RAPPORT 25/2008

Competitive policies in the Nordic Energy Research and Innovation Area eNERGIA

Part 1: Country reports

Antje Klitkou, Trond Einar Pedersen, Lisa Scordato and Åge Mariussen

NIFU STEP

Rapport 25/2008
ISBN 978-82-7218-581-6
ISSN 1504-1824

The publications of NIFU STEP are available at www.nifustep.no

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Part 1: Country reports

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Preface

This report outlines the energy research and innovation policy in the Nordic and Baltic countries – Denmark, Finland, Iceland, Norway, Sweden, Estonia, Latvia and Lithuania.

The report is the result of the research project Competitive policies in the Nordic Energy Research and Innovation Area (eNERGIA). The project was co-funded by Nordic Energy Research and NIFU STEP. The objective of the project was to determine possible policy interventions targeted at the development and commercial promotion of promising renewable energy production technologies in the Nordic countries.

The report is based on an analysis of the framework conditions for the sector innovation systems for energy production, with a focus on research and innovation policy in the Nordic and Baltic countries. We identified the key actors and institutions in all the eight countries studied. In addition, we conducted a performance assessment based on the quantitative indicators of publishing and patenting, international collaboration and funding data. Using these indicators as a basis, we conducted an analysis of the strengths, weaknesses, opportunities and threats (SWOT analysis) of the Nordic sector innovation systems for energy production. This analysis identified common or diverging characteristics, challenges, framework conditions, energy-technology specialisation and, most important of all, cases of good practice in key technologies.

The project included two workshops, and the results of these are also reported here. The outcomes of the workshops have been used in several parts of the project:

- A Nordic workshop on the environmental consequences of deployment at scale of these technologies to replace existing energy systems, with a focus on wind energy and photovoltaic energy, carbon dioxide capture and storage, and second-generation bioenergy.
- A Nordic workshop on policy implications for Nordic Energy Research.

The report comprises three parts:

Part 1: Country reports
Part 2: Technology reports
Part 3: Special reports

The results are summarised in the *Synthesis report.*

The authors of these reports are Antje Klitkou, Trond Einar Pedersen, Lisa Scordato and Åge Mariussen. We want to thank Nordic Energy Research for funding this project and our colleagues from NIFU STEP for their comments on the project. In addition, we would like to thank the participants at our workshops and the interview partners in our case studies for their valuable contributions.

Oslo, 1 July 2008

Per Hetland
Director

Liv Langfeldt
Head of Research in Research and Innovation Policy

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Introduction

This (Part 1: Country reports) is the first report about the results from the eNERGIA project. The second report mainly deals with selected renewable energy technologies from different perspectives, while the third report sums up the SWOT-analysis, the eNERGIA workshops and the case studies of good practice. A short synthesis report summarises the entire project.

This first report is the presentation of the countries studied in the project – Denmark, Finland, Iceland, Norway, Sweden, Estonia, Latvia and Lithuania.

The policy system and the political framework conditions that underpin energy related industrial activity are reviewed for each country. This includes energy strategies, laws and regulations, R&D and innovation policies and instruments, and international collaboration. Key actors and institutions in the public domain, research and education, and non-governmental organisations are mapped. Finally, the descriptions of the countries include also technology specific overviews of R&D-intensive firms in the energy sector.

1. The Nordic countries

An important indicator in energy policy discussions is CO_2 emissions. The CO_2 emissions by the Nordic countries are below the level for the OECD as a whole (in 2005 11.02 t CO_2 per capita), but Finland had the highest emission rates, both in absolute numbers and per capita (Figure 1). Measured per capita, Sweden was leading in 2007.

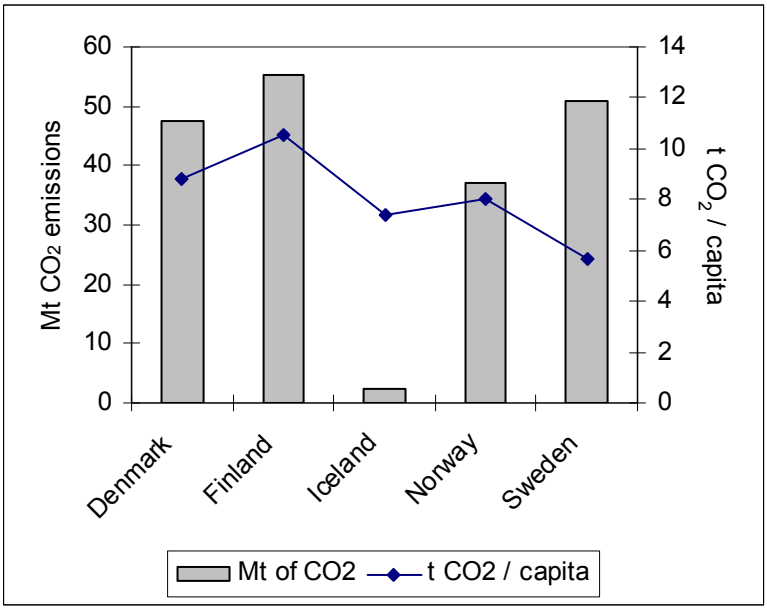

Figure 1: CO_2 emissions by country in 2005 – absolute numbers and normalised by capita for the Nordic countries. Source: IEA Key World Energy Statistics 2007, p. 48ff.

Looking at the ratio between electricity produced from renewable sources and gross national energy policy, Norway and Iceland are in a class of their own due to the high share of hydroelectric energy. Here again, Sweden comes out somewhat more favourably than Denmark and Finland. Whereas the share has been fairly stable during the last 10 years in Finland and Sweden, Denmark has made a remarkable improvement, seen in relation to a weak start in 1995.

An important explanatory factor behind these structural differences is different points of departure in terms of natural resources. This is also reflected in the scope and direction of energy *policy* which varies between Nordic countries.

In looking at policy systems, there are differences between countries in the ways in which the problems and major challenges of energy policy are defined. Accordingly, there are differences both in terms of what kind of ministries are involved, how ministries and directorates relate to each other, and how relations between energy policy and other fields of policy are organised. In this way, the networks of energy policy and the core actors in the field of energy policy are different.

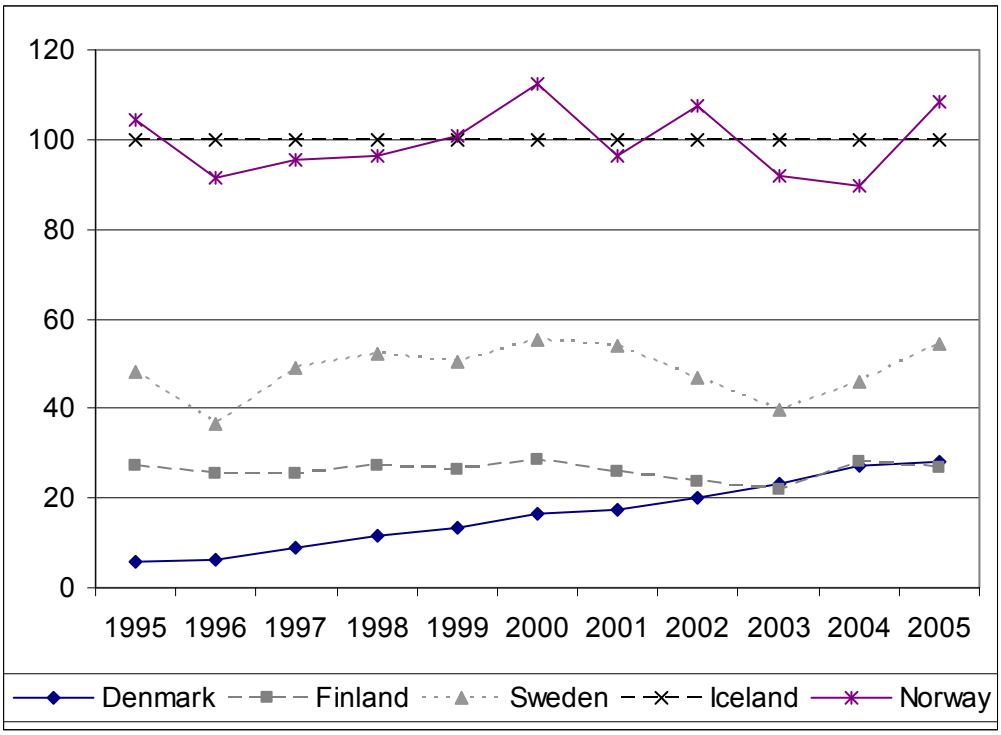

Figure 2: Ratio between electricity produced from renewable energy sources and gross national electricity consumption for the Nordic countries, 1995-2005. Source: Eurostat

Conversely, if the sector in charge has the authority to define the way in which the problems and opportunities are identified, the problem may be seen as defined by the structure of the energy policy system. As problem definitions are challenged, networks of sectors and institutions defining energy policy may change. New sectors may get involved: the agenda is broader. Today, the need to develop more environmentally-friendly technologies to replace technologies and energy systems emitting CO_2 is a factor which is widening the traditional narrow system of energy policy, making it more dynamic. Energy policy and innovation policy are combined in different ways. As we will see below, in some countries such as Finland and Denmark, this may even lead to *integration* of science and innovation policy and energy policy, but this is only one of several possibilities.

Nordic countries have fairly heterogeneous policy systems, R&D systems and systems of innovation. In this situation, the impact of a national hegemonic discourse or agenda in energy policy should not be seen as determining in any 1:1 way *actual* industrial or R&D *achievements* in terms of science and innovation. For instance, industries and universities may be involved with R&D and innovations in areas far outside domestic energy policy making. Energy research and production technologies may well be developed without any linkage to the existing upstream domestic energy system which is likely to be at the core of interest for energy policy making in the narrow sense. The major sectors involved in energy policy systems are:

- "narrow" energy policy, related with national energy systems, energy supply etc.
- National security policy
- Environmental policies

- Innovation and science policies
- Industrial and regional development policies.

The traditional agenda for energy policy formerly concerned issues relating to domestic energy provision and safety, the development of domestic energy systems, domestic and trans-national regulations of trade in energy, and the development of trans-national energy systems.

In countries with export-based upstream energy production, attention has to be paid to issues relating to the management of resources, including application for industrial purposes, distribution and export. In Estonia and Norway, for instance, petroleum resources are central. In Iceland, thermal power is at the core of interest, and basis for new industrial sectors. This vitalizes the old link between energy policy and **industrial policy**.

In various ways, the issue of energy supply and energy safety relates to policies of national security. These questions are at the top of the agenda in countries such as Finland, Latvia and Lithuania. Here, the dependency on fossil energy supplies from Russia is seen as a challenge. These **national security** considerations go hand in hand with the promotion of **environmentally-friendly support of new sources of energy based on domestic forest resources** as well as a renewed emphasis on **nuclear energy**.

Some energy technology systems create problems with CO_2 emissions. This broadening of the narrow perspective leads to new relations between **energy policy, environmental policy and various forms of innovation and industrial development policy.**

One particularly important part of upstream energy production is based on forest resources as various forms of wood products are used. These forest-based energy systems activate several other policy sectors. In Finland and Sweden, this has resulted in efforts to coordinate **energy policy, environmental policy and various forms of industrial development, innovation, regional planning and regional development policies**. Through the EU Structural Funds, Interreg, and other programs, these Swedish–Finnish approaches have been diffused to Estonia, Latvia and Lithuania. This influence has resulted in an increased awareness in these countries of the relation between energy policy and environmental policy, and also a new insight into the possibilities of combining environmental development and national security policies. This also results in innovations and new energy systems, with deep implications for construction industries, domestic etc. The core example in this respect is Finland where these policies are closely coordinated through institutional mechanisms such as “super-ministries”. Another strategy is to develop *new* energy technologies and systems. This is the main thrust of Denmark, which has less forest resources compared to Sweden, Finland or Norway. Here, the relation between **energy policy, environmental policy and science and innovation policy** is at the core. It is here we must look for the Danish improvements during the last 10 years. However, we find an increasing attention to these issues also in other Nordic countries.

1.1 Denmark

Policy and regulation framework conditions

Introduction to national energy technology and production

According to the First Progress Report for Denmark's National Reform Programme (Danish Government, 2006)) Denmark has achieved good results in the sector of sustainable energy (Table 2), energy savings and energy technology development. Denmark is now above EU average in the development and use of alternative energy sources, having increased the ratio between the electricity produced from renewable energy sources and the gross national electricity consumption from 5.8 per cent in 1995 to 28.2 per cent in 2005.

The government aims to strengthen these positions for avoiding being outdated. The energy sector contributes to economic growth and employment. The share of renewable energy has increased from 3% of all electricity generation in 1990 to 25% in 2004. The energy intensity is 35% below the IEA average due to efforts to improve efficiency, but the IEA advises more focus on efficient transport, cost-effectiveness and market concentration (International Energy Agency, 2006).

The export of energy technology and equipment has increased from DKK15.843b in 1996 (5.2% of the total industrial export) to DKK51.797b in 2007 (9.2% of the total industrial export) (for details, see Energistyrelsen og Energibranchen, 2008). About two-thirds of the energy technology and equipment export in 2007 came from wind power technology and equipment. The two Danish companies, Vestas Wind Systems and Siemens Wind Power, together have about 30% of global market shares for wind technology and equipment.

Denmark has considerable strengths in following fields:

- Renewable energy and its integration in existing energy systems
- Energy efficient and clean electro power station technology
- Efficient and flexible application of energy and energy saving.

Denmark possesses considerable expertise in the energy sector. In the areas of wind energy and waste management in particular, Denmark is among the leading countries. The high level of energy know-how translates into a remarkably high energy efficiency throughout the Danish energy sector. The flexibility of the Danish workforce and the district heating infrastructure are important for the Danish energy industry.

The energy mix of Denmark and the position of renewable energy sources is summarised in Table 1 and Table 2. Interesting are the high share of hard coal for electricity generation and the high share of wind power. A special feature in Denmark is the stable level of energy consumption since the late 1970s (compare Thomassen, 2008).

Table 1: Denmark Country Summary Table.
Sources: Eurostat (2007) Energy Yearly Statistics 2005; European Commission (2003b) Biofuels Directive; European Commission (2008) Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources COM (2008)

General information	
Population (2006)	5 437 272
Land area	42 394 km² (60% used for agriculture)
Macroeconomic Information	
GDP per capita in PPS (2006)	126.0
Real GDP growth rate (2006)	3.9
EU Targets for the share of energy from RES	
RES target in 2005 (% of final consumption of energy)*	17.0
RES target 2020 (% of final consumption of energy)*	30
Biofuel target (2010)	5.75
Biofuel target (2020)**	10
National targets for the share of energy from RES	
RES target 2011 (% of final consumption of energy)**	20
Electricity generation – total 2005 (in GWh)	*36 276*
Hydro	23
Wind	6 614
Nuclear	-
Conventional thermal of which:	29 639
- Hard coal	15 466
- Lignite and peat	-
- Petroleum products	1 371
- Natural gas	8 818
- Biomass	3 982
Consumption	*33 514*
Exports and imports	
Exports	11 574
Imports	12 943

*European Commission (2008)
** Dansk Regering (2008)

Table 2: Renewables in Denmark in 2005. Source: IEA[1]

	Municipal Waste*	Industrial Waste	Primary Solid Bio-mass**	Biogas	Liquid Biofuels	Geo-thermal	Solar Thermal	Hydro	Solar Photo-voltaic	Tide, Wave, Ocean	Wind
Unit	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*
Gross Elec. Generation	**1809**	**0**	**1898**	**274**	**0**	**0**	**0**	**23**	**2**	**0**	**6614**
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*				

[1] IEA: http://www.iea.org/Textbase/stats/renewdata.asp?COUNTRY_CODE=DK

Gross Heat Production	**23602**	**0**	**20284**	**1154**	**0**	**66**	**53**
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*1000 tonnes*	*TJ*	*TJ*
Production	36951	0	53656	3830	71	132	411
Imports	0	0	13762	0	0	0	0
Exports	0	0	0	0	-71	0	0
Stock Changes	0	0	0	0	0	0	0
Domestic Supply	**36951**	**0**	**67418**	**3830**	**0**	**132**	**411**
Statistical Differences and Transfers	2	0	141	0	0	0	1
Total Trans-formation	**34766**	**0**	**33268**	**3343**	**0**	**132**	**53**
Electricity Plants	0	0	0	20	0	0	0
CHP Plants	30753	0	22113	3114	0	0	0
Heat Plants	4013	0	11155	209	0	132	53
Other Transformation	0	0	0	0	0	0	0
Energy Sector	**0**	**0**	**0**	**22**	**0**	**0**	**0**
Distribution Losses	0	0	0	0	0	0	0
Total Final Consumption	**2187**	**0**	**34291**	**465**	**0**	**0**	**359**
Industry	1016	0	3510	60	0	0	0
Transport	0	0	0	0	0	0	0
Residential	0	0	28028	0	0	0	269
Commercial and Public Services	1171	0	707	331	0	0	90
Agriculture / Forestry	0	0	2046	74	0	0	0
Fishing	0	0	0	0	0	0	0
Other Non-Specified	0	0	0	0	0	0	0
Non-Energy Use	0	0	0	0	0	0	0
- of which Petrochemical Feedstocks	0	0	0	0	0	0	0

* Municipal Waste: the split for renewable and non-renewable waste is also available
** Primary Solid Biomass: data are also available for charcoal

Government energy action plans and strategy documents, in particular energy technology focus areas and priorities

During the 1990s, the Danish government had a focus on renewable energy resources, environment and sustainability (*Energiplan Energi 21* - Miljø- og Energiministeriet, 1996) and formulated concrete goals for shares of renewable energy production. This resulted in increased funding of research. This governmental policy was also corroborated by the Danish legislation (compare legislative acts in Table 3).

The government under Fogh Rasmussen prefers a focus on a commercial exploitation of R&D in the sense of introduction of new technologies on the basis of market conditions. The government avoided in the beginning concrete goals for shares of renewable energy production. That policy resulted for some years in serious cuts in public funding of

energy R&D and provoked an intense public debate. The government soon realised that energy and energy R&D are important issues for governmental policy and consequently strove in 2004 to achieve broad political agreement about the future energy infrastructure.

