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Nordic Energy Research within the Framework of Energy System Transition

Task 2 Working Paper of the GoReNEST Project

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Abstract

This working paper is produced for the purposes of the GoReNEST project. The overall aim of the GoReNEST project is to present an analytical system transition framework as a potential tool for supporting the Nordic energy system transition, its governance and related policy-making. The MLP transition management approach was used as a starting point for the analytical framework that was developed in GoReNEST Task 1 (see Könnölä et al., 2008). In GoReNEST Task 2, recent and ongoing Nordic research was examined vis-à-vis the different elements, categories and topics of the system transition framework. This working paper summarizes the results of GoReNEST Task 2.

The focus of this working paper is on Nordic research that is intended to support the governance of energy system transition. When assessing the potential of the MLP approach – and the analytical framework developed in GoReNEST Task 1 – it is important to know whether and how far the different elements and dimensions related to this approach have already been examined in Nordic energy research. For the purpose, (a) national level studies of Nordic countries, (b) studies carried out on Nordic level, and, (c) studies carried out with Nordic participation on European and international level, were examined in GoReNEST Task 2 with this aim. This working paper gives a first rough indicative overview of the contribution of these studies, paving the way for more extensive exercises in this respect.

Six relevant, partly overlapping research approaches were identified in GoReNEST Task 2: 1) societal embedding of energy innovations, 2) consumer research in energy markets, 3) energy system modelling and scenarios, 4) energy foresight and technology assessment, 5) energy RDT program and policy program evaluations, and 6) innovation studies and energy related new governance research. Each category is briefly described in this working paper, followed by brief presentations of relevant example projects and positioning of their contribution in relevant boxes of the system transition framework (vertically by development levels: landscape, regime, niche, and governance; horizontally by time perspectives: present, short-term, medium-term, and long-term).

GoReNEST Task 2 shows that Nordic research encompasses a number of interesting studies and projects in the six relevant areas of research approaches. In the light of the system transition framework, the contribution of these different studies and projects is also relevant for the governance of the energy system transition. Consequently, the existing research competencies in these areas are an important potential for the future research supporting the Nordic energy system transition, and hence it is worth building on these experiences and competencies in Nordic countries. The Nordic research is, however, scattered and fragmented among the six research areas, and the related aspects and dimensions of the systems transition framework. The overview also indicates relatively minor collaboration between relevant research communities, especially between energy system research and innovation system research. This may limit the effectiveness of these research communities in facing the multidisciplinary challenges of energy system transition. The MLP transition management approach and the comprehensive analytical framework of GoReNEST Task 1 offers, however, a potential common framework with the help of which relevant actors and actions can be mobilized around more effective joint-efforts that contribute to the transition towards sustainable energy systems. A systemic research agenda, considering the potential contribution of the various research approaches to the governance of energy system transition, is also needed.

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Preface

This working paper is an intermediate product of the GoReNEST project, reporting the results of GoReNEST Task 2. The overall aim of the GoReNEST project is to present an analytical system transition framework as a potential tool in the governance of Nordic energy transitions. In particular the framework is intended to support Nordic energy and climate policy-planning related to transition towards sustainable energy systems.

The energy research in the Nordic countries is extensive and different techno-economic and social aspects have been analysed in many studies. Hence, in analysing the potential use of system transition approach as a tool, it is important to know whether and how far different elements and dimensions related to this approach have already been examined in the Nordic energy research. Consequently, the present Task 2 report of the GoReNEST project considers mainly Nordic energy research in view of its potential contribution to the governance of energy system transition and using system transition framework as a policy-planning tool.

The working paper presents a compilation of relevant examples of Nordic energy research and related research approaches. The aim is to give a rough overview of the contribution of these studies, paving the way for more extensive exercises and more conscious utilisation of the various approaches. The examples include national level studies of Nordic countries, common studies of Nordic countries carried on Nordic level, and studies carried out with Nordic participation on the European and international level. The examples are grouped in six categories by research approach. Each category is briefly described before presenting the example projects and positioning them in relevant boxes of the system transition framework (vertically by development levels: landscape, regime, niche, and governance; horizontally by time perspectives: present, short-term, medium-term, and long-term). On the basis of the overview the report also draws conclusions and raises perspectives related to the future development of Nordic energy research in view of its potential contribution to the governance of energy system transition and using system transition framework as a policy-planning tool.

The project team of GoReNEST Task 2 consisted of Torsti Loikkanen, Annele Eerola, Tiina Koljonen, Robert van der Have and Nina Wessberg from VTT. The GoReNEST project is funded by Nordic Energy Research and VTT.

Contents

1. Introduction

Task 1 of the GoReNEST project presented an analytical framework for the governance of Nordic energy system transitions, with the intention of supporting Nordic energy and climate policy-making. The aim of Task 2 is to consider recent and current Nordic energy research – and related approaches and methodologies – from the viewpoint of the analytical framework presented in Task 1. The framework developed in GoReNEST Task 1 is based on a dynamic multi-level perspective (MLP) approach which understands transitions as outcomes of alignments between developments at multiple levels (see Könnölä et al. 2008). This working paper includes a short introduction to MLP model and the analytical framework, and after that, short illustrations of various relevant research approaches with relevant example projects/studies. The example studies are also positioned by different categories and topics of the analytical framework.

Chapter 1 is structured as follows: section 1.1 gives a short introduction to MLP approach and the analytical framework, section 1.2 presents the objectives and structure of the report, and section 1.3 introduces the example studies in focus and their classification principles.

1.1 Multi-Level Perspective (MLP) framework

The analytical framework for the governance of Nordic energy system transitions produced in Task 1 of GoReNEST project builds upon a dynamic multi-level perspective (MLP) approach which understands transitions as outcomes of alignments between developments at multiple levels. In the following this model is shortly introduced on a basis of Geels and Schot (2007) (Figure 1).

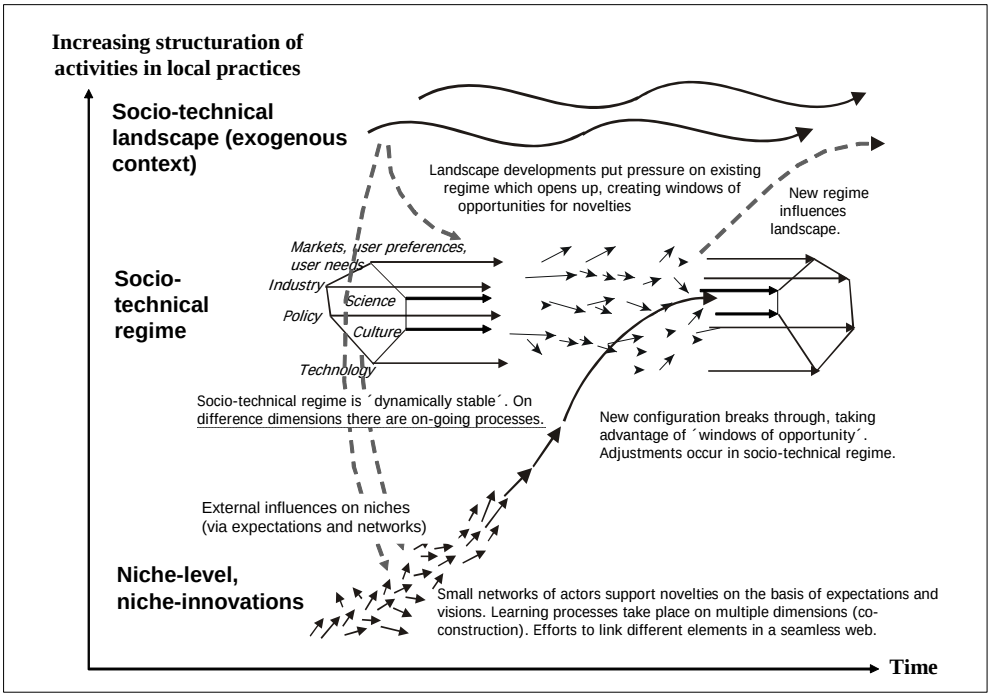

Figure 1. Multi-level perspective on transition (Source: Geels and Schot, 2007; Geels, 2002).

The typology of MLP is based on variations of *timing* and *nature* of multi-level interactions. According to Geels and Schot (2007) the first key concept is *sociotechnical regime* which is an extended version of *technological regime* by Nelson and Winter (1982), referring to shared cognitive routines in an engineering community and explaining patterned development along 'technological trajectories'. In sociological studies of technology this explanation is broadened based on the argumentation that scientists, policy makers, users and special-interest groups also contribute to patterning of technological development (Bijker, 1995). The socio-technical regime concept accommodates this broader community of social groups and their alignment of activities. Sociotechnical regimes stabilise existing trajectories in many ways: cognitive routines that blind engineers to developments outside their focus (Nelson and Winter, 1982), regulations and standards (Unruh, 2000), adaptation of lifestyles to technical systems, sunk investments in machines, infrastructures and competencies (Tushman and Anderson, 1986; Christensen, 1997).

The second key concept is *technological niches* that form the micro-level where radical novelties emerge (Geels and Schot, 2007). These novelties are initially unstable sociotechnical configurations with low performance. Hence, niches act as 'incubation rooms' protecting novelties against mainstream market selection. Niche-innovations are carried and developed by small networks of dedicated actors, often outsiders or fringe actors. The third key concept is the *sociotechnical landscape* which forms an exogenous environment beyond the direct influence of niche and regime actors (macro-economics,

deep cultural patterns, macro-political developments). Changes at the landscape level usually take place slowly (decades).

The MLP argues that transitions come about through interactions between processes at all these three levels: (a) niche-innovations build up internal momentum, through learning processes, price/performance improvements, and support from powerful groups, (b) changes at the landscape level create pressure on the regime and (c) destabilisation of the regime creates windows of opportunity for niche innovations. The alignment of these processes enables the breakthrough of novelties in mainstream markets where they compete with the existing regime. As Geels and Schot (2007) note, Figure 1 has become a somewhat standardised picture of this dynamic. As the articles of Smith et al. (2005) and Geels and Schot (2007), quoted largely above, well indicate there is, however, an on-going scientific controversy among the research community in the field about and further development of many details of the MLP framework.

In Task 1 of the GoReNEST project an extension is made to the above presented MLP framework by explicitly including even governance functions in it. In particular, the extended version includes the following governance functions: (1) Information services, networking, setting common agendas, (2) Strategic procurement, (3) Financing research and education, (4) Grants, equity support and fiscal measures (supply and demand), (5) Regulation and standards. The GoReNEST Task 1 working paper describes these functions in detail and illustrates their objectives and gives selected examples of governance functions (see Könnölä et al., 2008). Table 1 summarizes the overarching framework for the analysis of transition research and governance.

This working paper briefly discusses the objectives, contents and results of relevant example projects in six different research categories (see section 1.3). The example projects/studies are then placed on relevant boxes of the system transitions framework. In particular, the examples are positioned vertically according to their consideration of development levels (landscape, regime, and niche level) and the various governance functions (information services/networking/common agendas, strategic procurement, financing research and education, grants/equity support/fiscal measures, and regulation and standards) and horizontally according to time perspectives considered (present, short-term, medium-term, and long-term). On the basis of this exercise some interesting conclusions can be drawn, raising also some new perspectives for the future development of Nordic energy research in view of its potential contribution to the governance of energy system transition. On the other hand, the exercise also contributes to the assessment of the system transition framework as a policy-planning tool.

Table 1. Multi-level transition framework with different governance functions.

Landscape	**Change dimensions**	**Present**	**Short-term**	**Medium-term**	**Long-term**
	Technological				
	Industrial				
	Policy				
	Social				
Regime	*Technological*				
	Industrial				
	Policy				
	Social				
Niche	*Technological*				
	Industrial				
	Policy				
	Social				
Governance	**Functions**	**Present**	**Short-term**	**Medium-term**	**Long-term**
	Information services, networking, setting common agendas				
	Strategic procurement, (pre-)market				
	Financing research and education				
	Grants, equity support and fiscal measures (supply and demand)				
	Regulation and standards				

1.2 Objectives of the report

GoReNEST Task 2 focuses on recent and ongoing Nordic energy research that is intended to support the governance of energy system transition. A number of different research approaches are considered relevant in this respect (see section 1.3). After identifying the relevant research approaches a brief overview is given in this working paper for each category of research. The contents and contribution of the various example studies are examined with the help of the analytical framework developed in GoReNEST Task 1 (see Table 1 of this working paper). The overviews include (a) national

level studies of Nordic countries, (b) studies carried out on Nordic level, and (c) studies carried out with Nordic participation on European and international level. The objective is to draw preliminary conclusions with regard to Nordic competencies and experiences in supporting the governance of energy system transition. For the purpose, the scope and coverage of the various approaches taken in relevant Nordic research are examined, pointing also out some important issues related to the future development of Nordic energy research. Another aim of this working paper is to give some guidance for assessing the potential of the system transition framework as a policy-planning tool.

1.3 Example studies in focus

The research approaches considered in this working paper include:

1. Societal embedding of energy innovations
2. Consumer research in energy markets
3. Energy system modelling and scenarios
4. Energy foresight and technology assessment
5. Energy research and technology program evaluations, policy program evaluations
6. Innovation studies and energy related new governance research.

The approaches and methods of the categories 1–6 are to certain extent overlapping and intertwined (for example categories 3 and 4), and shall be considered as complementary to rather than separate from each other. The nature of research in each category is briefly described in the beginning of the respective chapter (see chapters 2–7), followed by a presentation of the example studies at national, Nordic and EU/international levels. For each category, the example cases are also positioned in the analytical framework developed in GoReNEST Task 1 (presented in Table 1; see also Könnölä et al., 2008). In this way we can better understand the contribution of the various types of approaches for the governance of the Nordic energy system transition. The classification principles used for the positioning of the examples are presented in Table 2.

Table 2. Classification principles for positioning of the example projects, studies and cases.

Landscape level	Macro level environment and pressures, global trends and prospects are concerned
Regime level	Current system and its development are concerned (incl. industry, markets, S&T, education, culture, policy)
Niche level	Local case studies and/or experiments with radical novelties
Technological dimension	Relates to technological development
Industrial dimension	Relates to energy production and distribution system and industrial energy use
Policy dimension	Aims at effecting the decisions, e.g. concerning funding of research projects, common framework
Social dimension	Relates to e.g. customer decision making
Governance functions	Links to governance and/or political decisions
Information services, networking, setting common agendas	Relates to sharing of knowledge
Strategic procurement, pre-market	Relates to public procurement (early market phase, supporting the diffusion of the technology)
Financing research and education	Relates to financing of the energy RDD and/or relevant education
Grants, equity support and fiscal measures (supply and demand)	Relates to support systems
Regulation and standards	Aims at giving support to regulation and standard creation

The overview on the categories 1–6 in this report is based on web-based search, desk research, and on expert consultation within research institutes. The individual projects/studies mapped by GoReNEST Task 2 are listed in Table 3 (categorisation by level of study and research approach).

