



Annele Eerola & Torsti Loikkanen

Governance and Research of Nordic Energy System Transition

- Summary Report of the GoReNEST project

VTT TIEDOTTEITA – RESEARCH NOTES 2505

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ISBN 978-951-38-7328-8 (soft back ed.)

ISSN 1235-0605 (soft back ed.)

ISBN 978-951-38-7329-5 (URL: <http://www.vtt.fi/publications/index.jsp>)

ISSN 1455-0865 (URL: <http://www.vtt.fi/publications/index.jsp>)

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JULKAISIJA – UTGIVARE – PUBLISHER

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Technical editing Mirjami Pullinen

Edita Prima Oy, Helsinki 2009

Annele Eerola & Torsti Loikkanen. Governance and Research of Nordic Energy System Transition Summary Report of the GoReNEST project. Espoo 2009. VTT Tiedotteita – Research Notes 2505. 45 p. + app. 3 p.

Keywords energy system, system transition, transition management, governance, energy policy, innovation policy, policy planning

Abstract

Nordic actors are expected to take a proactive role in participating in the global and regional energy system transition processes that aim at sustainable development. This presumes a good understanding of the governance of the transition processes. The GoReNEST project was designed to contribute to this end. This Summary Report of the GoReNEST project presents an analytical MLP transition management framework to support the Nordic energy system transition, considers relevant Nordic energy research in the light of this framework and assesses the potential of this research in supporting the governance of energy system transition and related policy planning. An analysis of relevant governance and funding models is also presented, exploring the recent advances in R&D&I governance and funding models. The experiences of the GoReNEST project suggest that the awareness of the MLP transition management framework and its various elements should be enhanced, recognizing also the complementary roles of various research approaches in this respect. Better integration of energy system research and innovation research is also called for. Policy implications and needs for future research are also discussed, including recommendations for Nordic actors.

Preface

The Nordic countries – Denmark, Iceland, Finland, Norway and Sweden – have a good reputation where societal welfare, education and a clean environment are considered. They are also among the leading countries with regard to innovation and competitiveness measures and indicators. It is thus natural to expect that Nordic actors take a proactive role in participating in the global and regional energy system transition processes that aim at sustainable development. This presumes also a good understanding of the governance of the transition processes. The summary report of the Governance and Research of Nordic Energy System (GoReNEST) project is intended to contribute to this end.

The proactive role in global energy transition means that the Nordic countries actively search and adopt sustainable energy technologies and that they actively participate in developing new energy technologies and services that support sustainable developments. The Nordic countries should take an active role in facilitating sustainable developments even globally, including the new economies and developing countries. To make this a genuine win-win strategy, the Nordic actors should also actively utilise new business opportunities related to the global energy transition. Proper governance tools are needed to reach these aims.

The GoReNEST project was one of the innovation policy studies funded by Nordic Energy Research (NER) in 2007–2008. The innovation policy study program was launched by Nordic Energy Research in the beginning of 2007. It aims to aid Nordic decision-makers in their processes of developing efficient policies on science, technology and investment in new energy technologies and systems. This is intended to strengthen the Nordic research and innovation (R&I) area in new energy technologies and systems.

The innovation policy studies funded by NER examine the Nordic energy innovation policy from different perspectives, applying knowledge from several complementary disciplines. They provide insight into Nordic energy research

and innovation systems by developing indicators and analysis tools, mapping potentials of various technologies and policy instruments, developing recommendations for promoting investments, and investigating potential export markets for new Nordic energy technologies and solutions.

This report is the final summary report of the GoReNEST project (Governance and Research of Nordic Energy System Transition). The project was carried out by a multidisciplinary research team with expertise in innovation systems, energy systems, transition management and environmental policy. The aim of the research team was to bring new insight into the governance of energy systems transition, especially when examined from the Nordic actors' point of view.

The project team consisted of five VTT researchers (Annele Eerola, Tiina Koljonen, Torsti Loikkanen, Robert van der Have and Nina Wessberg) and two researchers (Javier Carillo-Hermosilla & Totti Könnölä) from Centre for Eco-Intelligent Management, Instituto de Empresa Business School, Madrid. This report is based on the outcomes of GoReNEST subtasks 1–4. In particular, the contribution and results of the various subtasks are here discussed, presenting also some recommendations for the Nordic key actors.

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Executive Summary

GoReNEST objectives

The objective of the GoReNEST project is to support the planning of sustainable energy policy in Nordic countries (1) by improving the understanding of the challenges of systemic changes and corresponding governance responses, (2) by increasing the awareness of energy transition perspectives, (3) by providing recommendations for the development of Nordic governance of energy system transition, (4) by supporting Nordic actors' proactive participation in the implementation of the international climate and energy initiatives (including the SET Plan of the European Union), and (5) by engaging Nordic actors in taking advantage of emerging energy and climate related opportunities.

Contents of the project

The GoReNEST project presents a comprehensive analytical framework for energy system transition, based on the approaches and models of transition management and societal embedding of innovations. These approaches have been applied extensively in analysing the transition of techno-economic systems in the fields of energy, environment and health especially in the Netherlands. The merits of the system transition approach are in a parallel multi-level and systemic analysis of issues and dimensions related to technologies, socio-economic development, research and innovation, and policy-making in question. Because this approach has been applied in Nordic countries only in few studies, the particular objective of the GoReNEST project is to consider its wider application potential in the Nordic context. The intention is to give support to the planning of energy policies in Nordic countries and hence to support the transition towards sustainable energy system.

Nordic research supporting energy-related policy making is quite extensive, including consideration of technological and socio-economic aspects. When examining the potential use of the system transition approach, it is important to know whether, in which way and how far different elements related to this approach have already been explored and analysed in the Nordic energy research. The GoReNEST project thus considers relevant Nordic energy research vis-à-vis different elements, categories and topics of the system transitions framework, and discusses the potential of this research in supporting the governance of Nordic energy system transition and related policy-planning. Some important energy research issues and themes for the future are also identified.

In addition, the GoReNEST project analyses a number of interesting funding and governance models with the help of an elaborated system transition framework. In particular, the practices and accrued experiences of these funding models are examined in order to assess their potential use and utilisation in the development of the Nordic energy system transition. The exploration of the recent advances in R&D&I governance and funding models is intended to pave the way towards improved coordination and governance of energy transition processes.

The GoReNEST project also starts a dialogue between the energy modelling experts and experts in transition management approach. The first step was realized in the context of the joint NEP2-GoReNEST stakeholder workshop in Copenhagen in November 2008 and the dialogue is intended to continue in different mutual platforms and events. The results of the GoReNEST project have been disseminated in several events related to the activities of Nordic Energy Research, as well as in form of written reports and conference papers. The primary target group of this summary report are the Nordic actors responsible for R&D&I programmes, strategies and policy-making related to energy system transition.

Main conclusions

The integrative multi-level system transition framework introduced by the GoReNEST study is still relatively unfamiliar to Nordic stakeholders in general and especially to the Nordic energy field. Accordingly, it is important to enhance the awareness of this framework and its elements in the Nordic context. In this way it is possible to benefit from this approach and its application to Nordic energy policy-planning towards sustainable transition. These actions include governance modes addressing integration, coordination, competition and co-

existence, and purposeful cross-border arenas that facilitate strategic orientation, programming and performance of research and innovation.

Nordic countries have been actively involved in various types of research aimed at supporting energy system transition, including such relevant issues as societal embedding of energy innovations, consumer research in energy markets, energy system modelling and scenarios, energy foresight and technology assessment, evaluations of energy research and technology programmes, and energy related innovation studies, governance research and benchmarking. The Nordic research encompasses many themes and dimensions which are relevant within the transition framework, but the research is scattered and fragmented vis-à-vis the framework. The framework allows the recognition of the complementary roles of various studies and approaches, and makes it also possible to identify currently neglected new items and approaches.

Energy system transition is a complex societal long-term change process in which governance efforts can play an important role. The analyses of the GoReNEST project suggest that the interplay between different governance modes and arenas is crucial. An important aspect of governance for system transition is cooperation and a mutual engagement of public and private actors and stakeholders ('co-ordination mode' of governance). However, due to the multi-level nature of system transition, a mixture of modes can also be very effective. For example, at the local level, the 'competition mode' may yield valuable outcomes due to the stronger incentives for local stakeholders to engage in a competitive process, and awareness of local circumstances and 'fitting' of technological options. Different governance and funding models with their practices and experiences can thus play an important role in the transition, but even more important may be the combined use of different modes that contribute to the development of the Nordic energy system transition.

