportunities relating to the cleantech space and described under the multi-layer perspective

4.3.2 Backcasting the transition pathway

The next chapter of the analysis describes backcasting the transition pathway. For backcasting it is important to have a clear starting point, objective and end vision. Reminding from the previous chapters, the underlying analysis focuses on the Finnish national sustainability transition as described in the respective strategies. The specific objectives for the analysis are defined as (1) *Finland will be a globally leading country of the green economy*; and (2) *Finland will achieve carbon- and resource neutrality by 2050.* In align with the research questions, the research respectively aims at understanding that *what can the (Finnish) cleantech industry do to facilitate the underlying sustainability transition***.**

In terms of backcasting, first a major transition path needs to be identified. The purpose of the transition pathway is to formulate a macro level transformative agenda. This transition pathway can then be elaborated into a more detailed roadmap, by using the key factors identified in the transition space to further elaborate the events in the transition path. To develop the transition path, the necessary developments are backtracked from the set vision to the current state of affairs, i.e. the baseline. The transition pathway describes the changes necessary for the transition to occur in a general thematic concept level. In the next chapters we will describe the backcast rationale for the transition path.

In terms of sustainable development, sustainability and cleantech, the visionary world where people live in a carbon and resource neutral society driven by a globally leading green economy, is a society that has gone through significant sustainability transitions in terms of its socio-technical systems, technology, ethics and cultural perspectives. Whereas one could predict the socio-technical systems or the technology of the future, predicting the mind sets of people in the future is complex if not impossible. The final transitions are bound to be mental and ethical, rather than political and technological, hence the last stage of the transformation shall be themed as (5) *paradigm change*. Preceding the paradigm change, a number of changes in the consumer and industrial practices have emerged and been implemented. These changes take time, but prior to having any effect, they must be integrated and infused in the socio-technical landscape. Hence structurally, (4) *landscape transitions* precede the paradigm change, but are a product of industrial and consumer changes. Though both industrial and consumer changes occur alongside, and both have strong signs of appearance, the current political environment is pushing harder for an industrial reform and transformation. Undoubtedly individual consumers are already changing their consumption patterns, but the large scale emergence of (3) *post-consumerism*, an era indicated by conscious consumption, requires that also industry has developed sufficient structures for manufacturing sustainable goods and operating under sustainable business models. Before a large scale (2) *eco-industrialization* has emerged, the post-consumerism can only be considered marginal. The landscape paradigm forces and other pressures are pushing for the change to more sustainable means of production, diffusion and use to emerge. This requires that national and global

(1) *policy formulation* creates clear long term strategies in coordination to support the transformation. If we invert the previously outlined major transition path, the structure of the pathway is from the *present*, to *policy formulation*, *eco-industrialisation*, *post-consumerism, landscape transitions, paradigm change*, and *future* of the vision.

The next step in the backcasting analysis is to match the transition pathway with the identified landscape, regime and niche key factors to elaborate the pathway. To do this, the key factors are divided based on the structure of the pathway. The distribution was not done on a corresponding thematic division, where e.g. policy formulation withholds all key factors relating to policy. Instead the key factors describe again a more detailed level of the hierarchical structure applied in the backcasting. The aim in dividing the key factors according to the transition pathway was to allow for a multi-level approach on describing and developing the transition roadmap. The division was done first based on the regime key factors, which form the core of the analysis. This was then elaborated with emerging and supporting niche key factors and with different landscape pressure factors. The constituting roadmap is illustrated in FIGURE 60. The illustration presents the timeline from now to future, below it the transition pathway and above it the roadmap.

Majority of all key factors are located in the now part of the timeline and transition pathway. This is due to the fact that key niche and regime actors and strategies need to be initiated for the later stages of transition to have the necessary foundations. Also many of the landscape pressures such as the paradigm forces, macroeconomics and global pressures already currently exist and exert pressures towards the regime. When looking at the proportions of niche vs. regime vs. landscape key factors, the majority of niche developments are located in the mid- and latter part of the timeline and transition pathway, whereas majority of regime key factors are located in the now and mid- parts. The explanation for this proportional development is partly linked to the enabling property if regime for latter stage niche emergences, but also that many important niche development relating to the large landscape transitions, such as the KETs in transport and energy take time to evolve and align within the socio-technical system.

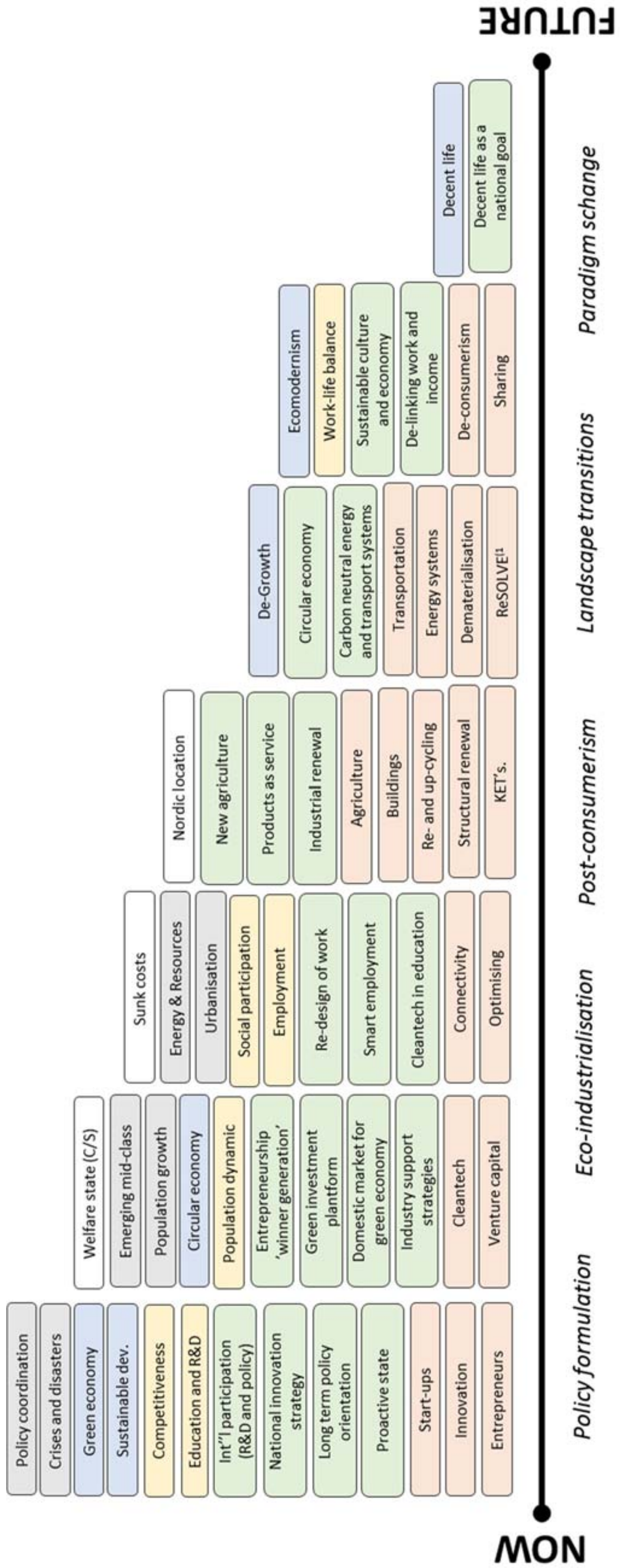


FIGURE 60. Transition roadmap for the national sustainability transition focusing on cleantech as the key transition actor.

4.3.3 Unfolding the roadmap and connecting with cleantech

The key factors in the roadmap constitute of *action-tasks* that describe a more concrete level of actions and tasks needed for enforcing the specific transition trajectories. This is the same for both landscape and niche key factors, as all are simplifications of larger themes, i.e. green economy, competitiveness or innovation. The action-tasks are specifically linked to cleantech following the objectives of the analysis. The purpose of unfolding the roadmap is not to illustrate in-depth technologies or policies necessary for the transition, but to generate examples action-task that constitutes the transition pathway.

4.3.3.1 International participation in policy and trade

The global and national developments relating to large scale paradigms and transboundary socio-technical systems are defined in the international arena. For example the policies relating to sustainable development are formulated in international collaboration, thought implemented nationally. It has become obvious by 2015 that failures in achieving the sustainable development goals causes human suffering, which also affects the Finnish national well-being (e.g. by costs and social distortion from a sudden influx of refugees). **It's strategically imperative that Finland as a leading country in sustainable development and decent life participates in the formulation of these policies, and more so, implements the commitments in the strategies.**

Failed actions in other international commons collaborations, as in climate change mitigation, can also cause Finland significant long term costs and harm. The Finnish environment is seen as a key source of human wellbeing and the core of future bio based circular economy. Changes in the climate system can have emergent and unexpected effects on this vulnerable environment, which will eventually affect also the economy. **It is Finland's best interest to participate in protecting the global and local commons (air, water, soil), especially due to the national agenda of green economy.** There is still a lack of urgency on global and national level relating to the risks related to not meeting the requirements of sustainable development. **Finland should position as a paradigm leader, emphasizing and leading the sustainability transition.**

In addition to participating in social and environmental policy formulation at the international arena, Finland should actively participate in the global trade negotiations. There are currently trends of both increased regulation and liberation in market. Since the 2001 Doha meeting, it has been widely discussed between WTO members that the tariff and non-tariff barriers on environmental goods and services should be reduced or, as appropriate, eliminated. Whereas WTO has not progressed, the US has progressed with its own Environmental Goods Agreement which targets liberalization of trade in environmental goods and services. The US plans at signing the EGA by the end of 2015. The agreement targets lowering the costs of environmental protection worldwide and the risks related to the investments, but it also means unlocking the opportunity for established exporters to enter a multi trillion dollar market.

