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Governance of Energy System Transition – Analytical Framework and Empirical Cases in Europe and Beyond. GoReNEST Project, Task 3

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Abstract

Task 1 of the GoReNEST project presented an analytical comprehensive framework of the system transition approach. In spite of that the system transition approach has some commonalities with innovation and energy systems and policies of Nordic countries, only few studies have applied this approach in Nordic countries. Accordingly the objective of Task 1 is to present this approach in detail and consider its wider application potential in order to support the transition towards a sustainable energy system in the future. The attention is paid also to the contribution of Nordic countries to the global transition towards sustainable energy system and the business opportunities from emerging global energy technology markets. Task 2 and Task 3 of the GoReNEST project build much on the system transition framework presented in Task 1.

The energy research in the Nordic countries is extensive and, besides technological alternatives, different economic and social aspects have been analysed in many studies. Hence, in analysing the potential use of system transition approach, 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 in the Nordic energy research. Accordingly Task 2 of the GoReNEST project considers Nordic energy research vis-à-vis different elements, categories and topics of the system transitions frame-work and assesses the potential of this research to contribute to the governance of Nordic energy system transition and policy-planning.

Governance and funding functions and models are an essential part of the transition framework. Hence, within the sys-tem transition framework, Task 3 of the GoReNEST project analyses such governance and funding models as well as the practices and accumulated experiences of these models especially in order to be able to assess their utilisation in the development of the Nordic energy system transition. Moreover Task 3 explores the recent advances in R&D&I governance and funding models.

The conclusions of Task 3 are as follows: Energy system transition is a complex techno-economic and social long-term change process in which governance efforts can play an important role. On a basis of presented empirical cases 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 techno-logical 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.

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Preface

Task 1 of GoReNEST project presented an analytical framework for the system transitions which can be utilized in the planning of the Nordic energy and climate change policy in the future. The framework offers a comprehensive approach and tool that supports a conscious and manageable transition of the energy system in the Nordic countries. The framework pays attention not only to Nordic transition of energy system but also to the necessary global transition, as well as to the utilization of related emerging business opportunities for the Nordic countries.

The energy research in Nordic countries has been extensive and, besides technological alternatives, in these studies different socio-economic aspects have been analysed from many aspects as well. Accordingly, in analysing the potential use of system transition approach, it is important to know whether and how far different elements and dimensions related to this approach have already been explored and analysed in the Nordic energy research. Accordingly Task 2 of the GoReNEST project considers current Nordic energy research vis-à-vis different elements, categories and topics of the system transitions framework, and assesses the potential of this research in order to contribute to the governance of Nordic energy sys-tem transition and related policy-planning. Moreover this consideration raises the important energy research issues and themes for the future with less emphasis so far but being relevant in the transition approach.

Governance and funding functions and models are an essential part of the system transition framework and are considered in detail in Task 3 of GoReNEST project. Task 3 elaborates, within the system transition framework, a detailed analysis of different governance and funding models and their practices and accumulated experiences in order to assess their potential use and utilisation in the energy system transition. Second Task 3 explores the recent advances in R&D&I governance and funding models on a basis of empirical case examples.

The project team of Task 3 of GoReNEST project consists of Totti Könnölä and Javier Carillo-Hermosilla from Centre for EcoIntelligent Management at Empresa Business School, Madrid and Torsti Loikkanen and Robert van der Have from VTT Innovation Studies.

Contents

List of symbols

ERIS	European Research and Innovation System
R&I	Research and Innovation
SHOK	Strategic Centres for Science, Technology and Innovation (Finland)
SET Plan	Strategic Energy Technology Plan of Europe

1. Introduction

Task 1 of GoReNEST project (Könnölä et al. 2008) presented an analytical framework for the governance of Nordic energy system transitions intended to support Nordic energy and climate policy-making. The framework offers an extensive approach and tool that enables a more conscious and manageable energy system transition in the Nordic countries, paying also attention to the global transition towards more sustainable energy production and consumption pattern as well as utilization of increasing global business opportunities in the Nordic countries.

Task 2 of GoReNEST project (Loikkanen et al. 2008) considered past and current Nordic energy research vis-à-vis different categories and topics of the system transitions framework with the aim to see how far different elements of transition framework have been analysed in the Nordic research and to assess the potential of this research to contribute to the governance of Nordic energy system transition. The Nordic research in the field is relatively representative in several areas within the energy system transition framework, and the research done and related research competencies and experiences are an important potential for the further research within the energy system transition framework.

The present Task 3 report of the GoReNEST project considers governance and funding functions and models that are an essential part of the systems transition framework. Hence, within this framework, this report first elaborates in more detail the analysis of different governance and funding models. This consideration is completed also by selected examples of recent international policy initiatives, most of them in energy field (Boxes 1–6). The purpose of presenting these examples is to concretely illustrate the essential features of the different governance modes, giving an idea of how far and in which ways versatile elements and dimensions of the systems transition framework have been taken into account in these various initiatives.

Second, this report analyses empirical case studies of European R&D&I in order to illustrate how different governance modes and arenas interplay in order to support different phases of a process of system transition. The selected cases on the governance and funding models, practices and experiences, considered in the report, are European R&I governance for hydrogen energy systems, Energy Transition Platforms in the Netherlands, Strategic Centers of Excellence in Finland, Canadian approach against climate change, and Strategic Energy Technology Plan of Europe (SET-Plan). The report addresses also cross-sectoral analysis related to opportunities and barriers in the implementation models and practices. Task 3 report is based on web-based search, desk research, and in some cases on expert consultation within research institutes.

2. Framework for Transition Governance

The analytical system transition framework produced by Task 1 of GoReNEST project integrates different transition phases, levels and dimensions and combines them with the governance functions. This report elaborates further and in more detail the analysis of governance in the systems transition framework.

2.1 Functions of governance

In view of the government engagement in the transitions in a proactive role, five governance functions were defined in the report of Task 1 of GoReNEST project (see also Table 1, illustrating the possible contents and objectives of these five governance functions):

- information services, networking, setting common agendas
- strategic procurement
- financing research and education
- grants, equity support and fiscal measures (supply and demand)
- regulation and standards.

In the report of Task 1 of GoReNEST project, the impacts of the described governance functions (Table 4 in Könnölä et al. 2008, in this report Table 1 below) were further considered with regard to the transition phases (Table 5 in Könnölä et al. 2008, in this report Table 2 below). As Table 1 indicates, the role of government policies plays a major role in these governance functions, and, moreover, many of these functions are already in the agenda of policy-making of the European Union and of the Nordic countries.

Table 1. Contents and objectives of the five governance functions.

Governance Functions:	**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 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

Different phases of the transition (*pre-development, take-off, acceleration, stabilization*, see Table 2 below, and Könnölä et al. 2008) are likely to require different kinds of governance with different objectives, tools and engagement of stakeholders (Lund, 2007). For instance the governance in the predevelopment and take-off phases needs to focus on the collaboration towards the establishment of development platforms and supporting competition between different platforms. Even though many even radical innovations emerge from regimes[1], it may be relevant that during the incubation phase the governance efforts foster also activities in which regime advocates (e.g. industrial, policy,

[1] "Regime" refers to the established mainstream techno-institutional policy, industrial and user system delivering a specific function in society. Carbon based energy and transport system is an example of regime (Könnölä et al. 2008).

RTD, etc.) have limited influence in order to ensure the development of competing alternative pathways and the diversity of technological options. The governance in the acceleration phase is likely to put emphasises on the measures to support the improvements in performance of the system and increasing collaboration with the regime advocates. Finally, in the stabilisation phases, the governance should seek the balance between optimization and system renewal (creating opportunities for the next wave of transition). Possible governance actions in the various phases are illustrated in Table 2.

Table 2. Governance functions and corresponding actions in the various transition phases.

Functions:	**Transition phases:**			
	Predevelopment	**Take-off**	**Acceleration**	**Stabilization**
Information services, networking, setting common agendas	Foster competing networks Competing strategies	Consolidation to few networks Consolidation of strategies	Emergence of the dominant network Emergence of the dominant strategies	Opening, diverging the dominant network Divergence of competing strategies
Strategic procurement, (pre-)market	Pre-market R&D support Demonstration projects	Solution-based lead market formation	Solution-based lead market formation	Performance-based procurement
Financing research and education	Pilot infrastructures and training and education for skills, RD&D nodes	Entrepreneurial skills formation		Cost management
Grants, equity support and fiscal measures (supply and demand)	Fostering diversity of viable options (different levels of ambition, engagement according to selected priorities; exchange of information to demonstration) Scientific excellence, quality Awards Credit guarantees Subsidies Vision-based procurement	Supporting convergence among options Priority-setting for quantity, critical mass Awards Credit guarantees Subsidies Solution, technology based procurement Lead market infrastructures, and institutions	Taxes Emission permits Performance based procurement Infrastructural and institutional expansion	Taxes Emission permits Performance based procurement Infrastructure and institution maintenance
Regulation and standards	Alternative enabling standards Regulatory plans Vision based regulation	Dominant standards Regulatory plans Vision based regulation	Dominant standard Regulatory support Top-Runner regulation	Regulating for performance and change

2.2 Towards multi-arena and multi-mode governance of system transitions

The report of Task 1 of GoReNEST project (Könnölä et al. 2008) addressed the governance functions and identified examples for addressing system transitions. In this paper, we elaborate the role of governance further, taking into account multiple modes and arenas in the governance of systems transitions. In the following sections 2.2.1–2.2.2 the governance is typified in four modes of governance (integration, coordination, competition and co-existence) which function on three different arenas (performing, programming and strategic orientation). The consideration of governance modes is completed by selected real-life examples of recent international policy initiatives mostly from energy field (boxes 1–6) in order to illustrate concretely how far and in which ways modes of governance of the systems transition framework have been taken into account in these initiatives. Section 2.2.3 presents the combination of these modalities of governance, shaping the three arenas, which influence on the different phases of transition process. Section 2.4 first combines the four modes of governance and the three arenas and, by presenting examples of policy initiatives within the framework of arenas and modes of governance, conceptualizes how the actors interact.