The research theme of energy system transition is multidisciplinary in nature. The GoReNEST study gives confirmation of the evident gaps and relatively minor collaboration between relevant research communities, especially between experts in energy system research and innovation system research. In some Nordic countries there is a strong tradition in energy system modelling also in international terms. The different future scenarios produced with the help of these models will help the decision-makers to understand what would be the 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 including different interests of a variety

of public and private stakeholders, multiple dimensions, time horizons, etc. In this respect the transition management approach offers a useful complementary framework: it helps to mobilize relevant actors and actions around shaping the transition towards sustainable energy systems of the future.

Policy implications

A mixture of different governance modes can be effective due to the multilevel nature of the system transition. In the planning of future energy systems a voluntary cooperation and engagement of public and private stakeholders will be important, referring particularly to the related coordination mode of governance. Effective governance requires integration of knowledge and experiences from various research traditions, including research on energy systems and modelling, innovation studies, societal embedding of innovations, consumer research, foresight, assessment of socio-economic and ecological consequences of technology, related energy program evaluations, and related benchmarking of available “best practices”.

The multi-level system transition approach and framework can be utilised as an integrative tool in the development of Nordic energy policy-planning, when harnessing multifaceted knowledge and resources for creating the long-term strategy and roadmap for the Nordic energy system transition. This approach enables, for example, conscious development of various horizontal policies and better coordination of relevant policy areas, such as climate policy, energy policy, innovation policy, development policy, industrial policies and regional policies. Companies, consumers and other stakeholders can also better recognise their role in the larger context and appropriately engage themselves into the long-term transition processes. The introduction of multi-level transition approach into the Nordic energy policy context may even encourage companies and consumers to take a leading role in the transition towards more sustainable energy systems. This kind of system transition can be supported by governance actions that pay attention to voluntary agreements, purchasing preferences, investments in R&D, allocation of venture capital, spin-offs, etc. Efficient transition towards more sustainable energy systems in the Nordic region can pave the way towards sustainable global energy systems too. Furthermore, the transition towards sustainable energy systems provides new business opportunities for the Nordic countries.

The transition management framework emphasizes the mutual understanding and commitment on versatile interest groups and stakeholders. Within this framework the coordination between ministries and authorities is important at national, regional and Nordic levels. Nordic participation in the European and international prospective work is of importance, and GoReNEST study encourages Nordic actors to proactively participate in the global and regional energy systems transition processes. Nordic actors' proactive role in the global energy transition means that (1) sustainable energy technologies are actively searched for and adopted in the Nordic countries, (2) Nordic actors actively participate in developing new energy technologies and services that support sustainable developments, (3) Nordic countries take an active role in facilitating sustainable developments also globally (including the emerging new economies and developing countries), and (4) Nordic actors actively utilise new business opportunities related to the global energy transition.

The transition management framework points out the importance of encouraging voluntary engagements and commitments between public and private stakeholders and help companies and consumers to recognise their roles in speeding up the long-term transition process. Creation of voluntary agreements with even more ambitious targets than those set and expected by the European Union can be important in this respect. Information services, education activities and financial policy instruments can, in turn, promote more sustainable purchasing preferences and investments in relevant R&D and innovation objects. Promising new sustainable energy technologies are today developed in cooperation between companies, research institutes and public sector actors. A need to create and support related spin-off companies by venture capital has been noted. The involvement of energy companies in such activities could be encouraged by developing proper incentives for the purpose.

The transition management framework gives also room for policies in boosting of balanced and parallel development activities at different levels and adequate interaction among the key actors. For example local niche-level experiments focusing on new types of technologies and solutions can be promoted. The Nordic industrial and R&D&I communities can be encouraged to join their forces behind promising projects, and cross-border demonstration platforms can be established for new 'zero-emission technologies'. Furthermore, the awareness, understanding and utilization of arising global business opportunities in the Nordic countries can be improved, noting that such efforts require close collaboration and cross-sectoral strategies between energy and manufacturing compa-

nies. Special tailor-made incentive schemes are also needed to support the emergence of sustainable CleanTech enterprises in energy field. Proactive future oriented legislation supports, in turn, the market introduction of new sustainable technologies and solutions. The Nordic experiences and the positive image of the Nordic countries can pave the way for the global transition as well.

Future research in the field

Policy implications of the transition management approach raise several items for the research agenda of the future. For example, the transition management framework points out the importance and relevance of such topics as the promotion of sustainable energy niche innovations by incentives, the establishment of new forms of collaboration between consumers, companies and other stakeholders to speed up the long-term transition process, and the encouragement of spin-off companies by venture capital of energy companies and related incentive schemes.

Strategic Energy Technology Plan of the European Union (SET plan) is aimed at accelerating the development and deployment of cost-effective 'low carbon technologies'. The importance of the SET plan calls for the introduction and application of the transition management approach in the Nordic context. The next step after the GoReNEST project could be application of the transition management approach in supporting the implementation of the SET plan in the Nordic countries. A multidisciplinary Nordic study – building on fruitful combinations of relevant expertise and research approaches (societal embedding, consumer research, energy system modelling, foresight and TA, etc.) and utilizing the strengths of the various research traditions and socio-economic/cultural/industrial/technological differences between the Nordic countries – would create proper conditions for mutual learning, making it also possible to accelerate the processes of energy system transition.

The suggested research topics presume intensive multidisciplinary collaboration between different research communities, for example between experts of energy system modelling, experts of transition approaches, and experts from innovation system studies. Accordingly also new multidisciplinary Nordic platforms are needed in order to encourage the collaboration of respective relevant research communities.

1. Introduction

Urgent actions are needed to ensure sustainable energy systems locally, regionally and globally. Given the severity of global warming and security threats in energy supply, it is considered urgent to develop common action plans to foster energy system transitions. Kyoto agreement was an important step towards this end, but more efficient international frameworks are needed. Towards this end, the post-Kyoto agreement is still to be negotiated. The European Union has, however, taken a proactive role in this respect by setting ambitious strategic energy policy objectives and by launching a comprehensive Strategic Energy Technology Plan (SET-Plan) that emphasises the need for a major technology shift in energy sector. This puts some pressure to the Nordic countries too: the energy systems must be developed so that the national-level targets can be achieved. On the other hand, this also opens up interesting new opportunities for the Nordic countries in form of technology exports and development of new businesses. With proactive policies the Nordic countries can also pave the way for sustainable developments at global level.

Revolutionary changes are needed in order to cope with the challenges of climate change mitigation and with energy security issues. Although it is possible to develop new and more sustainable technological solutions, and change attitudes and consumer behaviour, the energy system transition is going to be a complex and long-lasting process that effectively leads to desired developments only if well-coordinated and supported by a variety of stakeholders. The summary report of the GoReNEST project discusses the challenges of energy system transition with the aim of finding useful tools for Nordic actors to support the governance of the required energy system transition.

1.1 Challenges of energy system transition

The global challenges require changes beyond incremental and continuity type of performance improvements of present practices. They call for transitions towards radically different systems, major technology shifts in energy sector, towards the rapid diversification of energy production and efficiency. Transitions towards radically different systems are, however, complex societal co-evolutionary processes that are typically led by a series of gradual and parallel adaptations rather than visionary management or coordination. Indeed, desired transitions are often difficult to initiate and achieve, because the prevailing system acts as a barrier to the creation of a new system. Still, visionary coordination of policies, regulation, corporate strategies and social learning may overcome some barriers and foster new innovation efforts providing sufficient impetus towards system transition. Here, it is crucial to link long-term visions with the short and medium term strategies to generate favourable industrial, policy and social conditions leading to common action towards transition.

Taking advantage of the need for renewal of the existing energy system at large requires, though, an insight into the process of how large socio-technological systems emerge and evolve. This knowledge can then be used to gain insight into how a transition towards a sustainable energy system can be best facilitated; how opportunities for developing new systems and profiting from new innovations can be achieved. Techno-institutional changes are usually difficult to achieve due to institutional lock-ins in prevailing systems. Also the energy system transition is going to be a complex and long-lasting process that leads to desired developments only if well-coordinated and supported by a variety of stakeholders. New governance approaches and coordinated engagement of different stakeholders is thus needed to overcome the barriers and to efficiently direct the European and Nordic initiatives.

1.2 European policy objectives and SET-Plan

European Union has been active in its climate and energy policy. The goals of the EU energy policy reflect the global challenges posed by the climate change and UN Millennium Development Goals, but are also intended to support the competitiveness of the EU, to increase EU's self-sufficiency in energy supply, and to ensure sound environmental developments in the EU area.

The European Union has proposed the two degree limit for the global temperature rise and it has also been active in setting and proposing emission reduction policies and targets for the whole EU and for the member states. In order to contribute to the two degree target, EU has taken the indicative objective to reduce its emissions by 60 to 80 percent by 2050. As an intermediate target, EU aims at a unilateral 20% reduction in greenhouse gas emissions and a 30% reduction if other countries take comparable commitments, a 20% share for renewables in final energy consumption and a 20% energy efficiency improvement by 2020.