Finland should actively participate through its networks and other means of influence on the development of global free-trade negotiations so that the resulting agreements would support the export of key Finnish technologies and control global trade of unsustainably produced energy and resource intensive products.

4.3.3.2 National innovation strategy and R&D

Research, development and innovation are becoming more global and network driven. This is due to increased international collaboration in basic research, globalization of large companies, and also because the international institutions finance multilateral international research (e.g. EUs' FP's). In global comparison the Finnish universities and RTO's do not rank well, though both the education and innovation systems are highly respected internationally. R&D&I is a key driver in the larger transition from industrial economy towards knowledge economy and the direction of research guides mainstream and niche technological trajectories. To support the national sustainability transition and cleantech at particular, **Finland must influence the global research agenda towards the future needs of sustainable socio-technical systems and the following paradigm change**.

Innovation, R&D and industry support are all strategically and economically important, but a distinction needs to be done between supporting existing technologies and future key enabling technologies[37]. Simplified, no matter how much continued investments telegrams or telefax would have received during their times, mobile phones and e-mail would still have surpassed them in utilization rate due to the superior value offering. Development of ICT would not have possible without KET's in semiconductors. EU acknowledged the role of KETs in forming a High Level Group on Key Enabling Technologies (HLG-KET) in 2010. The background for the group establishment was the acknowledgement that KET's play a crucial role especially in facilitating reindustrialisation within energy, resource efficiency, smart cities, circular economy, cleantech and bioeconomy. The group submitted its final report and conclusions for the EC in June 2015. The main difficulty in relation to KET's in EU was, according to the report, translating scientific knowledge base into commercial goods and services. EU has a wide range of common policies ranging from agriculture to finance, but no common industrial policy even though one of the fundaments of EU is the single market approach. (DGG, 2015) **To support cleantech Finland must generate a national *sustainable innovation strategy* that is clearly focused on basic research on key enabling technologies and innovations that apply the KET's in sustainable industrial scale solutions.** Whereas in industrial terms KET's can revitalize old industries and develop new ones, they are also the enablers for

---

[37] Key enabling technologies are core technologies that are needed for the development and manufacture of wide range of technologies forming the socio-technical systems. For example the development of semiconductors allowed electronics, advanced batteries are needed for future smart grids and electric mobility.

larger systemic changes. For the cleantech industry to succeed in the future, this is exactly what is needed. Changes in the practices of socio-technical regimes are preceded by innovations in technology (e.g. digital imaging transformed photography). Finland needs to facilitate, to link, and to cluster the businesses effectively for them to be able to identify and commercialize *the right innovations in the right time and in the right markets*. **Finland must position itself as a leading hub of international cleantech research (i.e. KIC[38]) to be able to attract funding, top researchers and access to the latest technology to make sure the Finnish businesses stay in the front line of global needs and technology**.

If we compare the global development trends in investments to R&D and resulting patents, US, China and India have exceeded EU and are already leading by far. In comparison, China and India invest three times the amount EU does for R&D, and whereas Finland and Europe are contributing most of their R&D efforts to basic research, the rest of the world focuses more on the applied research. (DGG, 2015) Countries as US and China are already doing this. Especially US acknowledges that the ultimate goal of innovation is successful market introduction, preceded by industrial scale production capabilities. Examples of this are the US Department of Energy (DoE) grants to domestic and foreign companies, totalling hundreds of millions of euros, for investments in US based production facilities of new energy technologies, e.g. advanced batteries[39]. To be able to compete for the position of global leadership in green economy and achieve carbon and resource neutrality, **Finland needs to redefine innovation to integrally include commercialization and increase investments especially for later stages of TRL**[40].

To have a resilient industry environment, one needs to master both the R&D and manufacturing (this is how e.g. Samsung dominates the consumer electronics). Basic research or R&D is not enough, but innovations need to be commercialized to build value. Finland's strength is the strong manufacturing sector that has the potential to fabricate innovations. In the global environment, high level manufacturing does not to follow R&D, contrarily, R&D locates close to the strong manufacturing hubs (whether it is ICT, biotech, engines, etc.) Finland has historically had a strong high tech manufacturing and ICT sectors. **Finnish cleantech must combine world class R&D&I and future innovation driven manufacturing for building competitive design-production ecosystems.**

4.3.3.3 Long term policy orientation

The Finnish government has in the past years had a tendency of reformulating visions and generating new strategies and policy programs for every

---

[38] Knowledge and Innovation Communities are an EU term for research hubs where universities, RTOs and industry can collaborate on specific topics

[39] See e.g. https://www.whitehouse.gov/the-press-office/24-billion-grants-accelerate-manufacturing-and-deployment-next-generation-us-batter

[40] TRL is the technology readiness level, used to describe technology maturity from theoretical level to mass market readiness (e.g. EU uses scale 1-9)

government. This is typical to parliamentary democracy, but if the visions are also re-aligned it generates a dilemma of focusing more on the process than on the progress. In the last years a number of strategies relevant to the focus of this study have been changed, such as the sustainable development strategy (2006, 2013) and the energy and climate strategy (2008, 2013, new strategy expected again in 2016). **Finland should define clearly the future vision of well-being and measurable long term sustainable development targets, such as carbon and resource neutrality, and develop strategies that enable the society to sustainably self-manage towards the set targets.** The current sustainable development strategy provides a good vision for Finland, clear targets for sustainable development and the underlying transgovernance process is a functional means for co-management. The system does not though provide tools for criticism, allowing bankrupt strategies such as the Government Strategy to Promote Cleantech Business in Finland, be passed into implementation. It is important that short term strategies are connected with long term objectives, but they must reflect the real baseline environment and have a realistic timeframe. Poor short term strategies will have a de-moralizing effect on long term visions.

The long term policy orientation requires that sustainability is seen from systems perspective, and as earlier noted, as a moving target with intrinsic uncertainty. If we target an increase (or decrease) in something, what happens when we have achieved it? By definition we will not be sustainable, just more sustainable. Developing strategies that have only quantifiable objectives and metrics for sustainability and decent life lapse from this definition. Progress should be measured, undoubtedly, but the accuracy of the measurements should not overcome the process itself. For example measuring the quality of life by measuring expected lifetime is as comparing apples and cars – whereas one might taste good, the other can provide long mileage. **In generating long term policy objectives the validation and evaluation should be both quantifiable and qualifiable.**

4.3.3.4 Proactive state

One of the key elements of the social contract concept serving as a template for the Finland we want by 2050 sustainability strategy is the notion of the proactive state. This notion describes a state that actively sets priorities for the sustainability transformation, while at the same time increasing the number of ways in which its citizens can participate, and offering the economy choices when it comes to acting with sustainability in mind. The Finnish sustainability strategy defines many objectives which can be described as acts of a proactive state. For taking the strategies to practice **Finland should develop platforms where sustainable innovations and cleantech are favoured in contrast to traditional technologies in procurements and develop subsidy or rewards systems for consumers making sustainable choices**.

4.3.3.5 Entrepreneurship and winner generation

There are no simple ways of encouraging entrepreneurship. Cleantech and emerging entrepreneurial economy both have potential to do this. **By local and global cleantech success stories by the Finnish SMEs, the industry can encourage the development of a joint definition of winner generation**. When a number of success stories emerge, more high skilled people are pulled towards accepting the risk of entrepreneurship in hope of the reward. Also, **a growing cleantech industry pulls more potential entrepreneurs to the specific sector**.

Increases in entrepreneurship and subsequent start-ups are very much a result of increased niche innovation. The niches for the innovation-entrepreneurship-start-up nexus need hence to be in order before a successful entrepreneurial economy can emerge. At current the government niche incentives and accountability end after the start-ups have been appointed the offered services and business development tools. This system must also be renewed. **The government institutions must transform from providing guidance to entrepreneurs, top supporting entrepreneurs and entrepreneurship.** From the macroeconomic perspective, **Finland must acknowledge that the best way to increase employment and economic value added generation is by enabling more SME's to enter the market with innovative enabling technologies**.

4.3.3.6 Green investment platforms

One of the identified problems for cleantech businesses and the growth of green economy is limited venture and growth stage financing that could bridge the gap from lower TRL level R&D to commercial ventures. New businesses, especially innovative cleantech companies often face financial stress, though being cash flow efficient. The Finnish government has tried to address this financial stress by allocating R&D and investment loans to businesses at lower TRL, and 'challenge funds' like the NIY[41] through TEKES and loans through Finnvera for mid-stage TRL. The mature TRL full scale applications are mainly financed with debt finance, leveraged through EU grants[42]. Venture capital is currently seen in part complimentary and in part competitive. The question therefore becomes whether non-dilutive government finance i.e. government can be responsible for the winner selection?

Government support in facilitating green growth SMEs is needed, also financially, but the rules should be clear and the government role should only be supportive[43]. Also as a significant number of the eco-innovative cleantech businesses are micro- and SME businesses, there needs to be operational

---

41 NIY is the Young Innovative Companies challenge fund where if selected the company can gain up to EUR 1 million in non equity diluting finance.

42 e.g. the Stora Enso 'biofactories' and Outokumpu/Gasum 'LNG ports'

43 This is already the case e.g. in the Finnish Industry Invest, a government sanctioned venture finance institution.

support instruments for these potentially globally disruptive businesses. This means a step towards supporting the full entrepreneurial life cycle.