In the selection of project examples, the aim has been to identify a sufficient number of examples of each approach and examine to which areas in 'system transition and governance' they best fit. An exhaustive overview of all relevant Nordic research was not strived for. Rather, the objective is to give a sufficient and representative illustration of the selected six research approaches, paving thus the way for more extensive analyses and more conscious use of the various approaches in supporting the desired energy system transitions and their governance. Projects and studies familiar to the research team (for instance, studies carried out by VTT or including VTT contribution) were somewhat easier to include in the analyses, taking into account the practical restrictions (for instance, the GoReNEST budget and deadlines). On the other hand, there were some specific technology areas that were considered interesting for the purposes of the GoReNEST exercise (e.g. studies focusing on hydrogen and fuel cells represent and illustrate some interesting niche-level developments and governance attempts that are intended to support the development of a new technology with significant long-term potential). Although these kinds of examples might be somewhat over-represented in this overview, this shouldn't affect the overall conclusions, taking into account the objectives of the exercise.

Table 3. Summary of the example studies with Nordic contribution mapped by GoReNEST Task 2.

Type of study	National-level examples (project/study/case)	Joint-Nordic examples (project/study/case)	EU-level examples (project/study/case)	Other international examples (project/study/case)
Societal embedding of energy innovations	JUMESCO (F), JUMPE (F), PIVCO City Bee (N), HyNor (N), Hydrogen Link (D), Hydrogen Sweden (S)	SHHP (D,N,S + F&I) GreenNano (D,F,S)	Create acceptance (F) Roads2HyCom (D,I,N,S)	
Consumer research in energy markets	Woodstoves (N) Low-energy houses (F) Climate Bonus (F)		(Create Acceptance, F) Changing Behaviour (F) (CHANGE, F)	
Energy system modelling and scenarios	Energy Visions 2050 Times-Pola, Times Trip Times EU & Tiam EU Global waste EV-Coal, EV-Windfall EV-EFOM-EMM, EV-Kyoto Kotrollstation 2008 Styrmedel Vindkraft 2020 Teknologiscenarier 2025-08, 2025-07 Danish CO_2 2020-50 Adaptation-VATT EC-Allocation	NEP1, NEP2 CES 2 grader Climate 2050 CO_2 pass through	RES2020 REACCESS NEEDS 2 grader RES2020 ETP 2008	
Energy foresight and technology assessment (TA)	Danish Energy Foresight Energia 2010 Energi 2020+ Risoe Energy Reports 1–6 Renewable energy sources till 2030 in Finland	Nordic H2 Foresight	HyWays	
Energy RDD program evaluations	Energy research in Finland		EU energy research evaluation The State and prospects of European Energy Research European funded research on H2 & FC CO_2 Capture & storage projects in EU Energy Futures INNER	IEA evaluation – Finland IEA evaluation – Sweden
Energy-related innovation studies, new governance research and benchmarking	SFINNOREG INNOREG I–II		HyCom HYPOGEN	ISU WP 08.12-13

2. Societal embedding of energy innovations

The ‘societal embedding approach’ refers here to projects and studies where the main emphasis is to support the successful market introduction of innovations that are considered beneficial from the societal point of view. The support is in form of facilitating fruitful dialogues between the stakeholders (technology producers and developers, technology users, relevant societal actors). The aim is to increase the mutual understanding of the technology itself, the real-world context in which the technology is used, and the prerequisites of successful market introduction and diffusion of the technology. In this way the stakeholder dialogues also contributes to the development of the technology, actor networks and the required infrastructure (incl. the built environment, institutions, legislation and norms).

The example projects here briefly presented relate to renewably energy, energy savings and more sustainable transportation. The examples projects have been carried out in individual Nordic countries (2.1), as joint Nordic efforts (2.2), or in the form of EU or other international cooperation with Nordic contribution (2.3). Some example studies explicitly state that they are using the ‘societal embedding’ approach. For some others the approach is more implicit, although the targets and some of the action modes are the same.

Furthermore, some additional examples of using this approach in the context of energy innovations elsewhere or in some broader contexts are briefly listed in the end of the chapter (2.4). Although these examples do not include any Nordic contribution, they were considered relevant for understanding the potential contribution of the approach in the Nordic context.

2.1 Example studies in Nordic countries

VTT studies on societal embedding of innovations related to renewable energies and energy saving Reported cases: JUMESCO & JUMPE (Finland)

Description: ESCO is a service based on the idea that energy service companies offer customers the service of taking responsibility for the outcome of energy saving investments by financing, designing or installing equipment, and letting them appropriate part

of the returns by saved costs. In the JUMESCO case customers take responsibility for the outcome of energy saving investments by financing, designing and installing equipment, and gaining returns from savings realised. An experiment led by VTT Technology Studies adapted ESCO to the Finnish market. Societal embedding was then carried out through interviews and workshops with key actors. In the **JUMPE** case the focus was in increasing the use of wood pellets for heating. The possibilities of constructing a market for climate-friendly energy technologies by applying the process of societal embedding of innovations are examined. The role and usefulness of experiments for broader transition to sustainable development and the relevance of societal embedding of innovations as a management tool for experiments were examined too. ***Sources:*** Väyrynen et al., 2002; Kivisaari et al., 2004.

Projects supporting the market introduction of electric and hydrogen vehicles*: *PIVCO *(Norway),* ***HyNor*** *(Norway),* ***Hydrogen Sweden, Hydrogen Link*** *(Denmark)*

Description: The **PIVCO** project facilitated the market introduction of the City Bee electric vehicle for urban transportation in Norway. Societal embedding took place by intensifying stakeholder communication and by developing relevant infrastructure (creating production facilities, recharging stations, and a maintenance network). Government and consumer agencies were not represented, however.

HyNOR, Hydrogen Sweden and Hydrogen Link facilitate, in turn, the market introduction of hydrogen fuelled vehicles in selected road routes of Norway, Sweden and Denmark, respectively. Societal embedding takes place by creating active stakeholder networks, relevant infrastructure and by promoting the development of norms, standards and legislation. These national-level projects have also joined their forces in the form of Scandinavian Hydrogen Highway Partnership (SHHP; see the next section).

2.2 Joint Nordic example studies

Scandinavian Hydrogen Highway Partnership (SHHP)

Description: SHHP was started as a collaboration initiative aiming to accelerate the introduction of hydrogen as a vehicle fuel in particular, and as an energy carrier in general. The SHHP vision is to make the Scandinavian region one of the first regions in Europe where hydrogen is commercially available and used in a network of refuelling stations. The SHHP constitutes a trans-national networking platform that catalyses and coordinates collaboration between three national networking bodies. Countries: Norway, Sweden, Denmark. The project is co-funded by NER in 2007–2008. The project is supported by the SHHP Innovation Networks project funded by NICe in 2007–2009, with the intention of including also relevant Icelandic and Finnish actors in the Scandinavian innovation/learning network. ***Source:*** http://www.scandinavianhydrogen.org.

Societal embedding of Green Nano – Commercialising green nanotechnology in Nordic construction industry (Green NanoCon)

Description: The question addressed in this project was whether the emerging nanotechnologies can offer novel solutions to challenges related to new demands for higher energy efficiency and environmental performance in the construction sector. The project established a Nordic platform for analyzing and promoting the industrial uptake of green nanotechnology in construction, by linking actors, pool and communicate information. Participating organisations: NaNet (Danish), FinNano (Finnish), Nano Øresund (Swedish/Danish). ***Source:*** http://www.nordicinnovation.net/prosjekt.cfm?Id=3-4415-205.

2.3 Relevant EU studies with Nordic contribution

Create Acceptance – Social acceptance of renewable energy and rational use of energy technologies[1]

Description: The aim of the project was to increase understanding of social acceptance of renewable energy and rational use of energy technologies. The project built upon the Socrobust tool (evaluation and monitoring tool and a management framework for assessing the potential long-term S&T options for an innovation to become embedded in society). The Create Acceptance project, however, aimed to enhance the tool from an innovator's tool into a multi-stakeholder tool. The project was co-funded by the European Commission within the Sixth Framework, Programme (2002–2006). The project partners were from Netherlands, Iceland, Finland, UK, Spain, Italy, Hungary, Poland, France and Germany. According to Create Acceptance study, 'societal acceptance is not necessarily an issue of accepting or rejecting a specific technology, but rather pertains to the way in which the technology is introduced in a new context'. Socially acceptable projects thus tend to 1) be locally embedded, 2) provide local benefits, 3) establish continuity with existing physical, social and cognitive structures and 4) apply good communication and participation procedures and sometimes also need 5) the capacity to leverage the social support to overcome difficulties in financing, policy instability or lacking market power. ***Sources:*** Heiskanen et al., 2007; Heiskanen, 2006a, 2006b, 2006c; Maack, 2006 and other documents available on website http://www.createacceptance.net. In addition, Heiskanen and Lovio, 2007.

[1] Some case studies of the Create Acceptance project could also be classified as consumer research; see Chapter 3.

Roads2HyCom, technical and socio-economic issues associated with the use of Fuel Cells and Hydrogen in a sustainable energy economy

Description: The project was a partnership of 29 stakeholder organisations supported by the European Commission Framework Six programme (an integrated project of FP6 019733). The project studied technical and socio-economic issues associated with the use of Fuel Cells and Hydrogen in a sustainable energy economy, by combining expert studies in technology status, energy supply and socio-economics with an active programme of engagement with key stakeholders, especially early adopters of the technologies. It supported the creation of early adopter communities, and Roads2HyCom is running a series of workshops for regional and community leaders who would like to learn more about setting up successful hydrogen and fuel cell community projects and their value in regional development. Nordic partners from Denmark, Island, Norway and Sweden. ***Source:*** http://www.roads2hy.com/.

2.4 Other relevant projects and studies

SOCROBUST. Innovation project evaluation and monitoring tools and a management framework for assessing the potential long-term S&T options for an innovation to become embedded in society. Partners: University of Lancaster, Universidad Carlos III, University de Toulouse I, University of Twente, ECN, CNR, Armines Reference period: from 1st of March 1999 to 30th of June 2001 Financed within the TSER Programme of the European Commission

Sustainable Transport/ Strategic Niche Management. Source: Hoogma et al., 2002.

Managing breakthrough innovations. Sources: Jolivet et al., 2002; Jolivet et al., 2003.

Strategic niche management for biofuels. Source: Van der Laak et al., 2006.

The Expansion of Renewable Energies in Germany. Source: Mautz, 2007.

***Managing sustainable development. Source*:** Kemp & Martens, 2007.

2.5 Setting the studies on the framework and conclusions

In order to better understand the contribution of the approach to the governance of the Nordic energy system transition, the GoReNEST team positioned the example projects/studies/cases into the analytic framework of GoReNEST Task 1. The results of the positioning tasks within the category ‘societal embedding of energy innovations, are presented in Table 4.

Table 4. Contribution areas of the example cases using the 'societal embedding' approach. Examples with Nordic contribution positioned into the analytic framework of GoReNEST Task 1.

	Change dimensions	Present	Short-term	Medium-term	Long-term
Landscape	*Technological*				
	Industrial				
	Policy				
	Social				
Regime	*Technological*				
	Industrial				
	Policy				
	Social				
Niche	*Technological*	JUMESCO JUMPE PIVCO HyNOR, Hydrogen Link Hydrogen Sweden SHHP Green Nano Roads2HyCom	JUMESCO JUMPE SHHP HyNOR, Hydrogen Link Hydrogen Sweden Green Nano Create acceptance: case biogas plant Roads2HyCom	SHHP HyNOR Hydrogen Link Hydrogen Sweden Create acceptance: case CO_2 capture & storage	Create acceptance: cases hydrogen in transport, CCS
	Industrial	JUMESCO JUMPE Green Nano SHHP HyNOR, Hydrogen Link Hydrogen Sweden	JUMESCO JUMPE Green Nano SHHP HyNOR, Hydrogen Link Hydrogen Sweden Roads2HyCom	SHHP HyNOR Hydrogen Link Hydrogen Sweden	
	Policy		SHHP HyNOR, Hydrogen Link Hydrogen Sweden	SHHP HyNOR Hydrogen Link Hydrogen Sweden	
	Social	JUMESCO JUMPE PIVCO Create acceptance: case low energy housing Roads2HyCom	JUMESCO JUMPE SHHP Roads2HyCom	SHHP	

	Functions	Present	Short-term	Medium-term	Long-term
Governance	*Information services, networking, setting common agendas*	JUMESCO SHHP JUMPE SHHP HyNOR, Hydrogen Link Hydrogen Sweden Green Nano Create Acceptance Roads2HyCom	JUMESCO SHHP JUMPE SHHP HyNOR, Hydrogen Link Hydrogen Sweden Green Nano Create Acceptance Roads2HyCom	Create Acceptance	Create Acceptance
	Information services, networking, setting common agendas *Strategic procurement, pre-market*	JUMESCO SHHP JUMPE SHHP HyNOR Hydrogen Link Hydrogen Sweden Green Nano Create Acceptance Roads2HyCom	JUMESCO SHHP JUMPE SHHP HyNOR Hydrogen Link Hydrogen Sweden Green Nano Create Acceptance Roads2HyCom Green Nano SHHP HyNor	Create Acceptance SHHP HyNOR	Create Acceptance
	Financing research and education				
	Financing research and education *Grants, equity support and fiscal measures (supply and demand)*	JUMESCO JUMPE Green Nano (SHHP)	JUMESCO JUMPE Green Nano (SHHP)		
	Regulation and standards			SHHP HyNOR Hydrogen Link Hydrogen Sweden	

In conclusion, the example studies related to the societal embedding of energy innovations have been carried out in Nordic countries, as joint Nordic efforts and as EU-level projects. In addition, some other relevant studies applying this approach were identified. According to the considerations and interpretations of the GoReNEST research team, the contribution of the example studies – with Nordic contribution and using this approach – is on niche and governance level, the main emphasis being in supporting the short- and medium-term developments. Accordingly, these studies and related experiences and research resources can be utilized in the further development of the research on societal embedding of energy innovations, as well as in defining the complementary roles of the various approaches in the governance of the Nordic energy system transition.

3. Consumer research in energy markets

The ‘consumer research approach’ refers here to projects and studies where the main emphasis is in examining the consumer behaviour, the various factors that influence the behaviour and the ways and tools by which the consumer behaviour can be changed.

The example projects here briefly presented focus on consumer perceptions of improved woodstoves, perceptions of low-energy house residents, aiding the consumers in their choices of food, living and transport, interaction between energy users and the promoters of energy efficient solutions when supporting change in energy use and energy services, and guided consumer behavioural changes towards the post-carbon society, The examples projects have been carried out in individual Nordic countries (3.1) and in the form of EU cooperation with Nordic contribution (3.2). Some example studies explicitly state that they are using the ‘consumer research approach’. For some others the approach is more implicit, although the targets and action modes are similar.