2.2.1 Modes of Governance

Building on cultural theory (Thompson et al., 1990) of social organisation, we identify four different modes of governance. According to the cultural theory, social organisation can be understood in view of the extent to which an individual is bound in a unit (or social group) and in view of the degree to which an individual's life is determined by external prescriptions (rules and norms). We abstract these basic "forces" to the higher societal level of R&I governance. This allows us to understand more systematically how R&I governance can exercise its influence. Two dimensions can be illustrated as axes that form four approaches[2] to social organisation. Building on Tukker and Butter (2007), from the view point of governance, we define four modes, respectively (Figure 1):

- integration of R&I efforts
- co-ordination of R&I activities
- competition between R&I activities
- co-existence.

[2] A fifth possible way of social organisation would be the solitary person who escapes from coercive or manipulative social involvement altogether. However, this is not relevant for our abstraction.

With each of the four governance modes described below, we will introduce one real-life example, presented in boxes 1–6.

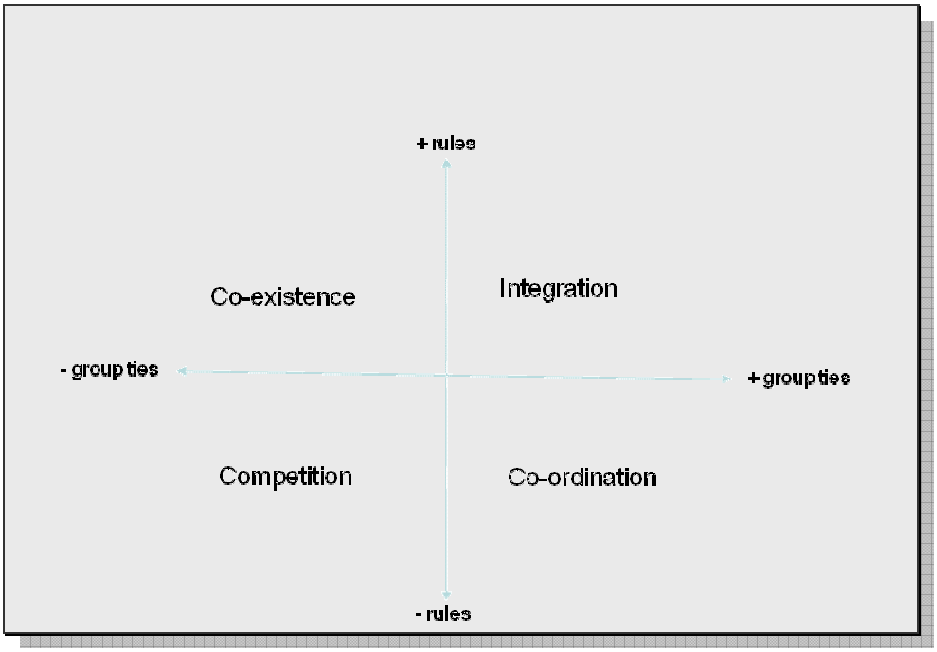

Figure 1. Modes of Governance (modified from Tukker and Butter, 2007).

Integration

Integration mode of governance relies on to the hierarchical structures and the use of power and respective means to direct the R&I system. In line with the cultural theory, the existence of strong rules and group ties refer to hierarchies, e.g. asymmetrical transactions that require accountability – hierarchical structures are used to set and execute the plans in order to direct the system. In the innovation policy literature such projects have been referred as "mission oriented" policy measures (e.g. Ergas 1987). For instance, a good example of such a hierarchical top-down approach is the Kennedy´s "Man on the Moon" project, which integrated the considerable resources and efforts to reach an ambitious goal. ITER and Galileo, described in boxes 1–2, are examples of projects in which the Member States and third parties have set up hierarchical structures that enable sufficient allocation of resources for large-scale R&I activities.

BOX 1. ITER, International Project on Fusion Power

ITER is a joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power. The partners in the project - the ITER Parties - are the European Union (represented by EURATOM), Japan, the People´s Republic of China, India, the Republic of Korea, the Russian Federation and the USA. ITER will be constructed in Europe, at Cadarache in the South of France.

The construction costs of ITER are estimated at five billion Euros over 10 years, and another five billion Euros are foreseen for the 20-year operation period. The contributions of the ITER Parties will for the largest part consist of components for the machine, so-called in kind contributions.

In June 2005, it was decided by the Parties to construct ITER in Cadarache, in the South of France. On 21 November 2006, a Joint Implementation Agreement was signed by the Parties, which established the international ITER Organization. The ITER Organization owns the ITER device and is responsible for all aspects of the project: the licensing procedure, hardware procurements mostly provided in kind by the Parties, the operation period, and ultimately for decommissioning of ITER at the end of its lifetime.

(Source: http://www.iter.org/a/index_nav_1.htm.)

BOX 2. Galileo European Satellite Project

Satellite navigation users in Europe today have no alternative other than to take their positions from US GPS or Russian GLONASS satellites. Yet the military operators of both systems give no guarantee to maintain an uninterrupted service. Galileo will be Europe's own global navigation satellite system, providing a highly accurate, guaranteed global positioning service under civilian control. It will be inter-operable with GPS and GLONASS, the two other global satellite navigation systems. A user will be able to take a position with the same receiver from any of the satellites in any combination. By offering dual frequencies as standard, however, Galileo will deliver real-time positioning accuracy down to the metre range, which is unprecedented for a publicly available system.

Galileo is a joint initiative of the European Commission (EC) and the European Space Agency (ESA). The Galileo partners include the GNSS Supervisory Authority, which replaced the Galileo Joint Undertaking (GJU) on 1 January 2007. The GJU initiated the development of a full set of applications through calls for ideas in the framework of the European Commission's research and development programmes. The GJU was also intended to select a Galileo concessionaire within a private-public partnership.

(Source: http://www.esa.int/esaNA/GGG0H750NDC_galileo_0.html.)

Co-ordination

Co-ordination mode builds on the egalitarian perspectives in the governance. In line with the cultural theory, strong group ties and low rules, mean that different actors are equally important. Hence, instead of hierarchical relations enforcing action, the changes

are achieved through the building of voluntary coalitions of actors with equal status (symmetrical transaction) and the sense of accountability (actors consider themselves accountable to one another). Thus, mutual learning and intensive communication among actors to coordinate required common action is considered as the key element in the co-ordination mode of governance. In particular, the implementation of the Dutch transition management in the national transition platforms seems to follow the principles of the co-ordination mode of R&I governance (we will go in more detail on this case later in this report).

In the context of the European Research Area, already in the Fifth Framework Programme (FP5) the Commission implemented a strategic shift from the funding of technological development towards a more comprehensive innovation policy with the emphasis on the open-method of coordination (OMC), which is an inter-governmental mechanism of voluntary cooperation of European policies (Arrowsmith et al., 2004; Kaiser & Prange, 2004; Schäfer, 2006). In the innovation policy field, the OMC has been implemented by introducing new networks, stakeholder forums and policy processes or, more generally, coordination tools which encourage stakeholders to co-ordinate and self-organize the formation of common RD&D agendas (Könnölä et al., in press). Such coordination tools have been promoted, for example, within 'Integrated Projects', 'Networks of Excellence', 'ERA-Nets', 'European Technology Platforms' and most recently 'Technology Initiatives'.

BOX 3. The International Partnership for the Hydrogen Economy

Purpose of the initiative:

The International Partnership for the Hydrogen Economy (IPHE) provides a mechanism to coordinate multinational research, development and deployment programs that advance the transition to a global hydrogen economy. The IPHE leverages limited public and private resources; reviews the progress of collaborative projects; identifies promising directions for research, development, demonstration, and commercial use; provides technical assessments for policy decisions; prioritizes, identifies gaps, and develops common recommendations for international codes, standards and safety protocols; and maintains communications with the private sector and other stakeholders to foster public-private collaboration that addresses the technological, financial and institutional barriers to a cost-competitive, standardized, widely accessible, safe and environmentally benign hydrogen economy.

Official government partners:

Australia, Brazil, Canada, China, France, Germany, Iceland, India, Italy, Japan, New Zealand, Norway, Republic of Korea, Russia, United Kingdom, the United States of America, and the European Commission.

Non-member participants:

International Organizations: Asia-Pacific Economic Cooperation and International Energy Agency.

Civil Society and Private Sector: Individuals and members of industry associations with an interest in the hydrogen economy are informed about activities within the IPHE and are encouraged to participate and interact with the IPHE. Please see http://www.iphe.net/LGSA.htm for a list of the industry stakeholder associations that constitute the "IPHE Liaison Group of Stakeholders Associations."

Partnership goals:

The IPHE will be successful when the following factors characterize the world's transportation and stationary power sector:

- Hydrogen-powered vehicles are competitive with conventional vehicles.
- The price and availability of hydrogen are competitive with conventional fuels.
- Hydrogen fuel is conveniently available to hydrogen vehicle drivers, based on improved fuelling and storage infrastructure.
- Hydrogen energy storage technologies will allow personal transportation systems to operate at the same levels of safety, performance and range as today's gasoline powered vehicles.
- An internationally consistent system of safety codes and standards related to hydrogen utilization is developed and adopted.
- Distributed power generation using hydrogen fuel is cost competitive with traditional stationary power systems.

Progress toward goals:

The inaugural IPHE Ministerial meeting was held November 19-21, 2003 in Washington DC. The IPHE's original 16 partners signed a "Terms of Reference" document and the partnership's Steering and Implementation-Liaison Committees held their initial meetings and charted their next steps.