To address the issue of green investment platforms **Finland must develop finance tools to government co-finance private sector VC investments in cleantech and sustainability**. Different models for such platforms exist, as e.g. the YOZMA equity program applied in Israel and the Multi Asset Fund for Industrial Renewal[44] discussed by ETLA. Another potential for cleantech and green economy investments is in bridging finance to company and project level from large global institutional funds. For this money to trickle down effectively there needs to be a chain of direct investment funds and funds-of-funds (FOF) that the institutional funds can invest as per their investment criteria. To leverage both the national economic growth and pension fund return, **Finland could create an imperative (and encourage) pension funds to allocate investments in domestic non-listed equity or project VC funds, or FOF's, focused on cleantech and sustainability.**

4.3.3.7 Domestic market for green economy

One of the most critical things for new product introduction is customer testing and piloting of the technology. If Finland wants to achieve carbon and resource neutrality and become a leader in green economy, **it is necessary that Finland develops a domestic market that be used to test and market the cleantech innovations, which through implementation facilitate the sustainability transition of the whole socio-technical system**. To develop a domestic market Finland must also engage in proactive measures to support sustainable clean technologies in both public and private procurement, and to discourage the use of carbon and resource consuming technologies.

4.3.3.8 Industry support strategies

Advancing green economy and cleantech requires industry support strategies at national level. Typical national level directing and supporting strategies are (1) *pricing instruments to change behaviour with respect to water, waste and transport*; (2) *shifting tax burden in favour of environmental related taxation*; (3) *eliminating environmentally harmful discrepancies in tax systems;* (4) *managing subsidies to promote green technologies and phasing our environmentally perverse subsidies*; (5) *supporting the development of green infrastructure and accelerating improvements in energy efficiency*. (OECD, 2015) Also in relation to global export of the green economy products and innovations (6) *export finance solutions to help client side finance and decrease of importer risks.*

---

44 Multi Asset Funds for Industrial Renewal are a new model discussed under ETLA as a new way of leveraging IVC and GVC to SME debt and equity. To follow up the discussion see eg. http://www.etla.fi/en/columns/smart-money-multi-asset-funds-for-industrial-renewal/

4.3.3.9 RE-design of work

Work is going through significant changes in the coming decades. Already two decades ago, economist James Rifkin (1996) predicted that work would diminish as automation, robotics and artificial intelligence takes over low- and mid-level work. ETLA has even predicted that digitalization is threats one third of Finnish jobs (Optio, 2015). Our understanding of work originates from the agricultural and industrial era, where manual, repetitive work was the norm. Unemployment itself is a new concept of the industrial era, and today the term has already reached a stigmatizing level.

It is fair to accept that work will change. Long term steady employment will decrease and people will work more on project basis, which poses a threat for steady income and economic well-being. A sustainable development would be to share the remaining work more equally amongst the employees. **Finland must address the change of work by redefining work and unemployment legislation to acknowledge the changing environment**. Work should be perceived not as an intrinsic goal of a productive society, but a societal function that serves the greater good. **Finland should also prepare for the actual decrease in the quantity of repetitive work, by analysing possibilities for e.g. citizen pay schemes.**

4.3.3.10 Smart employment

If work is seen as a social function, not only as a means to achieve individual increased economic well-being, labor related skills can be defined according to task and function. Work does not necessarily need to be the main focus of individual interests, but people can work and immense mentally at different topics. Work must also conform to the faster cycles of the entrepreneurial knowledge economy, where the required skills evolve and emerge faster. **Finland must develop educational pathways that allow people to educate fast and in-work, to gain basic skills in new occupations**. **Companies should also be allowed to continue educating employees in collaboration with institutes to train interested individuals for official degrees** (ie. oppisopimus).

The future work will be less bound to locations and specialists will move and work globally physically and through modern communication tools and platforms. **The green economy can develop solutions for sharing work and working globally interconnected.** The leading position of Finland in green economy and cleantech, and the country's positioning as an innovation and R&D hub also draws new foreign labour to the country. **Finland must develop programs to encourage global specialists to move in and, or work remotely, for the Finnish institutions and industries**. In radical terms, Finland could e.g. provide tax deduction programs for specialists moving their accounts to Finland.

4.3.3.11 Industry and education

Education is integral for the development of the green economy, cleantech innovations and the resulting carbon and resource neutral society. The changing work also changes the requirements set forth for education. It is not enough to learn a profession, but today more important is to learn to learn. Also in the future many basic ICT skills are native for the enrolling students, and digitalization will cause many people to have lower practical skills, again causing realignment of education. **Finland must develop educational pathways together with the industry that addresses the learning needs for both low level- and higher level educated labour.**

Also the need for higher level education will increase. It is not necessary, nor meaningful, that there would a single education trajectory from the age of 6 to 25, from elementary school to post graduate. Instead **industry must take responsibility of higher level education in aligning, financing and partaking in education and research.** This means the development of new educational trajectories where e.g. master degrees could be studied at a later age, supported in part by the employing industry financing. **Finland should also facilitate the transition to high level sustainability and cleantech education by providing free on-line educational programs**[45]. This strategy would help increase the global awareness of Finnish education, green economy and cleantech, and help position Finland as a leading cleantech R&D hub.

4.3.3.12 New agriculture

The agricultural sector must feed the 9.6 billion people that are going to inhabit the planet by 2050. Half of these people will live in cities and urban surrounding. According to FAO (2009) the food production must increase by 70% by 2050 to address the needs of the growing population. The growth has to be achieved in spite of the limited availability of arable lands, the increasing need for fresh water and other less predictable factors, such as the impact of climate change. Finland faces the same problem (and opportunity), though not through domestic population growth, but through the globalization of food industry. Food is a likewise common in the sense that water is. It is similarly governed through international conventions, but it is more guided through consumers and market activities.

To address the issues of increasing the quality and quantity of agriculture and rationalizing the logistics chains, the goal should not be in industrializing agriculture, but in '*sustainabilising*' it. Green economy and cleantech have a great potential in facilitating this. **Finland can use regulation to assert sustainable land use policies and encourage sustainable farming practices and the use of local products**. Cleantech has a great potential in re-defining agriculture. **Cleantech can develop solutions for *precision farming* with**

---

45 Referred to as MOOC's Massively Open Online Courses provided already today by a number of global leading universities.

sensors and big data, *biotech* solutions for microbial fertilization of fields, resurrecting the soils, enhancing crop properties and developing biofertilizers, building *circular ecosystems* where industrial side streams such as composts, water, heat, and nutrients are utilized in urban greenhouses, amongst others.

4.3.3.13 Products as service

An emerging trend supporting both entrepreneurship and sustainability are the product service systems. These 'eco'systems span from product oriented to use oriented to results oriented. The fundamental change in relation to today's product or service oriented systems is that ownership of the product is no longer expected. Typical business models are e.g. renting and pay per use. The PSS is a critical step towards dematerialization and sharing culture. **Finland must actively promote new business models supporting sustainable PSS's, since they are in the core of green economy life cycle thinking**.

Cleantech has huge global potential in PSS. The key is in developing new sharing, and re- and up-cycling solutions for consumers and industry. The existing value chains in the production-use-diffusion structures of our socio-technical systems have a huge potential for increasing resource and carbon efficiency. **Finnish cleantech must engage in locating and generating value added solutions to existing products and services as new product service systems**. By integrating the Finnish cleantech SMEs in global business value chains and life cycles through product service systems solutions, the industry can gain significant global competitiveness.

4.3.3.14 Industrial renewal

Industrial renewal refers to a large scale transition of socio-technical regime institutions, such as policy, education, R&D, finance, and enterprises. The fundament is a shift from the current declining export sectors—forest industry, metal and machinery industry, electronics, and information and communication technology towards carbon and resource saving solutions supporting and profiting from the future paradigms. **Finland must develop a national strategy how to support the transition of the existing sectors towards green economy leaders, while supporting the emergence of new cleantech solutions in the key sectors of transport, energy systems, agriculture, buildings and other KET's**.

Cleantech can generate the innovations and commercialise ventures supporting industrial renewal. To support the process the engagement of all available knowledge and competencies and active cooperation of various stakeholders, including governments, financial institutions and civil society is required.

4.3.3.15 Circular economy

Circular economy is a systems thinking approach towards the production-use-diffusion of products and services. In the traditional economic model products and services are perceived as produce-use-discard processes where efficiency is gained from reducing the input of resources per manufactured unit. Circular economy aims at optimizing these flows and acknowledges that a resilient system must maintain or increase the resource stocks. Theoretically circular economy builds upon the 3R's adding remanufacture and extending upon the systems thinking. Finland has a great potential in optimizing and also dematerializing its economic system through circular economy principles. **Finland must develop a circular economy policy that supports businesses and industrial consortiums that operate under circular economy principles.**

Circular economy also provides vast opportunities for cleantech entrepreneurs. Using waste streams as raw materials can be a commercially competitive option, or the waste supplier (raw material supplier) can share the savings from waste management as profits with the circular economy supplier.

4.3.3.16 Carbon neutral energy and transport systems

Key in de-carbonizing our socio-technical systems is in carbon neutral energy and transport systems. Finland and other Nordic countries have already set targets for a carbon neutrality by 2050 and strategies, as the Finnish (MEE, 2014) *Energy and Climate roadmap 2050*. The Finnish roadmap presents scenarios and predictions, as well as measures to tackle the carbon emissions. The strategy does not though include specific targets or measures. Achieving neutrality requires that the implementing short term strategies are well constructed and aligned with the roadmap. **The Finnish short term strategies should be brave and accept short term costs.** For Finland to be amongst the first countries globally to drive such a transition and to participate in innovation and commercialization of necessary solutions provides a global competitive advantage.

4.3.3.17 Sustainable culture and economy

After landscape transitions have materialized into the socio-technical systems, also a more sustainable culture and economy has emerged. The new culture and economy are reflected by mainstreaming de-consumerism and sharing economy, and the pressures from global eco-modernism and -liberalism influence new work life balance paradigm to emerge, driven by the possibility to de-link work and income. A sustainable economy acknowledges that Finland does not need to be biggest producer and supplier of solutions globally, but that it is enough to supply in an amount that provides a sustainable level of well-being. As technology and client demands change, it is better to be small and agile, then large and slow.