3.1 Example studies in Nordic countries

Woodstoves in Norway, a study of consumer perceptions of improved woodstoves

Description: The study was carried out on households in the city of Oslo; out of the 1200 surveys issued, 808 were returned. All the households investigated had received a subsidy for changing an old woodstoves with an improved woodstove. The results of the study imply that when marketing a modern technology for bioenergy heating, both public authorities and producers should consider issues related to the users’ perception of subjective norm, such as perceived status of using bioenergy or environmental concerns, when designing campaigns to promote the use of woodstoves. The study was funded by the Norwegian Research Council. ***Source:*** Nyrud et al., 2008.

Life and living in low energy houses (LEHs), a Finnish NCRC study of technical solutions in low energy houses, satisfaction, lifestyles and changes for residents

Description: The study examined the life and living in low energy houses in Finland. A new research framework was developed for studying the topic on large scale. The main

research questions include: 1) What aspects are relevant for studying the behavior of residents in low energy houses?; 2) What are the differences in types of low energy houses, applications and the use of these applications?; 3) How have consumption patterns changed since people are living in a low energy house, from the perspective of the user?; 4) Does living in a low energy house result in a rebound effect?; 6) Does the extent of influence of the resident on the building process influence the change in consumption pattern?; 7)Does living in a low energy house result in lower total energy consumption than living in a standard house? ***Source:*** Daniëls, 2007.

Climate Bonus, developing a tool for aiding the choices of food, living and transport of individual households

Description: The key purpose of the project was to assess the possibilities and effectiveness of a bonus system for households, which incites them to consume in such a way that greenhouse gas (GHG) emission are reduced and incites retailers to offer a product portfolio that advances the choice for low GHG solutions by households. The project examined the characteristics of an acceptable and user-friendly tool, with the aim of developing such a tool for aiding the choices of food, living and transport of individual households. The project coordinated by VATT was included in Tekes ClimBus programme.

3.2 EU-projects with Nordic participation

Changing Behaviour, supporting change in energy use and energy services

Description: The project was intended to support change in energy use and energy services. An action research project with focus on the interaction between energy experts and energy users, energy demand management programmes and the kind of information they need to change the behaviour of their target groups. The study expressed that decisions about energy should not be isolated from their social context. So, rather than examining the attitudes of energy users, more focus should be placed on the interaction between energy users and the promoters of energy efficient solutions – how and where they meet and how they interact. The project was funded by the EU 7th Framework Programme Energy theme (contract number: 213217). The project partners are from Estonia, Finland, Germany, Greece, Hungary, Latvia, Lithuania, the Netherlands and the UK. ***Sources:*** Heiskanen & Rask, 2006; Hodson & Marvin, 2008.

CHANGE – Creating the hub for effective and guided consumer behavioural changes towards the « post-carbon » society[2]

Description: The objective of the proposed CHANGE project was to design, validate and implement a new and plausible scientific framework to assess social response and behavioral changes in energy demand and use in construction, electric power and transport sectors. The project proposal was linked to three EU 6th Framework studies CEERES (Contract number: 510325), Create Acceptance[3] (Contract number: 518351) and NEEDS[4] (Contract number: 502687). The proposal consortium included also Nordic partners from Finland and Sweden.

3.3 Setting the studies on the framework and conclusions

In order to better understand the contribution of the approach to the governance of the Nordic energy system transition, the GoReNEST team positioned the example projects/studies/cases into the analytic framework of GoReNEST Task 1. The results of the positioning tasks within the category 'consumer research in energy markets' are presented in Table 5.

In conclusion, the example studies related to the consumer research in energy markets have been carried out in Nordic countries and at EU-level (no joint Nordic effort in this area was identified by the GoReNEST team). According to the interpretations of GoReNEST research team, the contribution of Nordic studies related to this approach has been mainly on niche and governance level, with potential contribution to regime level too. These studies and related experiences and research competencies can be utilized in the further development of consumer research in energy markets, as well as in defining the complementary roles of the various approaches in the governance of the Nordic energy system transition.

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[2] A project proposal submitted to the EU 7th Framework Programme (SSH Call, Lot 'Socio-economic factors and actors that shape the post-carbon society'). The proposal was positively evaluated, but didn't get funding after all.

[3] See Chapter 2.3 for a brief description of the Create Acceptance project. Although the basic approach of the Create Acceptance project was classified as 'societal embedding of energy innovations', the project also uses the methods and approaches of 'consumer research' (see Table 5).

[4] See Chapter 4.3 for a brief description of the NEEDS project.

3. Consumer research in energy markets

Table 5. Contribution areas of the example cases using the 'consumer research' approach. Examples with Nordic contribution positioned into the analytic framework of GoReNEST Task 1.

	Change dimensions	Present	Short-term	Medium-term	Long-term
Landscape	*Technological*				
	Industrial				
	Policy				
	Social				
Regime	*Techno-logical*				
	Industrial				
	Policy				
	Social	Climate Bonus	Climate Bonus		
Niche	*Technological*	Woodstoves in Norway	Create acceptance case-studies: biogas plant	Create acceptance: case-CO_2 capture & storage	Create acceptance: case hydrogen in transport, CCS
	Industrial				
	Policy				
	Social	Woodstoves in Norway Life & Living in LEHs Climate Bonus Create acceptance: case low energy housing	Climate Bonus		
Governance	Functions	Present	Short-term	Medium-term	Long-term
	Information services, networking, setting common agendas	Life & Living in LEHs Climate Bonus Create acceptance	Life & Living in LEHs Climate Bonus Create acceptance Changing behaviour	Create acceptance Changing behaviour (CHANGE)	Create acceptance Changing behaviour (CHANGE)
	Strategic procurement, pre-market				
	Financing research and education				
	Grants, equity support and fiscal measures (supply and demand)	Woodstoves in Norway			
	Regulation and standards			(CHANGE)	(CHANGE)

4. Energy system modelling and scenarios

The ‘energy system modelling and scenarios approach’ refers here to projects and studies where the main emphasis is in examining the energy systems with the help of quantitative models. The most usual approach is to optimize the selected target functions (for instance minimizing the emissions or investment and/or operating costs with some given framework conditions) under some specific conditions. By varying the assumptions, and correspondingly the parameters and equations by which the framework conditions are expressed, several alternative scenarios can be created. The outcomes of the quantitative model calculations are usually presented in graphical form (for instance, showing the optimal share of various primary energy sources at different time points of interest, using some given framework conditions and specific assumptions concerning the technological developments, prices, etc.).

The example projects here briefly presented focus on long term developments of the energy systems, given the challenges of the climate change. Use of renewable energy, energy security and emission reduction, as well as the potential and impacts of emission trading are among the important issues examined. Also more specific studies (focusing on waste management, allocation plans for emission quotas, techno-economical potential of windpower, the impact of CO_2 and fuel prices, etc.) are among the examples listed in this chapter. The examples projects have been carried out in individual Nordic countries (4.1), as Nordic joint efforts (4.2) and in the form of EU and other international cooperation with Nordic contribution (4.3). The use of modelling and/or scenario approach is usually explicitly stated.

Relevant examples were relatively easy to identify for the ‘energy systems and modelling approach’. This partly reflects the long tradition of this approach within the energy sector in general and at VTT in particular. Cooperation between the GoReNEST and NEP2 projects further emphasised the importance of this approach and the need to better understand its contribution from the viewpoint of the Nordic energy system transition.

4.1 Studies in Nordic countries

4.1.1 Finnish examples

VTT STUDIES FOR FINNISH MINISTRIES

Energy Visions 2050

Description: Energy Visions 2050 was Tekes-funded VTT project, which aimed at making technology scenarios for Finland, Europe and globally to achieve the EU's 2 degree target for greenhouse gas emissions. The background report for was compiled on the request of the Finnish Ministry of Employment and the Economy for preparing the Finnish new energy and climate strategy. ***Sources:*** VTT, 2009 (draft manuscript); Savolainen et al., 2008.

Times Trip – Assessing the effort-sharing in ambitious global climate scenarios

Description: The VTT project aimed at assessing the properties of alternative effort sharing schemes in ambitious long term climate policies, and the ability of the Triptychmethod to take into account different properties of country groups (e.g. Resources, industrial structure, emission sources). Research was carried out by VTT from Finland and Ecofys from the Netherlands. Financed by the Finnish Ministries of Environment and Trade and Industry (today Ministry of Employment and the Economy) and VTT. ***Source:*** http://www.environment.fi/print.asp?contentid=200395&lan=en&clan=fi (in Finnish).

Times EU – Unilateral emission reductions of the EU and multilateral emission reductions of the developed countries

Description: The VTT project, ordered and funded by the Ministry of Trade and Industry for Finland (today Ministry of Employment and the Economy), assessed the impact of the unilateral greenhouse gas emission reductions proposed by the EU on the structure of European and Finnish energy systems with global TIMES and Finnish TIMES models. ***Source:*** Ekholm et al., 2008.

Tiam EU – Global energy and emissions scenarios for effective climate change mitigation

Description: The VTT project, funded by the Finnish Ministry of Environment was aimed at studying global climate policy and greenhouse gas mitigation scenarios in order to support the international climate egotiations during the Finnish EU presidency in 2006. The modelling work concentrated on modelling the achievement of the 2 ºC stabilization target of the EU. Deterministic and stochastic scenarios with the TIAM model. ***Source:*** Syri et al., 2008.

Global waste – Global climate change mitigation scenarios for solid waste management

Description: The project generated global climate change mitigation scenarios for the solid waste management sector. The primary aim of this study was to give input for the IPCC 4th Assessment report to supplement and expand upon previous studies, e.g. IPCC SRES Scenarios in the IPCC Special Report on Emission Scenarios and the IPCC 3rd assessment report. The work was funded by Tekes, VTT and IPCC WG3 TSU. ***Source:*** Monni et al., 2006.

Times-Pola. Scenarios for the impacts of climate policy on energy economy

Description: The work ordered and funded by the Ministry of Trade and Industry for Finland (today Ministry of Employment and Economy) described the impacts of climate policies on Finnish energy economy with scenario analysis with Times and Pola models for Finland. ***Source:*** Forsström & Lehtilä, 2005.

VATT STUDIES FOR FINNISH MINISTRIES[5]

EV-Kyoto. Scenarios for the effects of the climate and energy strategies on national economy

Description*:** The study was ordered and funded by the Ministry of Trade and Industry for Finland (today Ministry of Employment and Economy) and considered the economic effects of using emission trade and flexible mechanisms in Finland. The scenario analysis was done with an integrated model (EV) using bottom-up energy system model and macroeconomic equilibrium model created by VATT and VTT. ***Source: Honkatukia et al., 2005a.

Adaptation-VATT. Adaptation to climate change – Long term scenarios for the Finnish economy

Description: The work studied the ability of adaptation to climate change of the Finnish economy with a dynamic partial equilibrium model for the Finnish economy created by VATT. The work was ordered and financed by the Ministry of Agriculture and Forestry and the Ministry of Trade and Industry for Finland (today Ministry of Employment and Economy. ***Source:*** Honkatukia et al., 2005b.

[5] VATT is Government Institute for Economic Research in Finland.

EV-Coal – The economic effects of using ban for the use of coal with the EU Emissions Trading System

Description: The study evaluated the economic effects of using ban for the use of coal in condensing and CHP plants to complement domestic energy taxes and EU-wide emission trading. The work was ordered and funded by the Ministry of Trade and Industry for Finland (today Ministry of Employment and Economy). The scenario analysis was done with an integrated model (EV) using bottom-up energy system model and macroeconomic equilibrium model created by VATT and VTT. ***Source:*** Honkatukia, 2004a.

EV-Windfall. The increased profits in electricity production caused by emissions trading

Description: The study evaluated some alternative proposals to lower the costs of emissions trading by taxing the profits of intra-marginal producers with an EV-model. The work was ordered and funded by the Ministry of Trade and Industry for Finland (today Ministry of Employment and Economy). The scenario analysis was done with an integrated model (EV) using bottom-up energy system model and macroeconomic equilibrium model created by VATT and VTT. ***Source*****:** Honkatukia, 2004b.

EV-Allocation. The macroeconomic effects of different initial allocation plans for emission quotas

Description: The study compared three different allocation plans for emission quotas by assessing macroeconomic effects of abatement in each of them. The work was ordered and funded by the Ministry of Trade and Industry for Finland (today Ministry of Employment and Economy). The scenario analysis was done with an integrated model (EV) using bottom-up energy system model and macroeconomic equilibrium model created by VATT and VTT. **Source:** Honkatukia, 2004c.

EV-EFOM-EMM. The use of domestic energy taxes in the trading sectors in connection with EU-wide emissions trading

Description: The study evaluated three distinct tax scenarios for Finland with EV-model and EFOM energy system model. VTT's electricity market model (VTT EMM) was used to evaluate future market electricity prices. The work was ordered and funded by the Ministry of Trade and Industry for Finland (today Ministry of Employment and Economy). ***Source:*** Honkatukia et al., 2003.

4.1.2 Example studies in other Nordic countries

Vindkraft 2020. Techno-economical potential of windpower in Sweden

Description: The techno economical potential of windpower in Sweden was analysed with the Nordic Markal model. ***Source:*** Vattenfall & Profu, 2008.

Kotrollstation 2008. Long-term scenarios for the stationary energy system in Sweden

Description: The report evaluated long-term scenarios for the stationary energy system in Sweden with a MARKAL-NORDIC Model. The study was ordered and financed by Energimyndigheten. ***Source:*** Profu, 2007.

Styrmedel. The impacts of different policies on CO_2 emissions in Sweden

Description: The study analysed the impacts of different policies on CO_2 emissions in Sweden with a MARKA-NORDIC model. The study was ordered and financed by Energimyndigheten. ***Source:*** Profu, 2006.

Teknologiscenarier 2025–08

Description: The report included scenarios for the future Danish energy systems up to 2025. Several optimizing models were used, like SIVAEL, Balmorel and Samkornings-model. ***Source:*** Kofoed-Wiuff et al., 2008.

Danish CO_2 2020–50

Description: The study included scenarios for reducing Danish greenhouse gas emissions in 2020 and 2050 made with a streadsheed model STREAM. The project was ordered and financed by the Danish Energy Authority. ***Source:*** Karlsson et al., 2008.

Teknologiscenarier 2025–07

Description: The report included scenarios for the future Danish energy systems upto 2025 with Varighedskurvemodellen, Besparelsesmodellen and Energistromsmodellen. ***Source:*** Kofoed-Wiuff et al., 2007.

4.2 Nordic studies

STUDIES FOR THE NORDIC COUNCIL OF MINISTRIES

CO_2 pass through. The impact of CO_2/fuel prices and hydro inflow levels on Nord-Pool system

Description: The report looked at phase 2 of the EU Emission Treading System and provides information on the market fundamentals and key price drivers. Carbon price

scenarios were presented using Point Carbon's proprietary Carbon Price Forecaster model and these scenarios are used within Point Carbon's mid-term Nordic power model to examine the impact of CO_2/fuel prices and hydro inflow levels on NordPool system prices, level of power flows between countries, generation levels and emissions. ***Source:*** Point Carbon, 2008.