EU is also preparing the measures e.g. by extensions and developments of the EU Emission Trading Scheme (ETS) and by negotiating emission reduction targets for the sectors not included into ETS for the member states. A proposition to set a 10 per cent binding minimum target for biofuels or renewable energy in transport to be achieved by each Member State of the Union by 2020 and to introduce criteria to ensure that the biofuels used are sustainable in nature has also been given.

The EU has also recently launched a comprehensive Strategic Energy Technology Plan (SET-Plan) that emphasises the need for a major technology shift in energy sector to support sustainable developments. The aim of the SET-Plan is to accelerate the development and deployment of cost-effective low carbon technologies by improved planning and implementation of relevant incentives. Increased resources and international cooperation in the field of energy technology are also strived for in order to achieve the European objectives. For the Nordic countries this also provides new opportunities for developing the energy systems, technology exports and new businesses.

In the short term, it is important to improve the existing technologies and to widen the market-adoption of the improved technologies. Research targeted to reducing the costs and improving the performance of the ecoefficient existing technologies is, however, still needed. The commercial implementation of these technologies must be encouraged too. In the longer-term a new generation of low carbon technologies can be developed. New technologies and solutions that do not exist yet, but which have significant ecoefficiency potential in the future are thus searched for, with the aim of supporting their development. Among the current focus areas of the SET-Plan are second-generation biofuels; carbon capture, transport and storage; integration of renewable energy sources into the electricity network; and energy efficiency in construction, transport and industry. Also the third and fourth generation nuclear fission technologies are considered

promising at the moment. New types of fuels and zero emission technologies are, however, expected in the future. The focus areas are thus not fixed, but evolve with time and lessons learned.

Implementation of the SET-Plan prerequisites joint strategic planning. A European Community Steering Group and Information System have been established for the purpose. Each EU Member State is represented in the Steering Group, among them also three Nordic countries: Denmark, Finland and Sweden. In addition, Norway is represented in an observer role. The meetings of the Steering Group are prepared by 'sherpas' designated by the Member States in order to ensure fruitful dialogues. New industrial initiatives have also been launched in selected areas. These are in form of public-private partnerships and joint programmes between Member States. Scoping of the initiatives and programmes is by the industries through the European Technology Platforms.

Furthermore, a European Energy Research Alliance (EERA) is currently being created in order to better coordinate the programming of research centres and universities. The intention is also to significantly increase the financial and human resources to double the overall effort made in the EU within three years. Training of energy researchers is promoted too, including even new research and training opportunities.

Altogether, a prospective approach and intensified international cooperation is needed to prepare the energy networks for the future, increasing the EU's competitiveness and self-sufficiency in energy supply, as well as ensuring sound environmental developments in the EU area. The SET-Plan also provides opportunities for developing Nordic energy systems, technology exports and new businesses that contribute to sustainable energy solutions. These opportunities can, however, be best utilized by those who proactively address the need for change (a good example is the success of Danish companies with wind turbine technology).

1.3 NORIA Energy Policy Studies

The NORIA-energy programme aims to bolster the Nordic research and innovation area with regard to energy research and technology development, as well as to provide strategic recommendations for policy development in the areas of science, technology and investment in RDD and innovation. The programme was launched in 2007 by Nordic Energy Research following the Nordic Council of Ministers' report "NORIA – White Paper on Nordic Research and Innova-

tion”, which called for the formalisation and strengthening the Nordic region as a single Research and Innovation area.

Within the framework programme, Nordic Energy Research has commissioned seven studies between 2007 and 2008. These studies focused on different policy aspects, possibilities and strategies for increased cooperation, as well as on opportunities for Nordic actors in emerging markets. The studies examine the Nordic energy innovation policy from different perspectives, applying knowledge from several complementary disciplines. Developing indicators and analysis tools, mapping potentials of various technologies and policy instruments, developing recommendations for promoting investments, and investigating potential export markets for new Nordic energy technologies and solutions were among the issues examined. The GoReNEST project, focusing on the governance and research of Nordic energy system transition, was one of the seven NORIA energy programme studies.

2. GoReNEST project

2.1 Objectives and contents of the project

The GoReNEST project focused on the governance and research of Nordic energy system transition. The objective of the project is to support the planning of sustainable energy policy in Nordic countries (1) by improving the understanding of the challenges of systemic changes and corresponding governance responses, (2) by increasing the awareness of energy transition perspectives, (3) by providing recommendations for the development of Nordic governance of energy system transition, (4) by supporting Nordic actors' proactive participation in the implementation of the international climate and energy initiatives (including the SET Plan of the European Union), and (5) by engaging Nordic actors in taking advantage of emerging energy and climate related opportunities. The project consisted of five subtasks that were conducted by a multidisciplinary research team with backgrounds in innovation and energy system studies. The contents and methodologies of the various subtasks are discussed in the following section.

2.2 Project design

The GoReNEST project consisted of the following subtasks:

Task 1. Developing an analytical framework for the Nordic governance of energy system transition (Könnölä et al., 2008a). Evolutionary and institutional approaches were used as a starting point, incl. transition management and societal embedding of innovations.

Task 2. Analysing Nordic research in support of the governance of energy system transition. A working paper summarizing the findings was produced (see Loikkanen et al., 2009). Information gathering of the task was through web-based search and expert consultation, analysis of the information with the help of the conceptual framework developed in Task 1.

Task 3. Exploring governance and funding models and practices for energy system transition. A working paper summarizing the findings was produced (see Könnölä et al., 2009). Information gathering was through web-based search and expert consultation. The information was analysed with the help of a modified analytical framework (further elaboration of the conceptual framework of Task 1).

Task 4. Application of the framework in a small-scale pilot stakeholder process in the context of a stakeholder workshop in Copenhagen, Oct. 23 2008. The workshop was organized in cooperation with the Nordic Energy Perspectives project (NEP2). The 28 participants of the workshop included representatives of funding organisations, energy companies and associations/agencies, ministry of industry, and universities/research institutes.

Task 5. Reporting and dissemination of the results. The analytic framework and the contribution of the two subsequent subtasks are published and distributed as electronic publications in the VTT Working Papers Series (Könnölä et al., 2008a; Loikkanen et al., 2009; Könnölä et al., 2009) and as a parallel paper and presentation in the European DIME conference (Könnölä et al., 2008b). The preliminary results of the entire project were reported in the NORIA Energy Policy Seminar in Oslo in December 2008 (Eerola, 2008) and in the NER Board meeting in February 2009 (Eerola, 2009). This final Summary Report is published in the VTT Research Notes series with the intention of reaching a wider group of policy and decision makers. Some central ideas of the GoReNEST project are also disseminated through VTT's 'Energy Visions 2050' book that includes a brief discussion of energy system transition (see Savolainen et al., 2009).

2.3 MLP transition management framework

For the purposes of examining the challenges of energy system transitions and their governance, we characterise *system transition* as follows (Könnölä et al., 2008a):

- It deals with a *long term* continuous change process with parallel developments in different phases (i.e. predevelopment, take-off, acceleration and stabilisation) leading to a radically new system.
- It takes into account developments on *different levels* (niche, regime and landscape, i.e. micro, meso and macro levels). On these levels it addresses technological, industrial, political and societal changes.

The analytical framework for the governance of Nordic energy system transitions – produced in Task 1 of GoReNEST project – thus builds upon a dynamic multi-level perspective (MLP) which understands transitions as outcomes of

alignments between developments at multiple levels. The multi-level transition process is illustrated in Figure 1. In the following this model is shortly discussed.

The MLP framework argues that transitions take place through interactions between processes at three different 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, the basic form of Figure 1 has become a somewhat standardised general picture of this dynamic, although there is an on-going scientific debate on some details of the MLP framework.

The core idea of Figure 1 is that socio-technical changes happen in the interplay between different levels. The whole system is changed only if all levels – landscape, regime and niche – support the transition. Conflicts and pressures at the society can thus open up possibilities to a large systemic transition. In such a situation local innovations and experiments can be established and foster the system transition. The transition towards more sustainable energy systems only occurs if there are sufficient pressures from the operation environment and also enough niche-level local experiments with novel solutions that can be gradually adopted into the prevailing energy systems. Optimization of the prevailing systems should thus be complemented with more evolutionary approaches.

Considering the various dimensions of system transition

For fully understanding the challenges of energy system transition and the prerequisites of successful introduction of relevant innovations we need to consider changes in the technological, industrial, policy and social subsystems, as well as understand their inter-linkages. To explore the *technological change*, we should focus on potentially interesting technologies and identify major technological bottlenecks and opportunities for alternative technological future pathways. For improving our understanding about the key drivers and barriers of *industrial change* we must identify networks of technology developers, energy and technology providers, appliers (users), investors and related financing services, and examine the industry-wide co-operation and standardisation efforts. Routines and competences that mark the conditions of how energy companies and other organizations are able to create and exploit new technologies need also attention, as well as potential institutional lock-ins that may hinder the desired developments.