5 DISCUSSION

This research has aimed to connect the theoretical frameworks of sustainability, sustainable development and decent life into an applied objective of analysing how cleantech industry can contribute to Finland achieving a more sustainable future. The theoretical framework has focused on describing the background for the sustainable development and decent life discourse, and the emerging sustainability science and transition theory. In an attempt to connect the framework to the applied objective, the research has applied analytical methods from future studies. The following chapter will discuss both the theoretical and applied aspects of the study by answering the original research questions.

5.1 Responses to the research questions

Q1. Can the selected theoretical framework and methodology be integrated in a coherent way to describe a change process?

Sustainability science has both a theoretical and applied approach for developing necessary knowledge and for facilitating necessary transitions. The research has presented in-depth an extensive theoretical (and conceptual) framework that illustrates the construction and interlinkages of the concepts relating to sustainable development, decent life, sustainable systems, multi-layer perspective and sustainability transitions. The formulation of the theoretical framework has followed the tradition of earlier works by authors such as Geels, Bergh, Markard and Jorgensen (*inter alia*). The aforementioned have used the multi-layer perspective in framing historical sustainability transitions. The MLP framework has not widely been used in describing future events, as is the case in this study. There are other fields of transitions science, such as the strategic niche management, that elaborate from the MLP to construct future oriented policy process frameworks.

In terms of the theoretical framework, the research has aimed to contribute to the theoretical discourse of sustainability in the perspective of complex systems theory by defining sustainability as a systemic property and separating the social and individual level processes of sustainable development and decent life. Defining of sustainability as a systemic property and linking it to the larger global level perspective of sustainable development has provided a good tool for discussing both the present and future targets for change. It also allows connecting the non-time dependent sustainability (property) through systems thinking to concepts of redundancy and vulnerability. By simplifying the process of sustainable development in the future to the property of sustainability allowed to view the research problems from a hierarchically higher perspective. Also separating sustainable development and decent life as two different viewpoints for the same process allowed for understanding and discussing the differences in social and individual approach to sustainability. Undoubtedly these definitions are questionable as they are not mainstream definitions for the commonly used terms.

Socio-technical systems and the multi-layer perspective provide a good model for describing the human social and technological institutions where production, use and diffusion exist at different hierarchical layers of landscape, regime and niche. The concepts also acknowledge that function is born through interaction of actors at different levels, and that different types and structural levels of institutions have differing control over the actors and artefacts. By applying the frameworks to a national or city level allows for good conceptualization how different artefacts, ideas, actors and institutions are positioned in our socio-technical systems. Whether the transition is in the past or in the future does not seem to play an important role within the framework. Some areas of the model need clarifying though, as the conceptualization of the regime. Current majority of actors and institutions are acting in the socio technical regimes. A complimentary framework, e.g. Actor-Network Theory could contribute to better describing the interactions in the 'crowded' regimes.

The research methodology has been constructed on pragmatist paradigm and on applied analytical methods of normative scenario analysis. Pragmatism as paradigm is well suited on complex qualitative research problems due to the ontology and research methodologies being real world problem oriented. Normative scenario analyses (backcasting) as analytical method provides a simple but powerful analytical method for developing narratives for complex problems. There are no uniform methods for conducting backcasting, and the more complex the problems, the more complex the exercise. In transition science, backcasting is mainly used as participatory backcasting, where the process is collaborative in contrast to the approach applied in this research.

Integrating the multi-layer perspective and backcasting for constructing the transition space provided an excellent tool for arranging and structuring the landscape pressures and niche drivers, and for deducing the necessary regime key factors that could be critical for the change process. Structuring the transition space into a roadmap was done by first backcasting a transition pathway. The selected transition pathway provided a pivotal structure for aligning the landscape pressures, niche drivers and regime key factors to facilitate the events and pre-requisites necessary for the sustainability transition to occur. The multi-layer perspective and backcasting can be powerful tools for developing transition pathways and roadmaps. The process also highlighted the benefits of a participatory process in building a transition space.

As a conclusion the theoretical framework and methodology can be integrated in a coherent way to describe a change process. Defining the change process and limiting the factors under consideration are important for keeping the process clear and focused. Additional tools such as forecasting and visual transition space can be powerful additional tools. In modelling complex issues participatory processes should also be favoured.

Q2. How is the Finnish national sustainable development policy 'The Finland we want by 2050' aligned with the emerging discourse of systemic sustainability and decent life paradigm?

The Finland we want by 2050 strategy is built to reflect a transgovernance process. It focuses on a long term vision and operational commitments from dominant regime and niche actors with a 5+ year results framing. The strategy sets eight themes and a number of consequent objectives. The themes and objectives can be directly and indirectly monitored through a number of performance indicators. The themes consider equally environmental, social, cultural and economic sustainability from the global and individual perspectives of sustainable development and decent life.

The main focus of the strategy is on sustaining and advancing Finnish well being from a social and techno-economic standpoint. The sustainability strategy takes decent life clearly in account, and individuals are at the centre of the strategy. A number of the themes focus on well-being, participatory society and communities, and a number of key objectives focus on enhancing the equal opportunities for social, economic and cultural well-being of citizens. Of course better development in industry and in society's carbon and resource neutrality also help build individual wellbeing through enforcing the economic foundation of sustainable development.

The strategy is well defined and aligned with the emerging discourse of systemic sustainability and decent life paradigm, though it lacks in its perspective on global equity. The biggest hindsight of the strategy is the performance indicators. Having only quantitative indicators for qualitative objectives does not provide potential for holistic understanding of the development status nor open possible views for enhancing development. For example an objective "*all members of society will be guaranteed equal prospects for health, education and employment*" is measured by *life expectancy*, *income differentials*, *those aged 17 - 24 not in education or training* and *subjective well-being*. Even though the performance indicators are versatile and numerous, they do not allow for the same level of discussion as an objective qualitative and quantitative review. To address this, expert review of the sustainable development strategy should be conducted at the end of every parliamentary period (ca. every 4 years), to provide a background document for actions taken in the past towards achieving the targets and their benefits so far.

In terms of systemic sustainability, the transgovernance process acknowledges that no single actor can affect complex transitions, but that a multitude of actors is needed. The execution of the strategy is built upon operative commitments from regime actors. These commitments are self-formulated by the actors and must align with the themes and targets of the strategy. This target setting should not be allowed to confuse thinking that reaching a single (or a set of) sustainable development goals equals to fulfilling demands of sustainable development. As pointed out, sustainable development has no ultimate goal and hence must be viewed as continuous development cycle where each iterative round something new for consideration.

Q3. What can the (Finnish) cleantech industry do to facilitate the sustainability transition sustainable future - decent life for all (Finns)?

The original research question of the study was founded on the presumption that *cleantech companies are (one of the) key actors in sustainability transitions.* The rationale for this followed the logic that: (1) *for a sustainable future to materialize a sustainable socio-technical system is required*; (2) f*or new systems to materialize innovations are necessary*; and (3) *such innovations are generated by entrepreneurs and businesses operating in the cleantech sector*. The analysis for the sustainability transition was further clarified with two descriptive targets from The Finland we want by 2050 –sustainable development strategy: (a) *Finland will be a globally leading country of the green economy*; and (b) *Finland will achieve carbon- and resource neutrality by 2050*. These targets were chosen especially due to their linkages to sustainable innovation, technology and entrepreneurship.

The global paradigm forces and pressures are pushing for nations, industries and people to adopt sustainable development and its economic discourse of green economy and circular economy. Sustainability transitions are becoming a necessity due the changing population dynamics and urbanization, which causes pressures for energy and resource use globally. Finland is also suffering from a wide range of national level macroeconomic problems. The local problems are illustrated by changing population dynamics, increasing unemployment, weakening global production competitiveness and lack of interest in social participation. The Finnish industrial structure is currently raw material, manufacture and ICT driven. These traditional industries have suffered greatly in the 21st century economic crises and from the changing global economic environment. To address these pressures a number of niche developments are already taking place to transform our socio-technical systems and the way industries operate and people live. The key emerging industry addressing the necessary changes can be entitled cleantech. It is an umbrella term that covers a range of industries, technologies, services, and solutions that reduce the ecological impacts caused by human activity, save energy and natural resources, or improve social wellbeing.

To address the issues of global change and facilitate local economic sustainability, the government of Finland has defined green economy and cleantech as economic imperatives for sustaining well-being. For cleantech, the government has set ambitious targets (MEE, 2014c). The targets set in 2014 state that by 2020 Finland has achieved (1) *increasing the amount of cleantech businesses to 3000*; (2) *doubling the cleantech businesses turnover to € 50 000 million;* and (3) *creating at least 40 000 cleantech jobs in Finland*. Kotiranta (2015) has listed in a research by ETLA that the actual number of businesses operating integrally in the cleantech value networks in Finland is 762 and that the company's employ approximately 83 000 individuals. Kotiranta also notes that over 60% of the turnover currently generated in the cleantech sector is generated in manufacturing, and more than half of the jobs in the cleantech are offered by companies active in the manufacturing sector. Out of all cleantech companies, six[46] account for 65% of the entire turnover in cleantech.

The problem in relation to government targets is clear. The large business in raw materials, ICT and manufacturing dominate the Finnish industry and cleantech likewise. These dominant companies are already large and operate industries where they cannot grow fast – hence the targeted growth must originate from SME's in novel industries, or with new solutions to existing industries. To reach the national targets Finland would need to generate over 2000 new SMEs in the coming five years, that would employ over 40 000 new employees (ie. 20 per company) and generate approximately € 20 000 million in new turnover (ie. 10 million per company). It is very much debatable that would Finland have the potential to reach the target, even under aggressive policy setting.