2 grader. The impacts of climate scenarios reported on a Nordic level

Description: The report included reviews SRES scenarios and reports the impacts of climate scenarios reported on a Nordic level. ***Source:*** COWI & CICERO, 2008.

Climate 2050. The road to 60–80 percent reductions in the emissions of green-house gases

Description: The objective of the project was to analyse the measures and costs of reaching ambitious emission reduction targets in the Nordic countries by 2050. The three key sectors in focus were the Nordic energy sector (electricity and heating), the transport sector and other GHGs than CO_2. The analysis of each sector is made on a partial basis. The Nordic energy sector is analysed by simulations on a Nordic energy sector model, the MARKAL Nordic. The Climate Change Working Group of the Nordic Council of Ministers undertook the study in cooperation with PROFU, Sweden. ***Source:*** COWI & Profu, 2007.

NORDIC COOPERATION FINANCED BY NER, NORDIC COMPANIES AND RESEARCH INSTITUTES

NEP. Nordic Energy perspectives (NEP1 + NEP2)

Description: Nordic Energy Perspectives (NEP) is an interdisciplinary Nordic energy research project with the overall goal of demonstrating means for stronger and sustainable growth and development in the Nordic countries. The first phase focused on modelling of the Nordic energy systems with eight different Nordic models. In the second phase also a wider perspective is taken into account, i.e. global modelling and scenarios as well as qualitative/social aspects. The first phase was carried out in 2005–2006, the ongoing second phase was started in 2007 and will continue up to 2010. Co-funded by NER. ***Sources:*** Ryden et al., 2006; http://www.nordicenergyperspectives.org.

CES – Climate and Energy Systems

Description: This project examines what climate change would mean to Nordic Countries' renewable energy production system, including also some risk assessment focus. Global climate models are adapted in the Nordic climate till the year 2100. Impacts in the hydropower, wind power, solar power, biofuels and the total Nordic energy system

are covered. General conclusions outline that “most of the impacts are beneficial and none are catastrophic”. The first comprehensive report is mainly written from the natural science perspective. A project funded by NER, partners from each Nordic country (Denmark, Finland, Iceland, Norway, Sweden). ***Sources:*** http://www.os.is/ces; http://www.nordicenergy.org/section.cfm?id=3-0&path=17,49; Fenger, 2007.

4.3 EU and international studies with Nordic participation

RES 2020 – Renewable Energy Resources

Description: RES2020 project analyses the present situation in the renewable energy resources implementation in EU27, and defining future options for policies and measures. Concrete targets for the RES contribution that can be achieved by the implementation of these options are calculated, examining also the implications of the achievement of these targets to the European Economy. A number of future options for policies and measures are defined and they studied with the use of the TIMES energy systems analysis model, in order to analyze the quantitative effects on the RES development. TIMES offers the possibility of developing an aggregate parameter in order to quantify the impact of a wide range of support schemes. The results are combined to provide recommendations of optimal mix scenarios for policy measures, in order to ensure the achievement of the targets. Nordic partners: VTT/Finland, Chalmers Technical University/Sweden, Risoe National Laboratory/Denmark (tot. 14 partners). ***Source:*** http://www.res2020.eu/.

REACCESS – Risk of Energy Availability. Common Corridors for Europe Supply Security

Description: The main goal of the project is to build tools suitable for EU27 energy import scenario analyses, able to take into account at the same time the technical, economical and environmental aspects of the main energy corridors, for all energy commodities and infrastructures. Nordic participation: VTT/Finland, IFE/Norway (tot. 14 partners) ***Source:*** http://reaccess.epu.ntua.gr/.

NEEDS – New Energy Externalities Development for Sustainability

Description: The ultimate objective of the NEEDS Integrated Project is to evaluate the full costs and benefits (i.e. direct + external) of energy policies and of future energy systems, both at the level of individual countries and for the enlarged EU as a whole. In this context NEEDS refines and develops the externalities methodology already set up in the ExternE project, through an ambitious attempt to develop, implement and test an original framework of analysis to assess the long term sustainability of energy technology options and policies. To this end NEEDS is built as series of Research Streams, each addressing a specific area of research. NEEDS is supported by the Directorate General for Research of the European Commission in the context of the 6th Framework

Programme. Nordic participation: Chalmers Technical University & Lund University/Sweden, Elsam A/S/Denmark & Risoe National Laboratory, Meteorologisk Institut & SWECO (Norway) ***Source:*** http://www.needs-project.org.

Energy Technology Perspectives 2008 (ETP 2008). Scenarios and Strategies to 2050

Description: The updated report presents scenarios and strategies of energy technologies till 2050. IEA. The analysis draws on modelling work within the IEA Secretariat and expertise from the IEA international energy technology collaboration network. ***Source:*** http://www.iea.org/Textbase/techno/etp/index.asp; IEA, 2008.

4.4 Setting the studies on the framework and conclusions

In order to better understand the contribution of the approach to the governance of the Nordic energy system transition, the GoReNEST team positioned the example projects/studies/cases into the analytic framework of GoReNEST Task 1. The results of the positioning tasks within the category ‘energy system modelling and scenarios approach’ are presented in Table 6.

In conclusion, energy system modelling and scenario approach has a long tradition in the energy sector of the Nordic countries. The main contribution of this approach is in the landscape and regime levels, but in the light of the example studies the niche level seems to be by far ignored. Many of the energy system modelling and scenario studies also contribute to the governance of the Nordic energy systems in form of information services and by examining the impacts of different support systems and regulation. Examining the possibilities of strategic procurement (and other actions supporting the pre-market and early market phases of new energy technologies) were not included in the modelling work, however. The same holds for ‘financing research and education’. The example studies and related experiences and research competencies can be utilized in the further development of energy system modelling and scenario work, as well as in defining the complementary roles of the various approaches in the governance of the Nordic energy system transition.

Table 6. Contribution areas of the example cases using the 'modelling and scenarios' approach. Examples with Nordic contribution positioned into the analytic framework of GoReNEST Task 1.

	Change dimensions	Present	Short-term	Medium term (2020–2050)	Long term (2050->)
Landscape	*Technological*		NEP2	Energy Visions 2050 Times-Pola 2 grader RES2020 REACCESS NEEDS	Energy Visions 2050 Times-Pola 2 grader REACCESS NEEDS CES
	Industrial		NEP2	Energy Visions 2050 Times-Pola 2 grader RES2020 REACCESS NEEDS	Energy Visions 2050 Times-Pola 2 grader REACCESS NEEDS CES
	Policy		NEP2	Times Trip Times EU & Tiam EU Global waste Times-Pola RES2020 REACCESS NEEDS NEP2	NEP2
	Social			2 grader NEP2	2 grader NEP2 CES
Regime	*Technological*		EV-EFOM-EMM Kotrollstation 2008 Styrmedel NEP1 NEP2	Energy Visions 2050 Vindkraft 2020 Teknologiscenarier 2025–08 Teknologiscenarier 2025–07 Danish CO_2 2020–50 2 grader Climate 2050 RES2020 REACCESS NEEDS NEP1 NEP2	2 grader Energy Visions 2050 REACCESS NEEDS NEP2 CES
	Industrial		EV-Kyoto EV-Coal EV-Allocation EV-EFOM-EMM Kotrollstation 2008 Styrmedel NEP1 NEP2	Energy Visions 2050 Vindkraft 2020 Teknologiscenarier 2025–08 Teknologiscenarier 2025–07 Danish CO_2 2020–50 2 grader Climate 2050 RES2020 REACCESS NEEDS NEP1 NEP2	2 grader Energy Visions 2050 REACCESS NEEDS NEP2 CES
	Policy		EV-Kyoto Adaptation-VATT EV-Coal EV-Windfall EC-Allocation EV-EFOM-EMM Kotrollstation 2008	Energy Visions 2050 Adaptation-VATT Vindkraft 2020 Teknologiscenarier 2025–08 Teknologiscenarier 2025–07 Danish CO_2 2020–50 Climate 2050	NEP2

			Styrmedel CO_2 pass through NEP1 NEP2	RES2020 REACCESS NEP1 NEP2	
	Social		EV-Kyoto Adaptation-VATT EV-Coal EV-Windfall EV-Allocation NEP2	Adaptation-VATT 2 grader NEP2	NEP2 CES
Niche	*Technological*				
	Industrial				
	Policy				
	Social				
Governance	Functions	Present	Short-term	Medium-term	Long-term
	Information services, networking, setting common agendas		EV-Kyoto Adaptation-VATT EV-Coal EV-Windfall EC-Allocation EV-EFOM-EMM Kotrollstation 2008 Styrmedel CO_2 pass through NEP1 NEP2	Energy Visions 2050 Adaptation-VATT Vindkraft 2020 Teknologiscenarier 2025–08 Teknologiscenarier 2025–07 Danish CO_2 2020–50 Climate 2050 RES2020 REACCESS NEP1 NEP2 CES	2 grader Energy Visions 2050 REACCESS NEEDS NEP2 CES
	Strategic procure-ment, pre-market				
	Financing research and education				
	Grants, equity support and fiscal measures (supply and demand)		EV-Kyoto EV-Coal EC-Allocation EV-EFOM-EMM Styrmedel NEP1 NEP2	Energy Visions 2050 Vindkraft 2020 Teknologiscenarier 2025–08 Teknologiscenarier 2025–07 NEP2	
	Regulation and standards		EV-Kyoto EV-Coal EV-Windfall EC-Allocation EV-EFOM-EMM Kotrollstation 2008 Styrmedel CO_2 pass through NEP1 NEP2	Energy Visions 2050 Vindkraft 2020 Teknologiscenarier 2025–08 Teknologiscenarier 2025–07 Danish CO_2 2020–50 Climate 2050 RES2020 REACCESS NEP1 NEP2	

5. Energy foresight and technology assessment

The 'energy foresight and technology assessment approach' refers here to projects and studies where the main emphasis is in examining the future developments of energy technologies and their potential impacts. Explicit roadmapping to desired future states and/or some kind of action recommendations are usually included too. Although even modelling approach is sometimes used in these exercises, the main emphasis is usually in more qualitative expert assessments and/or interaction between the stakeholders. The process and the outcomes may be equally important in this respect.

The example projects here briefly presented focus on energy system developments at national or regional level, the developments of some specific technologies contributing to the future energy systems and/or the impacts of some specific technologies and developments on emissions and sustainable development. The examples projects have been carried out in individual Nordic countries (5.1), as Nordic joint efforts (5.2) and in the form of EU cooperation with Nordic contribution (5.3). Some of the example projects are explicitly defined as foresight or technology assessment projects. In some cases the classification into this category was not straight-forward, but the examples were included here because they still include some ingredients of this category.

5.1 Example studies in Nordic countries

Danish Energy Foresight

Description: Danish Society of Engineers has carried out a significant foresight effort focusing on energy for the future. The process consisted of several rounds of foresight projects with elements such as brainstorms, workshops, Internet-based dialogue members, scenarios, and roadmap seminars on six areas of energy technology. The project contributed to reformulation of the Governments' energy policy and expenditures on energy-related R&D. The project was initiated by Danish Society of Engineers (IDA) in 2006, and was participated by various types of stakeholders from industry, universities and research institutes, government and other public organisations. ***Sources:*** Dannemand Andersen et al., 2007; http://ida.dk/english/idaenergyyear/Sider/IDAEnergyYear2006.aspx.

Energi 2020+ in Norway

Description: Foresight study based on scenario approach and carried out as cooperation with research community, industry, policy-makers and other relevant actors. The study was conducted by Research Council. **Source:** Norges forskningsråd, 2005.

Energia 2010 – Technology Assessment for the Finnish Parliament

Description: The project concentrated to evaluate the effects of fine particles and radiation to human health in energy production (nuclear, natural gas, renewable energy sources). ***Source:*** Loikkanen et al., 2001.

Renewable energy sources till 2030 in Finland – Technology Assessment for the Finnish Parliament

Description: The report focused on the prospects of bioenergy and wind energy in Finland. ***Source:*** Helynen et al., 2002.

RISOE ENERGY REPORTS 1–6[6]

Report 1: New and emerging technologies – options for the future

Description: The report consisted of the global, European and Danish energy scene together with trends in development and emerging technologies. The global energy developments were presented based on the latest available information from authoritative sources like IEA, WEC, World Energy Assessment etc. Some of the major challenges were presented in terms of the changing energy markets in all regions, the focus on environmental concerns in the industrialised countries, and energy for development and access to energy for the poor in developing countries. The report presented the status of R&D in progress for supply technologies. The various technologies were assessed with respect to status, trends and perspectives for the technology, and international R&D plans. ***Source:*** Larsen & Sønderberg Petersen, 2002.

Report 2: New and emerging bioenergy technologies

Description: The report provided a critical examination of modern bioenergy, and describes current trends in both established and emerging bioenergy technologies. By examining the implications for the global energy scene, the report drew national conclusions for European and Danish energy supply, industry and energy research, and pre-

[6] Risoe Energy Reports were classified into this category. Although they do not represent typical foresight or TA projects, the entire series (http://www.risoe.dtu.dk/Knowledge_base/publications/Risoe_Energy_Report_series.aspx?sc_lang=en) can be seen as an effort to mobilise expert knowledge for more sustainable energy futures. As such these reports deserve to be included in GoReNEST Task 2.

sented the status of current R&D in biomass resources, supply systems, end products and conversion methods. Recent studies of emerging bioenergy technologies from international organisations and leading research organisations were reviewed. The report was based on internationally-recognised scientific material, and is fully referenced. The presentation of current global developments in bioenergy was based on the latest information from authoritative sources including the IEA, the World Energy Council (WEC) and World Energy Assessment. ***Source:*** Larsen et al., 2003.

Report 3: Hydrogen and its competitors

Description: The Report explained the current R&D situation, addresses the challenges facing the large-scale use of hydrogen, and makes some predictions for the future. The Report explored the current and future role of hydrogen in energy systems at Danish, European and global levels. It discussed the technologies for producing, storing and converting hydrogen, the role of hydrogen in the transport sector and in portable electronics, hydrogen infrastructure and distribution systems, and environmental and safety aspects of the hydrogen economy. The Report was based on internationally recognised scientific material, and was fully referenced and refereed by an international panel of independent experts. ***Source:*** Larsen et al., 2004.

Report 4: The Future Energy System – Distributed Production and Use

Description: The report covered the future of energy systems over the next 20–30 years. It dealt with sustainable energy in general, but paid special attention to system aspects and the distribution of energy through grids such as those used for natural gas, electricity, district heating and hydrogen. The focus was on industrialised countries, but the report also dealt with specific points relevant to developing countries, such as isolated energy systems. The transport sector was discussed only in the context of its use of energy supplied through the various grids. ***Source:*** Larsen & Sønderberg Petersen, 2005.