The main goals of Danish energy policy are formulated in *Energy strategy 2025* (Transport and Energy Ministry, 2005):

- Safety of energy supply
- Climate changes / CO_2 capture
- Commercial exploitation of energy technology.

The *Energy strategy 2025* is a follow-up of the political agreement from March 2004 about the future energy infrastructure (Økonomi- og erhvervsministeriet, 2004). It is based on analysis by experts where a broad range of technical background reports gave theoretical input into the Strategy (Danish Energy Authority, 2005).

The Minister for Transport and Energy proposed as a follow-up of the Energy strategy in 2007 an act on a new Programme for Energy Technology Development and Demonstration (EUDP) and received a broad range of comments in the hearing (Transport- og Energiministeriet, 2007).[2] The act was passed without changes on 1 June 2007, and was also accepted by the European Commission. The EUDP has started in 2008 with a budget of DKK210.6m.

In February 2008, the Fogh-Rasmussen government came to a political agreement with a broad range of political parties on the Danish energy policy for 2008 to 2011 (Dansk Regering, 2008). The agreement concluded that all legislation regarding renewable energy will be concentrated in a specific bill on renewable energy. This bill will come into force 1 January 2009 after a public hearing in the autumn of 2008. It shall cover national goals for municipal planning of windmills, accounting regulation for renewable energy facilities, compensation regulation, guarantee funds and a model for local co-ownership.

The Advisory Committee on Energy Research (REFU) is an important policy driver on energy research. On the initiative of the Danish Energy Agency, in April 2006 REFU formulated a Strategy for energy research, development and demonstration based on the Energy strategy 2025 (Rådgivende Energiforskningsudvalg, 2006). This strategy refers to the government's energy strategy and supports the desire to make increased public budgets for energy research part of the Globalisation Strategy. In addition, special strategies for the different fields of energy RD&D have been developed in collaboration with industry and the Ministry of Science, Technology and Innovation:[3]

- Biomass for energy production
- Fluid bio fuels
- Wind energy
- Solar panels
- Fuel cells

[2] The comments from the hearing can be found at: http://borger.dk/j2eebdk/app_hoering_showdoc/showDocument.jsp?p_docid=859766.

[3] For further information regarding these strategies see http://www.energiforskning.dk/sw3082.asp and http://www.ens.dk/sw16701.asp

- Energy efficiency
- Hydrogen technology
- Sea-wave power.

The aim was that research projects should relate to these strategies, but the ministry and REFU did not prioritize between the strategies.

In the case of renewable energy the following thematic sub-fields in energy RD&D have recently received much attention:

- Polymer based solar panels
- Production of a new type of bio-ethanol
- High temperature fuel cells.

A main challenge for the Danish energy research is improved coordination of the multitude of Acts, policy measures and instruments. The government has addressed this by establishing a new ministry in November 2007 – the Ministry for Climate and Energy, unifying expertise and policy tasks that target energy and climate change under a single ministry. The Danish Energy Authority is included here.

Table 3: Selected Danish government bills on energy

Government Bills on Energy	Year
Act no. 1209 The Electricity Saving Trust Bill	1996
Act no. 485 to promote energy and water savings in buildings	1996
Bill no. 234 The Electricity Supply Bill	1999
Bill no. 237 to Amend the Act on the Utilisation of Renewable Energy Sources etc.	1999
Act no. 450 on the promotion of savings in energy consumption	2000
Act no. 449 The Natural Gas Supply Act	2000
Act no. 772 The Heat Supply Act	2000
Act no. 1384 on Energinet Denmark	2004
Bill no. 555 on the Energy technology development and demonstration programme (EUDP)	2007

Environmental laws and regulations

Environmental policies are especially relevant for the development of the Danish energy policy, concentrating on climate change, CO_2 emissions and pollution by combustion engines and heating systems. Environmental policy has a great impact on energy policy and energy research policy. The formulation of clear goals for the share of renewable energy has contributed to an increased focus on research about renewable energy resources. Denmark introduced rather early taxes for CO_2 emissions from an relatively early date. The Hydrocarbon Tax Act (Table 4) was passed in 1993 and has subsequently undergone several revisions, latest in 2004.

The Danish Environmental Protection Agency which until recently was under the Danish Ministry of the Environment, is responsible for coordination and implementation of international negotiations and reporting obligations on climate issues within the European Union and the United Nations Climate Convention. The Agency is also responsible for coordination of national measures to follow up the Danish climate commitments, for

example, the fulfilment of Danish reduction commitments under the Kyoto Protocol and Danish implementation of the flexible mechanisms.

Denmark has ratified the EU directive on greenhouse gas emission allowance trading. The emission allowance trading scheme is an important element in the Danish Climate Strategy.

The Minister of Environment submitted the Danish National Allocation Plan 31 March 2004, as required according to the EU emission trading Directive. The allocation plan and the directive have been implemented in Denmark through an Act on CO_2 allowances administered by the Danish Energy Authority. Approximately 380 production units are covered by the CO_2 allowance trading scheme which came into force on 1 January 2005.

Table 4: Selected Danish government bills on climate and environment

Government Bills on Climate and Environment	Year
Act no. 792 Hydrocarbon Tax Act	1993
Act no. 959 The Danish Forest Act	1996
Act no. 570 on Taxes on Waste and Raw Materials	1998
Act no. 376 on CO_2 Quotas for Electricity Production	1999
Act no. 959 The Danish Forest Act	1996

Important R&D and innovation policy instruments

In the First Progress Report for Denmark's National Reform Programme (Danish Government, 2006), the Danish government proposed following new instruments regarding energy RD&D:

- a new energy technology development and demonstration programme for new, more efficient energy technologies, including sustainable energy, where the testing of new technologies can be resource demanding. This programme is an extension of the Government's Energy Strategy 2025. Programme funding will be given to public/private syndicates through tenders.
- a multi-annual development programme for second generation technology for bio-ethanol production. The purpose will be to test second generation technology on a larger scale and to increase the participation by private enterprises. A total of DKK200m will be earmarked for the programme over a four-year-period.
- market-based instruments for the promotion of energy savings and sustainable energy will supplement the current CO_2 quota system, aiming to reduce the use of fossil fuels. It is being considered whether the framework conditions for wind energy can be improved, including the securing of mounting areas for windmills and test and demonstration windmills.

We can distinguish between three main channels for funding of energy RD&D: The Strategic Research Council, the Danish Energy Authority and the PSO-programmes (Energi 2007, 2007)

The *Strategic Research Council* under the Ministry of Science, Technology and Innovation provides funding through the Energy & Environment Programme Commission (EnMi) for energy research projects concerning renewable energy

technologies and energy conservation. The funding amounted to €6.0m in 2005, €14.3m in 2006, €14.0m in 2007 and is expected to be about €12.5million in 2008.

The R&D budget of the Ministry of Transport and Energy (since 2008 is energy RD&D policy governed by the Ministry of Climate and Energy) has been changed considerably in 2007 with the announcement of the new EUDP. The funding is divided on three programmes:

1. The *Energy Research Programme (EFP)* administrated by the Danish Energy Authority (€10.1m in 2006 and €24.8m in 2007).
2. EFP has been replaced by the new programme, *Programme for Energy Technology Development and Demonstration (EUDP).* An act establishing the conditions for EUDP was approved by Parliament on 1 June 2007. Administration of EUDP will also be carried out by a secretariat in the Danish Energy Authority. In 2008 the programme has received €27.7m funding.
3. The two *PSO-programmes* (Public Service Obligation) administred by the energy companies – a subsidy payment from customers as a levy placed on every kWh of electricity sold in Denmark are fairly stable (€20.7m in 2006, 2007 and 2008):

- *The Clean Electricity Production Programme* (ForskEL) (established in 1999, managed by Energinet.dk) for electricity companies in the private sector. The programme shall ensure that these companies continue to conduct R&D for sustainable electrical power production despite of the liberalisation of the energy marked and greater competition. All funded R&D must be non-commercial. Recently the focus was on renewable energy, biomass, waste, fuel cells and combined production of heat and power. The annual budget for 2006, 2007 and 2008 was €17.3m.
- *The Energy Efficiency Programme* (ELFORSK) (launched in 2002, managed by Dansk Energi - ElFor, the Association of Danish Electricity Distribution Companies) has recently "focused on buildings, lighting, electronics for effect and measuring, behaviour, freezing and cooling, and industrial processes" (IEA: Denmark 2006 Review, p. 164f.) The annual budget for 2006, 2007 and 2008 was €3.3m.

In the new Energy Technology Development and Demonstration Programme (EUDP) that commenced in 2008, the following priority areas are of strategic importance for the ERDD in Denmark the coming years:

- Second generation biofuels for transport and other usages for biomass
- Wind power and relative technologies
- Fuel cell technologies
- Low energy buildings
- Energy saving solutions and flexible energy consumption
- Integration of energy technologies
- CO_2 cleaning.

In addition, there are research projects in the energy field funded by the *Danish National Advanced Technology Foundation.* The foundation funded energy R&D for about €6.9m in 2006, for €7.5m in 2007, and for €9.6m in 2008.

Table 5: Public funding for R&D on energy 2006-2008. In million euro (1 €=7.5 DKK). Source: Energi 2007 (2007)

	2006	2007	2008
Ministry of Transport and Energy	10.1	24.8	27.7
EFP	10.1	24.8	—
EUDP	—	—	27.7
PSO-programmes	20.7	20.7	20.7
ForskEL	17.3	17.3	17.3
ELFORSK	3.3	3.3	3.3
Strategic Research Council	14.3	14.0	12.5
EnMi	14.3	14.0	12.5
Danish National Advanced Technology Foundation (about 20% of all funding)	6.9	7.5	9.6
Sum of public R&D funding	*52.0*	*66.9*	*70.5*

International collaboration

The EU framework programmes

Denmark has participated actively in the EU framework programmes related to non-nuclear energy research. The FP5 ENERGIE was a great success for the Danish energy research sector. The level of funding received by the FP5 ENERGIE was about €59.2m of €958.3m of all EU's funding in this programme, this means that Denmark received about 6.2% of all EU funding in ENERGIE.[4] Highest funding received the R&D fields Renewable energy systems and fuel cells (€23m) and Renewable energy components (€13m). Denmark participated in 23% of the 780 collaborative projects under ENERGIE, in 41 projects had Danish participants the coordination function (for more information see Figures 4 and 5).[5] The participation in the FP5 was very important for the Danish research organisations and companies:

- to maintain their leading positions worldwide
- to contribute to an European balance with the American and Japanese industry
- to participate in the fulfilment of the EU's obligations of the Kyoto protocol.[6]

The Danish Energy Authority analysed the participation in the *EUFP6 (2003–2006)*. According to the DEA Danish research groups and companies have received project funding for about 5% (DKK280-340m) of the total funding of the programme (6.3 billion DKK). The funding was concentrated in short and medium term projects.[7]

Denmark participates in several ERA-Nets: the Photovoltaic European Research Area Network, in the ERA-NET Hydrogen and Fuel Cell Coordination Network, HY-CO and in the FENCO ERA-NET for clean fossil energy technologies (see also the table on ERA-Net collaboration in the section 3.3 Collaboration in ERA-NETs related to renewable energy).

[4] Achieved Danish EU funding from ENERGIE: http://www.ens.dk/sw17210.asp
[5] Danish participation in EU funded projects: http://www.ens.dk/sw16835.asp
[6] Compare also: http://www.ens.dk/sw17040.asp
[7] EU FP6: http://www.ens.dk/sw16829.asp

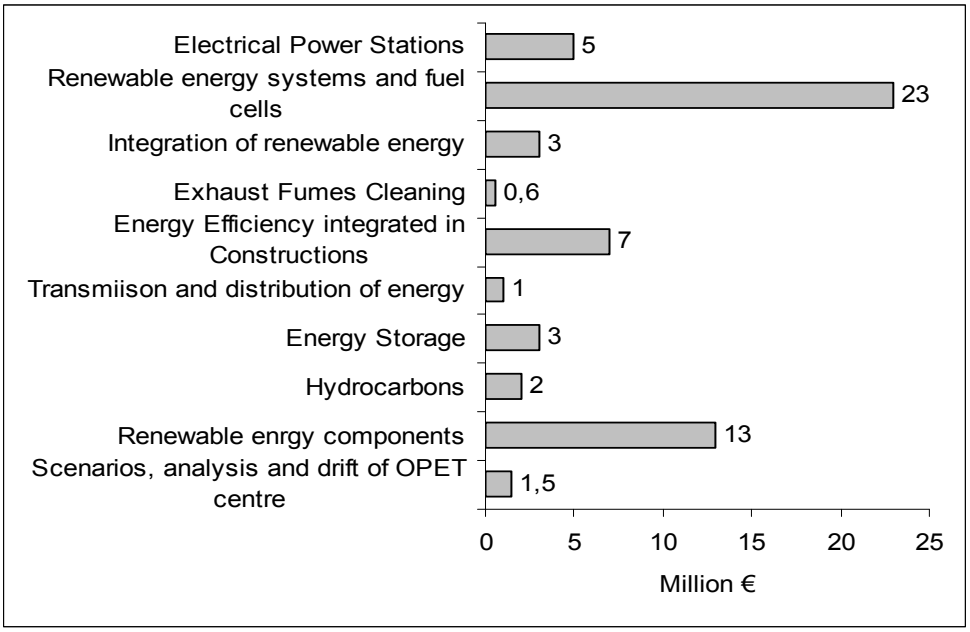

Figure 3: EU funding of Danish RD&D in the FP5 ENERGIE Thematic distribution. In million euro (€59.2m)

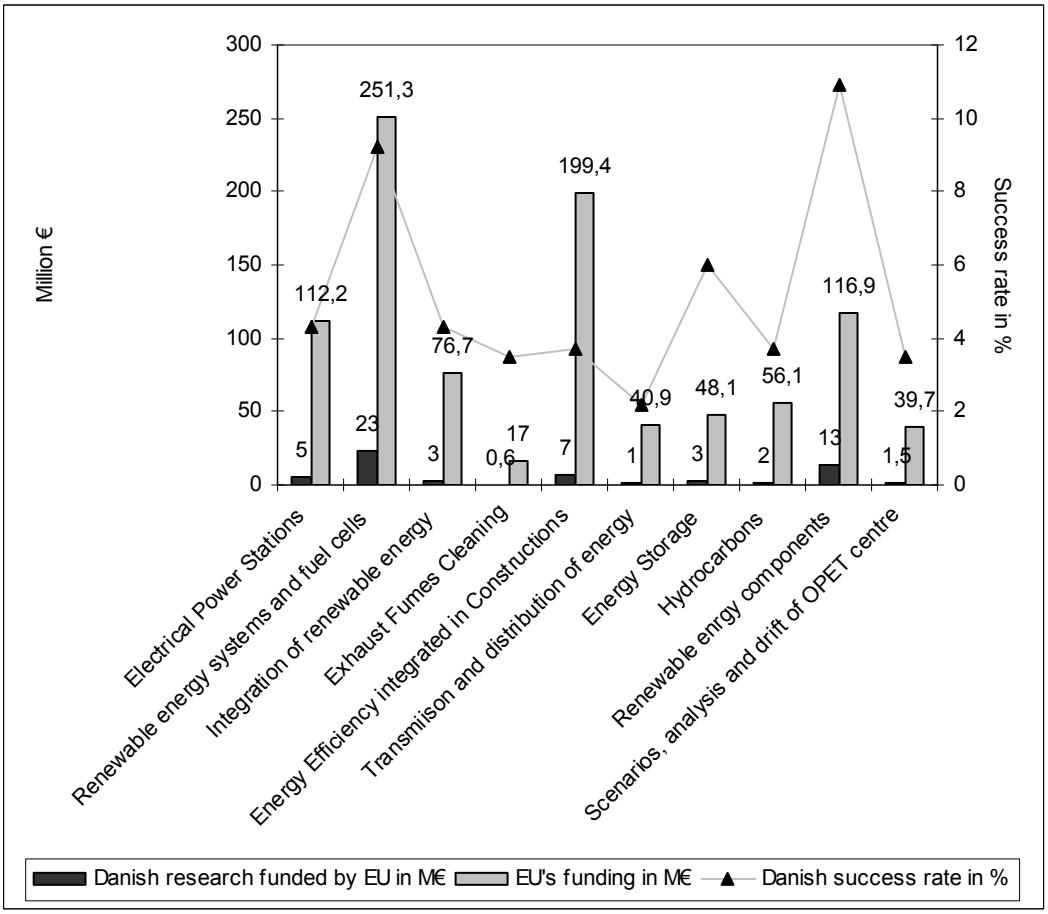

Figure 4: EU funding of Danish RD&D in the FP5 ENERGIE. In million euro. Source: DEA

The OPET Network - Organisations for the Promotion of Energy Technologies, was an initiative ny the European Commission aimed at promoting public awareness of current energy research through a new and challenging series of activities.[8] Denmark coordinated the OPET project Combined Heat & Power/District Heating (2003-2004).[9] The project was co-funded by the European Commission under the 5th Framework Programme.