In terms of a sustainable future and the specific transition targets analysed in this study, cleantech obviously a role to play. This study defines and recommends a significantly longer timeframe for analysis and target setting compared to the government cleantech strategies for 2020 (MEE, 2014c). The sustainability and cleantech target for 2050 in this study is carbon and resource neutral society that is a leader in the global green economy. To transform the society towards fulfilling the objectives, a number of socio-technical changes must occur on the niche, regime and landscape levels.

Finland has been ranked highly eco-innovative and well educated in most global rankings. We have the shown potential to develop future key enabling technologies and solutions for modern product service systems, but where Finland lacks is commercialization. In the future entrepreneurial knowledge economy, innovation needs to integrally include commercialisation. For cleantech to benefit and support this, the industry must help Finland transform towards a hub of global eco-innovation and R&D. Entrepreneurship must be encouraged to commercialise cleantech solution instead of lower TRL research, venture finance must leverage business development and a domestic market for

46 Wärtsilä, Oyj, Neste Oil Oyj, Nokia Oyj, UPM-Kymmene Oyj, Stora Enso Oyj and non-listed ABB Oy. Nomination of these companies as "cleantech" leaves room for questioning what is "cleantech" in Finland.

the cleantech products would support the local transition and be used as a test bench and reference for global markets. Also the state needs to participate. Policy tools that need to be further developed are strong global policy coordination for sustainable development and commons management, industry support strategies including tariffs, subsidies and taxation, and an innovation strategy that acknowledges eco-innovation as integral.

Whereas state has a role in facilitating cleantech, cleantech facilitates the socio-technical sustainability transition to a carbon and resource neutral society. The analysis has acknowledged a number of key factors where cleantech acts as a key actor. These are the emergent consumer niche developments where *sharing, re- and up-cycling, optimizing, products-as-service, connectivity* and *de-consumerism* are driving the change, and industrial niche developments of *regenerating, sharing, optimising, looping, virtualising* and *exchanging* are driving *dematerialization* and *structural renewal*. These niche developments driven mainly by cleantech actors will affect transitions in our socio-technical systems as energy systems, transportation, building and agriculture. Finally these technological transitions have the potential of making the socio-technical system carbon and resource neutral, and simultaneously changing the consumer habits and inducing a paradigm change a sustainable system.

The cleantech industry, together with strong political intent, has the best foreseeable potential in facilitating the sustainable future – a decent life – for Finland. Connecting the national sustainability baseline to the objectives of carbon and resource neutrality allowed this study elaborating a transition pathway and identifying relevant actors. The cleantech industry and eco-innovations were primary. Developing and commercialising eco-innovations from Finland also creates the potential for industry actors' leading the green economy. To achieve decent life for Finns also in the future, a healthy economic system is needed to support for basic needs. This foundation for Finland should be constructed by a heterogeneous industry of (1) *large raw material, ICT and manufacturing companies that operate resource and energy efficiently following circular economy principles*; (2) *small cleantech driven companies that provide value adding key enabling technologies and product service system services for the Finnish and global industries*; (3) *domestic service industries providing well-being services for the population*; and (4) *agricultural sector that provides competitive, locally produced, ecological, nutritional choices by collaborating with the cleantech and service sector.*

5.2 Shortfalls of the research

The combination of a theoretical and applied approach to defining, analysing and predicting a complex socio-technical transition from a single actor perspective is laborious and arduous. The theoretical background is constructed from combining a number of emerging research fields, causing the need to conceptualize and define a number of terms that are commonly considered general (i.e. sustainable development). These conceptualizations and definitions have anyhow been critical for the latter analytical work. Ambiguous terms, as one of the core terms *cleantech*, have been the cause of problems in the analysis.

Though cleantech has been defined well and clearly, the parameters of the definition allow for almost anything to be classified under the term. During the study, it was considered to define the term more clearly as “pure play”, but again, limiting would have been cumbersome.

The complexity and interrelatedness of the topics in the study contributed to the wide range analytical perspectives and to the generality. Also the fact that in the last years there have been globally a number of publications[47] by leading RTO’s, think tanks and policy institutions contributing to the debate on the necessities and actions for sustainability transitions caused the analysis and discussions to propagate. Thought the topic was narrowed, analysing, structuring and crystallizing a complex work would be better suited for a team than for an individual researcher.

5.3 Towards future research

This study has contributed a potential theoretical framework and tools for describing and analysing past, present and future sustainability transitions, sustainable innovations and how business and policy converge due to landscape pressures and niche developments. This framing allows researching a number of topics, not only through normative scenarios but also through forecasting, and combining both.

During the research a few prominent topics came up either from research literature or from analysis. Closely related to the current topic, though not applying the transitions theme is further investigations to eco-innovations and sustainable business models. These both have been studied and discussed, but not so much in combination. The joining concept in this research theme is further advancing the potential of product service systems and how eco-innovations or sustainable business models can help integrate or PSS to existing business value chains. This could be founded on LCA tools, which could be used to identify the potentially most beneficial connection points for eco-innovations in existing value chains. Another line of investigation is the success factors of various eco-innovations, whether internal or external. There is existing literature on success factors for new technology businesses, but it is also generally acknowledged that eco innovations have an important difference to traditional innovations whereas they aim at internalising the external environmental costs. Also the business model innovations are not widely researched yet, but are an emerging field of study. This could be connected to e.g. service business models (or PSS) with a more sustainability oriented focus in contrast to the typical technological innovations.

Combining complex problems with modelling is also a very interesting emerging field. Typically modelling is based on quantitative forecasting scenarios, where the rules are fixed. Combining qualitative backcasting and

---

47 e.g. The New Climate Economy reports, German Advisory Counsil on Global Change reports, Worldwatch Institute State of the World, World Resource Institute, Ellen MacArthur Foundation, etc..

forecasting scenarios could develop new tools for pathway analysis. Gamification is another emerging topic that could be combined with modelling and sustainability. It has been shown that gamification can generate better predictions then modelling and that in addition it can effect changes in behaviour. Developing sustainability models that integrate with gaming platform could generate completely new insight especially in the human and consumer perspective of sustainable development and parameters for sustainability transitions.

6 CONCLUSIONS

The study presented as analysis a baseline for present state of Finnish sustainable development and a backcasted roadmap for cleantech to facilitate a national transition towards sustainability. The analysis pointed out that the major pressures Finland faces in terms of sustainability are demographic and macroeconomic by nature: (1) *a decreasing and an aging population*; (2) *raw materials and manufacture rooted industrial structure*; and (3) *high economic wellbeing that has fostered individuality and self-realization in contrast to cultural development*. The emerging cleantech industry has potential of addressing these pressures by influencing *policy formulation*, effectuating *eco-industrialisation* and *post-consumerism,* and eventually leading to *landscape transitions* and *paradigm change*.

The analytical roadmap constructed atop the aforementioned describes the sustainability transition process in the context of the conceptual framework. As an additional conclusion though, the study also presents a set of policy guiding key observations and strategic considerations entitled *clean-steps*. The aim of these clean-steps is to guide the transition mind-set towards cleantech facilitating the Finnish sustainability transition in the tradition of sustainability science.

6.1 Ten 'clean-steps' to transition

1. Set sustainability challenges as bearing for cleantech

There is no arguing that the world is facing pressing sustainability challenges in the domains of agriculture, energy, transportation, raw materials, water and ecosystems. To address these challenges participatory policy, ecological taxation, sustainable innovations and both economic and socio-technical developments are needed. While the exact results of these developments remain uncertain, the direction of development is clear. In winning future visions, the socio-technical systems will be built respecting sustainable development and value will reflect decent life. Quality of growth will matter, as well as its rate.

2. Participate proactively in the transition

Transition is a process that requires most of all innovation and experimentation. Cleantech can facilitate the transition through its integral role as a niche agent. A functioning niche environment is a product of policy-, finance-, research-, and technology institutions. Through a shared niche agenda, cleantech can generate win-win scenarios for all related institutions. Timing is critical, as the next 15 years will instigate the global economic and socio-technical transformation. Pioneering will guarantee an advantage - followers are always second or later.

3. Promote the State to support sustainability

State plays the key role in governing national markets and in negotiating for global policies. Sustainability should be inherent to the national vision and policy processes. Cleantech must promote State to advance international lasting and equitable climate and energy policy that serves to implement an effective and predictable carbon pricing globally. To advance the export of Finnish cleantech, the State and industry must partake in global free trade agreements on environmental goods and services, and develop instruments to decrease export risks and facilitate client side financing for low carbon infrastructure exports.

Domestically cleantech must promote shifting taxation and subsidies in favour of energy and resource efficient investments, eliminating perverse subsidies and harmful tax discrepancies for un-sustainable technologies and supporting the development of a domestic cleantech market by supporting investments in green infrastructure and accelerated improvements in energy efficiency though public procurement and demonstration programs. Commitment on long term policies is essential. They shape market expectations, indicate the right investments and reduce risks.

Cleantech must also promote the State to formulate a national innovation and industrial renewal strategy. The fundaments of such strategy are to advance the global research agenda towards future sustainable socio-technical systems and to direct the national focus on future key enabling 'clean' technologies. With a clear mandate, cleantech can facilitate the success of existing industries in their renewal, create novel integrations for new and existing businesses in global value chains and innovate radical and systemic new solutions.

4. Adapt to the entrepreneurial knowledge economy

The global economic paradigm is changing from the managed economy towards entrepreneurial knowledge economy. The change increases the role of entrepreneurship and of knowledge as competitive advantage. Socio-technical and cultural transformations change how people are educated and work, and future businesses are defined by flexibility, diversity, novelty, innovation and clustering.