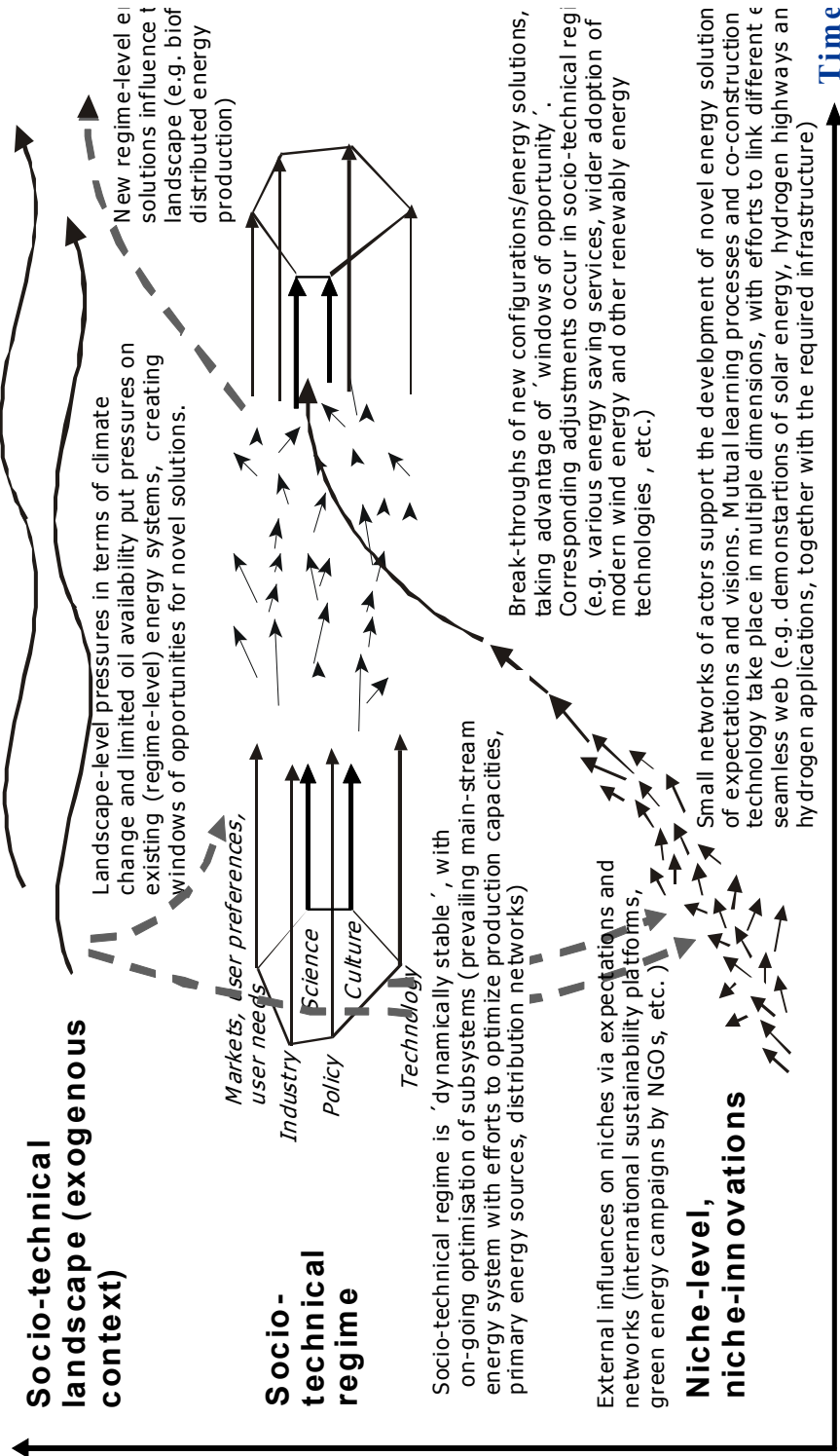


Figure 1. Energy systems transition according to a dynamic multi-level transition management approach (see e.g. Geels & Schot, 2007).

2. GoReNEST project

Correspondingly, to understand *policy change* we need to focus on institutional and legal frameworks, considering even the danger of (traditional) optimization-oriented policy efforts in reinforcing lock-in conditions to existing systems. Shaping the institutional context through strategic action so that proper conditions for novel innovations are created may be a really challenging task when new objectives contradict with the old ones. Furthermore, the success of energy system transition also depends on the experience and response of the end-users and those closely affected by the system. *Social change* may create demand for emerging new technologies but can also hamper the diffusion of promising technologies. The inter-linkages between the four system dimensions are illustrated in Figure 2.

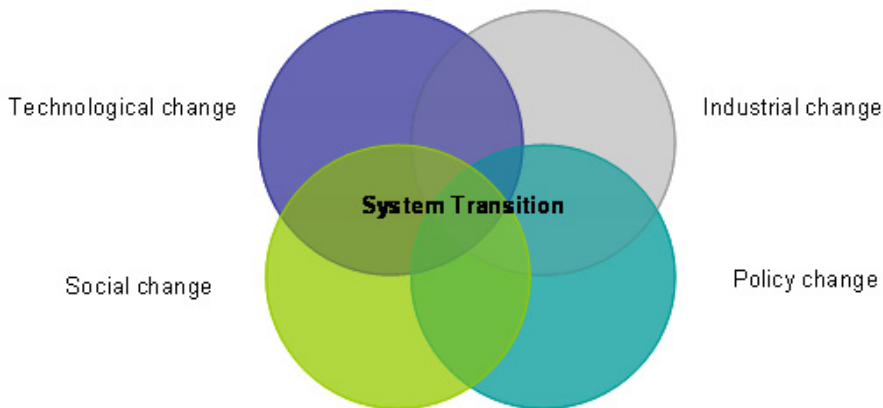


Figure 2. Linkages between technological, industrial, policy and social changes. Source: Könnölä et al., 2008a.

Altogether, the energy system develops through the gradual application and development of new technologies. The flow of changes in different phases is in continuous movement. Transition towards more sustainable energy systems is thus a complex and long-lasting process. A variety of tools and policy instruments are needed to facilitate development and transition and to avoid undesirable lock-ins that hinders the transition towards the desired targets.

Relevant policies – energy policy, climate policy, innovation and R&D policy, development and regional policies – cover the society in many fields. Intensified national and regional efforts in the Nordic area are needed to ensure concrete actions and commitment when facing the global challenges. Institutional support

and capacity building is also necessary to ensure that policymakers, regulators, local business entrepreneurs, and technical personnel have the motivation and skills required for supporting the desired developments. The aim of the GoReNEST project is to contribute to these aims. The contribution of the various sub-tasks is discussed in the following chapter.

3. Contribution of the GoReNEST subtasks

Despite a gradual policy application of transition approaches – especially in the Netherlands (e.g. the Fourth Dutch National Environmental Policy Plan 2001, and recent Transition Platforms), but also in diverse European and some Nordic research projects – the unfamiliarity and lack of experience in Nordic countries have meant that their use in policy-making and governance has received insufficient attention. Efforts in applying the approach for supporting the Nordic actors’ proactive participation in the global energy transition have, however, been quite limited or rather loosely coordinated so far. It was thus considered reasonable to explicitly introduce and further develop this framework for the Nordic key actors in the energy field. This was done in GoReNEST Tasks 1–4 that all contribute to this end.

3.1 Contribution of Task 1

In Task 1 of GoReNEST project an important extension was made to the MLP framework, including even the various governance functions in the analytical framework. In particular, the following governance functions are explicitly considered: (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 (see Könnölä et al., 2008a).

Developing policy instruments to support the desired developments

The governance of the complex multi-level and multi-dimensional energy system transition is not an easy task. With the help of appropriate policy instruments the transition process can, however, be facilitated towards the desired directions. The instruments can be targeted to modify the energy supply, energy transmission and/or the energy consumption directly or are expected to influence the desired developments in more diffuse ways.

Table 1 summarizes the possible contents and objectives of the five governance functions.

Table 1. Contents and objectives of the five governance functions (Könnölä et al., 2008a).