Denmark is also participating in COST – European Cooperation in the field of Scientific and Technical Research.[10] COST includes several actions related to energy R&D, for example the Research and Development of Bioethanol Processing for Fuel Cells (BIOETHANOL) under the domain Materials, Physical and Nano Sciences.[11]

Key actors and institutions

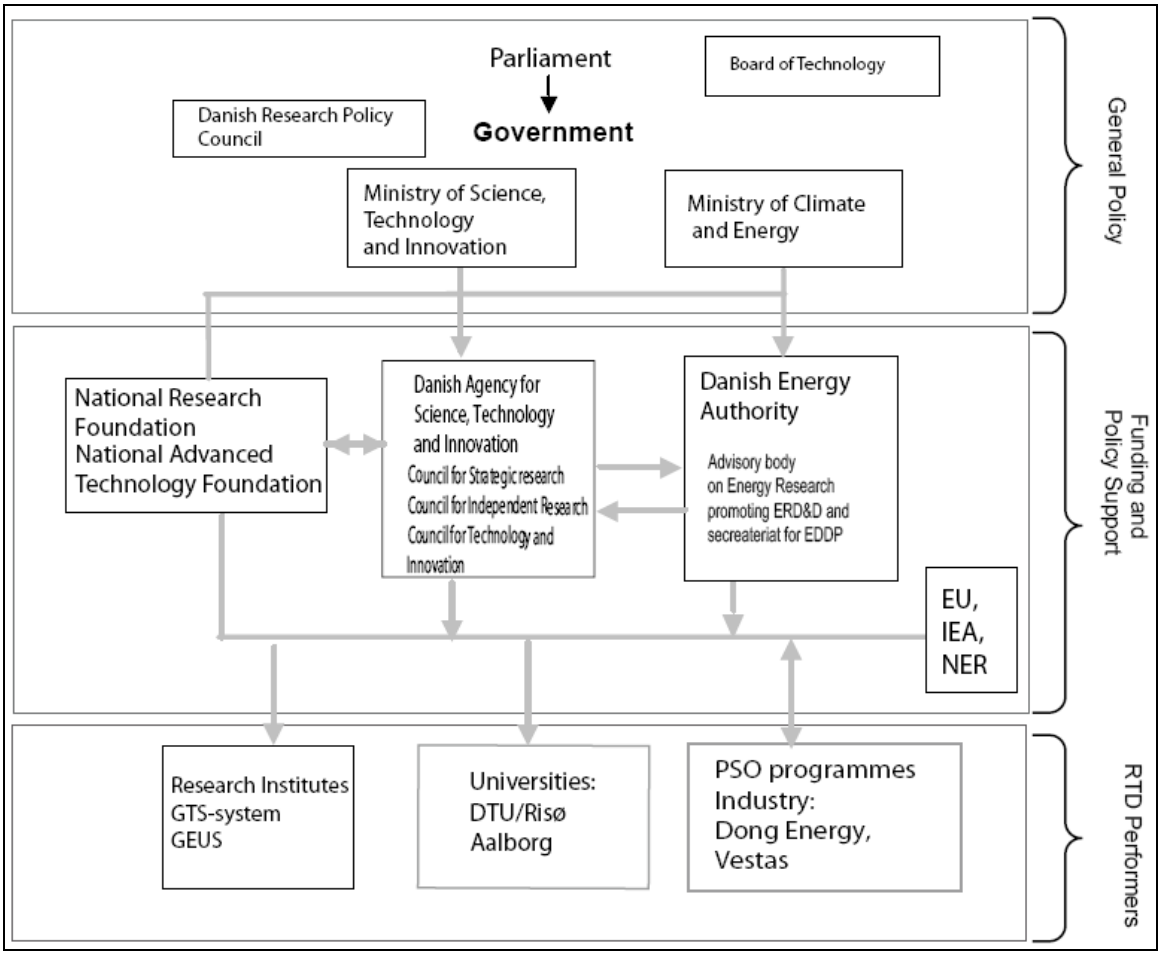

Figure 5: The Danish Energy Policy System. Source: NIFU STEP

The Danish energy policy system is shown in Figure 5. The policy system is characterised by several features:

[8] OPET: http://www.opet-network.net/default.htm
[9] Project link: http://www.opet-chp.net/default.asp
[10] COST: http://www.cost.esf.org/index.php
[11] BIOETHANOL: http://www.cost.esf.org/index.php?id=248&action_number=543

- strong association of energy policy with environmental policy
- responsibility for energy research located in several policy instruments, but mainly under energy authorities and the Strategic Research Council
- coordination between R&D policy actors (DEA, Strategic Research Council and research foundations)
- energy RD&D also under management of industry in PSO-programmes.

Government organisations

Ministries

Ministry for Climate and Energy
The Ministry for Climate and Energy was established after the re-election of the Fogh-Rasmussen government in January 2008. The Ministry is responsible for the coordination of governmental activities in climate and energy. The Danish Energy Authority DEA is an agency under the Ministry. Before 2008, energy issues were administered by the former Ministry for Transport and Energy.

Ministry for Science, Technology and Innovation
The Ministry is responsible for the coordination of governmental funded research activities and has established for this purpose an Agency for science, technology and innovation.

Governmental Agencies

Danish Energy Authority
The Danish Energy Authority was established in 1976, and is an Authority under the Ministry of Transport and Energy, since 2008 under the Ministry of Climate and Energy. The Danish Energy Authority carries out tasks, nationally and internationally, in relation to the production, supply and consumption of energy. The Danish Energy Authority administers the former Energy Research Programme (ERP), which funds R&D in the area of cleaner and more energy efficient technologies. The *Advisory Committee on energy research REFU* (Rådgivende Energiforskningsudvalg) gives policy advice to the Danish Energy Authority about strategies, scope and priorities of energy research, technology development and demonstration. The ERP also finances Denmark's participation in international energy research cooperation (IEA) and Nordic cooperation in the area.

Danish Agency for Science, Technology and Innovation
The Danish Agency for Science, Technology and Innovation is under the Ministry for Science, Technology and Innovation.

Danish Environmental Protection Agency
The Environmental Protection Agency is responsible for coordination and implementation of international negotiations and reporting obligations on climate issues within the European Union and the United Nations Climate Convention.

Research Councils

Danish Council for Strategic Research
The Danish Council for Strategic Research is part of the Agency for Science, Technology and Innovation, and helps other government research agencies to assess the quality of project proposals.

Other research councils are the *Danish Council for Independent Research and the Danish Council for Technology and Innovation.*

Research Foundations

Danish National Research Foundation
The Danish National Research Foundation gets help of the Strategic Research Council in the assessment of project proposals.
Danish National Advanced Technology Foundation
The Foundation gets help of the Strategic Research Council in the assessment of project proposals.

Intermediary organisations

Danish Board of Technology
The Danish Board of Technology gives policy advice, works with technology foresight and explores ethical issues regarding energy technology. The Danish Board of Technology organises foresight projects and public hearings in the Parliament and disseminates knowledge about technology, its possibilities and effects on people, society, and the environment.

Public research organisations

Universities

- Aalborg University, Institute for Energy Technology, Institute for Energy Planning
- Technical University of Denmark (DTU), Interdisciplinary Research Center for Catalysis (ICAT), MaxiFuels, Institute for Mechanics, Energy and Construction
- Technical University of Denmark (DTU), Biomass Gasification Group at Department for Mechanical Engineering
- Danish Research Consortium for Wind Energy (DTU, Copenhagen University (KU), Risø National Laboratory, Aalborg University and DHI Water & Environment): research collaboration and researcher education in the DAWE - Danish Academy of Wind Energy
- University of Copenhagen (KU)
- Roskilde University Center (RUC)
- University of Southern Denmark (SDU)
- Danish Center for Biofuels (DCB) is based on a cooperation between three research groups from DTU, Risø National Laboratory, now a part of the DTU and the Royal

Veterinary and Agricultural University (KVL), now a part of the Faculty of Life Sciences at the University of Copenhagen.

Research institutes

- Risø National Laboratory is a government research institute under the Ministry of Science, Technology and Innovation and merged with the DTU January 2007.
- Danish Building Research Institute SBi is now a part of the Aalborg University.
- Geological Survey of Denmark and Greenland (GEUS)
- National Environmental Research Institute NERI is now a part of the University of Aarhus.

GTS institutions

- Danish Technological Institute
- DHI Water & Environment
- FORCE Technology

Other R&D organisations with energy as a target

- *Graduate Schools:*
  - EnergyLabDK at DTU
  - Danish Academy of Wind Energy (DAWE) a collaboration between the Technical University of Denmark (DTU), Aalborg University (AAU), Risø National Laboratory and the Danish Hydraulic Institute (DHI)
  - Hydrogen and Fuel Cell Academy (HyFC) at Risø National Laboratory
- *Innovation Accelerating Research Platform Sustainable energy in a system* (Vedvarende energi sat i system)

Non-governmental organisations

The Danish Society of Engineers, IDA, is a professional association for engineers and other specialist groups working within engineering and technology, and has organised expert meetings about energy technology and an ongoing debate about research policy.
The Confederation of Danish Industries, DI, is a trade organisation and an employers' association. The mission of DI is to increase awareness of the enterprises in order to ensure that each individual member can produce and develop under still better conditions.
The Association of Danish Energy Companies is an industry association and umbrella organisation for associations and groups of energy companies in Denmark.
The Danish Hydrogen Association includes all organisations involved in hydrogen technology, from basic research to the commercial exploitation of research and technology in production, distribution, storage and use of hydrogen.
The Danish Research Consortium for Wind Energy is a collaboration between the Technical University of Denmark (DTU), Aalborg University (AAU), Risø National Laboratory, the Danish Hydraulic Institute (DHI) and. the University of Copenhagen with

the aim of strengthening wind energy-related research and development and education of researchers through intensified collaboration and coordination.
The Danish Standards Association (Dansk Standard) collaborates with foreign partners and the Danish industry on standardisation in the following subgroups:

- Solid mineral fuels
- Thermal Solar Systems and Components
- Petroleum products, lubricants and related products
- Photovoltaic conversion of solar energy
- Wind mill technology
- Solid bio-fuel
- Solid waste-fuel
- Hydrogen and fuel cells
- Steering of power systems and communication.

Firms

Value chain of the Danish energy industry

Danish energy industry is covering the whole value chain of energy related industry (compare Figure 6): from raw material extraction in the North Sea or use of waste or bio-materials, to energy production in CHP, wind mills etc., energy transmission/distribution and consumption of energy.

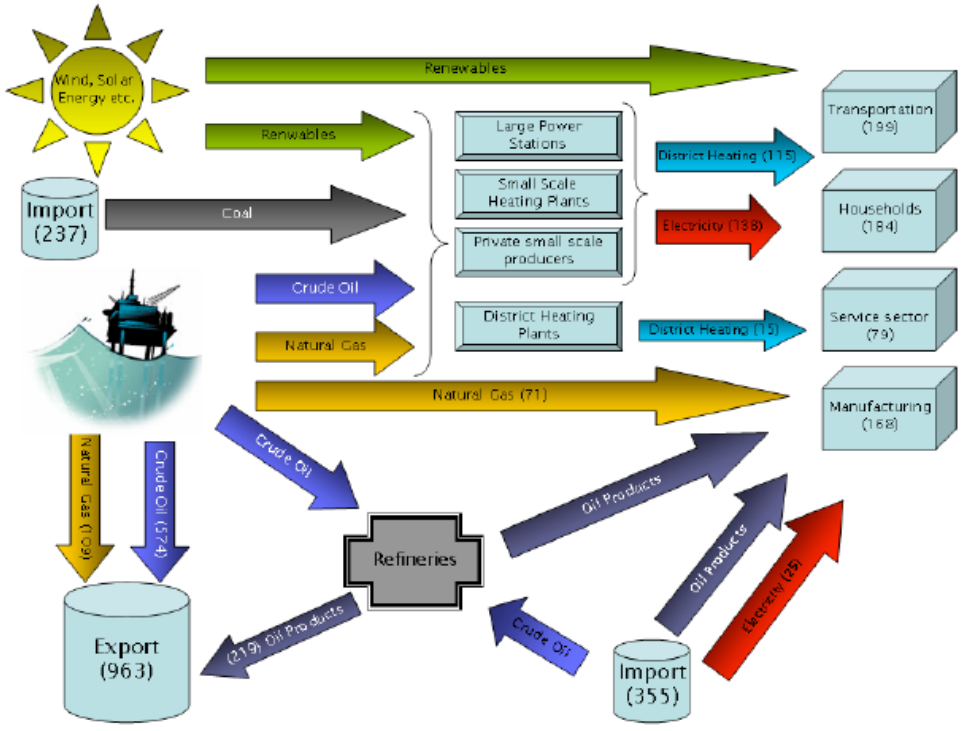

Figure 6: The value chain of the Danish energy industry. Source: Vækstfonden (2006, p. 13)

SWOT analysis of Danish energy industry

The SWOT analysis delivered by Væksfonden (Figure 7) has been an input in the SWOT analysis conducted by the eNERGIA project (compare eNERGIA report, Part 3).

STRENGTHS	WEAKNESSES
▪ High energy efficiency ▪ Wind power ▪ District Heating ▪ Waste management ▪ Flexible workforce ▪ Know-how	▪ Funding gap between public research and the market ▪ Size of the Danish market ▪ Lack of entreprenuers ▪ Low degree of knowledge sharing among knowledge institutions
OPPORTUNITIES	**THREATS**
▪ Large scale investment program from DONG Energy ▪ Fuel cells ▪ Energi efficiency ▪ Bio ethanol ▪ Exports	▪ Universities do not stimulate entrepreneurship ▪ Belief in prior strenghts ▪ Political dependence

Figure 7: SWOT analysis of Danish energy industry. Source: Vækstfonden (2006, p. 16)

The analysis of the R&D firm data gathered in this project gives on overview of the most important industry actors in selected energy technologies (Table 6). Some of the listed companies are active in several fields such as like DONG Energy, Elsam A/S and Haldor Topsoe A/S, while most of the companies are specialised in one field. The wind industry cluster covers the whole value chain and is one of most important export industries in Denmark. Another strong feature of Danish energy industry is bioenergy. This strength is also present in the more advanced technology field of second generation biofuels.

Danish energy advice services are very export intensive. The following service companies should be mentioned: COWI A/S, DHI Water & Environment, Elsam Engineering A/S, NIRAS Rådgivende Ingeniører og Planlæggere, Rambøll and Ødegaard & Danneskiold-Samsøe A/S.

Table 6: R&D based companies in Denmark active in selected fields of energy technology*

Firm name	Photo-voltaics	Wind	Hydro-electric power	Wave power	2nd Generation Biofuels	CCS
A2SEA AS		X				
ACTEC A/S	X					
ARCON SOLVARME A/S	X					

BIO-CIRCUIT APS					X	
Biocontractors A/S					X	
BIONEER AS						X
Bioscan A/S					X	
Bolding & Burchard Hydrodynamics GBR		X				
BONUS ENERGY A/S (part of Siemens)		X				
Burmeister & Wain Scandinavian Contractor					X	
CARL BRO AS		X				
DANISCO					X	
Danvest Energy (now part of NEG Micon, Vestas)		X				
DONG Energy (Danish Oil & Natural Gas Company)					X	X
DWS-Wincon I/S		X				
EC Power A/S		X				
Elsam A/S		X			X	X
ELTRA		X				
Energi E2						X
Gamesa Wind Engineering APS		X				
Green Farm Energy A/S					X	
Haldor Topsoe A/S					X	X
INVENSYS APV A/S					X	
JK Turbine APS			X			
kk-electronic A/S		X				
KM VINDMOLLER		X				
KRUGER AS					X	
LM GLASFIBER A/S		X				
Logima		X				
Mita-Teknik A/S		X				
NEG Micon A/S (now part of Vestas)		X				
NESA AS		X				
NORDEX ENERGY GMBH		X				
Novo Nordisk A/S					X	
NOVOZYMES A/S					X	
PlanEnergi SI		X				
PP ENERGY APS		X				
Samson Bimatech I/S					X	
Siemens Wind Power A/S		X				
SSP Technology A/S		X				
Union Engineering A/S						X
Vamdrup Special Transport APS		X				
Vestas Wind Systems A/S		X				
WAVE DRAGON APS				X		
Waveplane International A/S				X		
WEA TECHNOLOGY A/S		X				

* The selection criteria have been R&D activities documented in patent statistics, bibliometric statistics, R&D project funding by the EUFP5 or Nordic Energy Research and research reports.

1.2 Sweden

Policy and regulation framework conditions

Introduction to national energy technology and production

Electricity production in Sweden today is almost fossil-free. Close to fifty per cent of the electricity production is generated from hydro power and the remainder from nuclear power. The share of renewable energy sources in the energy system has increased rapidly during the last decade of which biomass accounts for the greater part of the increase. More than 60 per cent of district heating (approximately 40 per cent of the heating market in Sweden) fuel today is biomass. Energy production from wind power has also increased significantly during the last ten years. The ambition is to increase the annual electricity production from renewable energy sources with 17TWh by 2016 compared to 2002 (Government Bill 2005/06:154).

According to the European Commission Assessment of the National Reform Programme (December 2006), Sweden has made good progress in increasing public investment in R&D, and in bringing forward measures to encourage innovation. In particular, Sweden is doing well and is among the best in the EU in encouraging a sustainable use of energy.[12]

Sweden has a long tradition in energy research. Since the mid-seventies, Sweden has had an energy research programme aiming at reducing the use of energy and replacing oil with renewable sources of energy. In the 1980s, the strong pressure for phasing out nuclear energy production became a strong driving force behind energy research. Today, Sweden is in the forefront in an international perspective in several research and development areas such as biofuels, heat pumps and solar cells.

In recent years there has been more emphasis on research implementation through commercialisation. Commercialisation of knowledge and products in the field of energy technologies is still lagging behind when compared with other fields of technology. Since 2005, the Swedish Energy Agency has been focusing its activities on market-oriented initiatives through the new Department of Business Development and New Ventures.[13]

The introduction of various policy instruments has contributed to a gradual increase in the use of renewable resources. Two important instruments are the carbon dioxide taxation and the green electricity certificate systems introduced in 2003.

Table 7: Sweden Country Summary Table
Sources: Eurostat (2007) Energy Yearly Statistics 2005; European Commission (2003b) Biofuels Directive; European Commission (2008) Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources COM (2008)

General information	
Population (2006)	9080505
Land area	450,000 km²

[12] European Commission (December 2006) Assessment of National Reform Programme Sweden
[13] Swedish Energy Agency, Swedish Energy Research 2006

Macroeconomic Information	
GDP per capita in PPS (2006)	124.8
Real GDP growth rate (2006)	4.1
EU Targets for the share of energy from RES	
RES target in 2005 (% of final consumption of energy)*	39.8
RES target 2020 (% of final consumption of energy)*	49
Biofuel target (2010)	5,75%
Electricity generation total 2005(in GWh)	158 435
Hydro	72 874
Wind	936
Nuclear	72 377
Conventional thermal of which: - Hard coal - Petroleum products - Natural gas - Biomass	 648 1379 559 8 301
Consumption	132 373
Exports and imports	
Exports	21 968
Imports	14 576

*European Commission (2008).