Since the Ministerial meeting, the Partnership has added New Zealand as a member and each of the Committees have conducted five meetings (see italicized entries in the table in the Next Steps section) to organize the IPHE and facilitate activities that will achieve the goals of the IPHE.

Since its launch in 2003, the IPHE has established

- an active IPHE Secretariat, the principal coordinator of IPHE communications and activities
- an IPHE Evaluation Team to review proposed collaborative efforts
- a process for Stakeholder Involvement that allows both government and private sectors to work in partnership toward advancing the hydrogen economy
- a process for developing an IPHE Technology Priority Scorecard and Activities Matrix that will enable IPHE members to more effectively collaborate on research, development and demonstration (R,D&D) to address the key technology barriers to a hydrogen economy.

IPHE has developed

- working principles and criteria for IPHE endorsement of collaborative R,D&D projects and international events
- scoping Papers to provide the foundation for the development of the Priority Scorecard and Activity Matrix. The papers summarize the current state of technology, identify technical barriers to commercial deployment, and further prioritize concrete projects, events and actions to be undertaken by IPHE Partners that will advance technology development and deployment
- outreach materials and web publications to disseminate information and increase awareness on the objectives of IPHE and the benefits of a hydrogen economy
- a series of international workshops to identify specific collaborative opportunities to advance the hydrogen economy. These workshops have led to collaborative project proposals on fuel cells; hydrogen production; hydrogen storage; regulations, codes and standards; socioeconomics of hydrogen; and hydrogen education.

Resources:

The USG hosts the IPHE Secretariat Office, including a Visiting Analyst from the Republic of Korea, through 2007. Other IPHE partners have provided financial and in-kind resources for meetings, workshops and conferences.

In 2003, President Bush committed to fund hydrogen fuel and fuel cell vehicle R, D, &D at $1.7 billion from FY 2004 - FY 2008. The USG is actively pursuing collaborative R, D&D projects and activities using the IPHE framework in order to effectively leverage the Presidential resource commitment with resources from the private sector and other IPHE members to advance the transition to the hydrogen economy.

Additional information: http://www.iphe.net.

BOX 4. The Clean Energy Initiative: Powering Sustainable Development from Village to Metropolis

Purpose of Initiative:

This initiative seeks to provide millions of people in the developing world with access to affordable, reliable, clean, healthy, and efficient energy services. This U.S.-led, multi-year, initiative has four programs to achieve key goals:

- **The Global Village Energy Partnership** will increase access to modern and affordable energy services in areas either not served or under-served by current energy delivery systems. (USG lead: USAID)
- **Efficient Energy for Sustainable Development** will improve the productivity and efficiency of energy systems, while reducing waste and pollution, saving money, and improving reliability through more energy efficient processes and technologies, and production modernization. (USG lead: DOE)
- **The Partnership for Clean Fuels and Vehicles** will reduce vehicular air pollution in developing countries through the promotion of clean transportation fuels (e.g. unleaded gasoline, low sulphur fuels), and vehicles. (USG lead: EPA)
- **The Partnership for Clean Indoor Air** will promote healthier indoor cooking and heating practices to reduce the estimated 1.6 million annual, preventable deaths associated with breathing indoor air pollution from burning traditional biomass fuels (wood, dung, crop residues) and coal indoors for home cooking and heating. (USG lead: EPA)

Partners:

- **The Global Village Energy Partnership (GVEP)**: More than 1,000 organizations (government, private sector, and civil society) representing over 90 countries have committed to the Partnership's Statement of Principles, thereby becoming GVEP partners. The partner breakdown includes 44% from NGOs, 31% from the private sector, 11% from bilateral and developing country governments, 7% consultants, 3% from multilateral organizations, and 4% other. For a complete listing of partners, please visit the GVEP website at http://www.gvep.org.
- **Efficient Energy for Sustainable Development (EESD)**: More than 80 organizations (government, industry, and civil society) have committed to the objectives of the Efficient Energy for Sustainable Development Partnership. The partner breakdown includes 30% from business and industry 21% from NGOs and academia, 20% financial institutions, 20% from bilateral and country governments, and 8% multilateral organizations. The EESD website, www.pi.energy.gov/clean_energy_initiative offers a complete listing of partners.
- **Partnership for Clean Fuels and Vehicles (PCFV)**: Over 80 organizations from government, industry, and civil society have committed to the Partnership for Clean Fuels and Vehicles. The partner breakdown includes 22% from NGOs, 30% from the private sector, 30% from governments, and 18% other (international organizations, private consultants, academic institutions). A complete list of partners can be found at http://www.unep.org/pcfv/main/main.htm.

- **Partnership for Clean Indoor Air (PCIA)**: The Partnership has grown to more than 120 organizations working in 67 countries to improve health, livelihood, and quality of life by reducing exposure to indoor air pollution from household energy use. The partner breakdown includes 14% from governments, 79% from NGOs and the private sector, 7% from multilateral organizations, and 4% other. A complete list of partners can be found at www.PCIAonline.org.

Partnership Targets:

- **The Global Village Energy Partnership**: Targets established for the 10-year Partnership, to be accomplished by the year 2012, include over 30 countries with a National Action Plan for energy-poverty programs; over 400 million additional people with access to modern energy services; and over 50,000 communities serviced with electricity.
- **Efficient Energy for Sustainable Development**: The EESD partnership seeks to achieve its objectives through activities along three tracks: promoting public sector leadership by example; facilitating locally managed financial programs to attract affordable and long-term financing; and advancing sustainable community design and development. The partnership aims to achieve at least 10% energy efficiency gains through project development in up to 20 host countries over 10 years; establish U.S. community partnerships in up to 8 countries; and facilitate government energy management plans saving at least 10% of budget overhead costs in up to 10 countries.
- **The Partnership for Clean Indoor Air** is bringing together governments, industry, and non-governmental organizations to increase the use of affordable, reliable, clean, efficient, and safe home cooking and heating practices. The Partnership aims to reduce the mortality related to indoor air pollution in targeted areas by 50%. The Partnership is mobilizing the resources and expertise of Partners to achieve its' mission by focusing on four priority areas: addressing social and cultural factors through public awareness and education campaigns; developing local markets and financing mechanisms for improved cooking alternatives; improving the design and performance of cooking and heating technologies; and monitoring the indoor air pollution, health and environmental impact of interventions.
- **The Partnership for Clean Fuels and Vehicles** is a global partnership focused on eliminating lead in gasoline worldwide and reducing sulphur in gasoline and diesel fuels, along with support for the development and adoption of cleaner vehicle requirements. Partnership goals include the global elimination of lead in gasoline by the end of 2008, and a world-wide goal of reducing sulphur in transportation fuels to less than 50 ppm.

Resources:

- The U.S. launched the Clean Energy Initiative at the World Summit on Sustainable Development with a commitment of $42 million. U.S. funds will leverage up to $400 million in additional resources from other partners, over the next several years.

Additional information: http://www.sdp.gov/.

Competition

Competition driven governance mode relies on the markets as a principle mechanism for social organisation. According to the cultural theory, low group ties and hierarchical rules mean that actors are offered equal opportunities, which are exploited mainly through symmetrical transactions driven by individual interests. In line with the invisible hand of Adam Smith, such fragmental transactions in the markets form all together the efficient use of resources in the system. Hence, the role of governance is limited in support of the well functioning of the markets rather than directing the markets. For in-

stance, the development of European common markets and tax reductions as R&I incentives can be seen as examples of competition mode of governance of the R&I system.

BOX 5. Japanese Top-Runner Program

When the Kyoto Protocol was entered into and greenhouse gas reduction goals were established, strengthened energy conservation measures were specified as leading measures to counter global warming. Japan consequently revised the Energy Conservation Law in April 1999 with the goal of strengthening the legal underpinnings of various energy conservation measures. As a staple energy conservation measure for the residential and commercial sector and the transportation sector, the Top Runner Program was introduced to advance energy efficiency of machinery and equipment:

- METI standards for 21 energy-using products.
- The ''top-runner'' regarding energy efficiency becomes the basis of the product standard (weighted average).
- Efficiency standard becomes mandatory for national producers and importers once the target year is reached.
- ''Name and shame'' approach is used as an intermediate instrument.
- Combined regulations: Green Procurement Law (2001), Green automobile tax, Annual awards for energy efficient products, energy label, support for innovative retailers.

The fulfilment of the standards is generally very positive. Several products have achieved the standard before the target year (air conditioners, cars, computers, videotape recorders). Increased competitiveness of the products has confirmed by producers. It is now needed to consider specifying additional product categories from commercial machines and equipment which are currently covered only by 20%, and newly prevailing high energy-consuming products. Regarding commercial machines and equipments, many products are exempted from the target candidates due to the lack of established objective and quantitative method to measure the energy consumption efficiency. Therefore, it is particularly required to examine the measuring method and strengthen the countermeasures for commercial sectors where energy consumption considerably increases.

Sources: Jänicke (2008) and The Top Runner Program in Japan: http://www.eccj.or.jp/top_runner/index_contents_e.html.

Co-existence

Co-existence as a governance mode is fundamentally a reactive approach to develop the system. According to the cultural theory low group ties and strong rules mean that despite the existence of rules there is no sense of accountability that would lead to proactive use of hierarchical structures. Still the rules limit the expression of individual interests which might drive to change. Thus, the passive approach may be adopted until the benefits are considered clearly higher than the costs of participation, e.g. free-riding. Co-existence mode of governance can be seen in the European context as a limited efforts in some Member States in the participation in the development of the R&I system both in the national and the European level. Such wait-and-see approaches may be

driven partly by uncertainties in the future of the ERIS and partly by the lack of capabilities to take up more proactive modes of governance.
In conclusion, the essential content of each of the four modes of governance considered above are shortly summed up in Table 3.