Report 5: Renewable energy for power and transport

Description: The report addressed status and trends in renewable energy, and gave an overview of global driving forces for transformation of the energy systems in the light of security of supply, climate change and economic growth. More specifically status and trends in renewable energy technologies, for broader applications in off grid power production (and heat) were discussed. Furthermore the report addressed wider introduction of renewable energy in the transport sector, for example renewable based fuels, hybrid vehicles, electric vehicles and fuel cell driven vehicles. ***Source:*** Larsen & Sønderberg Petersen, 2006.

Report 6: Future options for energy technologies

Description: The report gave an overview of the energy scene together with trends and emerging energy technologies. The report presented status and trends for energy technologies seen from a Danish and European perspective from three points of view: security of supply, climate change and industrial perspectives. The report addressed energy supply technologies, efficiency improvements and transport. ***Source:*** Larsen & Sønderberg Petersen, 2007.

5.2 Common Nordic studies

Nordic H2 Energy Foresight

Description: The Nordic H_2 Energy Foresight was a joint research project involving 16 partner organisations, including R&D institutes, energy companies and industry, from the five Nordic countries – Denmark, Finland, Iceland, Norway and Sweden. It was executed from January 2003 till June 2005. The aim of the foresight was to provide decision support for companies and research institutes in defining R&D priorities and to assist governmental decision-makers in making effective framework policies for the introduction of hydrogen energy. The objectives of exercise: (1) To develop socio-technical scenarios for a future hydrogen society and explore roadmaps to commercialisation of hydrogen production, transport, storage and utilisation; (2) To contribute as decision support for companies, research institutes and public authorities in order to prioritise R&D and to develop effective framework policies, and (3) To maintain and develop scientific and industrial networks in this field. ***Source*****:** http://www.h2foresight.info.

5.3 EU exercises with Nordic contribution

HyWays – an integrated project to develop the European Hydrogen Energy Roadmap

Description: HyWays was an integrated project, co-funded by research institutes, industry and by the EC under the 6th Framework Programme [contract N° 502596]. Member state specific results for greenhouse gas emissions, preferred hydrogen production and infrastructure technologies were estimated for the timeframes 2020, 2030 and 2050, paying attention to the build-up of supply infrastructure and end-use technologies. The project included also model-based quantitative work. The results were integrated into a proposal for an EU Hydrogen Energy Roadmap for the participating areas. The project was performed from April 2004 and was finalized after 39 months in June 2007. The Nordic partners were from Norway (Phase 1 & 2) and Finland (Phase 2). ***Source:*** http://www.hyways.de/.

5.4 Setting the studies on the framework and conclusions

In order to better understand the contribution of the approach to the governance of the Nordic energy system transition, the GoReNEST team positioned the example projects/studies/cases into the analytic framework of GoReNEST Task 1. The results of the positioning tasks within the category 'foresight or technology assessment approach' are presented in Table 7.

Table 7. Contribution areas of the example cases using the 'foresight or technology assessment' approach. Examples with Nordic contribution positioned into the analytic framework of GoReNEST Task 1.

	Change dimensions	Present	Short-term	Medium-term	Long-term
Landscape	Technological				
	Industrial				
	Policy		Nordic H2 Foresight Energia 2010 HyWays	Nordic H2 Foresight Energia 2010 HyWays	Nordic H2 Foresight Energia 2010 HyWays
	Social				
Regime	Technological		Danish Energy Foresight Nordic H2 Foresight HyWays	Danish Energy Foresight Nordic H2 Foresight HyWays Risoe Energy Rep. 1–6 Energia 2010	Danish Energy Foresight Nordic H2 Foresight HyWays Risoe Energy Reports 1–6 Energi 2020+
	Industrial	Renewable energy sources till 2030 in Finland.	Danish Energy Foresight Nordic H2 Foresigh HyWays Renewable energy sources till 2030 in Finland	Danish Energy Foresight Nordic H2 Foresight HyWays Energia 2010 Renewable energy sources till 2030 in Finland	Danish Energy Foresight Nordic H2 Foresight HyWays Energi 2020+ Energia 2010 Renewable energy sources till 2030 in Finland
	Policy		Danish Energy Foresight Nordic H2 Foresight HyWays	Danish Energy Foresight Nordic H2 Foresight HyWays Energia 2010	Nordic H2 Foresight HyWays Energi 2020+ Energia 2010
	Social		Nordic H2 Foresight HyWays	Nordic H2 Foresight HyWays Energia 2010	Nordic H2 Foresight HyWays Energi 2020+ Energia 2010
Niche	Technological		Danish Energy Foresight Nordic H2 Foresight HyWays	Danish Energy Foresight Nordic H2 Foresight HyWays	Danish Energy Foresight Nordic H2 Foresight HyWays
	Industrial		Danish Energy Foresight Nordic H2 Foresight HyWays	Danish Energy Foresight Nordic H2 Foresight HyWays	Danish Energy Foresight Nordic H2 Foresight HyWays
	Policy		Danish Energy Foresight Nordic H2 Foresight HyWays	Danish Energy Foresight Nordic H2 Foresight HyWays	Nordic H2 Foresight HyWays
	Social		Nordic H2 Foresight HyWays	Nordic H2 Foresight HyWays	Nordic H2 Foresight HyWays

	Functions	Present	Short-term	Medium-term	Long-term
Governance	Information services, networking, setting common agendas		Danish Energy Foresight Nordic H2 Foresight	Danish Energy Foresight Nordic H2 Foresight Renewable energy sources till 2030 in Finland.	Danish Energy Foresight Nordic H2 Foresight
	Strategic procurement, (pre-)market		Nordic H2 Foresight	Nordic H2 Foresight	Nordic H2 Foresight
	Financing research and education		Nordic H2 Foresight	Nordic H2 Foresight	Nordic H2 Foresight
	Grants, equity support and fiscal measures (supply and demand)		Nordic H2 Foresight	Nordic H2 Foresight Renewable energy sources till 2030 in Finland.	Nordic H2 Foresight
	Regulation and standards		Nordic H2 Foresight	Nordic H2 Foresight	Nordic H2 Foresight

In conclusion, several example studies using the energy foresight and technology assessment approach were identified. The main contribution of these approach covers the regime, niche and governance levels. In some cases attention is paid to the policy dimension of landscape developments too. The main emphasis is in the medium- and long-term developments, but short-term issues are paid attention too. The example studies and related experiences and research competencies can be utilized in the further development of foresight and technology assessment approaches, as well as in defining the complementary roles of the various approaches in the governance of the Nordic energy system transition.

6. Energy research and technology program evaluations

The 'energy research and technology program evaluation approach' refers here to projects with the emphasis in evaluating the contents and impacts of RTD programmes that focus on energy issues and technologies. Two examples of national energy policy evaluations are also included. The example projects here briefly presented are carried out by international consultants or expert groups who focus on specific RTD programmes and policies at national, Nordic or EU level. Most examples are explicit program/policy evaluations, but some of the examples could have been included in 'technology assessment category' too.

The examples here listed are considered relevant for the governance of Nordic energy system transition, although there is not always explicit Nordic participation in the studies themselves. Some Finnish examples are first briefly presented (6.1), followed by EU evaluations (6.2) and evaluations by IEA (6.3).

6.1 Evaluation studies in Finland

Energy Research in Finland 1999–2005. International Evaluation. Publications of the Academy of Finland 14/06. Academy of Finland, Helsinki

Description: The primary objective of the evaluation was to determine the scientific quality of the field of energy research in Finland during the period of 1999–2005. The panel gave 10 recommendations: three of them related to research results and five concerning the university activities. ***Source:*** Makkonen, 2006.

6.2 EU and other international evaluations

The State and Prospects of European Energy Research

Description: The overall aim of this study was to obtain a broad picture of the EC NNE (non-nuclear energy) RTD (research and Technology Development) portfolio in com-

parison to Member Sates and Third Country RTD by means of a comparative and synthetic approach. Besides European countries also USA and Japan were involved in the study. Research efforts introduced roughly (in million €) in the sectors as follows: hydrogen and fuel cells, CCS, photovoltaics, concentrated solar thermal, wind energy, ocean energy, bioenergy, geothermal energy, electricity grids and socio-economic research. Nordic countries have their strengths in CCS (Norway), biomass (Finland and Sweden), wind technologies (Denmark), ocean energy (Denmark) and geothermal energy (Iceland). Finland has also been active in developing international electricity grid. The US clearly focuses on efficiency technologies, hydrogen and fuel cells. Japan focuses also on efficiency technologies, but also hydrogen and selected renewables are seen promising. EU research is more general and split, and stakeholders are diverse, while in US and in Japan the research is more specific and stakeholders more selected. EU gains for knowledge, Japan and US products and services. ***Source:*** EC, 2006a.

SWOT-analysis on common strategic issues on research programmes on innovative energy systems for the ERANET INNER

Description: The report aimed at highlighting: internal factors that are strengths and weaknesses of national programmes regarding management of the programmes and research achievements, and external factors, potential benefits (opportunities) and potential barriers hindering international cooperation (threats). Programmes evaluated were members of the INNER project that contributes to strengthening European efforts to define a policy and sustainable approaches to find new ways (energy technologies) to meet the challenges of European energy economy; to establishing a secure energy supply, which is environmentally sound, while decreasing our dependence on imports. NER (Nordic Energy Research), RCN (Research Council Norway) and STEM (Swedish Energy Agency) were partners in INNER. Research portfolio 2003–2006 of NER, RENERGI of Norway and Swedish Energy R&D Programme were programmes evaluated in this report. ***Source:*** Larrue & Eparvier, 2006/2007.

Energy Futures. The role of research and technological development. Directorate-General for Research, Sustainable Energy Systems 2006

Description: The publication aimed to give an overview of the methods and results concerning the future challenges in energy. Using various tools for energy foresight – quantitative models, Delphi survey and back-casting approach – Energy futures analysed Europe in a world context. It also highlighted the importance of research in the energy field. Finally, it presented EU projects in this field at the cross roads of technology and socio-economy. ***Source:*** EC, 2006b.

***European funded research on hydrogen and fuel cells – periodical review* 2002–2006**

Description: Periodical review of the EU hydrogen and fuel cell R&D with the aim of intensifying European strategies for the purpose (incl. HFC-JTI). In 2007, the EU was estimated to lie around five years behind the US and Japan technology developments in the field of hydrogen and fuel cells. This was considered to be due to the dispersed nature of the EU research environment. The US, and Japan were also seen to have better-developed processes for technology validation and assessment. The projects funded by EU FP6 were generally acknowledged to constitute a good and balanced portfolio, however. Nordic countries have been actively involved in the FP6 HFC projects. ***Sources:*** EC, 2007a; EC, 2006c; http://www.hfpeurope.org.

CO_2 Capture and storage projects. European Commission. Project synopses

Description: The exploration of opportunities given by CO_2 capture and storage in mitigating the climate change challenge. Norway was the most active of Nordic countries in this area, but also Denmark, Sweden and Finland have participated in the projects. ***Source:***

Assessing the impact of energy research. EU energy research evaluation

Description: The report was about the evaluation of the energy research in EU member states. Finland, Sweden and Denmark have been members of the evaluation group known as EREVIA – Energy Research Evaluation and Impact Assessment. The key recommendations of the report concern the methodology of the evaluation process and policy of the evaluation process. ***Source*****:** EC, 2005.

6.3 Energy policy evaluations by IEA

IEA carries out regularly energy policy evaluations or the member countries which are available in IEA web-site (http://www.iea.org/). Evaluations have been carried out from Sweden, Finland, Norway and Denmark of Nordic countries. Two of these reviews are briefly described below[7].

Energy Policies of IEA Countries – Finland 2007 Review

Description: This was evaluation type study of energy policies of Finland. *Conclusions:* The government of Finland should: 1) continue to address energy security concerns in a comprehensive and sustainable manner, placing focus not only on import security, but

[7] For corresponding reviews of Norway and Denmark, see http://www.iea.org/textbase/nppdf/free/2005/norway2005.pdf and http://www.iea.org/textbase/nppdf/free/2006/denmark2006.pdf.

also on domestic supply diversity, new renewables and energy efficiency; 2) continue building on efforts to enhance longer-term policies that encourage energy efficiency. Give more top-down, strategic guidance to the energy R&D community on long-term energy policy priorities. ***Source:*** OECD/IEA, 2008a.

Energy Policies of IEA Countries – Sweden 2008 Review

Description: This was evaluation type study of energy policies of Sweden. *Conclusions:* The government of Sweden should: 1) Clarify the conditions for the use of existing and future nuclear power; capacity, with due consideration to electricity prices, climate change; mitigation and security of energy supply; 2) Continue efforts to reduce oil use in the transport sector, especially by encouraging more efficient fuel use and by promoting alternatives to oil based road transport, including transport of freight; 3) Focus efforts to increase the supply of renewable energy on sources that are deemed the most sustainable, based on an evaluation of their economic, environmental and social benefits. ***Source:*** OECD/IEA, 2008b.

Promoting Energy Efficiency Investments. Case Studies in the Residential Sector. IEA

Description: The publication provided illustrations of policies and measures implemented in five IEA member countries and the European Union. Each case included relevant background and contextual information, as well as a detailed evaluation of each policy according to five pre-defined criteria: relevance, effectiveness, flexibility, clarity and sustainability. Nordic countries not explicitly. ***Source:*** OECD/IEA & AFD, 2008.

6.4 Setting the studies on the framework and conclusions

In order to better understand the contribution of the approach to the governance of the Nordic energy system transition, the GoReNEST team positioned the example projects into the analytic framework of GoReNEST Task 1. The results of the positioning tasks within the category ‘energy RTD program evaluations’ are presented in Table 8.

Table 8. Contribution areas of the example cases using the 'energy RTD program evaluation approach'. Examples with Nordic contribution positioned into the analytic framework of GoRe-NEST Task 1.

	Change dimensions	Present	Short-term	Medium-term	Long-term
Landscape	*Technological*	INNER	Energy Futures INNER	Energy Futures	Energy Futures
	Industrial				
	Policy	EU energy research evaluation			
	Social				
Regime	*Technological*	Energy research in Finland The State and prospects of European Energy Research	Energy research in Finland The State and prospects of European Energy Research		
	Industrial				
	Policy	European funded research on hydrogen and fuel cells	European funded research on hydrogen and fuel cells	European funded research on hydrogen and fuel cells	
	Social				
Niche	*Technological*	European funded research on hydrogen and fuel cells	European funded research on hydrogen and fuel cells CO_2 Capture and storage projects in EU	European funded research on hydrogen and fuel cells CO_2 Capture and storage projects in EU	
	Industrial				
	Policy				
	Social				
Governance	Functions	Present	Short-term	Medium-term	Long-term
	Information services, networking, setting common agendas				
	Strategic procurement, pre-market				
	Financing research and education	The State and prospects of European Energy Research European funded research on hydrogen and fuel cells INNER EU energy research evaluation	The State and prospects of European Energy Research European funded research on hydrogen and fuel cells INNER	INNER European funded research on hydrogen and fuel cells	
	Grants, equitysupport and fiscal measures (suppl. and demand)				
	Regulation and standards				

In conclusion, various example studies using the ‘energy RTD program/policy evaluation approach’ were identified by GoReNEST Task 2. They relate to different levels of the analytical framework (landscape, regime, niche and governance), but less in long term timescale. These studies and related experiences and competencies can be utilized in the further development of the ‘energy RTD program and policy evaluation approach’, as well as in defining the complementary roles of the various approaches in the governance of the Nordic energy system transition.