Governance Functions/ Types of policy instruments	Description	Objective	Examples
Information services, networking, setting common agendas	Cross-disciplinary, sectoral and regional/national networking Coordination of future plans and actions	Building new collaboration and/or breaking up lock-ins Supporting continuity and predictability (lower risks)	Brokerage Networks Strategic action plans - Information and brokerage - Foresight - Science parks, incubators - Social arenas, platforms - Systemic policies
Strategic procurement, (pre-) market	Occurs when the demand for certain technologies, products or services is encouraged in order to stimulate the market	Create demand and develop markets for innovative solutions	R&D procurement Public procurement of innovative goods Financing demonstration Projects as pre-market procurement
Financing research and education	Financing research and education	Develop research and education	University funding R&D and demonstration programmes Contract research
Grants, equity support and fiscal measures (supply and demand)	The use of economic instruments to influence on (perceived) risks and opportunities	Influencing preferences (both short and long-term)	Public venture capital Loss underwriting and guarantees Tax incentives, reductions Tradable emission rights Subsidies Partnerships Reimbursable loans R&D grants, prices
Regulation and standards	Regulation and voluntary industry standards	Predictability of benefits for first movers; extended and shared responsibility; better performance	Regulations Standards

3. Contribution of the GoReNEST subtasks

The policy instruments should also be tailored for the transition phase in question. For instance, in the *predevelopment/incubation phase* it is important to foster competing networks and strategies as well as diversity of viable options. Support for pre-market R&D, demonstration projects and pilot infrastructures, opportunities for adequate training, education and scientific quality are also needed. Appropriate awards, credit guarantees and subsidies can be helpful in these respects. Vision-based procurement and regulation, and alternative enabling standards may be some additional adequate tools.

In the *take-off phase*, on the other hand, it might be wiser to focus on consolidation of existing networks and strategies, supporting solution-based lead market formation, entrepreneurial skills formation and gaining sufficient critical mass. Awards, credit guarantees, subsidies and solution/technology-based procurement are among the appropriate tools here too, as well as support for lead market infrastructures and required institutional settings. Vision-based regulation, regulatory plans and some dominant standards may be helpful too in the take-off-phase.

When proceeding to the *acceleration phase*, the focus is likely to be in the emergence of the dominant networks and strategies, solution-based lead market formation, appropriate taxes and taxation principles, emission permits, performance based procurement, infrastructural and institutional expansion, dominant standards, regulatory support and top-runner regulation.

The analytical framework developed in GoReNEST Task 1 pays attention to all these various aspects of the transition process (levels, dimensions and phases; see Appendix A). The basic idea of the framework is to explicitly consider all important time-horizons (present state + short-term, medium-term and long-term developments), the three development levels related to the MLP approach (developments of socio-technical landscape, socio-technical regime, and niche-level innovations; see Figure 1), the four various change dimensions (technological, industrial, social and policy change; see Figure 2), as well as the five governance functions presented in Table 1. It was considered that such a framework would contribute to fruitful analyses that would facilitate the development of policies and governance practices covering all important elements. As a first step, the framework was used as a tool for analysing Nordic research in support of the governance of energy system transition. This was done in GoReNEST Task 2.

3.2 Contribution of Task 2

In Task 2 of the GoReNEST project (Loikkanen et al., 2009) current Nordic energy research was considered vis-à-vis different elements, categories and topics of the system transitions framework. The aim is to give some tools for assessing the potential of this research as contribution to the governance of Nordic energy system transition and related policy-planning. Moreover, this consideration raises some important energy research issues and themes for the future.

Nordic research supporting energy-related policy making is quite extensive. Even techno-economic and social aspects have been analysed in many studies. To assess the potential of system transition approach to support the governance of energy system transition in the Nordic context – using system transition framework as a policy-planning tool – it is important to know whether, in which ways and how far the different elements and dimensions related to this approach have already been examined by the Nordic researchers. GoReNEST Task 2 was planned to serve this need. The focus is thus on research that is intended to support the governance of energy system transition.

The studies and projects included in the GoReNEST Task 2 contain (a) national level studies of Nordic countries, (b) common studies of Nordic countries carried out on Nordic level, and, (c) studies carried out with Nordic participation on European and international level. Six relevant, partly overlapping areas of research approaches were identified: 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.

The information gathered in the GoReNEST Task 2 was analysed by using the analysis framework developed in the previous task (see Appendix A) and the above categorization of relevant research approaches. The studies and projects reviewed by the GoReNEST team were first located according to the six research categories and then positioned within these categories according to the various time-horizons, examination levels, change dimensions and governance functions in focus. The ultimate aim was to find out the time spans, examination levels, change dimensions and governance functions concerned by the various research approaches. Table 2 summarizes the positioning of the various types of study within the framework (abbreviations and numbering of the six research approach categories are used in the table).

3. Contribution of the GoReNEST subtasks

Altogether, GoReNEST Task 2 suggests that Nordic research encompasses a number of studies and projects in the six areas of research approaches and methods listed above. These studies and projects 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 the Nordic countries. The research is, however, scattered and fragmented in the six research areas as well as vis-à-vis the related aspects and dimensions of the systems transition framework.

As a research theme energy system transition is very multidisciplinary in nature. Still, the overview on Nordic energy research indicates relatively minor collaboration between relevant research communities, especially between energy system research and innovation system research. The projects are usually designed and coordinated by research teams that represent a particular research tradition, focusing on some specific aspects of energy system transition. If special attention is not paid to understanding the whole picture and integrating the findings of the various research traditions, useful inputs may be ignored and the various traditions are easily seen as competing efforts. The early experiences in cooperation with the Nordic Energy Perspectives project within the framework of GoReNEST Task 4 confirmed the communication gap and the challenges related to creation of mutual understanding. The importance of understanding the various perspectives and research traditions as complementary contributions to energy system transition and its governance is thus underlined.

3. Contribution of the GoReNEST subtasks

Table 2. Positioning the various types of study within the analytic framework of GoReNEST Task 1. (See Appendix B for the projects examined by GoReNEST Task 2.)

	Time horizon <i>Dimension</i>	Present	Short-term	Medium-term	Long-term
Landscape	<i>Technological</i>	Program evaluations (5) IS/GR/benchmarking (6)	Energy system models (3) Program evaluations (5) IS/GR/benchmarking (6)	Energy system models (3) Program evaluations (5)	Energy system models (3) Program evaluations (5)
	<i>Industrial</i>	IS/GR/benchmarking (6)	Energy system models (3) IS/GR/benchmarking (6)	Energy system models (3)	Energy system models (3)
	<i>Policy</i>	Program evaluations (5) IS/GR/benchmarking (6)	Energy system models (3) Foresight & TA (4) IS/GR/benchmarking (6)	Energy system models (3) Foresight & TA (4)	Energy system models (3) Foresight & TA (4)
	<i>Social</i>	IS/GR/benchmarking (6)	IS/GR/benchmarking (6)	Energy system models (3)	Energy system models (3)
Regime	<i>Technological</i>	Program evaluations (5) IS/GR/benchmarking (6)	Energy system models (3) Foresight & TA (4) Program evaluations (5) IS/GR/benchmarking (6)	Energy system models (3) Foresight & TA (4)	Energy system models (3) Foresight & TA (4)
	<i>Industrial</i>	(Foresight & TA (4)) IS/GR/benchmarking (6)	Energy system models (3) Foresight & TA (4) IS/GR/benchmarking (6)	Energy system models (3) Foresight & TA (4)	Energy system models (3) Foresight & TA (4)
	<i>Policy</i>	Program evaluations (5) IS/GR/benchmarking (6)	Energy system models (3) Foresight & TA (4) Program evaluations (5) IS/GR/benchmarking (6)	Energy system models (3) Foresight & TA (4) Program evaluations (5)	Energy system models (3) Foresight & TA (4)
	<i>Social</i>	Consumer research (2) IS/GR/benchmarking (6)	Consumer research (2) Energy system models (3) Foresight & TA (4) IS/GR/benchmarking (6)	Energy system models (3) Foresight & TA (4)	Energy system models (3) Foresight & TA (4)
Niche	<i>Technological</i>	Societal embedding (1) Consumer research (2) Program evaluations (5) IS/GR/benchmarking (6)	Societal embedding (1) Consumer research (2) Foresight & TA (4) Program evaluations (5) IS/GR/benchmarking (6)	Societal embedding (1) Consumer research (2) Foresight & TA (4) Program evaluations (5)	Societal embedding (1) Consumer research (2) Foresight & TA (4)
	<i>Industrial</i>	Societal embedding (1) IS/GR/benchmarking (6)	Societal embedding (1) Foresight & TA (4) IS/GR/benchmarking (6)	Societal embedding (1) Foresight & TA (4)	Foresight & TA (4)
	<i>Policy</i>	IS/GR/benchmarking (6)	Societal embedding (1) Foresight & TA (4) IS/GR/benchmarking (6)	Societal embedding (1) Foresight & TA (4)	Foresight & TA (4)
	<i>Social</i>	Societal embedding (1) Consumer research (2) IS/GR/benchmarking (6)	Societal embedding (1) Consumer research (2) Foresight & TA (4) IS/GR/benchmarking (6)	Societal embedding (1) Foresight & TA (4)	Foresight & TA (4)
Governance	<i>Information services, networking, setting common agendas</i>	Societal embedding (1) Consumer research (2) IS/GR/benchmarking (6)	Societal embedding (1) Consumer research (2) Energy system models (3) Foresight & TA (4) IS/GR/benchmarking (6)	Societal embedding (1) Consumer research (2) Energy system models (3) Foresight & TA (4)	Societal embedding (1) Consumer research (2) Energy system models (3) Foresight & TA (4)
	<i>Strategic procurement, pre-market</i>	IS/GR/benchmarking (6)	Societal embedding (1) Foresight & TA (4) IS/GR/benchmarking (6)	Societal embedding (1) Foresight & TA (4)	Foresight & TA (4)
	<i>Financing research and education</i>	Program evaluations (5) IS/GR/benchmarking (6)	Foresight & TA (4) Program evaluations (5) IS/GR/benchmarking (6)	Foresight & TA (4) Program evaluations (5)	Foresight & TA (4)
	<i>Grants, equity support and fiscal measures (supply and demand)</i>	Societal embedding (1) Consumer research (2) IS/GR/benchmarking (6)	Societal embedding (1) Energy system models (3) Foresight & TA (4) IS/GR/benchmarking (6)	Energy system models (3) Foresight & TA (4)	Foresight & TA (4)
	<i>Regulation and standards</i>	IS/GR/benchmarking (6)	Energy system models (3) Foresight & TA (4) IS/GR/benchmarking (6)	Societal embedding (1) (Consumer research (2)) Energy system models (3) Foresight & TA (4)	(Consumer research (2)) Foresight & TA (4)