Future work will require adapting to project based employment, changing organizations and varying skills requirements. Cleantech must pioneer global employment. A large pool of best talents remain un-utilized due to language and re-location requirements. By creating a reputation as a flexible, challenging and competitive employer, the Finnish cleantech can attract these talents.

Cleantech should acknowledge that to be competitive in the future, one must remain innovative and flexible. In this environment, strength is derived from clustering research, manufacture and finance to form value optimizing ecosystems. These ecosystems contrast with typical Poterian clusters by combining resources to semi-formal organisations, with shared and individual value generation models.

5. From 'made in Finland' to 'innovated in Finland'

Mastering innovation means leading the processes of research, development, manufacture and commercialization. Finnish cleantech needs to position itself as the leader of radical and systemic sustainable innovation. Such innovations have the potential of changing complete systems, sub-systems and their interactions towards more sustainable. Incremental efficiency gains can drive industrial renewal, but sustainability challenges can be only solved through radical and systemic innovations.

To advance industry innovation capacity, cleantech must collaborate with universities and RTO's to develop leading international research hubs that are able to attract funding, top researchers and access to the latest technology. To develop the research towards higher TRL manufacture, cleantech must collaborate with the strong manufacturing and ICT industries for smart manufacture ecosystems.

6. Making a habit of building winners

The lure of entrepreneurship for the best talent lies in the challenge and reward. Advancing entrepreneurship requires that potential for success exists, and that a joint definition of success, of a winner, exists. Cleantech must acknowledge and celebrate global industry success stories to facilitate the culture of building winners.

The Finnish system excels in providing guidance to new entrepreneurs. Cleantech must promote and participate in developing support also for existing entrepreneurs. From the Finnish macroeconomic perspective, cleantech and innovative SME's in general hold the best potential to increase employment and economic value added generation. The future growth will originate from winning SME's.

Independent venture capital is commonly accepted as the best institution for winner selection. There is a distinct lack of cleantech venture finance for businesses with radical and systemic innovations in Finland. Cleantech industry should address this and develop new clean investment funds investing in seed and pre-growth businesses. Due to the strategic nature, the high risk funds should be leveraged with government non-dilutive finance.

7. Understand what de-materialisation and de–carbonisation mean

Solving sustainability challenges require de-linking population growth, affinity and environmental impacts. De-materialisation and de-carbonisation of our socio-technical systems provide the trajectories necessary for successful de-linking. The most significant global impacts to de-materialisation and de–carbonisation can be achieved through changes in the electricity and transport systems, and living and consumption patterns. Cleantech must understand this imperative and its consequences to business-as-usual.

The de-linking paradigm opens a number of business opportunities that cleantech can and must address. Agriculture must adapt to feeding the growing urbanised population, energy becomes more de-centralized and diversified, urban transport is changing from individual car ownership, industries become more resource and energy wise, de-consumerism and sharing affects mass consumption, and the eventually the changing culture, education and work will transform the prevailing life paradigms. While the short term implications of these changes are incremental, cleantech must focus on the long term radical and systemic changes.

8. Pivot from products and services to 'product and service systems'

Traditionally businesses have been producing products, and services related to the products. A change has been emerging for the last decade. Today sellers and users of products see ownership as a potential hindrance to effective function. This originates from the misaligned interests between selling and using. Product service systems provide a solution for re-aligning these interests.

Traditionally strong Finnish raw materials, manufacturing and ICT sectors serve as an excellent partner and market for the Finnish cleantech to rapidly develop value adding incremental innovations through PSS solutions. This industrial background also furthers the understanding of existing value chains and life cycles in the production-use-diffusion structures to be optimized. For Finnish cleantech, this is a fast means of accessing the growing global market of resource and energy efficiency. In addition to optimising and incrementally innovating, PSS is functional for radical and systemic sustainable business model innovations with global transformative potential.

9. Design for circular economy

Circular economy builds upon the de-materialisation and de–carbonisation paradigms to describe a complex systems approach for production and use of biotic and abiotic resources. It aims at optimizing material and energy flows within the system to maintain or increase the resource stocks. In circular economy waste is averted and instead considered as a side stream that must be utilized.

Circular economy principles are an integral part of future economy. In principle 'waste aversion' is simple, but application to modern technology and society is complex and expensive. Finnish cleantech companies should focus advancing future circularity by integrating LCA into design, developing business models that close loops in present industries and innovate solutions around key enabling technologies that withhold restorative and regenerative properties allowing for effective re-use, re-manufacture and re-cycling.

Finnish cleantech should not only focus on the 'abiotic' spheres of circular economy, but also innovate for the 'biotic' cycles. Organic innovations for key enabling technologies in electronics, advanced materials and industrial biotechnology could bridge the biotic and abiotic cycles for increased sustainability. Future agriculture and aquaculture require efficient use of the biosphere, respecting ecosystem services and maintaining biodiversity.

10. Work to make cleantech obsolete

Cleantech is not a solution to sustainability, but a mere facilitator in a part of the transition. The past great transitions (e.g.) in transport or communication were facilitated by industries alike, innovating and building future infrastructure. Not many businesses of the early infrastructure remain, but the transformed landscapes and a number of strong winners still reign. None predicted that telegraphy would be preceded by telephones, the internet and todays handhelds. The same will be valid for cleantech. Many of the businesses and innovations will disappear, and terms as cleantech and circular economy fade away. Again, the new sustainable landscape and a number of strong winners will prevail. This is evolution.

This socio-technical evolution towards sustainable development also furthers a cultural transition towards the paradigm of decent life. Humans have always had urgency for development, without consideration for the direction. Decent life provides a compass that supports sustainability at individual level, as 'sustainable development at socio-technical level.

Everyone should work for cleantech to become obsolete. When this happens, we know that a transition has come to pass and we have progressed on the road to systemic sustainability.

REFERENCES

Allwood, J.M., Laursen, S.E., Russell, S.N., Rodriguez, C.M., Bocken, N.M.P. 2008. An approach to scenario analysis of the sustainability of an industrial sector applied to clothing and textiles in the UK. Journal of Cleaner Production 16, 1234-1246

Antal, M., Bergh, J. 2013. Macroeconomics, financial crisis and the environment: Strategies for a sustainability transition. Environmental Innovation and Societal Transitions 6, 47–66.

Auvinen, H. et al. 2014. Process supporting strategic decision-making in systemic transitions. Technology Forecasting and Social Change, http://dx.doi.org/10.1016/j.techfore.2014.07.011

Balachandra, P., Nathan, H. S. K., Reddy, B. S. 2010. Commercialization of sustainable energy technologies. Renewable Energy 35, 1842–1851

Bergh, J., Truffer, B., Kallis, G. 2011. Environmental innovation and societal transitions: introduction and overview. Environmental Innovation and Societal Transitions 1, 1-23.

Bettencourt, L. M. A. & Kaur, J. 2011. Evolution and structure of sustainability science. PNAS vol. 108., no. 49. 19545-19540. Available on-line: www.pnas.org/cgi/doi/10.1073/pnas.1102712108

Bjornali, S. E. & Ellingsen, A. 2014. Factors Affecting the Development of Clean-tech Start-Ups: A Literature Review. Energy Procedia 58, 43-50.

Boons, F., Montalvo, C., Wagner, M. Sustainable innovation, business models and economic performance: an overview. Journal of Cleaner Production 45, 1-8

Boons, F.,Lüdeke-Freund, F. Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. Journal of Cleaner Production 45, 9-19

Börjeson, L., Höjer, M., Drebborg, K-H., Ekvall, T., Finnveden, G. 2006. Scenario types and techniques: Towards a user's guide. Futures 38, 723–739

Carrillo-Hermosilla, J., Río, P., Könnölä, T. 2010. Diversity of eco-innovations: Reflections from selected case studies. Journal of Cleaner Production 18, 1073-1083.

Chen, C. 2009. Technology commercialization, incubator and venture capital, and new venture performance. Journal of Business Research 62, 93–103.

Citgroup. 2015. Citi Announces $100 Billion, 10-Year Commitment to Finance Sustainable Growth. Press release February 18, 2015. [cited 12.4.2015] Availabe on-line: http://www.citigroup.com/citi/news/2015/150218a.htm

Cleantech Finland. 2015. What is cleantech? [cited 25.4.2015] Available on-line: http://www.cleantechfinland.com/content/what-cleantech

Cleatech Finland. 2015. What is cleantech. [cited 2.4.2015] Available on-line: http://www.cleantechfinland.com/content/what-cleantech

Coenen, L., Lopez, F. 2010. Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. Journal of Cleaner Production 18, 1149-1160.

Credit Suisse. 2014. Global Wealth Report 2014. [Cited 4.6.2015] Available on-line: https://www.credit-suisse.com/us/en/news-and-expertise/research/credit-suisse-research-institute/publications.html

Croce, A., Marti, J., Murtinu, S., 2013. The impact of venture capital on the productivity growth of European entrepreneurial firms: 'Screening' or 'value added' effect? Journal of Business Venturing 28, 489-510

Dahl, A. L. 2012. Original article. Achievements and gaps in indicators for sustainability. Ecological Indicators 17 (2012) 14–19

Diamond, J., 2010. Collapse of some civilizations (BOOK)

Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control.

Doganova, L., Karnoe, P. 2014. Building markets for clean technologies: Controversies, environmental concerns and economic worth. Industrial Marketing Management xxx, xxx–xxx

Dolfsma, W., Seo, D., 2013. Government policy and technological innovation—a suggested typology. Technovation 33, 173–179

EEA European Environmental Agency. 2015. The European environment — state and outlook 2015. [cited 20.4.2015] Available on-line: http://www.eea.europa.eu/soer

EMF Ellen MacArthur Foundation. 2015. Growth Within: a Circular Economy Vision for a Competitive Europe. [cited 17.3.2015] Available on-line: http://www.ellenmacarthurfoundation.org/books-and-reports

EoE, 2013. Anthropocene. [Cited 6.5.2015] Available on-line: http://www.eoearth.org/view/article/150125/

Epley, N. 2015. Mindwise. Vintage. New York, NY. ISBN 978-0307743565

Eriksson, P., & Kovalainen, A. 2008. Qualitative methods in business research. Sage Research Methods Online.