7. Innovation studies, energy related new governance research, benchmarking

This last chapter contains examples of various approaches, including innovation studies, energy-related new governance research and benchmarking studies. Some Finnish examples of innovation studies are first briefly presented (7.1), followed by some interesting EU studies with Nordic contribution. Nordic and international benchmarking studies are presented separately in section 7.3.

7.1 Finnish example studies

SFINNOREG – The Role of Environmental Factors and Regulations in Innovation Processes

Description: The object was to study the role of environmental issues and related regulation in the development process of technological innovations. The study was based on two different data. First the study used the survey data of Finnish innovations (Sfinno™ database) commercialised during 1985–98. In descriptive analyses the profile of innovations where environmental issues and regulations have been significant to the development of the innovations are compared to the profiles of other innovations in the database. Second, five qualitative case studies were conducted to deepen the understanding of the role of environmental issues and regulations during the development process of innovations. ***Source:*** Hyvönen & Loikkanen, 2010.

INNOREG II – Environment-friendly Energy Innovations and Factors Influencing Them

Description: The study had the following objectives. (1) The study outlined the approach according to which innovations – technological, economic, social, behavioural, organisational or managerial – may create a basis for changing the ecological development towards a more sustainable path; (2) The study considered the opportunities which the integration of innovation and sustainable development may offer for businesses, export and consequent national competitiveness, as well as for the development of needed policy instruments; (3) The study considered themes, hypotheses and method-

ologies for the further more detailed research in this research area. ***Source:*** Hongisto et al., 2001.

INNOREG I – Integration of Innovation and Sustainable

Description: The study produced a description and analysis of three different types of innovation development, the analysis of previous and current development phases of CityFutura petrol, the future oriented analysis of bio-fuel pyrolysis technology, and respective future oriented analysis of innovative service concept for energy saving in industry. On a basis of interviews of identified key experts, the study explored the importance of policy instruments and other factors on the development of innovations. ***Source:*** Loikkanen & Hongisto, 2000.

7.2 EU Studies with Nordic contribution

HySOCIETY – Supporting the introduction of a safe and dependable hydrogen-based society in Europe

Description: Twenty European Institutions working towards the introduction of Hydrogen as an energy carrier in Europe HySOCIETY. The project (1) addressed the non-technical barriers to the deployment of hydrogen energy systems, (2) delivered lines of action on codes and standards, (3) measured for addressing infrastructure build-up and dissemination of information to different sectors of society such as the general public, decision makers and business leaders; (4) reviewed the social, economic and environmental impacts of hydrogen technologies; (5) highlight the opportunities for establishing a clean, safe, efficient hydrogen energy system in Europe. (EU FP5, execution Feb 2003 – Jan 2005). Among partners from Nordic countries VTT and SINTEF. ***Source:*** http://ec.europa.eu/research/energy/pdf/6_hysociety_en.pdf; http://www.ist-world.org/ProjectDetails.aspx?ProjectId=3b7a0d46d338425da03ca92b10ca1152.

Project/study: HyCOM prefeasibility study. EUR 21575 EN

Description: The study looked at the establishment of strategically located “hydrogen communities”, producing hydrogen from various primary energy sources, and using it for heat and electricity production and as a transportation fuel. It investigated the main technical, economic, social and environmental aspects as well as financial and regulatory barriers associated with the creation and operation of “hydrogen communities”. It also proposed a number of concepts for Hydrogen Communities and criteria with which a Hydrogen Community should be evaluated. Risoe as a Nordic partner. ***Source:*** Iacobazzi et al., 2005.

Project/study: HYPOGEN pre-feasibility study. EUR 21512 EN

Description: HYPOGEN (HYdrogen POwer GENeration) report presented the work of the ESTO in May-to-October 2004 under the guidance of SETRIS. The report covered the co-production of hydrogen and electricity from fossil fuels and the capture and storage of the carbon dioxide generated in the process. It identified the main technological, socio-economic, financial, legal and environmental constraints. Risoe as a Nordic partner. ***Source:*** http://energy.jrc.ec.europa.eu/Pages/2005IPTSPublications.htm.

HY-CO ERA-NET

Description: The ERA-NET HY-CO intended to implement sustainable European transnational joint research and development activities in the fields of hydrogen and fuel cells. The following six research themes were figured out to implement joint activities: (1) hydrogen production centralised, (2) hydrogen production decentralised, (3) hydrogen storage on board vehicles, (4) low-temperature fuel cell PEFC, (5) high-temperature fuel cells – SOFC, MCFC, and (6) deployment strategies. ***Source:*** http://www.hy-co-era.net/index.php?index=112.

Towards an evolutionary environmental economics

Description: The authors reviewed evolutionary economic modelling in relation to environmental policy. They discussed three areas in which evolutionary economic models have a particularly high added value for environmental policy-making: the double externality problem, technological transitions and consumer demand. They explored the possibilities to apply evolutionary economic models in environmental policy assessment, including the opportunities for making policy-making endogenous to environmental innovation. We end with a critical discussion of the challenges that remain. ***Source*** Faber & Frenken, 2008.

Stimulating renewable energy technologies by innovation policy

Description: The authors analysed the dynamics of three emerging innovation systems by using the system functions approach in which the underlying key activities that contribute to the build up of an innovation system are identified. The insights gained with respect to the dynamic functional patterns specific for each emerging innovation system allows us to identify system failures and develop policy and policy measures that start out from an innovation systems' perspective. The authors presented initial ideas on the building blocks for a more systemic policy aiming to support the development of new emerging innovation systems ***Source*****:** Negro et al., 2008.

A complex systems methodology for transition management

Description: There is a general sense of urgency that major technological transitions are required for sustainable development. Such transitions are best perceived as involving multiple transition steps along a transition path. Due to the path dependent and irreversible nature of innovation in complex technologies, an initial transition step along some preferred path may cut off paths that later may turn out to be more desirable. For these reasons, initial transition steps should allow for future flexibility, where we define flexibility as robustness regarding changing evidence and changing preferences. The authors proposed a technology assessment methodology that identifies the flexibility of initial transition steps in complex technologies. They illustrated the methodology by an empirical application to 2646 possible future car systems. ***Source:*** Schwoon et al., 2008.

The sustainable diffusion of renewable energy technologies as an example of an innovation-focused policy

Description: Renewable energy technologies constitute a techno-economic system that is radically different from conventional systems, in terms of density, structure, regulatory and management practices. Consequently, their incorporation into the production and management of energy has to be approached as an innovative and sustainable diffusion process of an alternative technology with system-wide consequences for the whole energy system. Here, an alternative approach was proposed, which integrates the supply- and demand-side perspectives, arguing that a successful policy for the speedy deployment of renewables should focus on the systemic innovation processes that characterize the development and sustainable diffusion of renewables. It was suggested that a strategy that focuses on selected niches should aim at the integration of the innovation dimension into a policy for renewables. Such a perspective may contribute to the growth of successful applications as well as to the development of the corresponding industry of equipment production and services, leading to the deployment of a new technological regime. ***Source*****:** Tsoutsos & Stamboulis, 2005.

7.3 Nordic and European benchmarking studies

Focus on Sustainable Development, Nordic Indicators 2006. Nordic Council of Ministers

Description: Indicator based study of energy and sustainability in Nordic countries.
Source: Norden, 2006.

Assessing the International Position of EU's Research and Technological Development and Demonstration (RTD&D) on Hydrogen and Fuel Cells

Description: The study was carried out in collaboration with JRC-IPTS and ESTO members composed of VTT, Fraunhofer ISI and Qinetiq. The study aimed at supporting

activities of the EU Technology Platform on Hydrogen and Fuel Cells by contributing to answer the following questions: (1) What is the worldwide RTD scenario in hydrogen and fuel cells?; (2) Is the EU investment level appropriate?; (3) Where are the gaps and opportunities? Consequently, the main interest of the study results lays in the possibility: (1) to extract implications for EU research policy in the field; (2) to provide elements for the EU strategy, and; (3) to identify areas requiring further research. VTT as a Nordic partner. ***Source:*** Amorelli et al., 2005.

PREMIA R&D, Demonstration and Incentive Programmes Effectiveness to Facilitate and Secure Market Introduction of Alternative Motor Fuels

Description: Alternative motor fuels are seen as one option to help the transport sector in reducing both its dependence on oil imports and emissions of greenhouse gases. The European Commission has consequently set the objective to substitute 20% of motor fuel consumption by 2020 by new and alternative fuels. Biofuels, natural gas and hydrogen are the main alternative fuels which can be expected to play a major role. PREMIA is a Specific Support Action in 6th Framework Programme of the EU. The aim of PREMIA was to assess the effectiveness of measures to support alternative motor fuels (a) in the EU-25, (b) based on international experiences, (3) in relation to the market maturity of AMF, (4) short term: biofuels, (5) mid/long term: hydrogen, (6) in national context. Project duration: June 2004 – May 2007. Partners: VITO (Belgium), JRC-IPTS (Spain), CERTH/HIT (Greece), VTT (Finland), SETREF (Greece). Sponsored by the EC, DG TREN. ***Source:*** http://www.ist-world.org/ProjectDetails.aspx?ProjectId=13b86e780bae4ca9bef6bd751da69ccf&SourceDatabaseId=7cff9226e582440894200b751bab883f.

7.4 Setting the studies on the framework and conclusions

In order to better understand the contribution of the approach to the governance of the Nordic energy system transition, the GoReNEST team positioned some of the most interesting example studies of the categories ‘innovation study, new government research or benchmarking approach’ into the analytic framework of GoReNEST Task 1. The results of the positioning tasks are presented in Table 9.

7. Innovation studies, energy related new governance research, benchmarking

Table 9. Contribution areas of the example cases using the 'innovation studies, energy related new governance research or benchmarking approach'. Examples with Nordic contribution positioned into the analytic framework of GoReNEST Task

	Change dimensions	Present	Short-term	Medium-term	Long-term
Landscape	Technological	HyCom HYPOGEN	HyCom HYPOGEN		
	Industrial	HyCom HYPOGEN	HyCom HYPOGEN		
	Policy	HyCom HYPOGEN	HyCom HYPOGEN		
	Social	HyCom HYPOGEN	HyCom HYPOGEN		
Regime	Technological	SFINNOREG	SFINNOREG		
	Industrial	SFINNOREG	SFINNOREG		
	Policy	SFINNOREG	SFINNOREG		
	Social	SFINNOREG	SFINNOREG		
Niche	Technological	SFINNOREG INNOREG I-II HyCom HYPOGEN	SFINNOREG INNOREG I-II HyCom HYPOGEN		
	Industrial	SFINNOREG INNOREG I-II HyCom HYPOGEN	SFINNOREG INNOREG I-II HyCom HYPOGEN		
	Policy	SFINNOREG INNOREG I-II HyCom HYPOGEN	SFINNOREG INNOREG I-II ISU WP 08.12-13 HyCom HYPOGEN		
	Social	SFINNOREG INNOREG I-II HyCom HYPOGEN	SFINNOREG INNOREG I-II HyCom HYPOGEN		
Governance	Functions	Present	Short-term	Medium-term	Long-term
	Information services, networking, setting common agendas	SFINNOREG INNOREG I-II PREMIA HyCom HYPOGEN	SFINNOREG INNOREG I-II PREMIA HyCom HYPOGEN		
	Strategic procurement, (pre-)market	SFINNOREG INNOREG I-II PREMIA	SFINNOREG INNOREG I-II PREMIA		
	Financing research and education	SFINNOREG INNOREG I-II PREMIA	SFINNOREG INNOREG I-II PREMIA		
	Grants, equity support and fiscal measures (supply and demand)	SFINNOREG INNOREG I-II PREMIA	SFINNOREG INNOREG I-II PREMIA		
	Regulation and standards	SFINNOREG INNOREG I-II PREMIA	SFINNOREG INNOREG I-II PREMIA		

In conclusion, the example projects relate to the landscape, regime, niche and governance levels, with focus on present state and short-term future developments. These studies and related experiences and research competencies can well be utilized in the further development of the approaches, as well as in defining the complementary roles of the various approaches in the governance of the Nordic energy system transition.

8. Summary

The energy research in the Nordic countries is extensive and different techno-economic and social aspects have been analysed in many studies. Hence, in analysing the potential use of system transition approach as a tool, it is important to know whether and how far different elements and dimensions related to this approach have already been examined in the Nordic energy research. Accordingly the present Task 2 report of the GoReNEST project considers Nordic energy research in view of its potential contribution to the governance of energy system transition and using system transition framework as a policy-planning tool. The report is a compilation of selected and relevant examples of Nordic energy research (and related approaches and methods), and to some extent also respective European research when observed relevant.

The report contains (1) national level studies of Nordic countries, (2) common studies of Nordic countries carried out on Nordic level, and, (3) studies carried out with Nordic participation on European and international level. The studies, approaches and methods considered are from the following six areas: societal embedding of energy innovations, consumer research in energy markets, energy system modelling and scenarios, energy foresight and technology assessment, energy research and technology program evaluations, policy program evaluations, and innovation studies and energy related new governance research. This report is not trying to give an exchaustive overview on research in view of its contribution to the governance of energy system transition, but, within the limits of GoReNEST project, rather indicate that Nordic countries execute in many relevant areas research with potential contribution to the governance of energy system transition. Many of the studies presented are from hydrogen research which is a relevant topic of energy and innovation policy not only on Nordic level and also on EU level. Moreover many studies presented are carried out by VTT which is due to the easy access of authors to this data. Nonetheless, the report gives a first rough overview of the energy research in view of its contribution to the governance of energy system transition.

The descriptions of energy research consists first of an overview and short illustrations on the objectives, contents and results of studies and projects made. Then each study or project identified are placed on relevant boxes of the table of the system transitions framework with

two dimensions, vertically the levels *landscape, regime, niche and governance,* and horizontally time perspectives *present, short-term, medium-term, and long-term*.

On a basis of this report following conclusions can be drawn. The Nordic research encompasses several studies and projects in the six areas of research approaches and methods listed above that are also relevant within the system transition framework. Consequently the research competencies in these areas are an important potential for the future research within the system transition framework, and hence it is worth building on the existing experiences and competencies in Nordic countries. The research is however scattered and fragmented in the six selected research areas when considered vis-à-vis the systems transition framework, due also to the fact that the research theme, energy system transition, is very multidisciplinary in nature. The overview on Nordic energy research indicates relatively minor collaboration between relevant research communities, especially between energy system research and innovation system research. Some Nordic countries have a strong tradition in energy system modelling and future scenarios produced by these models can help decision-makers in planning relevant and desirable short and long term goals and objectives under varying framework conditions and timelines. Modelling approach does not however tell how to reach the targets in the complex world of different interests of different public and private stakeholders, multiple dimensions, time horizons, etc. In this respect the transition management approach offers a useful framework and tool supporting policy-planning in mobilizing relevant actors and actions around shaping the transition towards sustainable energy system of the future.