Table 8: Renewables in Sweden in 2005. Source: IEA[14]

	Municipal Waste*	Industrial Waste	Primary Solid Biomass**	Biogas	Liquid Biofuels	Geothermal	Solar Thermal	Hydro	Solar Photovoltaics	Tide, Wave, Ocean	Wind
Unit	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*
Gross Elec. Generation	**1309**	**81**	**6848**	**54**	**65**	**0**	**0**	**72874**	**0**	**0**	**936**
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*				
Gross Heat Production	**21443**	**1144**	**92685**	**866**	**2741**	**0**	**0**				
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*1000 tonnes*	*TJ*	*TJ*				
Production	30817	1703	332291	1247	312	0	247				
Imports	0	0	0	0	0	0	0				
Exports	0	0	0	0	0	0	0				
Stock Changes	0	0	0	0	0	0	0				
Domestic Supply	**30817**	**1703**	**332291**	**1247**	**312**	**0**	**247**				
Statistical Differences and Transfers	0	0	0	0	0	0	0				
Total Transformation	**30817**	**1703**	**140798**	**1247**	**105**	**0**	**0**				

[14] http://www.iea.org/Textbase/stats/renewdata.asp?COUNTRY_CODE=SE&Submit=Submit

Electricity Plants	0	0	0	0	0	0	0
CHP Plants	23566	1456	105063	961	35	0	0
Heat Plants	7251	247	35735	286	70	0	0
Other Transformation	0	0	0	0	0	0	0
Energy Sector	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Distribution Losses	0	0	0	0	0	0	0
Total Final Consumption	**0**	**0**	**191493**	**0**	**207**	**0**	**247**
Industry	0	0	148673	0	0	0	0
Transport	0	0	0	0	207	0	0
Residential	0	0	26311	0	0	0	247
Commercial and Public Services	0	0	2500	0	0	0	0
Agriculture / Forestry	0	0	14009	0	0	0	0
Fishing	0	0	0	0	0	0	0
Other Non-Specified	0	0	0	0	0	0	0
Non-Energy Use	0	0	0	0	0	0	0
- of which	0	0	0	0	0	0	0
Petrochemical Feedstocks							

*Municipal Waste: the split for renewable and non-renewable waste is also available
** Primary Solid Biomass: data are also available for charcoal

Government energy action plans and strategy documents, in particular energy technology focus areas and priorities

The vision in Swedish energy policy is that the country will obtain all its energy from renewable energy sources in the long term. The continued transformation of the energy system and high security of supply are two important reasons for promoting electricity production from renewable energy sources in Sweden.[15]

To reach this goal, public funded research is seen as an important instrument. Sweden has more than three decades of experience in public funded research and programmes in the energy field. Some of the major phases in the development of the framework and the priorities in Swedish energy research are described hereunder.

Sweden started an energy research programme in 1975 as a response to the first oil crisis. The purpose was to adapt to the current world situation and respond to environmental needs.

Following a resolution in 1991, a Fund for Energy Technology (Energiteknologifonden) was established with the aim of supporting the development and introduction of new technologies to the market. In 1992, a biofuels programme was launched (FABEL). The total financial allocation was SEK625m (approximately €70m) for a five years period.

[15] (Government Bill 2005/06:154) *Renewable electricity with green certificates*

Following parliament's decision in 1997 to gradually phase out nuclear power and the government's energy policy resolution (Bill 1996/97)' the Long-Term Energy Policy Programme (1998-2004) was introduced. In total 5,6 billion SEK (ECU 0,64 b) was allocated to the programme distributed to energy research , support for energy technology development, energy demonstration projects and to energy related climate initiatives. The Swedish Energy Agency was responsible for implementing the programme together with The Swedish Agency for Innovation systems – Vinnova, the Swedish Research Council and the Swedish Research Council for Environment and Formas for Agricultural Science and Spatial Planning.[16]

In 2001, the government appointed a Commission on Energy Research, Development and Demonstration (the ERDD Commission) to examine and evaluate the initiatives included in the programme and to come up with proposals for a long-term energy policy for the planning period after 2003. The Commission's assessment of the ERDD programme concluded that the fragmentation of the programme and the insufficient focus on commercialisation were the major issues to consider for future improvements.[17]

In the light of the ERDD Commission's report, the Swedish Energy Agency received the assignment from the government to report on visions, measurable goals and concrete proposals for research, demonstration and development in the energy field. The report (FOKUS II), published in 2005, laid down the priority areas of Swedish long-term national energy research. The following priorities were proposed: Energy systems studies, the Building as an Energy system, the Transport sector, Energy Intensive Industry, Fuel-based Energy Systems and the Power system.[18]

In the "Government Bill on research and new techniques for the future energy system" (2005/2006: 127), the government formulates the visions and the thematic areas for the long term policy initiatives for research, development, demonstration and commercialisation in the energy field on the basis of the six thematic areas indicated by the Swedish Energy Agency (FOKUS II). The government expressed the importance of developing the potential for wind, wave and solar energy.

In January 2005, the government appointed a Commission on Oil Independence with the mandate to come up with concrete proposals on how to reduce Sweden's dependence on oil. In June 2006, the result of the commission was published in the report "Making Sweden an OIL- FREE Society". The report proposes far-reaching, concrete measures aiming at ending Sweden's dependence on oil by the year 2020. The objectives proposed were:

- a reduction of 40 to 50 per cent in the consumption of oil by road transport through the more efficient use of fuels and new
- no oil shall be used for heating residential and commercial buildings
- industry shall reduce its consumption of oil by 25-40 per cent. [19]

[16] SOU 2003:80
[17] SOU 2003:80 English summary
[18] The Swedish Energy Agency (ER 2005:38)
[19] Prime Minister's Office Commission on Oil Independence, final report June 2006

The new centre-right government appointed in September 2006 has proposed to allocate one additional billion SEK, (the initiative is named "Climate billion"), for the period 2008–2010 to strengthening measures against climate change. New measures that are being supported include:

- climate related research, €0.88m (SEK8m)
- energy efficiency €31.14m (SEK310m)
- support to second generation biofuels €16.51m (SEK150m for the period 2008-2010)
- a national grid for wind power €4.40m (SEK40m for the period 2008-2009)
- sustainable extraction of biomass from forests and crops €4.40m (SEK40m)
- climate investments in other countries €3.52m (SEK32m)
- establishing a programme for sustainable cities €37.44m (SEK340m).[20]

Table 9: Selected policy documents on energy and climate 2001-2007

Title of document	Date	Organisation	Type of document
Government Bills on Energy			
Proposition 2001/02:143 Samverkan för en trygg, effektiv och miljövänlig energiförsörjning	2001	Ministry of Industry	Gov. Bill
Proposition 2005/06:127 Forskning och ny teknik för framtidens energisystem	2005	Ministry of Sustainable Development[21]	Gov.Bill
Proposition 2005/6:143 Miljövänlig el med vindkraft - åtgärder för ett livskraftigt vindbruk	2005	Ministry of Sustainable Development	Gov.Bill
Proposition 2005/06:158 Åtgärder för att stärka kundernas ställning på energimarknaden m.m.	2005	Ministry of Sustainable Development	Gov.Bill
Proposition 2005/06:145 Nationellt program för energieffektivisering och energismart byggande	2005	Ministry of Sustainable Development	Gov.Bill
Proposition 2005/06:154 Förnybar el med gröna certifikat	2005	Ministry of Industry	Gov.Bill
Fiscal Policy Bill 2008 (2007/08:81), budget line 21 on energy	2007	Ministry of Finance	Gov. Fiscal Policy Bill
Government Bills on Climate and Environment			
Propositionen 2004/05:150 Svenska miljömål – ett gemensamt uppdrag	2004	Ministry of Sustainable Development	Gov.Bill
Proposition 2005/06:172 Nationell klimatpolitik i global samverkan	2005	Ministry of Sustainable Development	Gov.Bill
Proposition 2005/06:184 Utvecklad utsläppshandel för minskad klimatpåverkan	2005	Ministry of Sustainable Development	Gov.Bill

[20] Fiscal Policy Bill 2008

[21] From 1 November 2004 to 1 January 2007, during the cabinet of Göran Persson, the current Ministry of Environment was known as the Ministry of Sustainable Development (Swedish: *Miljö- och samhällsbyggnadsdepartementet*).

Proposition 2005/06:181 Miljöklassning av alternativa motorbränslen m.m.	2005	Ministry of Sustainable Development	Gov.Bill

Important R&D and innovation policy instruments

A wide range of policy instruments – notably energy innovation and RD&D, electricity certificates, carbon dioxide taxation (since 1991), subsidies and tax incentives – are being used to encourage the growth of renewable and green electricity. In Sweden, Energy R&D is an important policy instrument to meet national energy policy objectives. The Swedish Energy Agency is responsible for almost all Sweden's public funding for energy research. The Energy Research Programme (2005–2011) of the Agency focuses on six thematic areas: Energy systems studies, the Building as an Energy system, the Transport sector, Energy-intensive Industry, Fuel-based Energy Systems and the Power system. For the period 2006–2008, the Programme will distribute €91.4m (SEK830m) annually. Since 2005, the Energy Agency has sole responsibility for the Energy Research Programme, including basic research in the energy field. Cooperation with industry effectively doubles financing. The Energy Agency allocates €4.375 m (SEK42m) for basic energy research in the period 2007-2009.[22]

Within each of the six thematic areas, research is organised into specific programmes. Technology platforms have been created for each area and incorporate experts from private and public organisations.

Other programmes managed by the Swedish Energy Agency:

- The Programme for Improving Energy Efficiency in Energy Intensive Industries (PFE) came into force 1 January 2005 and intends to increase the efficiency of energy use among energy-intensive companies. The programme period for participating companies is five years. During the first two years of the programme period, the company must introduce and obtain certification for a standardized energy management system.
- The Sustainable Municipality programme is a five-year programme, which was launched in 2003 with the ambition to put the energy restructuring into a wider community perspective. These measures have had a positive effect on the reduction on CO_2 emissions and on the increase of renewable electricity production.
- The Swedish Climate Policy Research Programme is managed and funded the Swedish Energy Agency, the Swedish Environmental Protection Agency, the Foundation for Strategic Environmental Research and the Swedish Meteorological and Hydrological Institute. The programme allocates €5m annually to research that supports the Swedish climate strategy.[23]

In 2006, Sweden allocated in total 5.3 per cent of the total R&D investment to the energy sector. Included in this figure are public financed research and research and development

[22] http://www.energimyndigheten.se/WEB/STEMEx01Eng.nsf/F_PreGen01?ReadForm
[23] http://www.sweclipp.se/

in the private sector. The management of the public funds is mainly under the responsibility of the Swedish Energy Agency.

In 2007, the Swedish government allocated SEK816m (€90m) for research to the Energy Agency, which corresponds to 0.9 per cent of the total research allocation. In addition, the universities devote approximately the same amount to energy research. The Energy Agency estimates that there will be no dramatic increase in the budget in the coming two years.

According to estimates from the Royal Swedish Academy for Engineering Sciences (IVA) and Elforsk, government's allocations represent almost on-third of the total allocations in the energy field (4.8 billion SEK (€0.5 b) in 2006), corresponding to 5.3 per cent of total research allocations, – well in line with EU targets. (According to the EU R&D support plan for 2007–2013 the share of public R&D dedicated to the energy sector should be 4.6 per cent.)[24]

International collaboration

Swedish researchers participate in several international research projects on energy. In the sixth EU framework programme Sweden had a high participation rate. In the energy programme (ENERGY), a total of 97 projects received funding of which 37.1 per cent had Swedish participants, which is a high percentage compared with the Swedish average participation rate in EU framework programmes; 5.3 per cent of the funds went directly to Swedish contractors and 3-1 of the project coordinators were Swedish. [25]

Technology Platforms:

- The Swedish Energy Agency operates as secretariat for the Technology platform for bio-based motor fuels ("Biofuels for transport")
- EU Refuel project

IEA-cooperation:

- Working Party on Fossil Fuels
- Working Party on Renewable Energy Technologies
- Working Party on Energy End Use Technologies
- Fusion Power Coordinating Committee

Sweden also participates in the International Energy Agency's Photovoltaic Power Systems Programme.

Bilateral cooperation initiatives:

- Swedish-Japanese energy seminar 2007 (Vinnova)
- In June 2006, the Swedish Government and the State of California reached an agreement for cooperation on renewable fuels and energy
- In June 2007, a research exchange programme with China was established in the field of energy. Focus is on bio-energy with a budget is of SEK8.75m.

[24] Swedish Energy Agency, ER 2006:38
[25] VINNOVA, Swedish participation in the sixth framework programme.

Environmental laws and regulations

The Swedish Environmental Code came into force on 1 January 1999. It replaced fifteen previous environmental acts which were amalgamated into the Code. The Code contains 33 chapters comprising almost 500 sections. The Environmental Code is further elaborated and specified in the form of ordinances, regulations issued by public authorities and decisions taken in individual cases, for example "The Ordinance (1998:899) concerning environmentally hazardous activities and the protection of public health (Latest revision: 2002)".[26]

Key actors and institutions

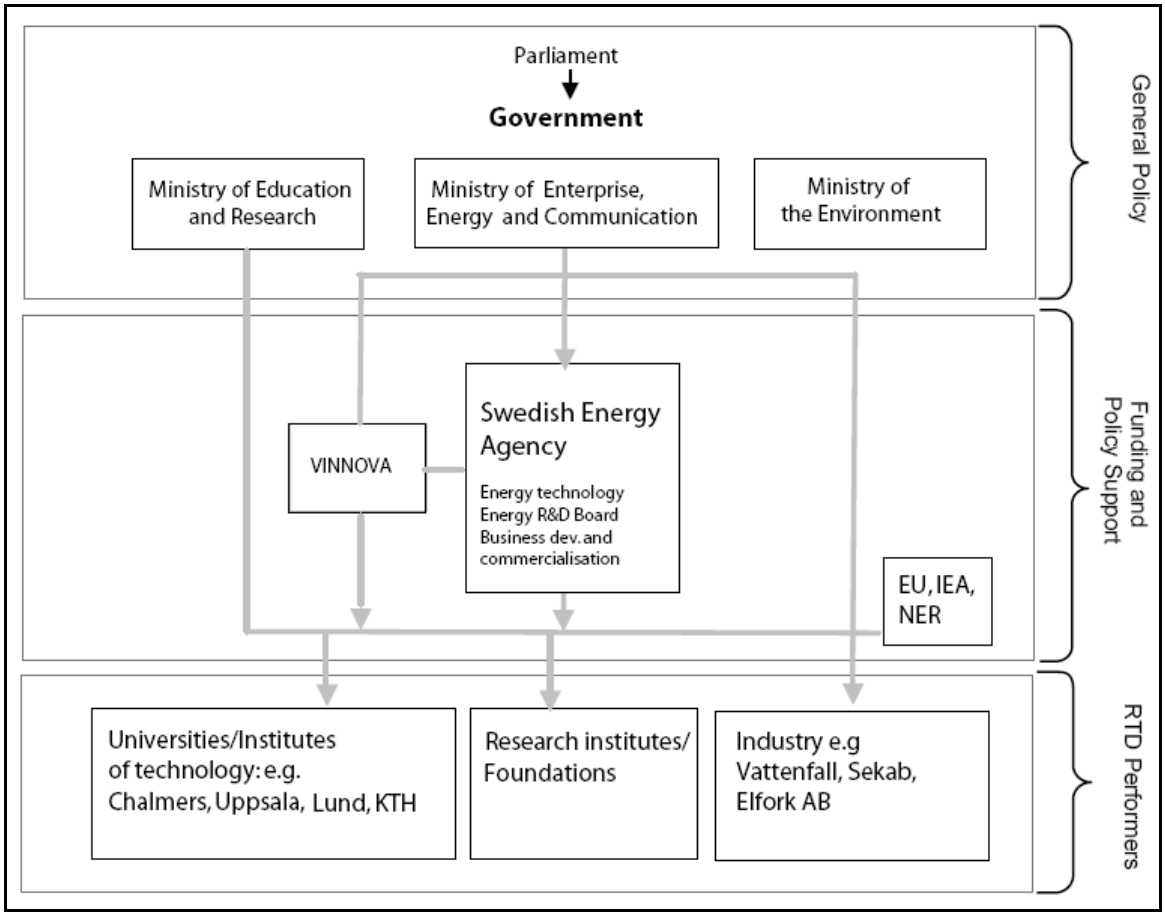

Figure 8: The Swedish Energy Policy System. Source: NIFU STEP

Government organisations

Ministries

The cabinet of the current Prime Minister, Fredrik Reinfeldt, which took office on 6th October 2006, decided to transfer energy issues from the former Ministry of Sustainable

[26] http://www.internat.naturvardsverket.se/documents/legal/hazard/ordinanc.pdf

Development (now the Ministry of the Environment) to the new Ministry of Enterprise, Energy and Communications. The areas of responsibility within the energy field include security of supply, reliable electricity transmission, renewable energy, wind power, energy R&D, electricity certificates and improved energy efficiency.