3. Contribution of the GoReNEST subtasks

For instance, some Nordic countries have a strong tradition in energy system modelling. 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 including different interests of various 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 systems.

GoReNEST Task 2 thus suggests that there is a need to develop a systemic research agenda, paying attention to the potential contribution of the various types of studies and research to the governance of energy system transition. The systemic research agenda should assure that the various approaches are utilized in a balanced and purposeful way. There should also be incentives and proper conditions for adequate integration of the approaches and findings. This can be encouraged at project level, as well as by developing transparent processes by which the contribution of various individual projects are explicitly positioned and integrated. Well-functioning dialogue platforms and integrative projects are apparently needed for the purpose.

3.3 Contribution of Task 3

Task 3 of the GoReNEST project further elaborated the analytic framework for the purpose of examining different funding and governance models from the system transition perspective (elaboration of the conceptual framework of Task 1). Different governance and funding models and their practices and accrued experiences were then analysed with the help of the framework in order to assess their potential use and utilisation in the development of the Nordic energy system transition. Furthermore, towards the improved coordination and governance of the energy transition processes, Task 3 explored the recent advances in R&D&I governance and funding models (see Könnölä et al., 2009).

The analysis framework used in analysing the information gathered in the GoReNEST Task 3 is presented in Table 3. A number of example cases – interesting funding and governance models that have recently been developed in different countries and regions – were examined in more detail. Table 3 summarizes the positioning of these example cases within the framework.

3. Contribution of the GoReNEST subtasks

Table 3. The modified framework for analysing the funding and governance models in GoReNEST Task 3. Example cases positioned within the framework. (See Appendix C for the explanations of the abbreviations.)

	Dimensions of change and agents	Integration	Co-ordination	Competition	Co-existence
Strategic orientation	Technological (R&D)	FCH JTI, Finnish energy SHOK, Canadian approach, SET-Plan	IPHE, SHHP, Dutch ETPs, Finnish energy SHOK, SET-Plan	(SET-Plan)	
	Industrial	FCH JTI, Finnish energy SHOK, Canadian approach, SET-Plan	HTP, FCH JTI, IPHE, SHHP, Dutch ETPs, Finnish energy SHOK, SET-Plan	Canadian approach, (SET-Plan)	
	Policy	FCH JTI, Finnish energy SHOK, Canadian approach, SET-Plan	Hy-Co, FCH JTI IPHE, SHHP, Dutch ETPs, Canadian approach, SET-Plan	(SET-Plan)	
	Social (NGOs)		IPHE, Dutch ETPs, Canadian approach		
Programming	Dimensions of change and agents	Integration	Co-ordination	Competition	Co-existence
	Technological (R&D)	FCH JTI, Finnish energy SHOK, Canadian approach, SET-Plan	HTP, FCH JTI, IPHE, SHHP, Dutch ETPs, Finnish energy SHOK, Canadian approach, SET-Plan	Dutch ETPs	
	Industrial	FCH JTI, Finnish energy SHOK, SET-Plan	HTP, Hy-Co, FCH JTI, IPHE, Dutch ETPs, Finnish energy SHOK, SET-Plan	Dutch ETPs, Canadian approach	
	Policy	FCH JTI, Dutch ETPs, Finnish energy SHOK, SET-Plan	Hy-Co, FCH JTI IPHE, SHHP, Dutch ETPs, Finnish energy SHOK, Canadian approach, SET-Plan	Dutch ETPs	
	Social (NGOs)		IPHE, Dutch ETPs		
Performance	Dimensions of change and agents	Integration	Co-ordination	Competition	Co-existence
	Technological (R&D)	FCH JTI, SHHP, Finnish energy SHOK, SET-Plan	Hy-Co, FCH JTI, SHHP, Finnish energy SHOK, SET-Plan	Hy-Co, FCH JTI, Finnish energy SHOK, SET-Plan	
	Industrial	FCH JTI, SHHP, Finnish energy SHOK, SET-Plan	Hy-Co, FCH JTI, SHHP, Finnish energy SHOK, SET-Plan	Hy-Co, FCH JTI, Finnish energy SHOK, SET-Plan	
	Policy	FCH JTI, Finnish energy SHOK, SET-Plan	Hy-Co, FCH JTI, Finnish energy SHOK, SET-Plan	Finnish energy SHOK, SET-Plan	
	Social				

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Altogether, the empirical cases examined in the GoReNEST Task 3 suggest that the interplay between different governance modes and arenas is crucial. An important aspect of governance for system transition is cooperation and a mutual engagement of public and private actors and stakeholders ('co-ordination mode' of governance). However, due to the multi-level nature of system transition, a mixture of modes can also be very effective. For example, at the local level, the 'competition mode' may yield valuable outcomes due to the stronger incentives for local stakeholders to engage in a competitive process, and awareness of local circumstances and 'fitting' of technological options. In conclusion, different governance and funding models with their practices and experiences can play an important role in the transition, but even more important may be the combined use of different modes that contribute to the development of the Nordic energy system transition.

3.4 Contribution of Task 4

In the GoReNEST project an attempt was made to develop a useful multi-level and multi-dimensional conceptual framework that would support Nordic actors' proactive participation in the global energy system transition. As described in the previous chapters, the framework was then applied to analysing relevant Nordic research and exploring various governance and funding models/practices (Tasks 2 and 3 of the GoReNEST project). In GoReNEST Task 4 the conceptual framework was, in turn, applied to facilitating stakeholder discussions in cooperation with the Nordic Energy Perspectives project (NEP2). The aim was to start a dialogue that would increase the mutual understanding among Nordic stakeholders and different research traditions. Starting the dialogue was considered important to ensure good conditions for Nordic actors' proactive participation in the implementation of SET plan.

In particular, the conceptual framework of the GoReNEST project was applied to facilitate the stakeholder discussions in the context of the joint NEP2-GoReNEST workshop in Copenhagen, October 23 2008. The 28 participants of the workshop included representatives of energy companies, energy associations and agencies, and funding organisations, as well as ministry, university and research institute representatives. Cooperation with the NEP2 project and the specific workshop provided thus a forum for testing the applicability of the framework in guiding stakeholder dialogues that focus on various aspects of the transition process and its governance.

The main emphasis of the Nordic Energy Perspectives project is in energy system modelling and production of alternative scenarios with the help of quantitative energy system models. As noted earlier, the future scenarios produced by these models can help decision-makers in planning relevant and desirable short- and long-term targets under varying framework conditions and timelines. Modelling approach does not, however, tell how to reach the targets in the complex world of different interests, variety of public and private stakeholders, multiple development dimensions, and various time horizons to be considered simultaneously. It was thus interesting to test if the transition management framework would stimulate the stakeholder dialogue in this respect, so that adequate attention would be paid also to the mobilization of relevant actors and governance actions at different levels (landscape, regime, niche), covering all relevant dimensions (technological, industrial, political and social).

The transition management framework was presented in the beginning of the workshop (see Eerola & Loikkanen, 2008). The morning session also introduced some relevant qualitative management research, focusing on sustainability-driven business models and strategies in energy companies, challenges and opportunities within the biomass sector, and governance and funding of clean technologies within the energy sector (Sandoff, 2008). The afternoon session was, in turn, devoted to various modelling presentations. The discussions in the morning session were directed mainly to niche-level issues, whereas the discussions in the afternoon session focused on the regime-level developments. The landscape-level pressures and challenges and the need for appropriate policy instruments were addressed both in the morning and in the afternoon.