It is important to note that Task 2 report of GoReNEST project was applying the system transition framework to already completed and on-going energy projects and programs, giving preliminary experience to utilize the framework in the planning of Nordic energy programs in the future. Accordingly, on a basis of this report, the need arises to develop a systemic research agenda in view of the potential contribution of research to the governance of energy system transition.

The framework used in analysing the information gathered in the GoReNEST Task 2 is presented in Table 10. The table summarizes the positioning of the various types of study within the transition management framework. Table 10 well indicates is that not any of the single areas considered[8] encompasses all the dimensions of system transition & governance framework, and consequently it is possible to get an overarching versatile overview only by combining different approaches. Some Nordic research activities seem however to exist in each partial field, and accordingly it is natural to build the

[8] The studies presented in this report are collected from the following six areas: societal embedding of energy innovations; consumer research in energy markets; energy system modelling and scenarios; energy foresight and technology assessment; energy research and technology program evaluations; policy program evaluations; innovation studies and energy related new governance research.

governance practices on a basis of these Nordic experiences and expertises within the transition management framework.

Table 10. The analytic framework developed by GoReNEST Task 1. Positioning of the types of study examined in GoReNEST Task 2 within the framework.

	Time horizon *Dimension*	Present	Short-term	Medium-term	Long-term
Landscape	*Technological*	Program evaluations IS/GS/benchmarking	Energy system models Program evaluations IS/GS/benchmarking	Energy system models Program evaluations	Energy system models Program evaluations
	Industrial	IS/GS/benchmarking	Energy system models IS/GS/benchmarking	Energy system models	Energy system models
	Policy	Program evaluations IS/GS/benchmarking	Energy system models Foresight & TA IS/GS/benchmarking	Energy system models Foresight & TA	Energy system models Foresight & TA
	Social	IS/GS/benchmarking	IS/GS/benchmarking	Energy system models	Energy system models
Regime	*Technological*	Program evaluations IS/GS/benchmarking	Energy system models Foresight & TA Program evaluations IS/GS/benchmarking	Energy system models Foresight & TA	Energy system models Foresight & TA
	Industrial	(Foresight & TA) IS/GS/benchmarking	Energy system models Foresight & TA IS/GS/benchmarking	Energy system models Foresight & TA	Energy system models Foresight & TA
	Policy	Program evaluations IS/GS/benchmarking	Energy system models Foresight & TA Program evaluations IS/GS/benchmarking	Energy system models Foresight & TA Program evaluations	Energy system models Foresight & TA
	Social	Consumer research IS/GS/benchmarking	Consumer research Energy system models Foresight & TA IS/GS/benchmarking	Energy system models Foresight & TA	Energy system models Foresight & TA
Niche	*Technological*	Societal embedding Consumer research Program evaluations IS/GS/benchmarking	Societal embedding Consumer research Foresight & TA Program evaluations IS/GS/benchmarking	Societal embedding Consumer research Foresight & TA Program evaluations	Societal embedding Consumer research Foresight & TA
	Industrial	Societal embedding IS/GS/benchmarking	Societal embedding Foresight & TA IS/GS/benchmarking	Societal embedding Foresight & TA	Foresight & TA
	Policy	IS/GS/benchmarking	Societal embedding Foresight & TA IS/GS/benchmarking	Societal embedding Foresight & TA	Foresight & TA
	Social	Societal Consumer research IS/GS/benchmarking	Societal embedding Consumer research Foresight & TA IS/GS/benchmarking	Societal embedding Foresight & TA	Foresight & TA
Governance	*Information services, networking, setting common agendas*	Societal embedding Consumer research IS/GS/benchmarking	Societal embedding Consumer research Energy system models Foresight & TA IS/GS/benchmarking	Societal embedding Consumer research Energy system models Foresight & TA	Societal embedding Consumer research Energy system models Foresight & TA
	Strategic procurement, pre-market	IS/GS/benchmarking	Societal embedding Foresight & TA IS/GS/benchmarking	Societal embedding Foresight & TA	Foresight & TA
	Financing research and education	Program evaluations IS/GS/benchmarking	Foresight & TA Program evaluations IS/GS/benchmarking	Foresight & TA Program evaluations	Foresight & TA
	Regulation and standards	IS/GS/benchmarking	Energy system models Foresight & TA IS/GS/benchmarking	Societal embedding (Consumer research) Energy system models Foresight & TA	(Consumer research) Foresight & TA

References

Amorelli, T., Naumanen, M., Walton, J., Wietschel, M., Hernandez, H. (ed.) and Lonza, L. (ed.) (2005). Assessing the International Position of EU's Research and Technological Development and Demonstration (RTD&D) on Hydrogen and Fuel Cells. EUR21685EN. ISBN 92-894-9745-9. ftp://ftp.jrc.es/pub/EURdoc/eur21685en.pdf.

Bijker, W.E. (1995). Of Bicycles, Bakelites and Bulbs: Towards a Theory of Sociotechnical Change. The MIT Press, Cambridge, MA, London, England.

COWI & Profu (2007). Climate 2050. The road to 60–80 percent reductions in the emissions of greenhouse gases in the Nordic countries. Copenhagen: Nordic Council of Ministries. TemaNord 2007:535. 59 p. http://norden.org/pub/miljo/miljo/sk/TN2007535.pdf.

COWI & CICERO (2008). Betydningen for Norden av 2 grader global oppvarming. Vurdering av sårbarhet og effecter av klmaendinger. Kopenhagen: Nordisk Ministerråd. TemaNord 2008:507. 153 p.

Christensen, C. (1997). The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Harvard Business School Press, Boston, MA.

Dannemand Andersen, P., Borup, M., Borch, K., Kaivo-oja, J., Eerola, A., Finnbjörnsson, T., Øverland, E., Eriksson, E.A., Malmér, T. and Mölleryd, B.A. (2007). Foresight in Nordic Innovation Systems. http://www.nordicinnovation.net/_img/nordic_foresight_forum_final_report.pdf.

Daniëls, A. (2007). Life and living in low energy houses, NCRC Working Papers 102 / 2007, Helsinki. http://www.ncrc.fi/files/5104/2007_102_workingpapers_life.pdf.

EC (2005). Assessing the Impact of Energy Research. EU energy research evaluation. European Commission, Directorate-General for Research/Sustainable Energy Systems, EUR 21354. ISBN 92-894-7325-8. http://ec.europa.eu/research/energy/pdf/erevia_en.pdf.

EC (2006a). The State and Prospects of European Energy Research. Comparison of Commission, Member and Non-Member States' R&D Portfolios. European Commission, Directorate-General for Research/Sustainable Energy Systems. EUR 22397. ISSN 1018-5593. http://ec.europa.eu/research/energy/pdf/portfolios_report_en.pdf.

EC (2006b). Energy Futures – The role of research and technological development. Directorate-General for Research/Sustainable Energy Systems. EUR 22039. ISBN 92-79-01639-3. ISSN 1018-5593. http://ec.europa.eu/research/energy/pdf/energy_futures_en.pdf.

EC (2006c). European Fuel Cell and Hydrogen Projects 2002–2006. Project synopses. European Commision, Directorate-General for Research/Sustainable Energuy Systems, EUR 22398. ISBN 92-79-02692-5, ISSN 1018-5593. ftp://ftp.cordis.europa.eu/pub/fp7/energy/docs/hydrogen_synopses_en.pdf.

EC (2007a). European funded research on hydrogen and fuel cells – Review, assessment, future outlook. Hydrogen and Fuel Cell Review Days Brussels, 10–11 October 2007, conference proceedings. EUR 23171. ISBN 978-92-79-06940-6, ISSN 1018-5593. ftp://ftp.cordis.europa.eu/pub/fp7/energy/docs/h2fc_review_days_en.pdf.

EC (2007b). CO_2 Capture and Storage Projects – Synopses, EUR 22574. ISSN 1018-5593. http://ec.europa.eu/research/energy/pdf/synopses_co2_en.pdf.

Ekholm, T., Lehtilä, A. and Savolainen, I. (2008). Unilateral emission reductions of the EU and multilateral emission reductions of the developed countries. Assessing the impact of Finland with TIMES model. VTT Working Papers 96. Espoo. 57 p. (In Finnish). http://www.vtt.fi/inf/pdf/workingpapers/2008/W96.pdf.

Faber, A. and Frenken, K. (2008). Models in evolutionary economics and environmental policy: Towards an evolutionary environmental economics, ISU Working Paper #08.15. http://www.geo.uu.nl/isu/pdf/isu0815.pdf.

Fenger, J. (ed.) (2007). Impacts of Climate Change on Renewable Energy Sources: Their role in the Nordic energy system. Nord 2007:003, Nordic Council of Ministers, Copenhagen. ISBN 978-92-893-1465-7. http://www.norden.org/pub/sk/showpub.asp?pubnr=2007:003.

Forsström, J. and Lehtilä, A. (2005). Scenarios for the impacts of climate policy on energy economy. Espoo, VTT Working Papers 36. 71 p. + app. 9 p. (In Finnish) http://www.vtt.fi/inf/pdf/workingpapers/2005/W36.pdf.

Geels, F. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case study. Research Policy 31, p. 1257–1274.

Geels, F. and Schot, J. (2007). Typology of sociotechnical transition pathways. Research Policy 36 (2007), pp. 399–417.

Heiskanen, E. (2006a). Low energy housing (LEH). Case 2 of the Create Acceptance project, ECN-E--07-058. http://www.createacceptance.net/fileadmin/create-acceptance/user/docs/CASE_2.pdf.

Heiskanen, E. (2006b). Västerås biogas plant and Lund biogas plant. Cases 7 and 8 of the Create Acceptance project, ECN-E--07-058. http://www.createacceptance.net/fileadmin/create-acceptance/user/docs/CASE_7_en_8.pdf.

Heiskanen, E. (2006c). Snohvit CO_2 capture and storage project. Case 24 of the Create Acceptance project, ECN-E--07-058. http://www.createacceptance.net/fileadmin/create-acceptance/user/docs/CASE_24.pdf.

Heiskanen, E. and Lovio, R. (2007). User knowledge in Housing Energy Innovations. Proceedings of the Nordic Consumer Policy Conference 2007. http://www.consumer2007.info/wp-content/uploads/innovation%2016-%20Heiskanen.pdf.

Heiskanen, E., Hodson, M., Mourik, R.M., Raven, R.P.J.M., Feenstra, C.F.J., Alcantud, A., Brohmann, B., Daniels, A., Di Fiore, M., Farkas, B., Fritsche, U., Fucsko, J., Hünecke, K., Jolivet, E., Maack, M., Matschoss, K., Oniszk-Poplawska, A., Poti, B., Prasad, G., Schaefer, B. and Willemse, R. (2007). Factors influencing the societal acceptance of new energy technologies: Meta-analysis of recent European projects. Draft report of Create Acceptance WP2, (deliverable 3.1, 3.2 and 4), ECN-E--07-058. http//:www.createacceptance.net/fileadmin/create-acceptance/user/docs/E07058.pdf.

Heiskanen, E. and Rask, M. (2006). From Sociotechnical Theory to Sociotechnical Practice: An Action Research Project. http://www.energychange.info/component/docman/cat_view/16-project-outputs.

Helynen, S., Sipilä, K., Peltola, E. and Holttinen, H. (2002). Uusiutuvat energialähteet vuoteen 2030 Suomessa. Eduskunnan kanslian julkaisu 6/2002. (Renewable Energy Sources in Finland by 2030. Office of the Parliament of Finland, publication 6/2002. Available in Finnish in http://www.eduskunta.fi/triphome/bin/thw.cgi/trip?${APPL}=erekj&${BASE}=erekj&${THWIDS}=0.15/1266341355_25264&${TRIPPIFE}=PDF.pdf. Summaries in English and Swedish)

Hodson, M. and Marvin, S. (2008). Glossary of Intermediaries. Research Note 1 of Changing Behaviour project (213217), March 2008. http://www.energychange.info/index.php?option=com_content&view=category&layout=blog&id=25&Itemid=25.

Hongisto, M., Kuisma, J., Loikkanen, T. and Järvinen, P. (2001). Case Studies on Environment-friendly Energy Innovations and Factors Influencing Them (INNOREG II). Espoo, IEE reports no 16/2001. ISSN 1457-2494. http://www.vtt.fi/inf/julkaisut/muut/2001/innoene21_12_01ppp.pdf.

Hoogma, R., Kemp, R., Schot, J. and Truffer, B. (2002). Experimenting for Sustainable Transport – The approach of Strategic Niche Management. Routledge, London/USA/Canada. ISBN 978-0-415-27117-2.

Honkatukia, J., Kemppi, H. and Kerkelä, L. (2005a). Scenarios for the effects of the climate and energy strategies on national economy, VATT Discussion Papers 373. (In Finnish)

Honkatukia, J., Parkkinen, P. and Perrels, A. (2005b). Long term scenarios for the Finnish economy. VATT Government Institute of Economic Research. Helsinki, VATT Discussion Papers 363. 43 p. (In Finnish)

Honkatukia, J. (2004a). The economic effects of using ban for the use of coal with the EU Emissions Trading System. VATT, Government Institute of Economic Research. Helsinki, VATT Discussion Papers 355. 25 p. (In Finnish)

Honkatukia, J. (2004b). The increased profits in electricity production caused by emissions trading. Helsinki, VATT Discussion Papers 348. 26 p. (In Finnish)

Honkatukia, J. (2004c). The macroeconomic effects of different initial allocation plans for emission quotas. VATT, Government Institute of Economic Research. Helsinki, VATT Discussion Papers 329. 35 p. (In Finnish)

Honkatukia, J., Forsström, J. and Tamminen, E. (2003). The use of domestic energy taxes in the trading sectors in connection with EU-wide emissions trading. Helsinki, VATT, Government Institute of Economic Research. VATT Research Reports 102. 74 p. (In Finnish)

Hoogma, R., Kemp, R., Schot, J. and Truffer, B. (2002). Experimenting for Sustainable Transport – The approach of Strategic Niche Management. Routledge, London/USA/ Canada. ISBN 978-0-415-27117-2.

Hyvönen, J. and Loikkanen, T. (2010). The Role of Environmental Factors and Regulations in Innovation Processes (SFINNOREG), VTT Publications (forthcoming).

Iacobazzi, A., Di Mario, F., Hasenauer, U., Jørgensen, B.H., Nørgaard, P.B, Peteves, S.D., Shaw, S. and Soria, A. (eds.). (2005). HYCOM Pre-feasibility Study – Final Report. EUR 21575 EN. ftp://ftp.jrc.es/pub/EURdoc/eur21575en.pdf.