Table 3. Modes of governance.

Integration mode of governance • The proactive use of hierarchical structures with power and means to implement selected R&I activities
Co-ordination mode of governance • Coordination of voluntary engagement in coalitions in order to develop common R&I activities
Competition mode of governance • Optimising the market conditions for R&I
Co-existence mode of governance • Reactive, wait-and-see until new opportunities

2.2.2 Combining governance modes

According to Thompson et al. (1990), the cultural theory considers that the different forms of social organisation co-evolve in society: there is a positive feedback system that prevents extinction of any of them. In view of governance of the ERIS, it may be beneficial to develop structures that build not only one of these modes but on the positive feedback loops between the modes. Tukker and Butter (2007) suggest that systemic transition processes require the interplay of different dimensions of social organisation. For instance, transitions may emerge through proactive co-ordination that may lead to changes in competition and integration modes of governance. Alternatively, the governance system may adopt a co-existence mode until the abrupt changes in the environment force governments to take up new measures in other modes of governance – for instance an economic recession leading to uptake of new policy measures to incentivise R&I as a mean to create new economic growth.

In terms of governance of ERIS, the challenge is to combine the different approaches in an effective way in the identified three arenas of strategic orientation, programming and performing. Here, transition processes may start for instance from co-ordination mode (transition management in The Netherlands), and moving towards competition (Kioto Protocol) or Integration (ITER). Alternatively, transition analysis may start from the co-existence (lock-in) and radical change is made due to external factor (energy prices) and other modes are initiated.

Table 4 presents which functions of governance discussed in Table 1 correspond the various modes of governance.

Table 4. Modes and respective functions of governance.

Modes of Governance	**Functions of governance**
Integration	Strategic procurement, (pre-)market Financing research and education Regulation and standards
Co-ordination	Information services, networking, setting common agendas
Competition	Grants, equity support and fiscal measures (supply and demand) Regulation and standards
Co-existence	No specific governance functions applied

One recent example of the combination of different governance modes is the Lead Market Initiative (LMI) (COM(2007)860). The European Council endorsed the Commission's proposal in its broad based innovation strategy to launch a lead market initiative to develop an appropriate approach in a limited number of potential lead markets. Key features of such markets and of the initiative are:

- The aim is not "to pick winners", nor to artificially create a market for a given technology or pre-empt the development of other competing options.
- The assessment of the market potential and of the demand side (including of users' needs) is a crucial point.
- The added-value of the initiative is about developing a prospective, concerted and focused approach of regulatory and other policy instruments to allow a varied set of technologies and of innovative business models to meet rapidly the demand and to benefit from a mobilising effect generated by this initiative.

Six markets have been identified for the initial stage of the initiative; eHealth, protective textiles, sustainable construction, recycling, bio-based products and markets for renewable energies. These six market sectors are suitable for inclusion in this stage of the Lead Market Initiative, because they are (1) highly innovative, (2) supported by well characterised customer needs and (3) a strong technological and industrial base in Europe and (4) depending more than others on the creation of favourable framework conditions as a result of public intervention.

The LMI consists of coordinated priority actions in each market area. The actions deploy a core set of policy instruments. What follows, we discuss this set of policy instruments in relation with the LMI in the renewable energy.

- **Legislation:** The LMI constitutes an opportunity to improve the coordination of various sets of regulations across different policy areas that affect markets for innovative products and services. Reliable, lean and well designed legislative

and jurisdictional environments are essential for business to invest in innovation and for consumers to take up new products and services.

- **Public procurement:** Mobilising public authorities to act as 'launching customers' by promoting the use of innovation-friendly procurement practices is therefore a frequent measure in the action plans, taking into account risks and regulatory limitations.
- **Standardisation, labelling and certification:** More consistent technical, performance and product standards along the whole production chain, from raw materials to end products, could make standardisation more innovation-friendly.
- **Complementary instruments:** In certain market areas, measures to provide business and innovation support services, training and communication are deemed a necessary complement to the above policy instruments. In some instances, financial support and incentives which aim at facilitating the interaction of customers with the innovating companies and their solutions are considered advantageous. Such schemes could involve Structural Funds and State aid funding.

BOX 6. A Lead Market Initiative (LMI) in markets for renewable energy

Among the six chosen markets for the LMIs, it has also been identified markets for renewable energies. The set of policy instruments have been planned to implement in these markets:

Legislation

Promote the Internal Market in renewable energies by removing barriers to the integration of renewable energy sources in the EU energy system.

- Replace current legislation (e.g. Renewable Electricity Directive) with measures that: allocate the 20% renewable energy target amongst the Member States; require national action plans that set out pathways and to standardise EU guarantee of origin regimes to enable EU-wide flexibility in meeting national targets; create the framework for opening the market for guarantees of origin; set out environmental sustainability criteria; anticipate future qualifications and skills needed to favour the uptake of renewable energy sources.

Remove barriers for renewable energy development and simplify authorisation procedures.

- Remove planning and certification barriers to the uptake of renewables; Incorporate renewable energy in building codes; Provide guidelines for authorisation procedures; Eliminate red tape for SMEs.

Public procurement

Increase the share of renewable energy purchased by the public authorities.

- Establish a network between public purchasers of renewable energy to apply the Commission guide on public procurement for innovation; Identify via that network good practices in the field of procurement of renewable energy and promote their application across the EU.

Standardisation, labelling and certification

Reap the benefits of the EU internal market through a coordinated approach for standard setting and labelling on technologies for energy generation and transmission.

- Continue the process of adopting minimum energy performance standards (eco-design require-

ments) in the form of implementing Directives for 20 priority product groups including boilers, water heaters, consumer electronics, copying machines, televisions, standby modes, chargers, lighting, electric motors and other products.

- Ensure that appropriate measuring methods will be developed on time through CEN/CENELEC or other appropriate means. Products that do not meet the agreed minimum requirements may not be placed on the market (c.f. EEAP Priority).

Develop European sustainability standards in the value-chain for production of renewable energy in Europe.

- Begin with the creation of a bio fuels sustainability regime in the new renewable energy Directive. In line with the Biomass Action Plan, consider the extension of the regime to other areas.

Complementary instruments

- Mobilise public and private financing: Promote the exchange of experience in financing from such funding mechanisms as the EU Structural Funds, European Investment Bank initiatives specific to renewable energy – workshops, networks etc. Strengthen the EU support through e.g. CIP-IEE, LIFE+, FP7, or Structural Funds to bridge the gap between successful demonstration of innovative technologies and effective market entrance.

- Develop the state of the art business cases for an effective supply chain in different renewable energies.

- Anticipate the future qualifications and skill needs to uptake innovation in renewable energy and to enable its fast implementation.

- Support the internationalisation of renewable energy technologies.

- Further investigation and identification of the barriers hindering the commercialisation of renewable energies.

Sources: Communication "A lead market initiative for Europe" - COM(2007)860 (21.12.2007); Annex 1 - Thematic Action Plans.

2.2.3 Arenas of governance

Towards the comprehensive understanding of institutional arrangements of governance, it is crucial examine different arenas in which the governance appear. The typified three arenas build on the conceptual framework presented by Rémi Barré (2007) in the French Futuris project. The three arenas – or functional spaces – are the following (see also Schoen et al, 2008):

- **the arena of strategic orientation** of research, where visions are set concerning the future of the research system, the overarching objectives, and the level of funding for research and innovation policies
- **the arena of programming of research**, where programmatic and thematic priorities are set and where resources are allocated; in this second arena operate intermediation institutions, which prioritize, fund, regulate and interface R&I with the political processes and the stakeholders

- **the arena of research performance** in which operate the institutions which perform R&D, education and innovation (universities, research organisations, firms).

The arena of strategic R&I orientation

Strategic orientation refers to institutionalised mechanisms which are implemented through budgetary planning. For instance, EU and national budget allocations should be considered as key element in this function. Legal framework can be another critical factor for steering research. Regulations concerning environmental or social issues (for instance REACH) can contribute to steer research. Legislative bodies should therefore be considered as belonging to this steering arena. Also industry actors play an important role by selecting the R&I areas in which they decide to invest. The aggregated result of firms' individual strategic choices is essential in shaping the development of research. Finally, organisations of stakeholders (industry associations, or NGO...) which are involved in the production of long term visions and of strategic agendas (for instance within European Technology Platforms) identify desired futures and thus influence policymakers' strategic choices.

The arena of R&I programming

At the European level, the arena of R&I programming refers to the mechanisms performed by various European Commission, national ministries and agencies for translating macro-objectives (global amount allocated of resources along key orientations) in practical governance actions. These tasks cover the responsibilities for setting priorities and programming. The funding of research by industry actors plays also a role for programming the production of new knowledge.

The arena of research performance

The performance of research refers to the coordination of activities of all public research institutions (research organisations and universities) and of research performing firms. The key elements of the three arenas characterising their institutional arragengements are summarised in Table 5.

Table 5. Elements characterising institutional arrangements.

Strategic orientation arena: • Nature and importance of institutions coordinating strategic choices • Legal and social drivers steering research strategic choices • Stakeholders forum
Programming arena: • Nature and importance of coordinating transnational institutions (academies and learned societies) • Extent of private funding and market drivers
Performing arena • Transnational research centres • Shared large facilities and infrastructures • Intensity of transnational cooperation (established/raising/weak)

2.3 Arenas and modes of governance

Towards the comprehensive understanding of institutional arrangements of governance in specific R&I fields the three arenas of governance provide a relevant starting point for the analysis. To conceptualise how the actors interact on these arenas we define four modes of R&I governance. This supports the characterisation of the institutional arrangements in view of both the level (the arenas) and the form (the modes) of governance (see Table 6 for examples).