Governmental Agencies

The *Swedish Energy Agency* is a government agency under the Ministry of Enterprise, Energy and Communications[27] and is responsible for Sweden's national energy research programmes for the national energy restructuring process in Sweden. The objective of the restructuring is to build a sustainable and effective energy system. The agency manages almost all State funds for energy research (approx. €85m annually). Universities and technical colleges receive more than half of this total. Chalmers University of Technology in Gothenburg, Lund University and the Royal Institute of Technology in Stockholm receive most of the funds. Trade organisations and companies also receive support for research, development or demonstration of new energy technology. The agency has research collaboration agreements with various government organisations in different fields. The Energy Research and Development Board (EUN) is appointed by the government and is the decision-making body of the energy research programme. [28]

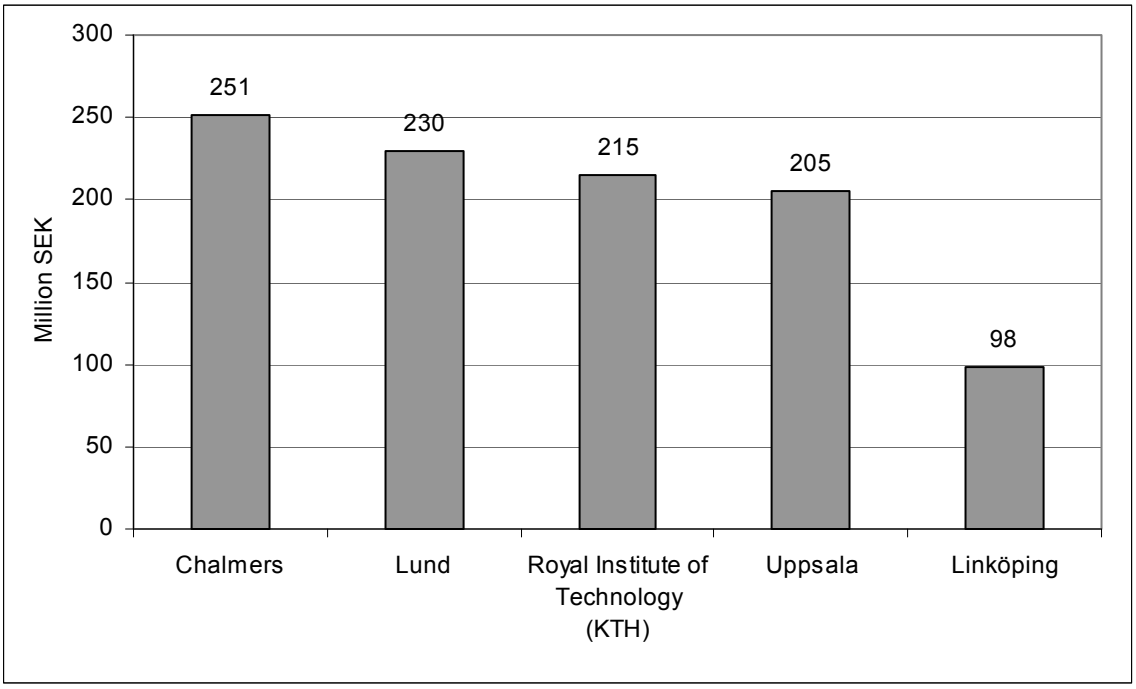

Figure 9: The five major receivers of funds from the Energy Research Programme 2002-2004. In million SEK. Source: Swedish Energy Agency ER 2006:38

The Swedish Governmental Agency for Innovation Systems (VINNOVA) is a State authority that aims to promote growth throughout the country. The particular area of

[27] Previously the Energy Agency was under the Ministry of Sustainable Development (today called Ministry of the Environment).
[28] A presentation of the Swedish Energy Agency (2006)

responsibility comprises innovations linked to research and development. The tasks are to fund the needs-driven research required by a competitive business and industrial sector, and to strengthen the networks that are such a necessary part of this work. VINNOVA collaborates with the Swedish Energy Agency especially on transport sector specific programmes, such as vehicle research.

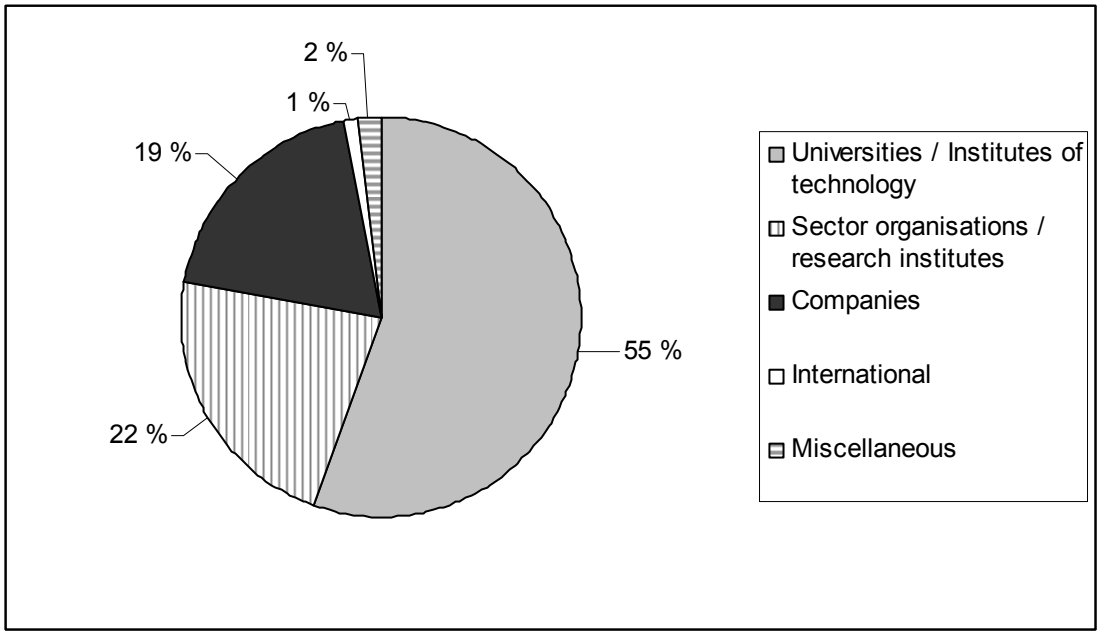

Figure 10: Recipients of funding from the Swedish Energy Agency in 2006. Source: Swedish Energy Agency

The Swedish National Grid (Svenska Kraftnät) is a state agency, operating since the early 1990s with the responsibility of administering and running the national electrical grid. Operations are primarily financed by the fees that power producers and network owners pay to transmit power across the grid.
Since July 2005, Svenska Kraftnät also has the system responsibility for the national supply of natural gas. The mission of Svenska Kraftnät is to:

- provide transmission of power on the National Grid well in compliance with security, efficiency and environmental requirements.
- perform the system operator function for electricity and natural gas cost-efficiently.
- promote an open and competitive Swedish, Nordic and European electricity and natural gas market.
- ensure a robust nationwide supply of electricity.

Research Councils

The Swedish Research Council is the largest provider of public funds (approximately SEK 2.5 billion annually) for Swedish basic research at Swedish higher education institutions (HEIs) and research institutes. The Research Council collaborates with the Swedish Energy Agency on basic energy research. Since 2005, the Research Council's

budget for basic energy research has been heavily reduced. The responsibility for energy research is now under the main responsibility of the Swedish Energy Agency.

The Swedish Research Council for Environment, Agricultural Science and Spatial planning (Formas) is a governmental research-funding agency related to several ministries: the Ministry of Environment, the Ministry of Agriculture, Food and Consumer Affairs, and the Ministry of Education, Research and Culture. Formas encourages and supports scientifically significant research related to sustainable development. Formas represents Sweden in several IEA programmes and promotes Nordic research cooperation within its areas of responsibility. Formas collaborates with the Swedish Energy Agency especially on issues concerning energy use in buildings.

The Swedish Environmental Technology Council (Swentec) has a business-policy assignment to strengthen Swedish companies' business opportunities and competitiveness within cleantech, environmentally adapted goods, manufacturing processes and services in both the national and international market. Swentec identifies technology areas and environmental problems where there is large growth and export potential, and where the Swedish offer lies at the forefront technically, economically and environmentally. Swentec is responsible for collecting information about Cleantech companies in Sweden. Cleantech companies are categorized according to the products and services they produce. The categorization of technology areas is based on the European Commission's Environmental Technologies Action Plan.

Research Foundations

The Foundation for Strategic Environmental Research (Mistra) supports strategic environmental research with a long-term perspective, aiming to solve major environmental problems. The main part of Mistra's funding is focused on broad-based interdisciplinary programmes. Mistra has funded projects related to solar energy and biomass research among others. Mistra is funding the programme "Fuel cells for a Sustainable Society" that is now in its third funding period 2007–2009, focusing on industrialisation of fuel cells.

Swedish Peat Research Foundation (TorvForsk) is a broad and general research foundation founded in 1983 by representatives of the peat industry. The purpose of TorvForsk is to initiate, plan, implement and evaluate research and development efforts of significance to the peat industry. Commencing in the spring 2007, R&D activities in the area of peat in Sweden have been reorganized and strengthened. A new research program has been developed and two organizations, the Swedish Peat Research Foundation (formerly known as SST) and the Swedish National Committee of the International Peat Society, have merged.

Gunnar Engströms ABB Foundation give awards to young, successful researchers for their efforts in Swedish energy research. Since 1983, the foundation has given awards to researchers annually.

Public Research Organisations

Universities

Chalmers University of Technology

The Division of Energy Technology at Chalmers University of Technology has a long experience of research in the areas of energy conversion and energy systems. Research covers the areas of energy conversion, sustainable energy systems and energy systems technology. The research covers combustion, carbon dioxide capture and energy system analysis and aims at contributing to find ways of decreasing the environmental impact caused by energy conversion and use. The division is participating in a number of national and international research projects.[29]

Ongoing research projects embrace global and European energy systems modelling as well as analysis of combustion processes. Examples of projects are:

- Analysis of the European energy system under different assumptions of carbon emission constraints
- Combustion of biofuels in fluidised beds.
- CO_2-free chemical loping combustion.
- Co-combustion of different fuels.
- The possible future role of biofuel gasification.

University of Lund, Faculty of Engineering

The Faculty of Engineering LTH is part of Lund University, one of Scandinavia's largest establishments for higher education and research in technical and engineering sciences. At the Department of Energy Sciences, research and teaching is carried out in energy engineering, mainly the transformation of energy to heat, electricity and propulsion, but also energy distribution and use. The common aim of all research at the Department is to develop resource-efficient solutions that save money and spare the environment. About 80 employees are working at the department.[30]

University of Uppsala

Energy research at Uppsala is multi-disciplinary in perspective, comprising environmental and security aspects in generating, storing, and using energy. Research is in progress at basic and applied levels in dry and wet solar cells, artificial photosynthesis, smart windows, wind power, wave power, production of hydrogen, hydrogen storage, batteries, fuel cells, transmutation (targeting nuclear waste), and fusion.

Research Institutes

The Royal Institute of Technology, Department of Energy Technology, KTH Energy Center (KTH-EC)

The Royal Institute of Technology's (KTH) funding level for energy related research is currently over €16.02m (150 MSEK) in various externally-funded projects. Financing is provided by the Swedish Energy Agency, the European Union, and other Swedish and

[29] http://www.chalmers.se/ee/EN/research/research-divisions/energy-technology
[30] http://www.lth.se/english/research/quick_guide_lth_research/energy_sciences/

international organizations. Catalytic combustion, wind power and hydro power are examples of research fields at KTH. KTH Energy Center is the initiator of the first Energy Park in Sweden.[31]

The Swedish Thermal Engineering Research Institute (Värmeforsk) is an institute for energy, process and manufacturing industry including forestry industry and energy consulting firms. Basic activities are concentrated on solving problems related to heat and power production. The applied research and the basic technical development at Värmeforsk are financed jointly by industry and state through the Swedish Energy Agency. Värmeforsk is a planning, administration and control body, and has no research staff or laboratories of its own.

The International Institute for Industrial Environmental Economics (IIIEE) at Lund University was established by the Swedish Parliament in 1994. The main research areas of the IIIEE are Sustainable Product and Service Systems, Distributed Economies, and Energy for Sustainable Development. Since January 2004, IIIEE is one of the eight European partners taking part in the Bioenergy NoE under the EU FP6.[32]

The Forestry Research Institute of Sweden (Skogforsk) is carrying out a four-year R&D programme on increasing the efficiency of forest bioenergy systems. The programme is being financed jointly by the Swedish Energy Agency and the forestry and energy sectors. The main focus of the research is to improve production and harvesting methods and to enhance collaboration in the haulage of logging residue with other raw materials. Skogforsk is coordinating the EU-FP6 project EFORWOOD – Sustainability Impact Assessment of the Forestry Wood Chain. The aim of the project is to provide methodologies that integrate sustainability impact assessment of the whole European forestry wood chain. The basic idea is that the European forest-based sector has a great potential to contribute to sustainable development by means of storing carbon dioxide through forest growth and substitution of CO_2 originating from fossil carbon by replacing products based on non-renewable materials. Close to 40 organisations are participating in the project, which have a budget of €20m for the period 2005-2009.

Elforsk AB is owned jointly by Svensk Energi (Swedenergy) and Svenska Kraftnät (The Swedish National Grid). The overall aim of Elforsk is to coordinate the industry's joint research and development. Operations are organised in five programme areas – Hydropower, Electricity and Heat Production, Transmission and Distribution, Electricity End-Use, and Strategies and Systems. Hydropower, wind power, carbon dioxide separation, nuclear power and effective combustion of biofuels are other examples of "climate neutral" technologies where Elforsk is devoting attention.[33]

[31] A list of ongoing projects can be found at: http://www.energy.kth.se/index.asp?pnr=17&ID=934&lang=0
[32] http://www.bioenergynoe.com/?_id=1
[33] www.elforsk.se

Non-governmental organisations

Sweden has a long tradition of strong non-governmental organisations actively participating in the political decision making process. In the renewable energy sector, several associations are actively involved in promoting renewable energies in Sweden.

VIP and ViS (*Vindkraftens Investerare och Projektörer* and V*indkraftsleverantörerna i Sverige)* represent suppliers, investors and project developers of wind power plants. The organizations were established in 2001 and jointly form the organization called *Swedish Wind Power*. The Swedish Wind Energy Association (SVIF) is promoting the development of wind energy in Sweden by dissemination of knowledge, fostering technical development and working together with public agencies.

The Swedish Bioenergy Association (SVEBIO) plays an active part in major political decisions concerning bioenergy in Sweden. Together with the Swedish Trade Council, Svebio has formed a network of Swedish bioenergy companies, the Swedish Bioenergy Group, to facilitate Swedish export of bioenergy solutions.

The Solar Energy Association of Sweden (SEAS) is a national organisation with close to 50 professional members representing Swedish industry as well as Swedish research institutes working with solar energy. The main SEAS activities include:

- Calls on authorities in order to improve the conditions for solar energy in Sweden,
- Development of information material for the public and decision-makers, etc.,
- Awards annually a Solar Energy Award (Solenergipriset) for an exemplary plant and an exceptional contribution to the development of solar energy in Sweden.
- Organising meetings for the solar industry in order to discuss common activities,
- Collect branch statistics together with SP,
- Organing research seminars together with the Swedish Energy Agency in order to facilitate the exchange of knowledge between researchers and the industry,
- Stimulatign enhanced knowledge of installers and other professionals in cooperation with member companies and SP,
- Supporting product quality via Solar Keymark – voluntary EU-certification – took early part in the definition of the requirements for P-labeling of collectors (a Swedish concept for quality labeling) together with SP.[34]

SERO is a Swedish non-governmental central organisation for regional and special organisations engaged in renewable energy. According to the organisation's web page SERO's main objective is to support and work for a rapid expansion of renewable energy sources in Sweden. At present, the main issues are to convince Swedish authorities to create a long-term support system which efficiently increases the investments and the expansion of renewable energy in Sweden and eliminates the obstacles in present laws and frameworks for renewable energy power stations. SERO represents and consists of the following renewable energy fields:

- Wind power
- Small hydro
- Solar energy
- Bioenergy

[34] www.svensksolenergi.se

- Hydrogen
- Electrical vehicles
- Energy for farmers.[35]

Firms

The analysis of the R&D firm data gathered in this project gives on overview of the most important industry actors in selected energy technologies (Table 10). Some of the listed companies are active in more than one technology field such as ABB and Vattenfall. Strong features in Swedish energy industry are in bioenergy and photovoltaic technologies.

Table 10: R&D based companies in Sweden active in selected fields of energy technology*

Firm name	Photo-voltaics	Wind	Hydro-electric power	Wave power	2nd Generation Biofuels	CCS
AB SKF		X				
ABB AB	X	X				
Acreo AB	X					
Akzo Nobel N.V.	X					
Anox AB					X	
Comsol AB			X			
Current Power Sweden AB			X			
Deltawind AB		X				
Demag Delaval Industrial Turbomachinery AB			X			X
Eka Chemicals AB	X					
Forsmarks Kraftgroup AB			X			
GE Energy (Sweden) AB			X			
Imego AB	X					
Malmö Water & Sewage Works					X	
Morphic		X	X			
SEKAB					X	
Siemens Industrial Turbomachinery						X
Solibro AS	X					
Swedish Biofuels AB					X	
Swedish Seabased Energy AB				X		
Swetree Technologies AB					X	
Tekniska Verken i Linkoeping AB					X	
Vattenfall AB		X	X			X
Vattenfall Utveckling AB	X					X
Vind- och Vattenturbiner			X			
Volvo Technology					X	
Ägir Konsult AB		X				

* The selection criteria have been R&D activities documented in patent statistics, bibliometric statistics, R&D project funding by the EUFP5 or Nordic Energy Research and research reports.

[35] www.sero.se

1.3 Finland

Policy and regulation framework conditions

Introduction to national energy technology and production

From the Middle Ages to the mid-1960s, Finland's energy production was based on hydropower, and the extensive, decentralised use of wood.[36] The height differentials among Finland's 200,000 lakes are not very great, though. Artificial lakes were built in Lapland in order to boost hydropower production, but their impact on the environment has also become a subject of debate. Since the 1960s, attempts have been made to reinstate firewood as one of the forest industry's raw materials, while at the same time a number of active measures were carried out to increase the yield of Finnish forests. Today, the forests produce more wood than ever before, and the annual increment exceeds felling.