Erzurumlu, S. S., Erzurumlu, Y. O. 2013. Development and deployment drivers of clean technology innovations. Journal of High Technology Management Research 24, 100–108.

European Union. What is an SME? EU recommendation 2003/361. Available on-line:http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/index_en.htm

EVA Elinkeinoelämän Valtuuskunta. 2014. Tästä Suomi Elää. [cited 23.8.2015] available on-line: http://www.eva.fi

EVA Elinkeinoelämän Valtuuskunta. 2015. Kuka suomessa tekee työt. [cited 23.8.2015] available on-line: http://www.eva.fi

EY. 2013. Global cleantech public pure-play (PPP) company analysis. [cited 25.4.2015]. Available on-line: http://www.ey.com

FAO. 2009. 2050: A third more mouths to feed [cited 23.8.2015] available on-line: http://www.fao.org/news/story/en/item/35571/icode/

Finnish Venture Capital Association FCVA. 2015. VC/PE industry in Finland 2014, preliminary statistics. FCVA. [cited 25.4.2015] Available on-line: http://www.fcva.fi

Freeman, C., Perez, C., 1988. Structural crisis of adjustment, business cycles and investment behaviour. In: Dosi, G., Freeman, C., Nelson, R., Silverberg, G.,Soete, L. (Eds.), Technical Change and Economic Theory. Pinter Publishers, London, pp. 38-66.

Fuenfschilling, L., Trüffer, B. 2014. The structuration of socio-technical regimes—Conceptual foundations from institutional theory. Research Policy 43, 772–791

Gazheli, A., Antal, M., Bergh, J. 2015. The behavioral basis of policies fostering long-run transitions: Stakeholders, limited rationality and social context. Futures 69, 14–30

Gaziolusyou, A. I. 2015. A critical review of approaches available for design and innovation teams through the perspective of sustainability science and system innovation theories. Journal of Cleaner Production xxx 1-12

Gaziolusyou, A. I., Boyle, C., McDowall, R. 2011. System innovation for sustainability: a systemic double-flow scenario method for companies. Journal of Cleaner Production 45, 104-116

Geels, F. W., 2001. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy 31, 1257–1274

Geels, F. W., 2004. From sectoral systems of innovation to socio-technical systems Insights about dynamics and change from sociology and institutional theory. Research Policy 33, 897–920

Geels, F. W., 2010. Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. Research Policy 39, 495–510

Geels, F. W., Kemp, R., 2007. Dynamics in socio-technical systems: Typology of change processes and contrasting case studies. Technology in Society 29, 441-455.

Geels, F.W. The impact of the financial–economic crisis on sustainability transitions: Financial investment, governance and public discourse. Environmental Innovation and Societal Transitions 6, 67–95.

Geert, V., Geels, F. 2007. The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960-2004). Energy Policy 35, 1025-1037.

Hatton, L. & Moorehead, J. 1997, 'Determining venture capital criteria in evaluating new ventures', unpublished working paper California State University, California.

Hernesniemi, H., Viitamo, E. 2006. Pääomasijoitukset ympäristöalalla ja tilastollisen seurannan kehittäminen. ETLA Discussion papers 1039. Available on-line: http://www.etla.fi

Hirsjärvi, S., Remes, P., & Sajavaara, P. 2001. Tutki ja kirjoita. Kirjayhtymä, Vantaa.

Hirvilammi, T. 2015. Kestävän hyvvinvoinnin jäljillä. Ekologisten kysymysten integroiminen hyvinvointitutkimukseen. Helsinki: Kela, Sosiaali- ja terveysturvan tutkimuksia 136, 304 s. ISBN 978-951-669-971-7 (pdf).

Holliday, C.O. Jr, Schmidheiny, S. & Watts, P. 2002. Walking the Talk: The Business Case for Sustainable Development. Sheffield: Greenleaf.

Horwitz, M., Mulloth, B. 2010. The interlinking of entrepreneurs, grassroots movements, public policy and hubs of innovation: The rise of Cleantech in New York City. Journal of High Technology Management Research 21, 23–30.

IDEA The International Institute for Democracy and Electoral Assistance, 2015. Voter turnrout. [cited 23.8.2015] available on-line: http://www.idea.int/

ILO International Labor Organisation. 2015. World employment and social outlook. [cited: 27.8.2015]. Available on-line: http://www.ilo.org/

Jorgensen, U., 2012. Mapping and navigating transitions—The multi-level perspective compared with arenas of development. Research Policy 41 (6), 996–1010

Kates, R. W. Sustainability Science. Science. Vol. 292 no. 5517 pp. 641-642 [cited 12.2.2015] Available on-line: http://www.sciencemag.org/content/292/5517/641

Kern, F. 2012. Using the multi-level perspective on socio-technical transitions to assess innovation policy. Technological Forecasting & Social Change 79, 298–310.

Klewitz, J., Hansen, E. G. Sustainability-oriented innovation of SMEs: a systematic review. Journal of Cleaner Production 65, 57-75

Knowles, V., Atkins, N., Pared, M., Youngman, R., 2013. European Cleantech Fundraising 2013-14: Investors have their own chasm to cross. Cleantech Group. Available on-line: http://www.cleantechgroup.com

Kotiranta, A., Tahvanainen, A., Adriaens, P., Ritola, M. 2015. From Cleantech to Cleanweb –The Finnish Cleantech Space in Transition. ETLA Reports No 43. Available on-line: http://pub.etla.fi/ETLA-Raportit-Reports-43.pdf

KSML Keskisuomalainen. 2015. Näihin maihin valtaosa suomalaisista maastamuuttajista lähtee. [cited: 27.8.2015]. Available on-line: http://www.ksml.fi/uutiset/kotimaa/maastamuuttokeskittyykymmeneen-suosituimpaan-maahan/2041407

Lorek, S. Spangenberg, J. H. 2014. Sustainable consumption within a sustainable economy - beyond green growth and green economies. Journal of Cleaner Production 63, 33-44

Luukkonen, T., Deschryvere, M., Bertoni, F. 2013. The value added by government venture capital funds compared with independent venture capital funds. Technovation 33, 154–162.

MA Millenium Ecosystem Assesment. 2005. Living Beyond Our Means: Natural Assets and Human Well-being (Statement of the MA Board). [cited 20.4.2015] Available on-line: http://www.millenniumassessment.org/en/Reports.html

MacMillan, I.C., Siegel, R., and Subba Narasimha, P.N., "Criteria used by Venture Capitalists to Evaluate New Venture Proposals," Journal of Business Venturing, 1, No. 1 (Winter 1985) 119-128.

Markard, J., Raven, R., Truffer, B., 2012. Sustainability transitions: An emerging field of research and its prospects. Research Policy 41, 955-967.

Markard, J., Truffer, B. 2008. Technological innovation systems and the multi-level perspective: towards and integrated framework. Research Policy 37, 596-615.

Mathews, A. J. 2011. Naturalizing capitalism: the next Great Transformation. Futures (43), 868-879.

ME Ministry of the Environment. 2013. sustainable development strategy 'The Finland we want by 2050". [cited 12.8.2015] available on-line: http://www.ym.fi/download/noname/%7B6D4F0465-02BE-492C-8FB7-70460A9CE6E5%7D/94793

ME Ministry of the Environment. 2015. Sustainable development. Web site. [cited 26.6.2015] available on-line: http://www.ym.fi/fi-FI/Ymparisto/Kestava_kehitys

Medeiros, J. L., Ribeiro, J. L. D., Cortimiglia, M. N. 2014. Success factors for environmentally sustainable product innovation: a systematic literature review. Journal of Cleaner Production 65, 76-86

MEE Ministry of Employment and the Economy. 2013. National climate and energy strategy. [cited 22.8.2015] available on-line: http://www.vm.fi/julkaisut

MEE Ministry of Employment and the Economy. 2014. Energy and Climate roadmap 2050. [cited 22.8.2015] available on-line: http://www.tem.fi/julkaisut

MEE Ministry of Employment and the Economy. 2014b.Finland as the path setter for natural resources economy in 2050. [cited 22.8.2015] available on-line: http://www.tem.fi/julkaisut

MEE Ministry of Employment and the Economy. 2014c. Government Strategy to Promote Cleantech Business in Finland. [cited 22.8.2015] available on-line: http://www.tem.fi/julkaisut

MF Ministry of Finance. 2012. Europe 2020 strategy – Finland's draft national program. [cited 22.8.2015] available on-line: http://www.vm.fi/julkaisut

Mont, O., Neuvonen, A., Lähteenoja, S. 2014. Sustainable lifestyles 2050: stakeholder visions, emerging practices and future research. Journal of Cleaner Production 63, 24-32

Munoz, P., Dimov, D. 2014. The call of the whole in understanding the development of sustainable ventures. Journal of business Venturing http://dx.doi.org/10.1016/j.jbusvent.2014.07.012

Myötänen, M., 2010. Microenterprises as the Growth Engines in Economies - The modeling of microenterprises in the existing growth theories and the real life survival from an innovation to a successful entrepreneurial venture. Masters thesis. Aalto University.

OECD Organization for Economic Cooperation and Development. 2013. Framework for Statistics on the Distribution of Household Income, Consumption and Wealth. [Cited 18.6.2015] Available on-line: http://www.oecd-ilibrary.org/

OECD, 2009. Green Growth: Overcoming the Crisis and Beyond. OECD, Paris.