Table 6. Examples within the framework of arenas and modes of governance.

	Integration	**Co-ordination**	**Competition**	**Co-existence**
Strategic orientation	FP7 Work Programme Lead Market Initiative (LMI)	Open Method Coordination (OMC) CREST Lead Market Initiative (LMI) International Partnership of Hydrogen Economy (IPHE)	Common markets, National R&I strategies Lead Market Initiative (LMI)	No transition agenda setting
Programming	Art. 169, 171 (ERA-NET Plus, JTI)	Era-NETs, ETPs	National programmes	No transition program setting
Performing	ITER	Partnering for stronger proposals	National project execution	No transition R&D

2.4 Arenas and modes of governance and phases of transition

Arenas and modes of governance can be lined with the transition phases to pinpoint the evolutionary perspective in the transition governance. Indeed, the governance of transition requires holistic view, how different modes on different arenas can interact to support transition in its different phases. In D1, we defined the following main transition phases:

- **predevelopment** (incubation) with the diversity of experimentation activities
- **take-off** of the process of transition
- **acceleration** of the change process with the increasing returns of economies of scale that support the diffusion of new solutions and lead to structural change
- **stabilization** with the decreases in the speed of societal change.

In Figure 2, the governance arenas and governance modes are combined with the phases of transition in order to provide an overall idea of the dimensions to be taken into account in the governance (see also Könnölä et al. 2008).

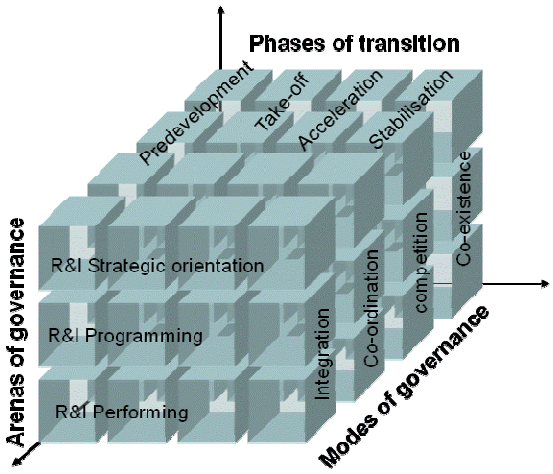

Figure 2. Linkages between the arenas and modes of governance and the phases of transition.

In order to develop action plans for systems transition it is beneficial to adopt agent based view that encourages the identification of key promoters and inhibitors of change. Towards this end, we elaborate and adjust the framework developed in D1 and consider the four dimensions of change also as groups of change agents in the system:

- technological change refers to R&D actors
- industrial change refers to industrial actors
- policy changes refer to policy-makers
- social change refers to third sector (non-governmental organisations, NGOs).

When the dimensions of change and agents are combined with the modes and arenas of governance it is possible to construct a framework to be used in the analysis of the transition governance initiatives and related activities within the system (see Table 7).

Table 7. Framework for the governance of systems transitions.

Strategic orientation	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)				
	Industrial				
	Policy				
	Social (NGOs)				
Programming	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)				
	Industrial				
	Policy				
	Social (NGOs)				
Performance	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)				
	Industrial				
	Policy				
	Social				

3. Case Studies

The aim of Chapter 3 is to illustrate how different governance modes and arenas can interplay in supporting the different phases of transition process. For this purpose Chapter 3 presents selected empirical case studies that are built on the system transition framework or at least on some key elements characterizing the system transition framework. In order to illustrate a variety of different empirical cases, the studies selected as case examples are relative recent ones, they origin from different national policy cultures in Europe, and they represent both national and European levels in policy-making. The first study, examined in Section 3.1, is the European R&I governance for hydrogen energy systems, its development and deployment. The second case study of Section 3.2 describes the Energy Transition Platforms in the Netherlands and their recent advances in the application of transition management framework in the energy sector. The third case study in Section 3.3 is about Strategic Centers of Excellence (SHOKs), the recent public-private partnership initiative in innovation policy in Finland. One of the SHOKs is related to energy issues and discussed in detail below. The fourth case study in Section 3.4 analyses the Canadian approach against climate change. The fifth case study in Section 3.5 is about the Strategic Energy Technology Plan of Europe (SET-Plan). Besides these cases, the report addresses cross-sectoral analysis related opportunities and barriers in the implementation models and practices.

3.1 European R&I governance for hydrogen energy systems

Hydrogen and fuel cell based energy systems is one of the areas in which European governance and research seem to have gradual evolved from co-existence to coordination and integration modes of governance as well as from the development of common strategic orientations towards the common programming and R&I performing.

Governance modes and arenas

Even though the co-existence of national research programmes is still reality, there have been major advances in the coordination and integration modes of governance in the Euro-

pean and international level. The International Partnership for the Hydrogen Economy (IPHE, see also Box 3 of this study) has provided multinational and multi stakeholder platform for the coordination of RD&D efforts in the field of hydrogen and fuel cells. The coordination mode of governance has also been strongly supported within the FP5 and FP6 in a number of activities in different sub-areas and geographical regions. For instance in the FP6, some 300 M€ were invested in the area covering fields such as energy systems, surface transport and aeronautics, materials, SMEs, new and emerging science and technology, training actions, and international co-operation. In particular, the HY-CO Era-Net has been a relevant mechanism to coordinate national programmes and launch joint calls. HY-CO has also provided an interface with the European H2/FC Technology Platform (HFP) both in HFP Member States Mirror Group of and interacted with the HFP Advisory Council.

In the national and regional level further advances have also emerged to coordinate activities among different stakeholders and national initiatives, for instance the Scandinavian Hydrogen Hyway Partnership (SHHP) constitutes a transnational networking platform that catalyses and coordinates collaboration between three national networking bodies – HyNor (Norway), Hydrogen Link (Denmark) and Hydrogen Sweden (Sweden). Furthermore, the collaboration consists of regional clusters involving major and small industries, research institutions and local/regional authorities. SHHP coordination activities include the development of joint implementation plan merging the three individual national plans, aiming at a large scale demonstration in Scandinavia as well as the development of standards and certification. Furthermore, SHHP has taken first steps towards integration mode of governance through the joint purchasing of hydrogen vehicles.

In Europe, the major leap towards the integration mode of governance was taken, when May 30, 2008, the EU's Competitiveness Council adopted the regulation on the establishment of the Joint Technology Initiative (hereinafter referred to as "JTI"). It will be implemented through Joint Undertakings within the meaning of Article 171 of the Treaty. The Fuel Cell and Hydrogen Joint Technology Initiative (FCH JTI) was established as a result of the work of European Technology Platforms, already set up under the Sixth Framework Programme covering selected aspects of research in their field. HFC JTI should combine private-sector investment and European public funding, including funding from the Seventh Framework Programme.

In May 2003 a Hydrogen and Fuel Cell High Level Group presented a vision report on “Hydrogen Energy and Fuel Cells – a vision of our future”, recommending, inter alia, the formation of a fuel cell and hydrogen technology partnership and a substantially increased RTD budget, as well as a demonstration and pilot programme to extend the technology validation exercises into the market development arena. In December 2003, the Commission facilitated the creation of the HTP, bringing together all interested stakeholders in a joint effort to move towards achieving the High Level Group’s vision. In March 2005, the said Technology Platform adopted a Strategic Research

Agenda and Deployment Strategy, aimed at accelerating the development and market introduction of fuel cell and hydrogen technologies in the Community.

The technology challenge facing fuel cells and hydrogen is of great complexity and scale and the dispersion of technical competencies is very high. Therefore, in order to achieve critical mass in terms of scale of activity, excellence, and potential for innovation, this challenge needs to be tackled in a focused and coherent way at EU level. This and its potential contribution to the Community policies, in particular energy, environment, transport, sustainable development and economic growth, call for the JTI approach in this sector. The objective of the JTI on "Fuel Cells and Hydrogen" is to implement a programme of RTD activities in Europe in the fields of fuel cells and hydrogen. These should be carried out, building on the EHFC TP, with the cooperation and involvement of stakeholders from industry including small and medium-sized enterprises (hereinafter referred to as "SMEs"), research centres, universities, and regions.

Between 2008 and 2017, the FCH JTI will have a budget of EUR 1 billion. The investment will be shared by its two founding members, the European Commission and the European Fuel Cell and Hydrogen Joint Technology Initiative Industry Grouping, a non-profit organisation uniting the sector's key players (New Energy World IG).

To that end, the FCH Joint Undertaking should be able to organise competitive calls for proposals for projects to implement the RTD activities. Research activities should respect fundamental and ethical principles applicable to the Seventh Framework Programme. Further financing options may be available, inter alia, from the European Investment Bank, in particular through the Risk-Sharing Finance Facility developed jointly with the European Investment Bank.

FCH JTI will in particular

- aim at placing Europe at the forefront of fuel cell and hydrogen technologies worldwide and at enabling the market breakthrough of fuel cell and hydrogen technologies, thereby allowing commercial market forces to drive the substantial potential public benefits
- support R&I in the Member States and countries associated with the Seventh Framework Programme (hereinafter referred as "Associated countries") in a coordinated manner to overcome the market failure and focus on developing market applications and thereby facilitate additional industrial efforts towards a rapid deployment of fuel cells and hydrogen technologies
- support the implementation of the RTD priorities of the JTI on Fuel Cells and Hydrogen, notably by awarding grants following competitive calls for proposals
- aim to encourage increased public and private research investment in fuel cells and hydrogen technologies in the Member States and Associated countries.