An important explanation of the good Finnish performance in bio-energy is the forest industry cluster. Forest industry complexes are energy self-sufficient. They generate their own energy from the forest.

From the 1950s, the use of fossil fuels (oil and coal) expanded rapidly. A gas pipeline from Russia to eastern Finland was completed in 1973 and was later extended to the Helsinki region, and to other regions in the west. Natural gas is mainly used by the forest industry and by towns for CHP.

Finland introduced nuclear power in the 1950s. Finland's first nuclear power plant was commissioned from the Soviet Union. It was equipped with Western-standard safety technology and a containment shell. Its two reactors have proved very reliable by Western norms. At the same time, a company owned by the power industry, commissioned two nuclear power units from Sweden (Asea). This illustrates Finland's finely balanced foreign policy at that point of time. In 2006, 16% of Finland's energy consumption was generated by these four nuclear power units. In recent years between 5% and 17% of electricity has been imported from Russia and Sweden.

But Finnish public opinion and public policy have changed recently. Currently, a fifth nuclear power plant is being built in Finland. It is based on so-called Generation III technology which is supposed to be more secure. The arguments that may have enabled the change in opinion and policy is above all the need for security of supply, but it is also stated that this type of nuclear plant is to be sustainable in the sense that the plant exploits the resources better. The result is less nuclear waste, higher degree of security and fewer basic problems. Finland is making plans for yet more nuclear power plants.

Today, Finland is one of the world's leading countries in utilizing renewable energy sources, especially bio-energy. The renewable energy sources account for one quarter of Finland's total energy consumption. In power production the share of renewable energy is close to 30%. In energy consumption however, oil and gas energy, mainly originating

[36] The historical information in this section is from www.virtual.finland.no, an Internet site that provides basic information about the country.

from Russia, represent 36%. Nuclear power plays a major role in Finnish energy policy. Approximately 25% of electricity consumed in Finland is produced with nuclear power.

Bio-energy – in particular wood and wood-based fuels – hydropower, wind power and solar energy are the most important forms of renewable energy. When it comes to industrial agglomeration, the renewable energy sector is historically intimately related to the pulp and paper cluster. For historical and geo-political reasons the energy sector is vital to security policy.

The energy policy drivers are the Finnish National Climate Strategy, which is the reaction to the Kyoto Protocol, and the national innovation policy of TEKES, which funds innovative research and development projects in companies, universities and research institutes. Finnish energy policy rests on three fundamental elements: energy, economy and environment. Thus, securing energy supply, a competitive price of energy and keeping the arising environmental emissions within the international commitments play a central role.

Table 11: Finland Country Summary Table.
Sources: Eurostat (2007) Energy Yearly Statistics 2005; European Commission (2003b) Biofuels Directive; European Commission (2008) Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources COM (2008)

General information	
Population (2006)	5266268
Land area	337 030 km²
Macroeconomic Information	
GDP per capita in PPS (2006)	117.2
Real GDP growth rate (2006)	5.0
EU Targets for the share of energy from RES	
RES-E share in 2005 (% of final consumption of energy)	28.5
EU RES-E target 2020 (% of final consumption of energy)*	38
Biofuel target (2010)	5.75
Electricity generation – total 2005 (GWh)	70 549
Hydro	13 784
Wind	170
Nuclear	23 271
Conventional thermal of which:	33 321
- Hard coal	6 492
- Lignite and peat	4 482
- Petroleum products	497
- Natural gas	11 251
Consumption	*80 935*
Exports and imports	
Exports	933
Imports	17 922

*European Commission (2008)

Government energy action plans and strategy documents, in particular energy technology focus areas and priorities

By international comparison Finland is considered to be a superpower in bio-energy. In recent years however there has been an increased enthusiasm for bio-energy because of targets set by the EU. While the target for the entire EU is to increase the proportion of renewable energy from 5.4% to 12% between 1997 and 2010, the proportion of renewable energy in Finland is already between 22% and 25%.[37] Government policy has now placed emphasis on renewable energy and on bio-energy in particular. With its forests, Finland has always been one of the leading countries in the use of bio-energy, but obtaining motor fuel from fields and forests is now being promoted besides just burning the waste from wood processing. But there is a fierce dispute about the different options, and there are many conflicting interests in the debate.

The National Climate and Energy strategy, introduced by the Government in 2005, recommends some remarkable changes to Renewable Energy Sources (RES) support policy in Finland. The strategy does not propose any new support instruments but it suggests changing existing ones. The need for supporting renewable power generation within the emission-trading sector has evaporated. Emission trading has increased the market price of electricity and thereby increased the competitiveness of CO_2-free power generation (from renewables, for example). The proposed strategy is directed towards new technology and to sectors that are not involved in the emission-trading scheme. Moreover, it is proposed that the tax fund for electricity from industrial wood waste and residues are terminated. The residing rationale for support of RES remains, namely security of supply and employment.[38]

Finland has taken the following regulatory and investment-related measures to encourage use of RES-E:[39]

- *Tax subsidies:* RES-E has been made exempt from the energy tax paid by end users.
- *Discretionary investment subsidies*: New investments are eligible for subsidies up to 30% (40% for wind).
- *Guaranteed access to the grid* for all electricity users and electricity-producing plants, including RES-E generators (Electricity Market Act – 386/1995).

[37] www.virtual.finland.fi

[38] Finnish National Climate Strategy, Outline of the Energy and Climate Policy for the Near Future – National Strategy to Implement the Kyoto Protocol, Ministry of Trade and Industry Publications 27/2005, Finland

[39] The information about regulatory regime is taken from the European Commission's Renewable energy fact sheet, see http://ec.europa.eu/energy/energy_policy/facts_en.htm

Table 12: Renewables in Finland. Source: IEA[40]

	Municipal Waste*	Industrial Waste	Primary Solid Biomass**	Biogas	Liquid Biofuels	Geo-thermal	Solar Thermal	Hydro	Solar Photo-voltaics	Tide, Wave, Ocean	Wind
Unit	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*
Gross Elec. Generation	**347**	**56**	**9239**	**22**	**0**	**0**	**0**	**13784**	**3**	**0**	**170**
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*				
Gross Heat Production	**2776**	**503**	**31973**	**927**	**0**	**0**	**0**				
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*1000 tonnes*	*TJ*	*TJ*				
Production	6587	2192	279363	1746	0	0	20				
Imports	0	0	4	0	0	0	0				
Exports	0	0	-3270	0	0	0	0				
Stock Changes	0	0	0	0	0	0	0				
Domestic Supply	**6587**	**2192**	**276097**	**1746**	**0**	**0**	**20**				
Statistical Differences and Transfers	0	0	0	0	0	0	0				
Total Transformation	**5347**	**1288**	**88251**	**1146**	**0**	**0**	**0**				
Electricity Plants	778	12	11443	7	0	0	0				
CHP Plants	3902	1242	69157	243	0	0	0				
Heat Plants	667	34	7651	896	0	0	0				
Other Transformation	0	0	0	0	0	0	0				
Energy Sector	**15**	**0**	**0**	**0**	**0**	**0**	**0**				
Distribution Losses	0	0	0	0	0	0	0				
Total Final Consumption	**1225**	**904**	**187846**	**600**	**0**	**0**	**20**				
Industry	1225	854	139531	500	0	0	0				
Transport	0	0	0	0	0	0	0				
Residential	0	0	40620	0	0	0	20				
Commercial and Public Services	0	50	2680	0	0	0	0				
Agriculture / Forestry	0	0	5015	0	0	0	0				
Fishing	0	0	0	0	0	0	0				
Other Non-Specified	0	0	0	100	0	0	0				
Non-Energy Use	0	0	0	0	0	0	0				
- of which	0	0	0	0	0	0	0				
Petrochemical Feedstocks											

* Municipal Waste: the split for renewable and non-renewable waste is also available
** Primary Solid Biomass: data are also available for charcoal

Energy laws in Finland largely reflect the Finnish energy sector configuration (see Table below). The nuclear energy production era is naturally depended on a set of laws.

[40] http://www.iea.org/Textbase/stats/renewdata.asp?COUNTRY_CODE=FI&Submit=Submit

Table 13: Selected Finish government bills on energy

Government Bills on Energy	Year
Nuclear Energy Act No. 990, with latest amendments in 2004	1987
Nuclear Energy Decree No. 161, with latest amendments in 2004	1988
Radiation Act No. 592, with latest amendments in 2005	1991
Electricity Market Act No. 386, with latest amendments in 2004	1995
Natural Gas Market Act No. 508	2000

Environmental laws and regulations

When it comes to environmental laws it is characteristic, and in line with the national energy configuration, that as the main source to biomass energy production, forestry is subject to several laws and regulations.

Table 14: Selected Finish government bills on climate and environment

Government Bills on Climate and Environment	Year
Waste Act No. 1072, with latest amended latest in 2004	1993
Act on the Financing of Sustainable Forestry No. 1094, with latest amendments in 2003	1996
Environmental Protection Act No. 86	2000
Act on Trade in Forest Reproductive Material, No. 241	2002

Important R&D and innovation policy instruments

The National Energy and Climate Strategy states that the most important measures which can decrease Finnish CO_2 emissions are those promoting renewable energy and efficient use of energy, and those reducing carbon intensity in energy production. RES in Finland are supported by investment aid and by taxation (see the section below on market regulation). Technology development and commercialisation of RES are also supported by funds. Figure 11 shows that in 2006 TEKES funded energy research with about €62-63m. The largest areas are energy end-use and bio-energy.

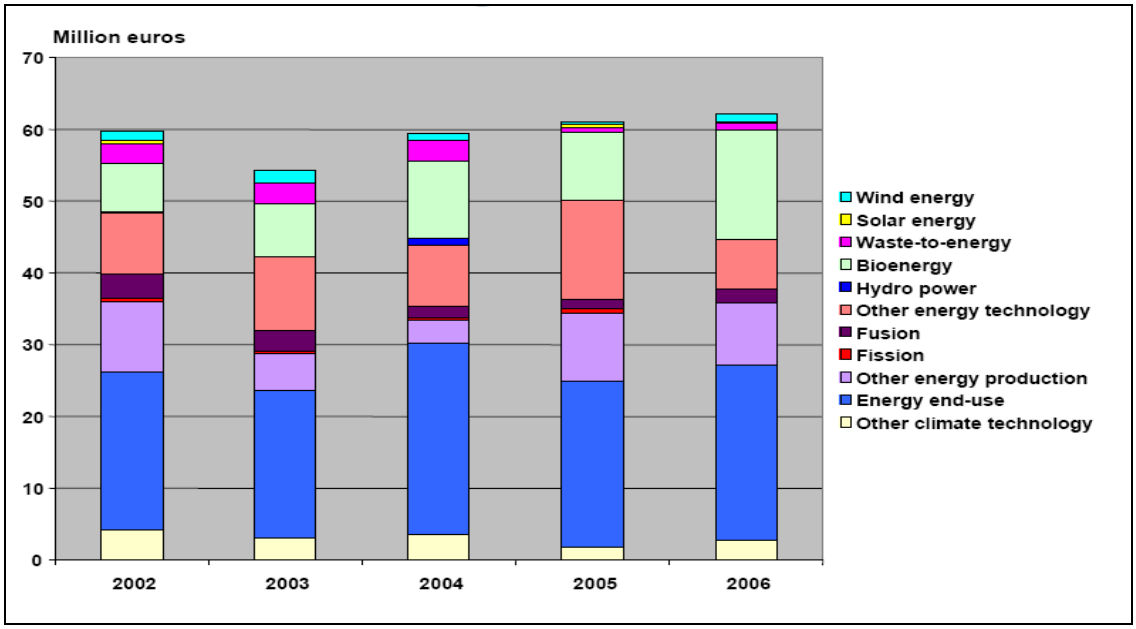

Figure 11: TEKES funding of energy and climate friendly technologies 2002-2006. Source: TEKES

An impressive total of around €500m was invested in five large-scale energy-related technology programmes in 2007. The five programmes include:

Name	Period	Total volume mill Euro
DENSY Distributed Energy Systems Tekes 2003-2007 Merinova	2003–2007	60
Climbus Business Opportunities in Mitigating Climate Change	2004–2008	70
Fuel cell	2007–2013	144
Biorefine – New Biomass Products	2007–2012	137
Sustainable Communities	2007–2012	92

Source: TEKES

Looking ahead, it is evident that as the largest actor in energy R&D funding TEKES will maintain its focus on energy and the environment. Moreover TEKES is willing to increase funding in the energy sector, in particular for challenging high-level projects. Research and industrial development in energy technology is in particular concentrated to the five Centres of Competence[41]:

- Jyväskylä Region Centre of Expertise
  - Bio-energy
  - Energy consumption in forest industry
- North Carelia Centres of Expertise
  - Future basic technologies
  - Material technology
- Tampere Region Centre of Expertise
  - Power and heat production
- Western Finland Centre of Expertise
  - Decentralized energy production
  - Power supply and use

The Energy Technology Competence Cluster strengthens the position of Finnish energy technology in the growing global markets. Cluster activities are focused on industrial enterprises that manufacture the machines and equipment required in the production, utilisation and distribution of energy, as well as on companies providing services in the field.

The Energy Technology Cluster Programme develops strong industry-based research, development, innovation and education environments. The programme has been put together based on the needs of businesses and organisations in the energy field. Its key objective is to strengthen their competitive ability and create the preconditions for the generation of new business and jobs. The main technological themes of the programme are bio-energy technologies, decentralised energy production, industrial energy solutions and electrical engineering.

[41] Source: Centres of Expertise Programs (OSKE) http://www.oske.net/en/

International collaboration

EU Framework Programmes

The Figure below shows that Finland participated in 86 non-nuclear energy projects in the fifth framework program of the European Union.

Table 15: Number of EU FP5 projects in non-nuclear energy by country. Source: Cordis

Country	Number of projects
DK	195
EE	22
FI	86
IS	4
LT	17
LV	16
NO	103
SE	176

The picture that emerges is that Germany and the UK are the most important collaborating partners with Finland. But overall Finland collaborates with several European countries in its FP5 projects.

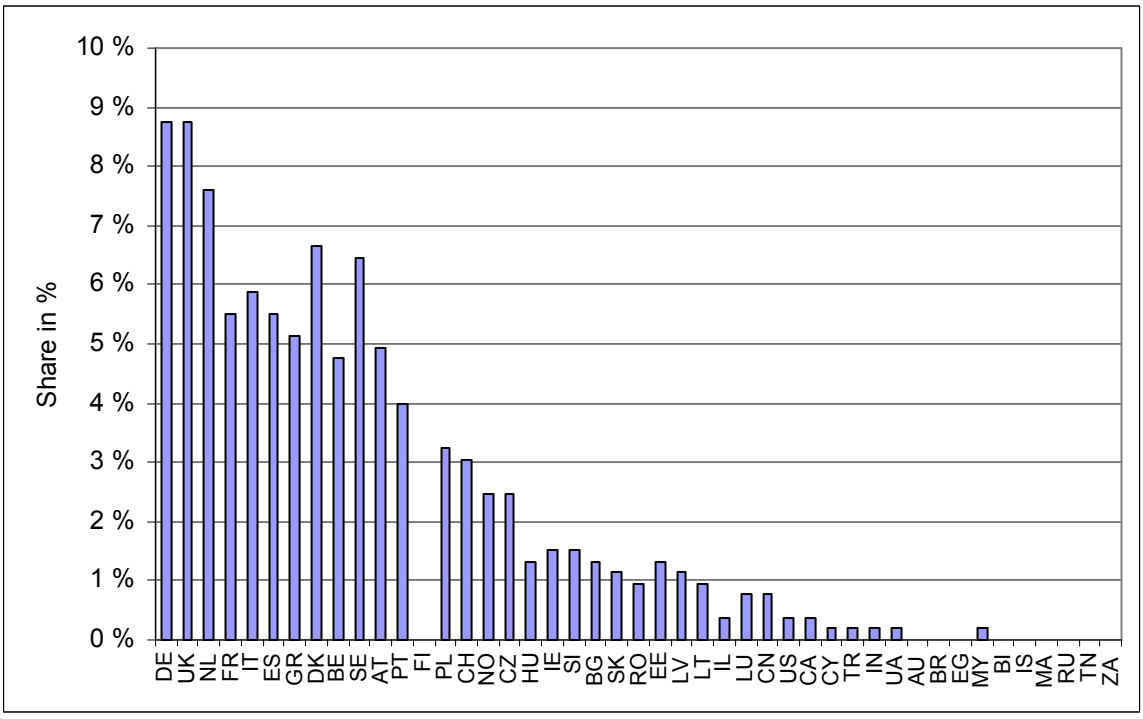

Figure 12: Finnish projects (N=86): Share of collaborating countries in non-nuclear energy projects under EU FP5. Source: Cordis

ERA-NET

Tekes, the Finnish funding Agency for Technology and Innovation, is a partner in the ERA-NETs for bioenergy and hydrogen and fuel cells.

Nordic Energy Research
In the context of Nordic energy research, Finland has active research actors, like the other Nordic contries. Helsinki Institute of Technology and VTT are the most important Finnish actors in collaborative research projects funded by Nordic Energy Research.

Co-authorship
NIFU STEP holds data of co-authorship in specific research areas, which is an indicator of collaboration, in particular indicating the strongest links between Finnish researchers and foreign researchers. In the area of solar photovoltaic research Finnish researchers have co-authorship mainly with researchers from USA, Germany and Sweden. In wind energy research the co-authorship pattern is similar but Swedish researchers collaborate more frequently with Finnish researchers. In 2nd generation biofuels, Russia has taken over as the biggest collaborating country in terms of number of researchers collaborating with Finnish researchers. In CO_2 related and hydropower-related research, the patterns of co-authorship between Finnish and foreign researchers are more balanced for several countries. No country seems to be more important than others, except for the fact that co-authorship within the hydropower research field is limited to countries that have activities in hydropower production.

Key actors and institutions

Government organisations

From 1 January 2008, the Ministry of Employment and the Economy (MEEC) will be a super ministry integrating the former Ministry of Trade and Industry, the former Ministry of Labour, and the Department for Development of Regions and Public Administration of the Ministry of the Interior. This new Ministry of Employment and the Economy, which has two ministers, will have the responsibility for energy policy and innovation policy.