The discussion topics included the general relevance of the system transition approach in implementing Nordic energy and climate change strategy, the messages of the case studies in the light of the GoReNEST framework and the guidelines for proactive energy system transition and its governance in the light of the MLP transition management approach. An introductory orientation material briefly describing the GoReNEST project and framework was delivered to the participants before the session.

The overall conclusion of GoReNEST Task 4 was that the MLP transition management framework, and the conceptual framework of the GoReNEST project, has some potential in widening the scope of stakeholder dialogues, providing useful tools for balancing the attention between the parallel developments in landscape, regime and niche levels. In this way these frameworks would also support the Nordic policy making and governance of the Nordic energy system

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transition. There are some challenges to overcome, however: the conceptual framework is considered interesting but difficult to understand without adequate guidance and background knowledge (only a few participants of the workshop were familiar with the transition management approach beforehand). It was also noted that there seems to be a gap between energy system research and innovation research. By increasing the interaction between the two communities – and ensuring that all relevant approaches are included – some of the perceived problems could probably be overcome. The complementary contribution of the various approaches to the governance of energy system transition should also be clearly understood.

GoReNEST Task 4 thus brought up some important issues that should be considered to support the proactive participation of the Nordic actors in the implementation of the SET plan and other international climate and energy initiatives. Among the messages are the following:

- Widening the scope of stakeholder discussions at national and Nordic levels is important to ensure balanced consideration of the parallel developments in landscape, regime and niche levels, and to understand their mutual interaction and dependences. The MLP framework (see Figure 1) that explicitly considers the various development levels and their interaction dynamics can be used as a tool for developing shared understanding and supporting fruitful dialogues.
- Nordic countries have good competencies in energy system and innovation research. Both competency areas and their appropriate integration are needed to proactively participate in the implementation of the SET plan and corresponding international initiatives. Increased interaction between the two communities of research is, however, needed in order to fully utilize the Nordic potential in this respect.
- The complementary role of the various research approaches in implementing the SET plan should be better understood among the Nordic actors. Joining the Nordic forces behind impactful multidisciplinary research programs would probably be a more fruitful strategy to support the proactive participation at European and global levels than concentration on certain approaches that live a life of their own.

Successful creation and implementation of the European SET plan prerequisites that all the elements of the system model are paid attention to in a balanced way.

The MLP framework can pave the way towards this end at European level too, making it easier to harness right type of competencies and expertise behind the efforts. In this way it is also possible to create robust strategies for the implementation of the SET plan in the Nordic countries as a part of European policy. Appropriate consideration of the various research traditions and their strengths – paying also attention to the industrial and cultural differences between the Nordic countries – is required to successfully participate in the global efforts towards more sustainable energy systems and to utilize also the new business opportunities potentially available for the Nordic countries.

4. Results of the GoReNEST project

On the basis of the GoReNEST project, it can be concluded that Nordic countries have been actively involved in various types of research with the aim of supporting energy system transition. This research includes approaches such as societal embedding of energy innovations, consumer research in energy markets, energy system modelling and scenarios, energy foresight and technology assessment, evaluations of energy research and technology programmes, and energy related innovation studies, governance research and benchmarking. There is, however, a communication gap between the communities of energy research and innovation research, and to some extent between the above listed specific research traditions too. The GoReNEST experiences also confirmed that the multi-level and perspective (MLP) transition management framework is still relatively unfamiliar to Nordic stakeholders in the energy field.

The findings of the GoReNEST project suggest that multiple governance modes and arenas are to be considered when supporting the Nordic energy system transition. Governance modes addressing integration, coordination, competition and co-existence should all be considered, as well as cross-border arenas for strategic orientation, programming and performance of RDI. Voluntary cooperation and engagement of public and private stakeholders is, however, important to achieve the desired goals with reasonable effort and time. A mixture of different governance modes, and national and cross-boarder arenas, would apparently be most effective due to the multilevel nature of the system transition.

Effective governance also requires integration of knowledge and experiences from various research traditions. Research on energy systems and modelling, innovation studies, consumer research, societal embedding of innovations, energy foresight and technology assessment (TA), and program evaluations and benchmarking provide complementary contributions. It is therefore important to acknowledge the Nordic competencies in all these fields and to build on these

competencies when striving for a more conscious utilization of the MLP transition management framework. By increasing the interaction between the various research communities the complementarities of their approaches and competencies can be better understood and utilized. This would facilitate the governance of energy system transition at national, Nordic and EU levels. In this way the Nordic countries would also be better equipped for utilising new technology export and business opportunities provided by the global transition towards more sustainable energy systems.

5. Recommendations for Nordic actors

The GoReNEST project team was asked to produce recommendations for Nordic actors on the basis of the experiences and findings of the GoReNEST project. Taking into account the global challenges energy production and consumption faces now and in the future, and the related political will at EU and Nordic levels, we recommend at least the following actions:

- Compilation of long-term Nordic roadmaps and strategies – and related exercises supporting the Nordic energy system transition – and harnessing multifaceted knowledge and resources behind these. The MLP transition management framework can be used as a general-level tool for increasing the mutual understanding and commitment and for recognizing the complementary roles of various actors. Active Nordic participation in the European and international prospective work is important too.
- Better coordination of horizontal policies (climate policy, energy policy, innovation policy, development policy, industrial and trade policies, and regional policies at national and Nordic levels). Coordination between ministries and authorities at national, regional & Nordic levels is important too.
- Encouraging voluntary engagement of public and private stakeholders. In particular, we would recommend voluntary agreements with more ambitious targets than those expected by EU. For the purpose, it is also important to help companies and consumers to recognise their roles in speeding up the long-term transition process. Providing adequate information services and education that facilitate sustainable purchasing preferences, investments in relevant R&D, allocation of venture capital to CleanTech, creation of spin-offs around new promising technologies, etc. is important in this respect.
- Ensuring balanced parallel developments and adequate interaction among the key players, paying attention to improvements in the existing energy sys-

tem and local niche-level experiments focusing on new types of technologies and solutions.

- Joining the forces behind promising Nordic RDD projects, for instance in form of cross-border demonstration platforms for new ‘zero-emission technologies’. Lead market principle can be applied as an instrument in introducing new innovative technologies into the Nordic markets.
- Increasing the understanding and widening the utilization of new business opportunities in the Nordic countries. Cross-sectoral strategies and cooperation are important in this respect. Energy companies can be encouraged to act as venture capitalists in promising CleanTech enterprises by creating incentives and appropriate mechanisms for the purpose.
- Proactive legislation that encourages innovation and supports the market introduction of new sustainable technologies and solutions in the Nordic area.
- Taking advantage of the positive image of the Nordic area in paving the way for global transition. Clean environment, welfare and high education, and high investments in innovation create some specific pressures and expectations on the Nordic countries. On the other hand, these values also provide a good starting point for being forerunners in the energy system transition and its governance.

When thinking about the possible supportive actions by Nordic Energy Research, the GoReNEST project suggests the following:

1. Explicit consideration of the basic elements of the MLP transition management framework when designing and communicating NER strategy and research programs. This would support the development of mutual understanding and shared meanings, enabling cross-border and cross-disciplinary cooperation for tackling the global challenges and actively taking part in the implementation of the SET plan.
2. Organisation of seminars and more continuous platforms for facilitating genuine dialogue between experts in energy systems and experts in innovation systems, and between various sub-communities within these. Intensive cooperation between NER and NICE (Nordic Innovation Centre) is needed for the purpose. Involvement of policy and decision makers can be facilitated by linking the seminars and platforms with relevant processes and events at Nordic, national and regional levels.

5. Recommendations for Nordic actors

3. Development of a Nordic information and educational service that guides the citizens and decision makers towards sustainable decisions and purchasing preferences. NER funding and coordination role is needed for the purpose. Harnessing the best expertise in each Nordic country – and considering all relevant categories of research and expertise (incl. the six categories reviewed for GoReNEST Task 2) - is recommended in order to develop and implement appropriate tools for the purpose. Credible Nordic information tools are likely to induce the European-level practices too.
4. Development of notable Nordic demonstration platforms for promising new technologies that have real potential to contribute to transition towards more sustainable energy systems. Fluent cross-border cooperation, financial support and visibility are needed to make the demonstration platforms internationally attractive and to facilitate the development of new businesses in the Nordic countries. NER can play an important role in developing the required conditions in the pre-market phase of technology development in this sense. Promotion of the Nordic area as an interesting demonstration context, channelling of the required resources behind the common Nordic demonstration platforms and involvement of national- and regional-level stakeholders are among the key issues to be considered for the purpose. Nordic countries can together apply lead market approach in the Nordic area as an encouragement and incentive toward new sustainable energy technologies.
5. Development of appropriate incentives for Nordic energy companies (and other big companies with mature businesses) to act as venture capitalists in the CleanTech sector. Both research and organised dialogues between the stakeholders are needed for the purpose. NER and NICE could take an active role in promoting the idea and in launching relevant research programs and discussion platforms.