OECD. 2015. "Better Life Index 2015", OECD Social and Welfare Statistics (database). [cited 22.5.2015] Available on-line: http://dx.doi.org/10.1787/data-00823-en

OECD. 2015b. The state of Finland 2015. [cited 23.8.2015] available on-line: http://www.oecd.org

OECD. 2015c. Entrepreneurship at glance. [cited 23.8.2015] available on-line: http://www.oecd.org

OECD. 2013. How's Life? 2013: Measuring Well-being. OECD Publishing, Paris. [cited 22.5.2015] Available on-line: http://dx.doi.org/10.1787/9789264201392-en

Official Statistics of Finland (OSF): Population projection [cited: 27.8.2015]. Available on-line: http://www.stat.fi/

OPTIO. 2015. Konttorin kuolema. 10/2015.

OXFAM. 2013. The Cost of Inequality: How wealth and income extremes hurt us all. Media Briefing. Ref. 02/2012. [cited 12.5.2015] Available on-line: http://policy-practice.oxfam.org.uk/publications

Paglia, J. K., Harjoto, M. A., 2014. The effects of private equity and venture capital on sales and employment growth in small and medium-sized businesses. Journal of Banking & Finance 47, 177–197

Pesonen, H.-L., Ekvall, T., Fleischer, G., Huppes, G., Jahn, C., Klos, Z.S., Rebitzer, G.,Sonnemann, G.W., Tintinelli, A., Weidema, B.P., Wenzel, H. 2000. Framework for scenario development in LCA. Int. J. Life Cycle Assess. 5 (1), 21-30

PMO Prime Ministers Office. 2013. Government Report on the Future: well-being through sustainable growth. [cited 22.8.2015] available on-line: http://vnk.fi/julkaisu?pubid=2209

Popa, F., Guillermin, M., Dedeurwaerdere, T. 2015. A pragmatist approach to transdisciplinarity in sustainability research: From complex systems theory to reflexive science. Futures 65, 45–56

Pujari, D. 2006. Eco-innovation and new product development: understanding the influences on market performance. Technovation 26, 76–85.

Rifkin, J. 1996. The End of Work: The Decline of the Global Labor Force and the Dawn of the Post-Market Era

Robertson, S. 2015. A longitudinal quantitativeequalitative systems approach to the study of transitions toward a low carbon society. Journal of Cleaner Production xxx, 1-13

Rockström, J., Steffen, W., Noone, K., Persson, Ã., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., De Wit, C.A., Hughes, T., Van Der Leeuw, S., Rodhe, H., Särlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., Foley, J.A. 2009. A safe operating space for humanity. Nature 461, 472–475.

Rouhinen, 2014b. Presentation in Berlin, 26.06.2014. on line www.sd-network.eu/.../DAY%20TWO_4_Rouhinen.pdf

Rouhinen, 2014c. Prenestation in Brussles 16.1.2014 on line wachstumimwandel.at/wp-content/.../04-Rouhinen.pdf

Rouhinen, S. 2014. Matkalla mallimaaksi? Kestävän kehityksen juurtuminen Suomessa. Doctoral Dissertation. Itä-suomen yliopisto. ISBN 978-952-61-1596-2

Ruth, M., Kalnay, E., Zeng, N., Franklin, R. S., Rivas, J., Miralles-Wilhelm, F. 2011. Sustainable prosperity and societal transitions: Long-term modeling for anticipatory management. Environmental Innovation and Societal Transitions 1, 160–165.

Sartorius, C. 2006. Second-order sustainability – conditions for the development of sustainable innovations in a dynamic environment. Ecological Economics 58, 268-286.

Seuring, S. 2008. Sustainability and supply chain management, An introduction to the special issue. Journal of Cleaner Production, 16 1545-1551.

Singh, R. J., Murty, H. R., Gupta, S. K., Dikshit, A.K. 2009. Review: An overview of sustainability assessment methodologies. Ecological indicators 9, 189–212

"Sipola, S. 2015. Understanding growth and non-growth in entrepreneurial economies. Analysis of startup industries and experimental winner generation in

Finland, Israel and Silicon Valley. Doctoral dissertation. University of Oulu."

SITRA Suomen Itsenäisyyden Juhlarahasto. 2013. Kestämätön Käy Kalliiksi. 10 teesiä kestävään talouteen. [cited 2.3.2015] Available on-line: http://www.sitra.fi

Smith, A., Vob, J., Grin, J. 2010. Innovation studies and sustainability transitions: the allure of the multi-level perspective and its challenges. Research Policy 39, 435-448.

Spangenberg, J.H., 2008. Sustainable Development e Past Conflicts and Future. Challenges. Taking Stock of the Sustainability Discourse. Westfälisches Dampfboot, Münster.

SSI. 2012. Sustainable Society Index data. [cited 23.8.2015] available on-line: http://www.ssi.org

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., Vries, W., Folke, C., Gerten, D., Heinke, J., Mace, G., Persson, L. M., Ramanathan, V., Reyes, B., Sörlin, S. 2015. Planetary Boundaries: Guiding human development on a changing planet. Science Vol. 347 no. 6223

Temmes, A., Virkamäki, V., Kivimaa, P., Upham, P., Hildén M., Lovia, R. 2014. Innovation policy for sustainability transitions in Finnish transport. TEKES review 306/2014. ISBN 978-592-457-576-8. Available on-line: http://www.tekes.fi

Teppo, T. 2006. Financing clean energy market creation - clean energy ventures, venture capitalists and other investors. Doctoral dissertation. ISBN 951-228227-5 (online). Helsinki University of Technology. Helsinki.

The Finnish Innovation Fund SITRA. 2006. Cleantech rahoitusmarkkinat. ISBN 951-563-547-0. Available on-line: http://www.sitra.fi

The Finnish Innovation Fund SITRA. 2007. Cleantech Finland - improving the environment through business. Finlands national action plan to develop environmental business. ISBN 978-951-563-599-0. Available on-line: http://www.sitra.fi

Thurik, A. R:, Stam, E., Audretsch, D. B. 2013. The rise of the entrepreneurial economy and the future of dynamic capitalism. Technovation 33, 302–310

Toimiala Online. 2015. Työ- ja Elinkeinomisteriö. Database. [cited 25.4.2015]. Avaliable on-line: http://www2.toimialaonline.fi/

Tyebjee, T.T., Bruno, A.V. 1984. A Model of Venture Capitalist Investment Activity. Management Science, 30, No. 9, 1051-1066.

Työ- ja elinkeinoministeriö TEM 2015. Nuorten kasvavien yritysten merkitys, menestystekijät ja yritystukien rooli kasvun ajurina. Työ- ja elinkeinoministeriön julkaisu 10/2015. Available on-line: http://www.tem.fi/

Työ- ja elinkeinoministeriö TEM 2015. Valtioneuvoston periaatepäätös kasvun uusien kärkien cleantechin ja biotalouden vauhdittamisesta. Cleantechin strateginen ohjelma. Available on-line: http://www.tem.fi/

Työ ja yhteiskunta, 2014 artikkeli

UN United Nations. 2010. Sustainable Development: From Brundtland to Rio 2012. Background paper. [cited 3.6.2015] Available on-line: www.un.org/.../GSP1-6_Background%20on%20Sustai..

UN United Nations. 2015. Post 2015 unedited agenda for SDGs. [cited 23.8.2015] available on-line: http://www.unep.org

UNDP United Nations Development Program. 2014. Human development report 2014. Sustaining Human Progress: Reducing Vulnerabilities and

Building Resilience. [cited 5.6.2015] Available on-line: http://www.undp.org/content/undp/en/home/librarypage/hdr.html

UNEP, 2011. Towards a Green Economy. Pathways to sustainable development and poverty eradication. United Nations Environmental Program, Nairobi.

Vallförs, S. 2009. Den svenska CleanTech-marknaden – aktörer och finansiering. Master's thesis. SLU Institutionen för energi och teknik. Uppsala.

Vangel, J. 2011. Exploring social structures and agency in backcasting studies for sustainable development. Technological Forecasting & Social Change 78, 872–882

WBGU. 2011. World in Transition – A Social Contract for Sustainability. [cited 23.8.2015] available on-line: http://www.wbgu.org

WCED (World Commission on Environment and Development), 1987. Our Common Future, London.

Vergrat, P. J., Quist, J. 2011. Backcasting for sustainability: Introduction to the special issue. Technological Forecasting & Social Change 78, 747–755

Wessberg, N., Dufva, M., Kohl, J. Policy Brief: systeeminen muutos ja innovaatiot. TEKES Ohjelmatoiminnan strateginen tuki. No. 10/2014

Viitala, J. 2012. Private equity firms and the benefits of specialisation: Nordic evidence pre and during the financial crisis. Master's thesis. Aalto University. Helsinki.

Worldbank. 2015. New World Bank Green Bond Is a Story of Market Growth and Innovation. Feature story February 25, 2015. [cited 12.4.2015] Available on-line: http:// www.worldbank.org/en/news/feature/2015/02/25/green-bond-story-market-growth-innovation

Wu, J. 2013. Landscape sustainability science: ecosystem services and human well-being in changing landscapes. Landscape Ecology 28, 999–1023

WWF. 2012. Living planet report 2012. Biodiversity, biocapacity and better choises. [cited 20.4.2015] Available on-line: wwf.panda.org

WWF. 2014. Global cleantech innovation index 2014. [cited 23.8.2015] available on-line: http://wwf.panda.org

Yang, Y., Sollén, I. 2013. Investments in the Swedish cleantech sector. Masters Thesis. Umeå School of Business and Economics. Umeå.

Zacharaki, A., Meyer, G. D. 1998. A lack of insigh: Do venture capitalists really understand their own decision process? Journal of Business Venturing 13, 57-76