It can be summarised that the HY-CO Era-Net together with the HTP offered sufficient coordination mode of governance that have lead to the establishment of FCH JTI, e.d. integration mode of governance. Even though the competitive calls have been chosen as

an important to instrument to support the excellence of new RD&D efforts in HFC JTI, it seems that competition mode of governance opportunities in terms of the development of market incentives have not been addressed sufficiently, which may become increasingly important when the R&I efforts lead to a wider market application. There seems to be an important challenge ahead how to integrate hydrogen and fuel cell issues for instance in lead market initiatives. Furthermore, despite the efforts in IPHE and some individual FP6 and FP7 research projects, there seems to be a lack of coordination to include a wider set of stakeholders to create a better understanding on civic and societal aspects. Finally, considering the EU27, there seem to be major differences between the governance approaches chosen by different member states. Whereas some member states like Germany, France, Great Britain and Denmark has been highly active in coordination and integration efforts, several countries have rather chosen the mode of co-existence. There difference may also require further attention. Table 8 positions the main European initiatives for development of hydrogen based energy systems in the developed framework for analysis.

Table 8. Main European initiatives for development of hydrogen based energy systems.

	Dimensions of change and agents	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
Strategic orientation	Technological (R&D)	FCH JTI	IPHE, SHHP		
	Industrial	FCH JTI	HTP, FCH JTI, IPHE, SHHP		
	Policy	FCH JTI	Hy-Co,FCH JTI IPHE, SHHP		
	Social (NGOs)		IPHE		
Programming	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)	FCH JTI	HTP, FCH JTI, IPHE, SHHP		
	Industrial	FCH JTI	HTP, Hy-Co, FCH JTI, IPHE		
	Policy	FCH JTI	Hy-Co,FCH JTI IPHE, SHHP		
	Social (NGOs)		IPHE		
Performance	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)	FCH JTI, SHHP	Hy-Co,FCH JTI, SHHP	Hy-Co,FCH JTI	
	Industrial	FCH JTI, SHHP	Hy-Co,FCH JTI, SHHP	Hy-Co,FCH JTI	
	Policy	FCH JTI	Hy-Co,FCH JTI		
	Social				

Transition phases and dimensions

Until today the R&I efforts in the area have focused largely on the pre-development and take-off phases and only recently on the issues on the acceleration and stabilisation phases. However, in order to promote the transition to the wider application of fuel cells and hydrogen based energy systems it is crucial to address acceleration and stabilisation issues. Towards this end, it is crucial to address wider techno-institutional conditions present in the energy sector that may lock-out emerging energy solutions such as hydrogen based energy systems. From the viewpoint of the dimensions of systems transition, it can be concluded the following:

- Technological change: Framework programmes and diverse national programmes have supported technology development. Considerable efforts have been made to develop new technologies, but still major obstacles exist for instance in the hydrogen storage and the efficiency of fuel cells.
- Industrial change: The area has gathered together companies from different sectors, which has materialised in the HTP and further on in the industry engagement in the FCH JTI. The multitude of studies on the role of standardisation and regulation has been made but much need to be done in order to develop favourable market conditions.
- Policy change: In particular, the HY-CO Era-Net has created important basis for the European cooperation among the Member states. This cooperation has also supported the increased engagement of the Commission and finally its key role in the FCH JTI. However, policy support to standardisation and regulatory changes have been limited.
- Social change: The most of the main initiatives in this sector seem to have paid limited attention on the social change dimension. Some FP projects though have specifically addressed the social change aspects, in particular the project International Partnership for the Hydrogen Economy (IPHE). It is likely that once the field evolves and the technologies become more mature also social aspects and related stakeholders will play more important role, which may not have been the case until today.

Box 7. HySafe – Safety of Hydrogen as an Energy Carrier

Purpose of the initiative:

The introduction and commercialization of hydrogen as an energy carrier of the future makes great demands on all aspects of safety. Technologies and applications allowing the use of hydrogen should provide at least the same level of safety, reliability, and comfort as today's fossil energy carriers.

The HySafe network will focus on safety issues relevant to improve and co-ordinate the knowledge and understanding of hydrogen safety and support the safe and efficient introduction and commercialization of hydrogen as an energy carrier of the future, including the related hydrogen applications. The overall goal of HySafe is to contribute to the safe transition to a more sustainable development in Europe by facilitating the safe introduction of hydrogen technologies and applications.

Hydrogen safety issues are subject to numerous research efforts. However, there are still a number of knowledge gaps with significant deficiencies in terms of safe technical solutions, including mitigation techniques, and in the availability and scope of widely accepted and harmonized standards and methodologies, together with associated regulatory issues. Development of a robust and reliable framework to assess the safety of hydrogen technologies and applications, and to harmonize testing procedures and Quality Assurance standards in the EU is therefore necessary.

The main objective of the HySafe network will therefore be to strengthen, integrate and focus fragmented research efforts to provide a basis that will allow removal of safety-related barriers to implementation of hydrogen as an energy carrier. In this way the network will also contribute to promoting public awareness and trust in hydrogen technology within Europe by providing a basis for communicating the risks associated with hydrogen.

The network intends to promote the development of an integrated, competitive scientific and industrial community in Europe capable of jointly addressing the challenges presented by the development of an excellent safety culture across Europe. There is some existing co-operation in the field, but much of the existing research output is not necessarily easy to obtain. Substantial benefits can be expected from making it easy to identify and use existing information and from preventing duplication of work.

There are certain historical differences in the methodologies and approaches for addressing safety issues. This concerns differences in probabilistic and deterministic approaches in safety studies and differences in the approaches of industry, research organisations, and public authorities. Development of a common understanding and common approaches will benefit all partners involved, as they gain access to improved methodologies based on the input and experience from others. This will also help to facilitate the safe introduction of hydrogen technologies and applications.

Partners:

The consortium consists of 25 partners including research organizations, governmental agencies, universities, industry from 12 countries: Germany (5 partners), France (3), Norway (3), UK (3), Netherlands (2), Spain (2), Denmark, Greece, Italy, Poland, Sweden, Russia and Canada.

The Advisory Council includes a balanced representation of partners, distinguished scientists outside the network, and representatives from industry and authorities, Integration of > 100 researches and doctoral students

Partnership goals:

The objectives of the network include

- to contribute to common understanding and approaches for addressing hydrogen safety issues
- to integrate experience and knowledge on hydrogen safety in Europe
- to integrate and harmonise the fragmented research base
- to provide contributions to EU safety requirements, standards and codes of practice
- to contribute to an improved technical culture on handling hydrogen as an energy carrier
- to promote public acceptance of hydrogen technologies.

These objectives are to be achieved by

- developing, harmonising and validating methodologies for safety assessments
- undertaking safety and risk studies
- establishment of a hydrogen incident and accident database
- creation of a set of specialised research facilities
- identification of a set of specialised complimentary codes and models that can be used for safety studies
- promoting fundamental research necessary to address hydrogen safety issues
- extracting net outcomes from safety and risk assessment studies as input to EU-legal requirements, standards and codes of practice
- organizing training and educational programmes on hydrogen safety, including on-line mode (e-Academy)
- disseminating the results through the HySafe website, a Biennial Report on Hydrogen Safety, 4and a Biennial International Symposium on Hydrogen Safety.

Additional information: http://www.hysafe.org/.

3.2 Energy Transition Platforms in the Netherlands

The Dutch "Energy Transition" initiative is a governmental initiative supporting structural change towards a sustainable energy supply-use system on the national level. It emanates from recognition of undesired dependency on a few energy-supplying nations, and an undesired change in environmental and climate conditions. Whereas current policy is focused on achieving objectives in 2010, the Energy Transition policy is focused on the period after 2010. It was recognised that system changes have occurred historically, and have had an impact on society and technology (e.g. change from wind- to steam power, or change from coal to natural gas).

At first, a long-term envisioning project on energy generation laid the basis for the initiative, which originally had the year 2050 as its time horizon. It also served to formulate the first objectives as to provide direction, but which can be adjusted during the Energy Transition initiative where needed. The transition occurs along three broader trajectories: 1) the use of renewable sources, 2) energy saving and 3), clean fossil sources and the use of advanced technologies.

At first, the transition approach was applied by the government on three themes: gas, industrial efficiency, and biomass. Both the government and market actors started projects in these areas, and developed common visions, outlined transition paths and set up experiments in order to begin these paths. Later, and in more themes, eventually 23 paths emerged, and these were subsequently given coherence in seven themes, which currently give long-term direction to energy policy in the Netherlands. Each theme has its own 'transition platform', which have the tasks of developing a vision (2020/2050) for their individual theme, to formulate the transition paths that enable realisation, and provide concrete first steps to be taken. The goal is that this creates innovative potential for the Netherlands, and to identify bottlenecks in policy and regulation.

The current Transition Platforms for energy are

- sustainable mobility
- green raw materials
- chain efficiency
- new gas
- sustainable electricity supply
- energy in the constructed environment
- greenhouse as energy source.

Each platform is formed by market participants, scientific- and civil organisations, as well as the government. As such, they are public-private frameworks for cooperation, which focus on achieving a sustainable energy supply.

Besides the energy system, the government also applies the transition approach in other areas in which structural change is desired: transition towards sustainable agriculture, sustainable mobility, and biodiversity. All transition trajectories have three components of sustainable development in common: economic growth, social development and environmental requirements.

An example of results in the themes New Gas and Chain Efficiency is the construction of a collective heating system for a new residential area of ca. 3 000 houses. In 2004, a local municipality issued a tender for the construction, management, and exploitation of the new heating system. The tender contained a minimal energy performance level requirement for the location (Energy Performance Level 7), set by the municipality. In order to achieve this performance level, the energy company that won the bid will supply the new houses with sustainable heating, which will be obtained from a local farmer who realised a fermenting installation, and supplies natural gas and biomass to a local energy central that drives the system. The central generates 2 MW electrical power, and 2, 6 MW of thermal power, exceeding the minimum EPL by one level. Other examples from the platform Green raw materials include the start of a private sector Biodiesel plant, and in the platform Chain Efficiency the gasification of high-calorie waste in the paper industry, or in the theme of Sustainable Mobility the generation and supply of truck-fuel from fermented bio-waste, collected from households. Many more examples exist of private ventures investing in new business opportunities from the various transition platforms.