The GoReNEST project also raises several items for the research agenda of the future. For example, within the transition management framework, such topics are of relevance as the promotion of sustainable energy niche innovations by proper incentives, required new forms of collaboration between consumers, companies and other stakeholders in speeding up the long-term transition process, and encouragement of spin-off companies and new types of mechanisms for

mobilizing the required venture capital. A relevant next step for the GoReNEST study could be the application of transition management approach to support the implementation of the SET plan in the Nordic countries. Such a study would benefit of the strengths and diversities of Nordic countries. Multidisciplinary approach building on a fruitful combination of relevant expertises and research approaches is suggested in this respect.

6. Summary and conclusions

Reaching the policy goals of sustainable developments is not straight-forward. Although it is possible to develop new and more sustainable technological solutions for energy production, conversion and consumption, the new solutions need to be supplemented with corresponding changes in attitudes and consumer behaviour. Right type of actions from companies and governments are needed too. For this reason, consultation across multiple ministries, as well as engagement with business investors, community groups, and Non-Governmental Organizations (NGOs) is needed. Institutional support and capacity building would ensure that policymakers, regulators, local business entrepreneurs, and technical personnel have the motivation and skills needed to ensure sustainable developments. Cooperation across the international community is, in turn, a prerequisite for ensuring the desired developments even for less developed countries (Savolainen et al., 2009).

The developments are also affected directly by companies and consumers who may also take a leading role in facilitating the transition towards more sustainable energy systems. Compliance with environmental standards, voluntary agreements striving for sustainability targets, investments in new sustainable energy technologies/services (in form of R&D, venture capital or spin-offs) and sustainable purchasing preferences are among the tools by which individual companies and consumers can have a direct influence on the developments.

The challenges of more sustainable and well-functioning energy systems are formed and faced in interaction by policy makers, companies and consumers who look at the problem from different viewpoints. Information on available alternatives and their impacts is, however, usually inadequate, and the attitudes of decision-makers and consumers do not change over-night when new information is received. This makes the roles of policy-makers, industrial-decision makers and consumers entwined: conscious awareness rising programs and cam-

paings can facilitate and speed up attitude changes towards more sustainable consumer behaviour, corporate social responsibility and long-term thinking. Educational institutions, public authorities, NGOs and media play an important role in changing the attitudes. Attitude changes and serious attention to social responsibility issues, in turn, open up windows of opportunities for new types of market-based instruments to mitigate the climate change and to reach the UN Millennium Development Goals.

The benefits and threats of climate change and energy security may vary depending on the stakeholders and interest groups. Short-term operational-level interests also easily down-play longer-term strategic objectives. For this reason, it is not easy to direct the developments towards the ambitious targets when the transition of energy systems is considered. Desired developments are, however, easier to strive for when fruitful dialogues are taking place between the various interest groups and when the various policy fields coordinate their efforts in a reasonable way. It is thus important that policy and industry efforts at global, regional and national levels are in line with each other. This prerequisites well-grounded strategies, roadmaps and action plans, as well as appropriate forums and tools for this kind of stakeholder cooperation. Commitment of policy makers, policy advisors, public authorities, governmental organisations, industrial players, relevant agencies, NGOs and end-users is important in this respect. The changes in end-user needs and attitudes deserve special attention, as well as potential institutional lock-ins that might hinder the desired developments.

There is an urgent need for a gear-shift in the energy system transition when facing the challenges of today. Understanding the complexity of the transition process and its governance is a prerequisite for successful strategies and action plans. The ambitious long-term targets of energy production and consumption cannot be achieved without understanding the dynamics of the transition process and the interconnectedness of the developments at different levels.

Acknowledgements

The authors are grateful for the materials produced by the GoReNEST project team. Totti Könnölä and Javier Carrillo-Hermosilla from the Centre for Eco-Intelligent Management at Empresa Business School, Madrid, as well as Robert van der Have, Tiina Koljonen and Nina Wessberg from VTT deserve special thanks for the purpose. We also appreciate the opportunity to cooperate with the Nordic Energy Perspectives project when testing the potential of the GoReNEST framework in facilitating stakeholder dialogues. The key people in this respect were Bo Rydén from Profu (coordinator of the NEP2 project) and Anders Sandoff from Gothenburg Business School. The ideas have also developed in the context of writing a chapter for the book “Energy Visions 2050”, an effort coordinated by Ilkka Savolainen and Lassi Similä at VTT.

This study has been possible due to financial support received from the Nordic Energy Research and VTT Technical Research Centre of Finland. Nordic Energy Research has also provided important opportunities to reflect the ideas in the context of NORIA Energy Policy Workshops.

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Appendix A

Analysis framework developed by GoReNEST Task 1.

Landscape	Change dimensions	Present	Short-term	Medium-term	Long-term
	Technological				
	Industrial				
	Policy				
	Social				
Regime	Change dimensions	Present	Short-term	Medium-term	Long-term
	Technological				
	Industrial				
	Policy				
	Social				
Micro	Change dimensions	Present	Short-term	Medium-term	Long-term
	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				

Appendix B

A summary of the example studies and projects examined by the GoReNEST Task 2.

Type of study	National-level Nordic examples (project/study/case)	Joint-Nordic examples (project/study/case)	EU-level examples with Nordic contribution (project/study/case)	Other relevant international examples (project/study/case)
<i>Societal embedding of energy innovations</i>	JUMESCO, JUMPE PIVCO City Bee HyNor, Hydrogen Link, Hydrogen Sweden	SHHP GreenNano	Create acceptance Roads2HyCom	
<i>Consumer research in energy markets</i>	Woodstoves Low-energy houses Climate Bonus		(Create Acceptance) Changing Behaviour (CHANGE)	
<i>Energy system modelling and scenarios</i>	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 2025-07/08 Danish CO2 2020-50 Adaptation-VATT EC-Allocation	NEP1, NEP2 CES 2 grader Climate 2050 CO2 pass through	RES2020 REACCESS NEEDS 2 grader RES2020 ETP 2008	
<i>Energy foresight and technology assessment (TA)</i>	Danish Energy Foresight Energia 2010 Energi 2020+ Risoe Energy Reports 1–6; Renewable energy 2030 in Finland	Nordic H2 Foresight;	HyWays;	
<i>Energy RDD program evaluations</i>	Energy research in Finland		EU energy research evaluation The State and prospects of European Energy Research; European research on H2&FC CCS projects in EU Energy Futures INNER	IEA evaluation–Finland IEA evaluation–Sweden
<i>Energy-related innovation studies, new governance research & benchmarking</i>	SFINNOREG INNOREG I-II		HyCom HYPOGEN	ISU WP 08.12-13

See Loikkanen et al. (2009) for more detailed information on the individual studies and projects.

Appendix C

Example cases examined in GoReNEST Task 3.

The following funding and governance models were examined and analysed by the GoReNEST Task 3:

- European R&I governance for hydrogen energy systems (HTP, FCH JTI, Hy-Co) and related international and Nordic initiatives (IPHE, SHHP)
- Energy Transition Platforms in the Netherlands (Dutch ETPs)
- Strategic Centers of Excellence – a new tool in Finnish innovation system (Finnish energy SHOK)
- Canadian approach against climate change (Canadian approach)
- Strategic Energy Technology Plan for Europe (SET-Plan)

For more detailed information see the Task 3 report of the GoReNEST project (Könnölä et al., 2009).

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Title Governance and Research of Nordic Energy System Transition		
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ISBN 978-951-38-7328-8 (soft back ed.) 978-951-38-7329-5 (URL: http://www.vtt.fi/publications/index.jsp)		
Series title and ISSN VTT Tiedotteita – Research Notes 1235-0605 (soft back ed.) 1455-0865 (URL: http://www.vtt.fi/publications/index.jsp)		Project number 23145
Date November 2009	Language English	Pages 45 p. + app. 3 p.
Name of project GoReNEST		Commissioned by Nordic Energy Research
Keywords Energy system, system transition, transition management, governance, energy policy, innovation policy, policy planning		Publisher VTT Technical Research Centre of Finland P.O. Box 1000, FI-02044 VTT, Finland Phone internat. +358 20 722 4520 Fax +358 20 722 4374

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The GoReNEST project was one of the innovation policy studies funded by Nordic Energy Research in 2007–2008. The Summary Report of the project is intended to serve Nordic policy and decision makers and other key actors responsible for relevant research funding and strategies.

ISBN 978-951-38-7328-8 (soft back ed.)
ISSN 1235-0605 (soft back ed.)

ISBN 978-951-38-7329-5 (URL: <http://www.vtt.fi/publications/index.jsp>)
ISSN 1455-0873 (URL: <http://www.vtt.fi/publications/index.jsp>)