IEA, 2008. Energy Technology Perspectives (2008). Scenarios and Strategies to 2050, June 2008. ISBN 978-92-64-04142-4. http://www.iea.org/Textbase/techno/etp/index.asp.

Jolivet, E., Laredo, P. and Shove, E. (2002). Managing breakthrough innovations: the Socrobust methodology. Ecole de Mines and Lancaster University.

Jolivet, E., Laredo, P. and Shove, E. (2003). Managing breakthrough innovations: theoretical implications from – and for – the sociology of science and technology, Presentation for the 2003 ASEAT Conference Knowledge and Economic & Social Change: New Challenges to Innovation Studies, Manchester, April 7–9.

Karlsson, K., Jørgensen, K., Werling, J., Pedersen, H.Ø. and Kofoed-Wiuff, A. (2008). Danish greenhouse gas reduction scenarios for 2020 and 2050. Danish Energy Authority, Copenhagen. 98 p.

Kemp, R. and Martens, P. (2007). Sustainable development: how to manage something that is subjective and never can be achieved? Sustainability: Science, Practice, & Policy, Fall 2007, Vol. 3, Issue 2. http://ejournal.nbii.org/archives/vol3iss2/0703-007.kemp.pdf.

Kivisaari, S., Lovio, R. and Väyrynen, E. (2004). Managing Experiments for Transition – Examples of Societal Embedding in Energy and Health Care Sectors. In: Elzen, B., Geels, F.W. and Green, K. (eds.).F System Innovation and the Transition to Sustainability. Theory, Evidence and Policy. Edwar Elgar. Pp. 223–250.

Kofoed-Wiuff, A., Werling, J., Markussen, P., Behrmann, M., Pedersen, J. and Karlsson, K. (2007). Det fremtidige danske energisystem. Teknologiscenarier. Teknologirådet, København. 106 p.

Kofoed-Wiuff, A., Werling, J., Markussen, P., Behrmann, M., Pedersen, J. and Karlsson, K. (2008). Det fremtidige danske energisystem. Teknologiscenarier. Teknologirådet, København. 109 p.

Könnölä, T., Carrillo-Hermosilla, J. and van der Have, R. (2008). System Transition, Concepts and Framework for Analysing Nordic Energy System Research and Governance, VTT Working Papers 99. http://www.vtt.fi/inf/pdf/workingpapers/2008/W99.pdf.

Larrue, P. and Eparvier, P. (2006/2007). SWOT-analysis on common strategic issues on research programmes on innovative energy systems for the ERANET INNER. Final Report of the project Innovative Energy Research ERA-NET, TECHNOPOLIS Sept. 2006, rev. Jan. 2007. http://www.nordicenergy.net/_upl/swot_final_report.pdf.

Larsen, H. and Sønderberg Petersen, L. (eds.). (2002). New and emerging technologies – options for the future. Risoe Energy Report 1, October 2002. 64 p. ISBN 87-550-3082-3. Risø-R-1351(EN). http://www.risoe.dtu.dk/Risoe_dk/Home/Knowledge_base/publications/Reports/ris-r-1351.aspx.

Larsen, H., Kossmann, J. and Sønderberg Petersen, L. (eds.). (2003). New and emerging bioenergy technologies. Risø Energy Report 2, November 2003. 48 p. ISBN 87-550-3262-1. Risø-R-1430(EN). http://www.risoe.dtu.dk/Risoe_dk/Home/Knowledge_base/publications/Reports/ris-r-1430.aspx.

Larsen, H., Feidenhans'l, R. and Sønderberg Petersen, L. (eds.). (2004). Hydrogen and its competitors. Risoe energy report 3, October 2004. 76 p. ISBN 87-550-3350-4. Risø-R-1469(EN). http://www.risoe.dtu.dk/Risoe_dk/Home/Knowledge_base/publications/Reports/ris-r-1469.aspx.

Larsen, H. and Sønderberg Petersen, L. (eds.) (2005). The Future Energy System – Distributed Production and Use. Risoe Energy Report 4, October 2005. 62 p. ISBN 87-550-3474-8. Risø-R-1534(EN). http://www.risoe.dtu.dk/Risoe_dk/Home/Knowledge_base/publications/Reports/ris-r-1534.aspx.

Larsen, H. and Sønderberg Petersen, L. (eds.). (2006). Renewable energy for power and transport. Risø Energy Report 5, November 2006. 72 p. ISBN 87-550-3515-9. Risø-R-1557(EN). http://www.risoe.dtu.dk/Risoe_dk/Home/Knowledge_base/publications/Reports/ris-r-1557.aspx.

Larsen, H. and Sønderberg Petersen, L. (eds.). (2007). Future options for energy technologies. Risø Energy Report 6, November 2007. 88 p. ISBN 978-87-550-3612-3. Risø-R-1612(EN). http://www.risoe.dtu.dk/Risoe_dk/Home/Knowledge_base/publications/Reports/ris-r-1612.aspx.

Loikkanen, T. and Hongisto, M. (2000). Integration of Innovation and Sustainable Development (INNOREG I), IEE Reports 05/00. Espoo, VTT, 2000. 138 p.

Loikkanen, T., Turkulainen, T. and Kuusi, O. (2001). Energia 2010 – Teknologian arviointi. Delfoi-paneelitutkimus tulevaisuuden energiavalinnoista. Eduskunnan kanslian julkaisu 8/2001 (Energy 2010 – Technology Assessment. Delfoi panel study on the future energy alternatives. Office of the Finnish Parliament, publication 8/2001; available in Finnish in http://www.eduskunta.fi/triphome/bin/thw.cgi/trip?${APPL}=erekj&${BASE}=erekj&${THWIDS}=0.49/1266340549_458803&${TRIPPIFE}=PDF.pdf. Abstracts in English and Swedish)

Maack, M. (2006). ECTOS hydrogen project. Case 22 of the Create Acceptance project, ECN-E--07-058. http://www.createacceptance.net/fileadmin/create-acceptance/user/docs/CASE_22.pdf.

Makkonen, S. (ed.). (2006). Energy Research in Finland 1999–2005. International Evaluation. Publications of the Academy of Finland 14/06. Academy of Finland, Helsinki. Edita Prima Oy, Helsinki 2006. ISBN 951-715-625-1 (print), 951-715-626-X (pdf). http://www.aka.fi/Tiedostot/Tiedostot/Julkaisut/14_06%20Energia-alan%20arviointi.pdf.

Mautz, R. (2007). The Expansion of Renewable Energies in Germany between Niche Dynamics and System Integration – Opportunities and Restraints STI Studies, Vol. 3, No. 2, December 2007, pp. 113–131. http://www.sti-studies.de/fileadmin/articles/mautzstivol3no2-2007.pdf.

Monni, S., Pipatti, R., Lehtilä, A., Savolainen, I. and Syri, S. (2006). Global climate change mitigation scenarios for solid waste management. VTT Publications 603. Espoo. 51 p. http://www.vtt.fi/inf/pdf/publications/2006/P603.pdf.

Negro, S.O. Hekkert, M.P. and Smits, R. (2008). Stimulating renewable energy technologies by innovation policy. ISU Working Paper #08.13. http://www.geo.uu.nl/isu/pdf/isu0813.pdf.

Nelson, R.R. and Winter, S. (1982). An Evolutionary Theory of Economic Change, The Belknap Press of Harvard University Press.

Norden (2006). Focus on Sustainable Development Nordic Indicators 2006, Nordic Council of Ministers, Nord 2006:003. ISBN 92-893-1358-7. http://www.norden.org/da/publikationer/publikationer/2006-003/at_download/publicationfile.

Norges forskningsråd (2005). Energi 2020+. Sluttrapport fra et foresight-prosjekt. ISBN 82-12-02221-8, 82-12-02222-6. http://www.forskningsradet.no/CSStorage/Flex_attachment/82-12-02222-6.pdf.

Nyrud, A.Q., Roos, A. and Sande, J.B. (2008). Residential bioenergy heating: A study of consumer perceptions of improved woodstoves. Energy Policy, Vol. 36, Issue 8, pp. 3169–3176.

OECD/IEA (2008a). Energy Policies of IEA Countries – Finland 2007 Review. ISBN: 978-92-64-03071-8. http://www.iea.org/textbase/nppdf/free/2007/finland2007.pdf.

OECD/IEA (2008b). Energy Policies of IEA Countries – Sweden 2008 Review. ISBN 978-92-64-04333-6. http://www.iea.org/textbase/nppdf/free/2008/Sweden2008.pdf.

OECD/IEA and AFD (2008). Promoting Energy Efficiency Investments. Case Studies in the Residential Sector. ISBN 978-92-64-04214-8. http://www.iea.org/textbase/nppdf/free/2008/PromotingEE2008.pdf.

Point Carbon (2008). Relationship between CO_2, fuel and electricity prices and the effect on Green House gas (GHG) emissions in Nordic countries. Copenhagen: Nordic Council of Ministers. TemaNord 2008:528. 108 p.

Profu (2006). Ekonomiska styrmedel i energisektorn. En utvärdering av dess effekter på koldioxidutsläppen från 1990. Stockholm: Statens Energimyndigheten. ER: 2006:06. 85 p.

Profu (2007). Beräkningar med MARKAL-NORDIC inför kontrollstation 2008. Mölndal: Profu. 29 p.

Ryden, B. (ed.). Abildgaard, J., Carlén, B., Engberg Pedersen, T., Fritz, P., Hamarsland, G., Gipperth, L., Havskjold, M., Honkatukia, J., Koljonen, T., Koreneff, G., Müller Engelbrektson, I., Ravn, H., Sandoff, A., Sköldberg, H., Springfeldt, P.E., Tennbakk, B., Tolonen, J., Torgersen, L., Unger, T., von Schemde, A. and Widmark, A. (2006). Ten perspectives in Nordic energy. Final report for the first phase of the Nordic Energy Perspectives project. PR-Offset, Mölndal. ISBN 91-631-9259-4. http://www.nordicenergyperspectives.org/Ten%20perspectives%20introd.pdf. (See also http://www.nordicenergyperspectives.org/offprint.pdf.)

Savolainen, I., Similä, L., Syri, S. and Ohlström, M. (2008). Technology pathways 2050. Deep greenhouse gas emission reductions enabled by technology in Finland. VTT Tiedotteita – Research Notes 2432. Espoo. 215 p. http://www.vtt.fi/inf/pdf/tiedotteet/2008/T2432.pdf. (In Finnish)

Schwoon, M., Alkemade, F., Frenken, K. and Hekkert, M.P. (2008). A complex systems methodology for transition management. ISU Working Paper #08.12. http://www.geo.uu.nl/isu/pdf/isu0812.pdf.

Smith, A., Stirling, A. and Berkhout, F. (2005). The governance of sustainable socio-technical transitions. Research Policy 34, pp. 1491–1510.

Syri, S, Lehtilä, A., Ekholm, T., Savolainen, I., Holttinen, H. and Peltola, E. (2008). Global energy and emissions scenarios for effective climate change mitigation – Deterministic and stochastic scenarios with the TIAM model. International Journal of Greenhouse Gas Control, Vol. 2, Issue 2, April 2008, pp. 274–285.

Tsoutsos, T.D. and Stamboulis, Y.A. (2005). The sustainable diffusion of renewable energy technologies as an example of an innovation-focused policy. Technovation, Vol. 25, Issue 7, July 2005, pp. 753–761. http://dx.doi.org/10.1016/j.technovation.2003.12.003.

Tushman, M. and Anderson, P. (1986). Technological discontinuities and organization environments. Administrative Science Quarterly, 31, pp. 465–493.

Unruh, G.C. (2000). Understanding carbon lock-in. Energy Policy 2000, Vol. 28, pp. 817–30.

Van der Laak, W.W.M., Raven, R.P.J.M. and Verbong, G.P.J. (2006). Strategic niche management for biofuels: Analysing past experiments for developing new biofuel policies. Energy Policy, Vol. 35, Issue 6, June 2007, pp. 3213–3225. http://dx.doi.org/10.1016/j.enpol.2006.11.009.

Vattenfall & Profu (2008). Vindkraft i Framtiden. Möjlig utveckling i Sverige till 2020. Stockholm: Elforsk. Elforsk rapport 08:17. 96 p.

Väyrynen, E., Kivisaari, S. and Lovio, R. (2002). Societal embedding of innovations related to renewable energies and energy saving. In: Technology and Climate Change CLIMTECH 1999–2002. Final Report – Tekes.

VTT (2009). Energy Visions 2050. VTT-Edita, WS Bookwell Oy, Porvoo.

Additional weblinks used:

http://www.scandinavianhydrogen.org

http://www.nordicinnovation.net/prosjekt.cfm?Id=3-4415-205

http://www.createacceptance.net/

http://www.roads2hy.com/

http://www.energychange.info

http://www.environment.fi/print.asp?contentid=200395&lan=en&clan=fi

http://www.nordicenergyperspectives.org

http://www.os.is/ces

http://www.nordicenergy.org/section.cfm?id=3-0&path=17,49

http://www.res2020.eu

http://reaccess.epu.ntua.gr/

http://www.needs-project.org

http://www.iea.org/Textbase/techno/etp/index.asp

http://ida.dk/english/idaenergyyear/Sider/IDAEnergyYear2006.aspx

http://www.eduskunta.fi/

http://www.h2foresight.info

http://www.hyways.de/

www.hfpeurope.org

http://www.iea.org/

http://www.iea.org/textbase/nppdf/free/2005/norway2005.pdf

http://www.iea.org/textbase/nppdf/free/2006/denmark2006.pdf

http://www.ist-world.org/ProjectDetails.aspx?ProjectId=3b7a0d46d338425da03ca92b10ca1152

http://ec.europa.eu/research/energy/pdf/6_hysociety_en.pdf.

http://energy.jrc.ec.europa.eu/Pages/2005IPTSPublications.htm.

http://www.hy-co-era.net/index.php?index=112.

http://ec.europa.eu/research/energy/pdf/6_hysociety_en.pdf

http://www.norden.org/pub/ovrigt/baeredygtig/sk/N2006003.pdf

VTT Working Papers

126 Mikko Metso. NoTA L_INdown Layer Implementation in FGPA Design results. 2009. 20 p.

127 Marinka Lanne & Ville Ojanen. Teollisen palveluliiketoiminnan menestystekijät ja yhteistyösuhteen hallinta - Fleet asset management - hankkeen työraportti 1. 2009. 65 s. + liitt. 10 s.

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131 Ilkka Hannula. Hydrogen production via thermal gasification of biomass in near-to-medium term. 2009. 41 p.

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133 Elisa Rautioaho & Leena Korkiala-Tanttu. Bentomap: Survey of bentonite and tunnel backfill knowledge – State-of-the-art. 2009. 112 p. + app. 7 p.

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135 Torsti Loikkanen, Annele Eerola, Tiina Koljonen, Robert Van der Have & Nina Wessberg. Nordic Energy Research within the Framework of Energy System Transition. Task 2 Working Paper of the GoReNEST project. 65 p.

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