Another energy-relevant actor concerning research is the Science and Technology Policy Council of Finland. The Council is part of the Ministry of Education and Science and chaired by the Prime Minister. It advises the Council of State and its Ministries on important matters concerning research, technology and its utilisation and evaluation. The Council is responsible for the strategic development and coordination of Finnish science and technology policy as well as of the national innovation system as a whole.

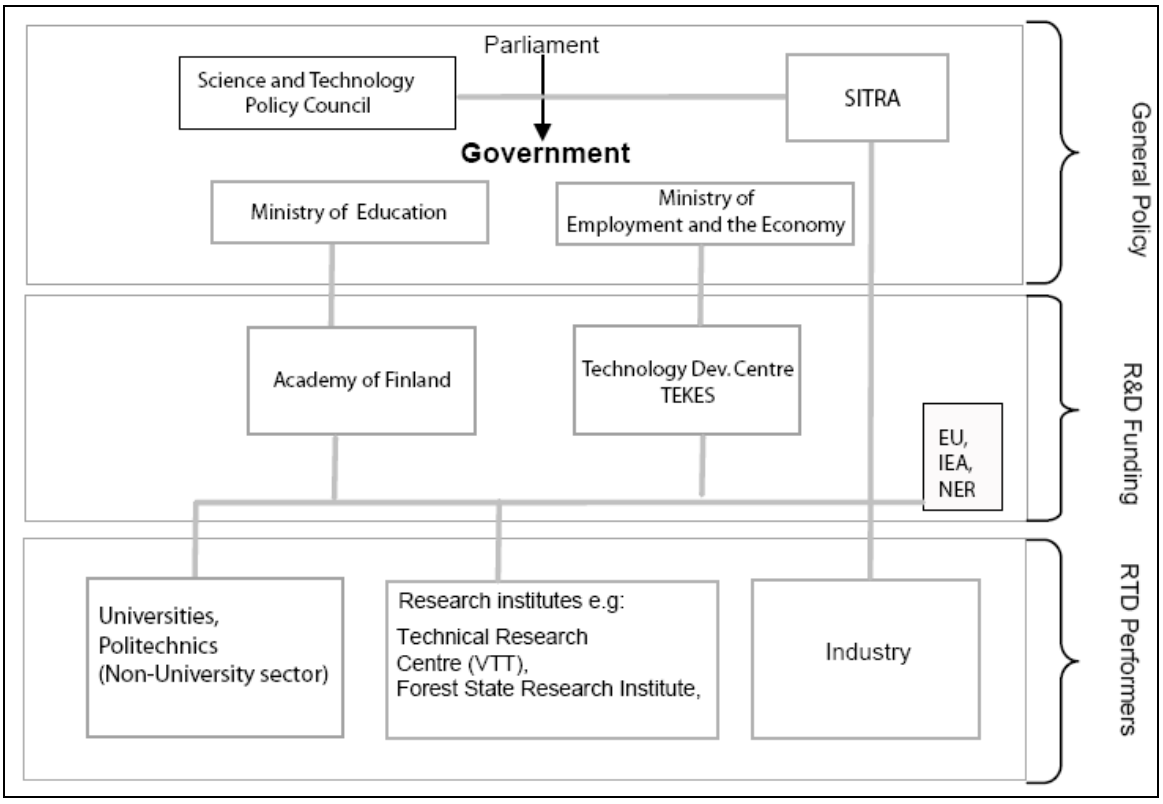

Figure 13: The Finnish Energy R&D System

Public research organisations

The Academy of Finland is the prime funding agency for basic research in Finland. Other key agencies funding science and technology in Finland are TEKES, the Finnish Funding Agency for Technology and Innovation, and SITRA, the Finnish Innovation Fund. The Academy operates within the administrative sector of the Ministry of Education. In 2006, the Academy of Finland published a commissioned international evaluation of energy research, which was prepared on basis of a resolution made by the Research Council for Natural Sciences and Engineering in 2005. The primary objective was to evaluate the scientific quality of energy research in Finland. The results, published in the report Energy Research in Finland 1999–2005, International Evaluation (Academy of Finland, 2006), provide an overview of energy research actors and institutions in Finland. We have used this evaluation as main source in the identification of Finnish energy research actors.

The evaluation covered 25 research units (departments) in 23 organisations. This included three units from the biggest research organisation, VTT. The table below gives the overview of the research units and their host organisations. The names of the units are indicating their fields of research, but the names are of course not adequate as descriptions of what is going on inside each research unit. Therefore, in order to give the overview of the research fields that are covered by the units, we refer to the table data which is extracted from the above mentioned evaluation report.

Table 16: The most important Finnish energy research units and their host organisations

Key	Name of unit	University/Research institute	Research personnel 2005 (FTE)
1	Renewable Energy Programme	University of Jyväskylä (UJ)	110
2	Department of Energy and Environmental Technology	Lappeenranta University of Technology (LUT)	84
3	Laboratory of Electric Power Systems	Lappeenranta University of Technology (LUT)	71
4	Department of Process and Environmental Engineering	University of Oulu (UO)	20
5	The Laboratory of Energy Economics and Power Plant Engineering	Helsinki University of Technology (TKK)	10
6	Laboratory of Energy Engineering and Environmental Protection	Helsinki University of Technology (TKK)	19
7	Laboratory of Applied Thermodynamics	Helsinki University of Technology (TKK)	16
8	Internal Combustion Engine Laboratory	Helsinki University of Technology (TKK)	13
9	Advanced Energy Systems: (New Energy Technologies)	Helsinki University of Technology (TKK)	16
10	High Voltage and Power Systems Engineering	Helsinki University of Technology (TKK)	19
11	Laboratory of Electromechanics	Helsinki University of Technology (TKK)	22
12	Institute of Energy and Process Engineering	Tampere University of Technology (TUT)	49
13	Institute of Materials Chemistry	Tampere University of Technology (TUT)	17
14	Institute of Automation and Control	Tampere University of Technology (TUT)	2
15	Institute of Electromagnetics	Tampere University of Technology (TUT)	21
16	Institute of Power Engineering	Tampere University of Technology (TUT)	23
17	Department of Electrical Engineering and Automation	University of Vaasa (UV)	11
18	Heat Engineering Laboratory	Åbo Akademi University (ÅA)	12
19	Process Chemistry Centre	Åbo Akademi University (ÅA)	47
20	Energy and Pulp & Paper	Technical Research Centre of Finland (VTT)	560
21	Projects related to energy research	Turku School of Economics and Business Administration (TuKKK)	8
22	Research area III: Environment and infrastructures	Government Institute for Economic Research (VATT)	12
23	Advanced Energy Systems: Nuclear	Helsinki University of Technology (TKK)	17
Total		23 units	1,179

Source: Energy Research in Finland 1999–2005, International Evaluation (Academy of Finland, 2006)

A significant actor that is not mentioned in the table above is Vaasa EMG Vaasa energy market research, part of the University of Vaasa. Energy market research is the main expertise of Vaasa EMG.

The table below shows that many research units are undertaking research in several areas. The most distinct observation is that three research units are fully engaged in future energy sources such as solar, fuel cells, fusion, etc.

Key research areas in the energy sector, as given by the assessed units in the international evaluation of energy research in Finland in 2006. (75-100% of used research time = ‘oooo’, 50-69% of used research time = ‘ooo’, 25-49% of used research time = ‘oo’, and 1-24% of used research time = ‘o’).

Table 17: Key research areas in the energy sector, as given by the assessed units in the international evaluation of energy research in Finland in 2006. Source: Academy of Finland (2006)

Unit	Energy production	Power plants	Emission control	Energy infra-structure	Energy conversion	Industrial energy efficiency	Future energy sources (solar, fuel cells, fusion etc.)
1		o	o	o	o	o	o
2	o	o	o	o	o	o	o
3	o			oo	oo	o	o
4		oo	oo	o		o	
5	o	o		o		ooo	
6			oo		oo	oo	
7	oo	o			ooo	oo	ooo
8					oooo		
9							oooo
10				oooo			
11	o	o	o		oo	o	
12	o	o	oo	o	oo	oooo	o
13							oooo
14	oo	oo	o			oo	
15	o		o	oo		o	o
16				oooo			o
17		o		oo	o	o	oo
18		o	o		o	oo	o
19		oo	oo		o	o	o
20	oo	o	o	o	o	o	o
21	o	o	o	oo	o	o	o
22			ooo			o	o
23							oooo

(75-100% of used research time = ‘oooo’, 50-69% of used research time = ‘ooo’, 25-49% of used research time = ‘oo’, and 1-24% of used research time = ‘o’)

Non-governmental organizations

Several non-governmental organisations are active and relevant for organisation, cooperation, development, and investment in the energy sector. The most important of these organizations are:

Finnish Natural Gas Association

The Finnish Natural Gas Association was established in 1986. Its main objectives are to improve the operational conditions of gas usage, to supervise common interests of the natural gas branch and to provide expert services. To achieve these objectives the association maintains contacts with authorities and other interest groups. The association organizes conferences and internal meetings for members.

Motiva OY

Motiva is an independent service organisation promoting a market for renewable energy sources and efficient energy use. The company produces, refines and disseminates

information, develops methods and boosts the introduction of advanced technology. Motiva implements the government's decisions on energy conservation and promotion of renewable energy sources.

Other renewable energy associations in Finland include the Finnish Wind Power Association and the Finnish District Heating Association

Finnish Science Park Association, TEKEL is a nationwide cooperation network of science parks and technology centres and connects 30 members in Finland's university cities. Established in 1988, TEKEL coordinates and implements cooperation among science parks, and acts as a mediator between policy makers and science parks. Members of TEKEL help hi-tech enterprises start up in business, grow and internationalise. The TEKEL science parks accommodate 2400 enterprises and other organisations – bringing together 44,000 experts working on different technology fields such as ICT, healthcare and medical technology, biotechnology, environmental and food technology, materials research and digital media

Many actors in Finland are supporting business development and investment, although not exclusively for the energy sector. This includes Finnish Industry Investment Ltd., Finnvera Plc, Finnish Venture Capital Association, Confederation of Finnish Industries (EK) and Federation of Finnish Enterprises.

Firms

The table below lists energy firms in Finland with R&D activity registered in patent statistics, bibliometric statistics, or R&D funding in the EUFP5 or Nordic Energy Research and other research reports.

Table 18: R&D based companies in Finland active in selected fields of energy technology*

Firm name	Photo-voltaics	Wind	Hydro-electric power	Wave power	2nd Generation Biofuels	CCS
ABB Oy	X	X	X			
ABS NOPON OY LTD			X			
AJAT OY, LTD	X					
ALIMETR LTD					X	
AW-Energy Oy				X		
Cuycha Innovation Oy						X
DELSITECH OY	X					
Fortum Oil			X		X	
FOSTER WHEELER ENERGIA OY					X	
FRACTIVATOR OY					X	
KEMIJOKI OY			X			
Lassila & Tikanoja Oyj					X	
MOVENTAS OY		X				
NAPS SYSTEMS OY	X					
Neste Oil Oyj					X	
OKMET OYJ	X					

Oxford Instruments Analytical Oy	X					
PRESECO OY					X	
SILECS OY Finland	X					
TRITONET LTD					X	
VERDERA OY					X	
Winwind Oy		X				
Wärtsilä					X	X

* The selection criteria have been R&D activities documented in patent statistics, bibliometric statistics, R&D project funding by the EUFP5 or Nordic Energy Research and research reports.

The table gives an overview of the most important industry actors in selected energy technologies. Some of the listed companies are active in more than one technology field, such as ABB OY and Fortum OY. The registered firms, seen altogether have strongest activities in solar photovoltaics and in second generation bio-fuels.

Finland has numerous firms in the energy sector. A comprehensive list is given in the appendix.[i]

1.4 Norway

Policy and regulation framework conditions

Introduction to national energy technology and production

Norway is one of the world's largest energy exporters. Energy consumption per capita is about at the level of neighbouring countries, but electricity is used to a much larger extent than in other countries. This is associated with a large power-consuming industry and the use of electricity for heating purposes. In 2006, total energy consumption was around 225 TWh of which electricity consumption was around 123 TWh. The domestic production of electricity almost equalled the domestic consumption, which was 121 TWh in 2006. Hydroelectric power is completely dominates electricity generation.

Norway is a significant crude oil and natural gas supplier. The government's paramount objective for the oil and gas activity is to ensure long term management and value creation on the Norwegian continental shelf within environmentally justifiable frames and in cooperation with other industrial sectors. Norway's major challenge is to unite its role as an oil and gas producer with the ambition to be a leading nation in environmental and climate policy. Environmental consideration has been present in Norwegian oil and gas production for a number of years. Severe environmental conditions have been placed on oil and gas extraction. Consequently Norwegian oil and gas production is today the cleanest in the world.

As a response to the prognosis of the International Energy Agency (IEA), which indicates an increase in the global demand for energy and the fact that fossil fuels still will cover some 80% of the energy demand over the next 25 years, Norway sees it as a main task to contribute to the development of clean energy. Another main task is to develop clean(er) fossil fuel production, i.e. without large CO_2 emissions that contribute to climate change. The battle against climate change and the challenges related to supply the world's energy demand are the most important reasons for the Norwegian government's efforts of CO_2 handling and sequestration. It is the government's policy that new gasworks shall have CO_2 handling. Economic measures will be taken and it is the objective that increased research in new technology shall contribute to future-oriented and efficient technologies so that CO_2 handling can be implemented. It is the objective that Norway shall be leading in this field (St. prp. nr. 1, 2007–2008).

The dominance of the oil and gas sector, which mainly is an export industry, and the hydroelectric power, mainly for domestic use, has strong influence on national energy priorities. RD&D capability building in the petroleum sector was a clear policy priority for Norway from on the start. This was reflected in both the establishment of the state oil company, Statoil, and in specifying licensing conditions, which required technology transfer from foreign companies to Norwegian organizations. The government systematically evaluated and rewarded foreign oil companies which contributed to Norwegian capacity building. Concessionary procedures were used as a policy instrument to force the international companies to engage in technology transfer[42]. This capability

[42] For further details see Hatakenaka et.al., 2006

building has contributed to the development of strong petroleum and gas companies, supplier and service companies, and public research organisations specialised in the field of petroleum and gas. Many of these companies have developed to become global players and collaborate successfully within RD&D projects and industrial projects both in Europe and other parts of the world.

According to the Key World Energy Statistics 2007, of the IEA is Norway one of the most important crude oil exporters in the world (Table 19). Regarding production and export of natural gas the position of Norway is still stronger (Table 20).

Table 19: Exporters of crude oil in 2005. Source: IEA Key World Energy Statistics 2007, p. 11

Exporters	**Mt**
Saudi Arabia	364
Russia	253
Iran	132
Nigeria	119
Norway	115
Mexico	100
Venezuela	97
United Arab Emirates	97
Kuwait	84
Canada	84
Rest of the World	*733*
World	**2 176**

Table 20: Producers and exporters of natural gas in 2006. Source: IEA Key World Energy Statistics 2007, p. 13

Producers	**Mm^3**	**Percentage of World output**	**Exporters**	**Mm^3**
Russia	656 290	22.0	Russia	202 844
United States	524 368	17.6	Canada	102 102
Canada	189 179	6.4	Norway	86 169
Iran	98 123	3.3	Algeria	64 363
Norway	91 834	3.1	Netherlands	54 660
Algeria	88 785	3.0	Turkmenistan	50 000
United Kingdom	83 821	2.8	Indonesia	34 865
Netherlands	77 295	2.6	Malaysia	31 230
Indonesia	72 096	2.4	Qatar	31 224
Turkmenistan	67 052	2.3	United States	20 521
Rest of the World	*1 027 709*	*34.5*	*Rest of the World*	*206 516*
World	**2 976 552**	**100.0**	**World**	**884 494**

With the large-scale hydroelectric energy activity, Norway has come far in terms of renewable energy production. Other types of renewable energy production are still not high on the priority list if we look at the latest national budget. The national budget

allocates finances to the large-scale activities within oil and gas and hydropower. The formulations about other renewable energy are limited to addressing wind power, in particular offshore wind power. The current plan implies processes linked to public approval of new renewable energy production offshore. It is the plan to arrange for future investment in offshore wind power through an efficient and predictable administration regime.

Table 21: Norway Country Summary Table.
Sources: Eurostat (2007) Energy Yearly Statistics 2005; European Commission (2003b) Biofuels Directive; European Commission (2008) Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources COM (2008)

Demographical information	
Population, millions (2006)	4660677
Land area	385,155 km²
Macroeconomic Information	
GDP per capita in PPS (2006)	186.3
Real GDP growth rate (2006)	2.2
EU Targets for the share of energy from RES	
RES-E share in 2005 (% of final consumption of energy)	n.a.
EU RES-E target 2020 (% of final consumption of energy)	90%
Biofuel target (2020)	14 TWh/Ca. 10% of 2007 consumption
Electricity generation – total 2005 (GWh)	138 108
Hydro	136 572
Wind	506
Conventional thermal of which: - Hard coal - Natural gas - Derived gases - Biomass - Industrial waste	1 030 43 355 90 379 163
Consumption	*111 915*
Exports and imports	
Exports	15 695
Imports	3 652

Government energy action plans and strategy documents, in particular energy technology focus areas and priorities

The Soria Moria declaration from 2005, which is the coalition policy agreement between the three parties in the Norwegian majority government, represents a fundamental guiding text for Norwegian energy policy. The declaration states that Norwegian energy policy on the one hand is to prioritise energy production and value creation on basis of

the Norwegian oil and gas resources, on the other hand the government is committed to a strong effort concerning development and investment in renewable energy technologies.