In terms of *government modes*, the transition platform approach seems to be mostly based on the governance mode of coordination, with a voluntary engagement of its public and private stakeholders. However, as the example above shows, some local projects by the platforms may also blend other governance forms such as the competition mode and even the integration mode to some extent (for example, new research organisations have been established as well).

When looking at the *arenas of governance*, the transition approach appears to operate mostly in two of the arenas we distinguish: strategic orientation (the platforms are an institutionalised mechanism, and regulation is also used to give direction) and pro-

gramming (macro objectives are translated by the government into practical governance actions such as priority setting, funding and programming).

In the *dimensions of system transition*, we observe the following:

- *Technological change:* The energy transition platforms has as one of it's core trajectories the use of advanced technologies, but also the use of renewable energy sources can be viewed as a transition toward new technologies in the broader definition. Clearly, the transition policy approach facilitates a manifold of experiments, new efforts and local development in order to drive technological change, which is also one of the main tasks of the initiative.
- *Industrial change:* A key aspect of the policy approach is the creation of 'movement' within the various erected platforms, in which companies, governments, organisations, and civil group collaborate. This seems to drive also industrial change, as new opportunities for business are more easily identified, and can seep into the regime level.
- *Policy change:* Characteristic to the transition policy is that it is an initiative from the government to achieve long-term, structural change. This means that there is a clear shift in the level of ambition regarding the extent of change, as well as in the length of the policy's time-horizon. Secondly, the policy stands for a more direct engagement of the government with the other stakeholders, which iteratively and interactively shapes the transition over the course of time.
- *Social change:* Also the dimension of social change has explicit attention in transition policy: civil engagement and the creation of acceptance of new technologies are key spearheads of the transition policy approach. In turn, the civil and governmental influence in shaping the transition policy and transition-paths of industry and technology in turn is considerable, and reflects the impact of social change on the societal level on development at the niche level.

Table 9. Energy Transition Platforms (ETPs) in the Netherlands vis-à-vis the framework of the governance framework.

Strategic orientation	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)		ETPs		
	Industrial		ETPs		
	Policy		ETPs		
	Social (NGOs)		ETPs		
Programming	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)		ETPs	ETPs	
	Industrial		ETPs	ETPs	
	Policy	ETPs	ETPs	ETPs	
	Social (NGOs)		ETPs		
Performance	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)				
	Industrial				
	Policy				
	Social				

In conclusion, the Energy Transition Platforms (ETPs) of the Netherlands seem to take into account not only the coordination but also the other dimensions of the governance framework. The reason of the emphasis on the coordination mode may be in the fact that the authorities in the Netherlands as well as Dutch research community have been among leading in developing the transition management approach in general. This again may result, among other things, from the fact that the Netherlands has a very long-term socio-economic and geographical planning tradition following from the scarce geographical land surface area and related tradition of occupying land from the sea area.

3.2.1 Strategic Centers of Excellence – a new tool in Finnish innovation system

The Finnish innovation system has become well-known internationally due to the rise among leading nations according to innovation system indicators. The explanations given to the impressive progress since the economic recession in the 1990s are related to the essential investments in private and public R&D, fast growth of ICT industries where Nokia with its extended ICT cluster has proved to be a global success, an ad-

vanced educational system according Pisa studies, and to the small country advantages, such as close informal networks between the industrial, research and policy communities. Such characteristics of private-public partnerships (PPP) are of importance from the perspective of transition management and related governance aspects as well.

Within the context of globalization the Finnish policy-makers are further developing and streamlining the national innovation system. Among the key challenges for the new broad-based innovation policy is the global climate change and related pressures to shift the energy production and consumption towards sustainable structures. National R&D organizations like Tekes, SITRA and VTT, together with innovation policy-makers, have carried out several studies on the alternative ways of mitigating greenhouse emissions and for supporting the national strategy to respond to the European and global climate change agreements.

Among the recent national means to respond to the climate change and any future challenges for innovation are the Finnish Strategic Centres for Science, Technology and Innovation (SHOKs). The SHOKs are a new funding instrument by the Finnish Funding Agency for Technology and Innovation (TEKES). The SHOKs are based on private-public partnerships of all key actors of the Finnish innovation system and are managed effectively by company type principles. The basic orientation for establishing SHOKs was the national foresight study Finnsight, executed by Tekes and the Academy of Finland (http://www.finnsight2015.fi/).

One of the SHOKs is a Strategic Centre for Science, Technology and Innovation in energy. In addition to targeting to clean energy processes and mitigating CO_2 emissions the strategy of energy SHOK consists of contribution to commercial energy innovations in the global markets in the fields of bio energy, renewables and energy saving. Related issues of importance are energy efficiency and life-cycle thinking in energy production and consumption.

Although energy SHOK is still in a very early phase, some of the key ideas behind this novel innovation approach can be considered within the framework of transition system and governance (Table 10).

As the very preliminary analysis in Table 9 indicates, the energy SHOK, as can be assessed for the moment in the very early stage of this new PPP innovation means, consists of several aspects within the framework of energy system transition and governance. The details of the real progress remain still to be seen and assessed in later stages of energy SHOK procedure.

Table 10. Energy SHOK and FinnSight 2015 in the framework for the governance of systems transitions.

Strategic orientation	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)	Energy SHOK	Energy SHOK FinnSight		
	Industrial	Energy SHOK	Energy SHOK FinnSight		
	Policy	Energy SHOK	Energy SHOK Finnsight		
	Social (NGOs)		FinnSight		
Programming	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)	Energy SHOK	Energy SHOK		
	Industrial	Energy SHOK	Energy SHOK		
	Policy	Energy SHOK	Energy SHOK		
	Social (NGOs)				
Performance	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)	Energy SHOK	Energy SHOK	Energy SHOK	
	Industrial	Energy SHOK	Energy SHOK	Energy SHOK	
	Policy	Energy SHOK	Energy SHOK	Energy SHOK	
	Social				

3.2.2 Canadian approach against climate change[3]

In October 2006, the federal government introduced Canada's Clean Air Act to Parliament along with the Notice of Intent to Develop and Implement Regulations and Other Measures to Reduce Air Emissions. The Act and the Notice set out the government's proposed plan to develop an integrated, nationally-consistent approach to the short-term regulation of greenhouse gas and air pollutant emissions in order to protect the health and environment of Canadians. In November and December 2006, extensive consultations were undertaken with the provinces and territories, industry, aboriginal groups, and health and environmental groups on elements of the proposed approach and the development of the regulatory framework. In April 2007, the government released its

[3] This case study used the following internet sources: http://www.nrtee-trnee.ca/ and http://www.ecoaction.gc.ca/.

Turning the Corner Plan and the Regulatory Framework for Air Emissions. This policy document commits Canada to very specific short-term action to achieve reductions of both air pollutant and GHG emissions. The Framework also commits the federal government to medium- and long-term GHG emission reduction targets of 20% below 2006 levels by 2020, and by 60% to 70% below 2006 levels by 2050. While the Framework identified short-term actions to achieve emission reductions prior to 2020, it did not specify policies or directions other than the emissions reduction targets after that date.

Following a formal request by the Government of Canada in November 2006, the National Round Table on the Environment and the Economy (NRTEE) elaborated the Advisory Report entitled Getting to 2050: Canada's Transition to a Low-emission Future. This report was published in October 2007, after a year of research, analysis, consultations, and deliberations by the NRTEE. Specifically, the NRTEE was asked to provide advice on how Canada could significantly reduce its GHG and air pollutant emissions by 2050. The NRTEE research and conclusions show that, with consideration for some key enabling conditions and acknowledgement of certain risks and uncertainties, a transition to a low-emission society is manageable, and may even provide some unique opportunities in terms of innovation and technology development.

In order to fulfil the long-term emission reduction targets for GHGs and air pollutants, NRTEE advice suggests the need of a transition to a low-emission society at many levels: transition in policy, transition in technology, transition in economy, and transition in society. They also conclude that delaying action to reduce GHG emissions comes with economic and environmental risks. One such risk is that, in the absence of a long-term climate change policy framework, energy infrastructure choices being made now will be increasingly difficult and costly to address in the future. On the environmental side, the main risk involves higher cumulative GHG emissions over the time period in question.

Table 11 applies our framework for the governance of systems transitions to the Canadian approach against climate change.

Regarding the confluence of the integration mode of governance and the strategic orientation arena of governance, the Canadian approach in the technological dimension of change aims to provide support for research and development, as well as strategic investments in infrastructure. In the industrial dimension, the integration approach relies in the establishment of regulatory standards, mainly in the parts of the economy that do not respond to a price policy (building and transport sectors). As to the integration mode suggestions of the NRTEE falling in the policy dimension of change, its report claims policy certainty as central, in order to create the long-term predictability required for new investment in innovation and technology. Moving on to the integration form of governance in the programming arena, the Canadian strategy highlights the importance of facilitate deployment of low-carbon technology in all segments of the economy. Their analysis shows that existing and near-term technologies are sufficient to meet the emission reduction targets, but all possible low-emission technologies will need to be widely deployed.

Table 11. Canadian approach against climate change in the governance framework.

Strategic orientation	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)	Strategic investments in infrastructure, and support for R&D			
	Industrial	Regulatory standards (building and transport)		Regulatory standards (building and transport)	
	Policy	Policy certainty regarding the future regulatory regime	Establish a Canada-wide plan		
	Social (NGOs)		Information programs to educate Canadians to take action on climate change.		
Programming	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)	Facilitate deployment of low-carbon technology in all segments of the economy	Demonstration programs		
	Industrial			Implement GHG emission price signal	
	Policy		Adaptive management approach to monitor progress and match policies to the required level of abatement		
	Social (NGOs)				
Performance	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)				
	Industrial				
	Policy				
	Social				

As shown in Table 11, the NRTEE report relies in co-ordination of climate change policies at a global level, to ensure that the adverse economic consequences of Canadian policy action – particularly in relation to their competitiveness – are minimized; and at the national level, to lead to better coordination of complementary federal, provincial

and territorial GHG emission reduction policies aimed at common or shared targets, time frames and actions. Also falling in the strategic orientation arena, the co-ordination of social actors is suggested by the establishment of information programs to educate Canadians and build support so that individuals can take action on climate change. In the arena of programming, this co-ordination of the technological change is suggested to be shaped through demonstration programs, in order to move the knowledge base forward on the desirable technologies. In the arena of programming, co-ordination and adaptive management practices, built-in monitoring and assessment mechanisms are suggested to ensure efficiency and effectiveness of policies to match the required level of abatement effort, and minimize and mitigate unanticipated adverse outcomes.

Finally, the strategic orientation of the competition mode of governance might be represented by mechanisms as the aforementioned regulatory standards in the building and transport sectors. In the programming arena, the NRTEE report urges the Government of Canada to implement a strong, clear, consistent and certain GHG emission price signal across the entire Canadian economy as soon as possible in order to successfully shift Canada to a lower GHG emissions pathway, achieve the targeted reductions for 2020 and 2050, avoid higher emission prices that a delay would entail, and reduce cumulative emissions released to the atmosphere. It is suggested that the most effective and efficient policy that would result in deep GHG emission reductions is a market-based policy, such as an emissions tax, a cap-and-trade system, or a combination of the two.

Concerning the dynamic of the transition phases, the NRTEE report highlights the importance of sequencing policy as they move forward in time, to ensure a successful transition:

1. Shifting the pricing policy. Their research indicates that the government's currently proposed domestic emission trading (DET) system for the large emitters will need to be replaced by either an upstream-cap-and-trade (UCT), or a complementary emission tax be added to the DET.
2. Sequencing the complementary policies. The current slate of regulations will need to be expanded to more fully address sectors such as transportation and buildings. Support for research, development and demonstration programs will be important so that innovation can occur and technology can be deployed as soon as possible. Finally, strategic infrastructure investments will need to be made as soon as possible, and will necessarily need to increase as they move out to 2020.
3. Increasing the stringency of all policies. An adaptive management approach will need to be adopted so that progress is monitored and policies are adjusted to match the required level of abatement effort, and also to minimize and mitigate adverse outcomes on certain groups or regions.

In conclusion, the Canadian transition approach to a low-emission society appears to operate mostly in the governance modes of integration and co-ordination, inside the

arenas of strategic orientation and programming. When looking at the dimensions of change, the technology and policy agents' roles predominate over the rest. It may be therefore advisable to enrich the governance system moving towards initiatives in the form of competition and the level of performance, and encouraging the role of the industry and the society as agents of change.

3.3 Strategic Energy Technology Plan

The strategic energy technology plan (henceforth, SET plan) by the European Commission has the aim to accelerate the development and deployment of cost-effective 'low carbon technologies' (COM, 2006). The plan comprises policy measures to improve planning, implementation, resources and international cooperation in the field of energy technology. As such, it should help to achieve European objectives in reducing carbon emissions. The plan has both a short-term and a long-term content, which makes the plan particularly relevant in the context of energy system transition policy.

3.3.1 Short-term objectives

In the short term, the plan aims to improve current energy technologies and their market-adoption. To this end, the plan proposes to increase research targeted to reduce costs and improve performance of existing technologies, as well as encouraging the commercial implementation of these technologies. The efforts should in particular involve second-generation biofuels, capture, transport and storage of carbon, integration of renewable energy sources into the electricity network and energy efficiency in construction, transport and industry.

3.3.2 Long-term objectives

In the longer term the plan aims to support development of a new generation of low carbon technologies. The activities to be carried out are meant to focus, among other things, on the competitiveness of new technologies relating to renewable energies, energy storage, sustainability of fission energy, fusion energy, and the development of Trans-European Energy networks.

Implementation of the SET plan will involve collective effort and activities in the private sector, the Member States and the EU, as well as internationally. The SET plan proposes a new governance method for energy technologies, based on joint strategic planning. Furthermore, the Commission will set up a European information system, comprising technology mapping and capacity mapping.

The Commission plans to gradually launch new European industrial initiatives, in wind energy, solar energy, bio-energy, capture, transport and storage of CO_2, the elec-

tricity network and nuclear fission, which will take the form of public-private partnerships or joint programmes between Member States. The European industrial initiatives are currently being scoped by industry, mainly through the European Technology Platforms. Furthermore, the Commission wants to create a European energy research alliance to better coordinate, in terms of programming, the efforts of research centres and universities. A prospective approach will also be adopted to prepare the future development of Trans-European energy networks and systems.

An increase in resources, both financial and human, is another major element of the SET plan in order to double the overall effort made in the EU within three years. In addition, the training of energy researchers will be promoted and new research and training opportunities will be created, to increase the number and quality of engineers and researchers. Finally, the SET plan makes provision for intensified international cooperation, in order to promote the development, marketing, deployment and accessibility of low carbon technologies worldwide.

In terms of *governance modes*, the SET plan appears to be closest associated with the mode of coordination, as one of its main hallmarks is to engage industry through public-private partnerships. However, the integration mode is also recognizable: the central role of financing R&I activities, as well as the development of Trans-European Energy networks. Then, the governance mode of competition can be faintly recognized in the latent function facilitation of competition through the Common Market. It is, however, unclear how competition is to take place.

In the *dimensions of system transition*, we can see that the initiative is predominantly concerned with achieving technological change: the renewal of current energy technologies, and – on the long run - the development of next generation technologies. Especially this latter is intended to open up business opportunities for European industry, and thus we can see that the creation and adoption of novel technology is expected to renew industry, marking alterations in the dimension of industrial change. Table 12 applies our framework for the governance of systems transitions to Strategic Energy Technology Plan of Europe.

In conclusion, within the framework for the governance of systems transitions the Strategic Energy Technology Plan of Europe seems to be relatively well represented in other dimension but in the social (NGOs etc.) dimension of the framework. This perspective seems to be taken into account relatively largely in the related Impact Assessment procedure of the European Parliament (see: Commission Staff Working Document, 2007).

Table 12. SET Plan vis-à-vis the framework of the governance framework.

	Dimensions of change and agents	Integration	Co-ordination	Competition	Co-existence
Strategic orientation	Technological (R&D)	**SET plan:** Technology is vital to achieve the EU Energy and Climate Change policy objectives.	**SET plan**	(SET plan)	
	Industrial	**SET plan:** Europe should lead competition, there are business opportunities, and need for European 'critical mass'.	**SET plan**	(SET plan)	
	Policy	**SET plan:** Council conclusions (02/08): reviewing the SET plan and establish a matter of priority an open-access European energy technology information and management system.	**SET plan**	(SET plan)	
	Social (NGOs)	"The SET-Plan must stem from a shared and inclusive European vision, involving all relevant actors." (SET plan 10.1.2007)			
Programming	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)	**SET plan:** E.g. the European Energy Technology Summit aimed for late 2009.	**SET plan**		
	Industrial	**SET plan:** E.g. the utilization of related European Technology Platforms, and launching at least two industrial initiatives in 2009 and 2010. European Industrial Initiatives: strategic technology alliances.	**SET plan**		
	Policy	**SET plan:** E.g. Joint strategic planning – European Community Steering Group and Information System; Increase in resources, both financial and human, reinforce international cooperation.	**SET plan**		
	Social (NGOs)				
Performance	**Dimensions of change and agents**	**Integration**	**Co-ordination**	**Competition**	**Co-existence**
	Technological (R&D)	SET plan	SET plan	SET plan	
	Industrial	SET plan	SET plan	SET plan	
	Policy	SET plan	SET plan	SET plan	
	Social				

Conclusions

Task 1 of the GoReNEST project presented an analytical comprehensive framework of the system transition approach. Despite the system transition approach has some similarities with the innovation and energy systems and policies in Nordic countries this approach has been applied in Nordic countries only in few studies. Accordingly Task 1 presents this approach in detail and considers its application potential in order to support the transition towards a sustainable energy system in the future.

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, it is important to know whether, how far and in which ways different elements and dimensions related to this approach have already been examined in the Nordic energy research. Consequently Task 2 of the GoRENEST project considers Nordic energy research vis-à-vis different elements, categories and topics of the system transitions framework and assesses the potential of this research to contribute to the governance of Nordic energy system transition and policy-planning. The GoReNEST Task 2 report concludes that the Nordic research encompasses several themes and dimensions that are relevant within the transition framework. Moreover, these research competencies are an important potential for the future research within the system transition framework. The research is, however, scattered and fragmented vis-à-vis the versatile aspects and dimensions of the framework. In conclusion, a wider utilization of the system transition approach raises several new needs and topics to Nordic research agenda.

Governance and funding functions and models are an essential part of the transition framework. Hence, within the system transition framework, Task 3 of the GoReNEST project analyses such governance and funding models, as well as the practices and accumulated experiences of these models, especially in order for be able to assess their utilisation in the development of the Nordic energy system transition. Moreover, Task 3 explores the recent advances in R&D&I governance and funding models.

The conclusions of the Task 3 of GoReNEST project are as follows: Energy system transition is a complex techno-economic and social long-term change process in which governance efforts can play an important role. On a basis of presented empirical cases

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.

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