Based on the Soria Moria declaration, the Norwegian National Budget (St.prp. nr.1 2007-2008) from the Ministry of Petroleum and Energy presents current Norwegian energy policy. It is important to emphasise that Norwegian energy policy is in rapid development, currently almost on a day-to-day basis. The main reason is that Norwegian energy policy is crucially dependent on EU policy and Russian energy policy. While EU policy, like Norwegian policy, has started to see energy policy integrated with sustainability policy, Russian energy policy is basically about huge gas extraction investments in the Arctic area. This is highly relevant to Norwegian decisions about investment and implementation of CO_2 cleaning, and to Norwegian engagement in Russian investments in gas extraction.

The priorities in the National Budget are summarised in the Government's status report from 17 October 2007 after about 2 years in office. This report emphasises the following policy priorities:

- Security of supply. Reduce the increase in consumption through energy saving measures while increasing energy production through renewable energy technology, upgrading/increase the efficiency of existing hydropower facilities and environmentally friendly use of gas.
- Contribute to international cooperation about environmentally friendly technology, energy systems and investment in renewable energy.
- Provide for an efficient and secure electricity grid. Revision of grid regulations preparing for energy saving and security of supply.
- New renewable energy: By means of a dedicated fund money for investment in environmentally friendly energy production is ensured. Wind energy, bio energy and smaller hydro power facilities are prioritised.
- An important policy measure in relation to new renewable energy development is the implementation of an in duty bound certificate market for this kind of energy production.
- New not mature energy technology is to be given priority by means of investment in research and development. The Norwegian Research Council and the publicly owned enterprise Enova are doing this jointly.
- The Government is arranging for increased use of water-borne heating and more efficient use of energy. This includes measures for energy saving and transfer to more environmentally friendly heating solutions.
- CO_2 handling (capturing and storage) is a main priority for the Norwegian Government. A public enterprise will have the aim to create a value chain from transport to injection of CO_2. This effort is one of the largest posts in the budget. Concessions for gasworks are to include mandatory CO_2-cleaning.
- The oil and gas extraction activity is to be maintained. A range of policy measures and efforts are included in order to develop this activity as much as possible in line with sustainable development.

Table 22: Renewables in Norway in 2005. Source: IEA[43]

	Municipal Waste*	Industrial Waste	Primary Solid Biomass**	Biogas	Liquid Biofuels	Geothermal	Solar Thermal	Hydro	Solar Photo-voltaics	Tide, Wave, Ocean	Wind
Unit	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*
Gross Elec. Generation	**86**	**6**	**293**	**0**	**0**	**0**	**0**	**136572**	**0**	**0**	**506**
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*				
Gross Heat Production	**5456**	**429**	**1316**	**8**	**0**	**0**	**0**				
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*1000 tonnes*	*TJ*	*TJ*				
Production	7806	491	44483	1054	0	0	0				
Imports	0	0	906	0	0	0	0				
Exports	0	0	-10	0	0	0	0				
Stock Changes	0	0	0	0	0	0	0				
Domestic Supply	**7806**	**491**	**45379**	**1054**	**0**	**0**	**0**				
Statistical Differences and Transfers	0	0	-103	0	0	0	0				
Total Transformation	**6588**	**491**	**2947**	**9**	**0**	**0**	**0**				
Electricity Plants	56	62	1223	0	0	0	0				
CHP Plants	3822	1	0	0	0	0	0				
Heat Plants	2710	428	1724	9	0	0	0				
Other Transformation	0	0	0	0	0	0	0				
Energy Sector	**0**	**0**	**0**	**0**	**0**	**0**	**0**				
Distribution Losses	0	0	0	410	0	0	0				
Total Final Consumption	**1218**	**0**	**42329**	**635**	**0**	**0**	**0**				
Industry	1218	0	15532	0	0	0	0				
Transport	0	0	0	0	0	0	0				
Residential	0	0	26509	0	0	0	0				
Commercial and Public Services	0	0	218	635	0	0	0				
Agriculture / Forestry	0	0	70	0	0	0	0				
Fishing	0	0	0	0	0	0	0				
Other Non-Specified	0	0	0	0	0	0	0				
Non-Energy Use	0	0	0	0	0	0	0				
- of which	0	0	0	0	0	0	0				
Petrochemical Feedstocks											

* Municipal Waste: the split for renewable and non-renewable waste is also available

** Primary Solid Biomass: data are also available for charcoal

[43] http://www.iea.org/Textbase/stats/renewdata.asp?COUNTRY_CODE=no&Submit=Submit

Energi21 - R&D strategy development

In the spring of 2007, the Ministry of Petroleum and Energy initiated a process had the objective of establishing a broad and unifying R&D strategy for the Norwegian energy sector. The process was to be broad and unifying in the sense that all actors in the sector were given the opportunity to be included. An operative strategy group organised dialogue meetings in which input, initiatives and suggestions from the actors were to be the result. The strategy group also organised a public inquiry/hearing. On basis of the input, six working groups were organised, each with the responsibility for a specific domain. The groups produced proposals for R&D strategies in each domain. The suggestions were assembled and put together as the final Energi21 report. The result of this process was reported in February 2008.

The vision of Energi21 is summarised in the following statement:

> Norway: Europe's energy and environmental nation – from national energy balance to green delivery. Norway has the natural resources, the competence milieus and the societal conditions to become Europe's leading energy and environmental nation (Energi21, 2008).

In order to fulfil this vision the strategy group suggests:

- R&D effort in five specific domains:
  - efficient energy consumption
  - climate friendly energy
  - CO2-neutral heating
  - an energy system for future demands
  - attractive framework conditions for R&D,
- A broad effort on education and basic and applied research.

Given the broadness of this energy policy development in Norway, Energi21 needs time to take effect. There is also need for more time to assess the strategy on the basis of our independent assessment of what is going on in concrete terms in the Norwegian energy sector.

Important R&D and innovation policy instruments

The policy priorities in the Energi21 strategy in the points above indicate research and development efforts within CO_2 handling, new renewable energy technology and petroleum energy technology. A fund of NOK 10 billion (€1.25 b.) has been established to finance research and development within wind energy, bio energy and smaller hydro energy projects. Before Energy21, the Green paper on research policy from 2004–2005 (Stort.meld. nr 20, Vilje til forskning 2004-2005) sketches energy research related to environmental issues and sustainable development as one of the main areas.

The Norwegian Research Council manages two large-scale research programmes on energy – Petromaks and Renergi, which in total have budgets of more than €70m per year. The Petromaks programme, which has fossil fuels extraction in focus, has 2.5 times the budget of the latter Renergi, which is concerned with renewable energy sources. The

table below gives an overview of the structure of budget allocations to thematic areas and competence areas in the Research Council of Norway (RCN) in the period 2002-2007.

Table 23: Overview of budget allocations of the Research Council of Norway (RCN) in the period 2002-2007 (million NOK) and percentage share. Source: RCN

Thematic areas	Million NOK	
Energy and environment	184.6	30.9
ICT inc. micro systems	111.0	18.6
Health and biotechnology	25.1	4.2
Ocean and food	6.1	1.1
Sum thematic areas	**326.8**	**55**
Competence areas		
New, functional and nano-structured materials	146.2	24.5
Fundamental physical and chemical phenomenon and processes at nm-level	43.8	7.3
Interface- and surface science and catalysis	6.5	1.1
Bio-nano science and bio-nano technology	23.4	3.9
Ethical, juridical and societal aspects, HMS and risk	18.4	3.1
Sum competence	**238.4**	**40**
Equipment and infrastructure		
Equipment	26.5	4.4
Infrastructure (measures of coordination, international collaboration)	6.0	1.0
Sum equipment and infrastructure	**32.5**	**5**
Total	**597.7**	**100**

It is not easy to identify renewable energy research from this table. The main picture is that around 30% of the almost NOK600m (ca. €75m) is allocated to the themes "energy and environment". In addition, there is some renewable energy related research in the category New, functional and nano-structured materials. This is basically research related to membranes for carbon cleaning.

Adding details to the table above, we elaborate on the most important research programmes in the RCN.

RENERGI

The research programme RENERGI – Clean Energy for the Future 2004–2013 – is one of the large-scale programmes of the Research Council of Norway (RCN), and addresses renewable energy research with a budget of more than €20m per year. The objectives and contents of the research programme include the following domains.

- Exploit and refine natural resources and infrastructure
- Contribute to research and technology based industrial development
- Knowledge about framework conditions and policy measures
- Develop research and competence environments.

The central research domains include:
1. Energy policy and international treaties
2. Energy market
3. Energy systems, infrastructure, planning and security of supply
4. Energy consumption
5. Renewable energy production
6. Hydrogen
7. Natural gas
8. Environmentally friendly transport technology (hydrogen, bio fuel)

Two programmes, NONOMAT and BIA, are making particular contributions to renewable energy technology and energy efficiency.

NANOMAT / BIA (Brukerstyrt Innovasjonsarena / User-directed innovation arena)
NANOMAT is one of the large-scale programmes of the RCN, commenced in 2002 and will continue until 2016. The programme has selected four research areas of which the area energy and environment receives highest priority. BIA (*User-directed innovation arena)* is funding research related to most industrial areas in Norway. The budget allocations in 2007 and 2008 to NANOMAT and BIA are shown in the table below.

NANOMAT budget allocation (Mill NOK)		
	2007	**2008**
Hydrogen	14.6	15.7
Solar energy	11.4	18.5
Batteries	1.1	1.8
Other renewables	0.4	2.9
	27.5	**38.9**

For BIA allocations to renewable energy and energy efficiency are shown.

BIA allocations and applications under consideration. Mill. NOK			
	2007	**2008**	**Applications 2008**
Solar energy	13.8	18.1	11.2
Other renewable	0.7	0.7	3.9
Energy efficiency	12.6	15.5	12.3
	27.1	**34.7**	**27.4**

CLIMIT programme
The CLIMIT programme was launched in 2005 and is the national programme for gas power technologies with CO_2 capture and storage (CCS). Gassnova SF and the RCN are administering the programme. The source of finance is the Ministry of Petroleum and

Energy and the programme shall promote research, development and demonstration of CCS technologies. The CLIMIT budget was ca. NOK145m in 2005. The budget in 2007 was NOK58.2m, of which NOK50.5m were used.

OG 21

OG21 is a national Task Force established by the Ministry of Petroleum and Energy of Norway in 2001 to assist the petroleum industry to formulate a national technology strategy for added value and competitive advantage in the oil and gas industry. The objective is to develop a more co-ordinated and focused approach to research and development throughout the oil and gas industry.

The OG21 national technology strategy for the petroleum industry focuses on:

- sustained profitability in the Norwegian petroleum industry and resource optimisation on the Norwegian Continental Shelf (NCS),
- increased technology and knowledge exports by exploiting the competitive advantages and internationalisation of the Norwegian service and supply industry.

The national technology strategy represents a consensus-based approach to the industry's views of the most important and urgent issues to be addressed by research and technology development. The strategy will be implemented in and by the industry, taking advantage of existing relevant programmes of the RCN (Petromaks, PetroForsk, Oil and Gas), Demo 2000 and other industry initiatives (CORD, FORCE, Deep Community).

The following technology target areas have been formulated:[44]

- Environmental Technology for the future
- Exploration and reservoir characterisation
- Enhanced recovery
- Integrated operations and real time reservoir management
- Sub sea processing and transport
- Deep water and sub sea production technology
- Gas technologies.

DEMO 2000

DEMO 2000 was launched in 1999 to accelerate the commercialisation of R&D in the oil and gas sector. The programme was a result of collaboration between the supply industry, the operating companies, research institutions and the Norwegian authorities. The initiative for the network came from the Confederation of Norwegian Engineering Industries. At the turn of 2005, the organization and structure of DEMO 2000 was altered. The management of the programme was formally transferred from the Ministry of Petroleum and Energy to the RCN. Until then, the RCN hosted the programme's management secretariat and provided administrative support, for example, through the council's accounting systems as well as providing secretarial capacity.

The rationale of DEMO 2000 is the re-vitalization of the Norwegian oil and gas supplying industry: goal is the improved long-term competitiveness in the oil sector and continued profitable development of Norwegian continental shelf resources.

[44] OG 21 Technology Target Areas: http://www.og21.org/files/TTA_nov_06.doc

Thematic areas for projects are:

- Sub-surface
- Drilling and well
- Sub sea and process
- Deepwater
- Gas utilisation
- System integration

DEMO 2000 is part of OG 21. DEMO 2000 is dependent on strategies developed by the national strategy task force OG 21. The application processes of DEMO 2000 and the current petroleum research program, PETROMAKS, are co-ordinated. Several DEMO 2000 projects have received PETROMAKS support in a previous phase.

PETROMAKS - Programme for optimal exploitation of petroleum resources
PETROMAKS was started in 2004 as one of the major research programmes of the RCN. The rationale of the program is to strengthen knowledge about oil and gas, to find more oil and gas, to recover more, to develop Norwegian industry and maintain a high level of health, safety and environment. The Ministry of Petroleum and Energy is responsible for the programme, but the RCN is managing the programme. With assistance from the government the RCN is stretching for an annual budget of NOK5-600m for petroleum R&D.
Thematic areas for R&D projects are:

- Environmental technology for the future
- Exploration and reservoir characterization
- Enhanced recovery
- Cost effective drilling and intervention
- Integrated operations and real time reservoir management
- Sub sea processing and transportation
- Deep water and sub sea production technology
- Gas technology
- Health, Safety and Environment

Norwegian political initiatives in 2008 indicate an increased R&D effort in renewable energy. It still remains to see where and how new financial effort is allocated.

International collaboration

International collaboration in research is an indicator of quality and activity. This section describes Norwegian research actors' participation in the 6th Framework Programme of the European Union (FP6) which was running between 2003 and 2006. The focus is on energy research, in particular renewable energy research and energy efficiency. The figure below is horizontally divided. The green squares above the black bold line indicate projects with Norwegian participation. The rows above the green squares are the different thematic areas to which the projects belong. The parts below the thick bold line indicate declined Norwegian proposals (pink) and declined but still waiting proposals (yellow).

There are eight thematic areas:

1. Clean renewable energy
2. Energy saving/energy efficiency
3. Alternative motor/engine fuels
4. Fuel cells
5. Energy carriers, in particular hydrogen/el.
6. Renewable energy sources
7. CO_2 handling
8. Socio-economic tools.

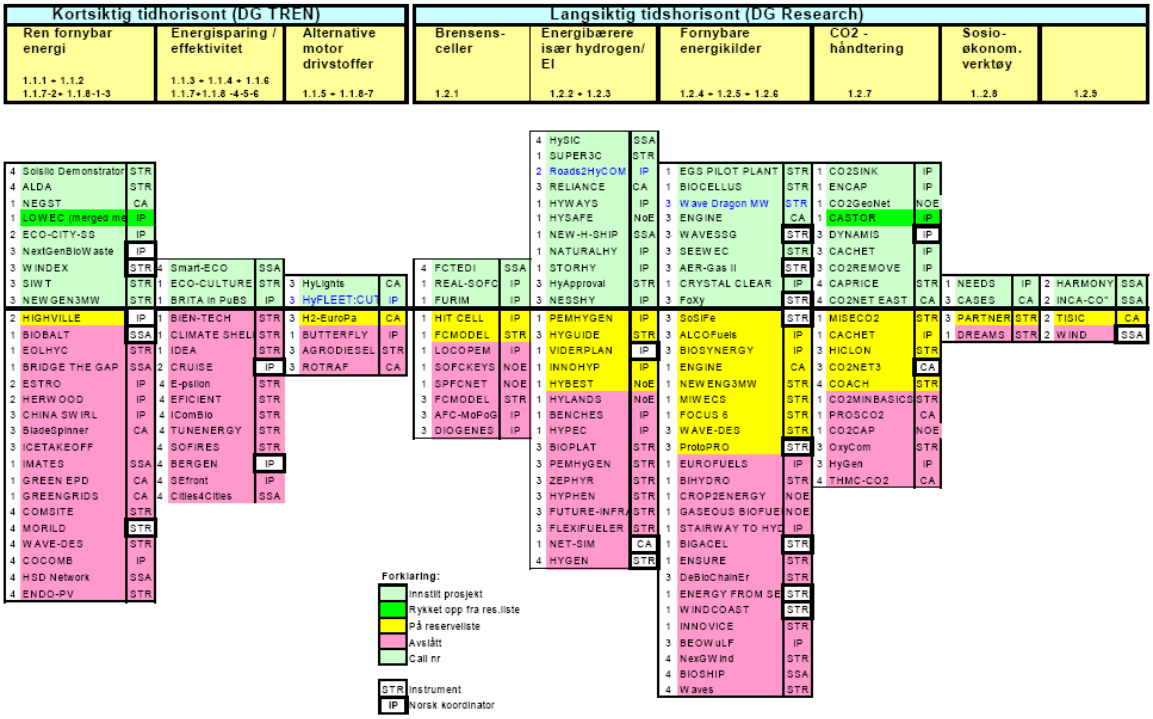

Figure 14: FP6 – Norwegian participation divided in sub-themes. Source: Amlund Hagen (2007)

Norwegian participation in energy research in the FP6 is strong in the thematic areas of 1. Clean energy, in particular renewable energy sources and their integration in the energy system, including storage, distribution and use, 5. New technologies for energy carriers/ transport and storage, in particular hydrogen, 6. New and advanced concepts in renewable energy technologies, and 7. Capture and sequestration of CO_2. In every domain there were around 10 projects. There were Norwegian coordinators in 15 of 39 projects. If we look at the areas below the bold line, there is, of course, high application activity in the mentioned areas as well. The thematic areas with less Norwegian activity include 2. Energy saving/efficiency, 3. Alternative motor/engine fuels, 4. Fuel Cells, and 8. Socio-economic tools and concepts for energy strategy.

According to the European Commission, Norway was among the top performers together with Belgium, the Netherlands, France and Switzerland, in the competition of FP6 project finances, i.e. a competition that included 80 nations and 150 000 R&D actors.

Environmental laws and regulations

From 1970 onwards a string of new Norwegian laws followed which aimed at regulating specific forms of environmental effects and certain social activities that are important for natural resources or environmental qualities.

Environmental legislation Acts in Norway covers most aspects of society. The following acts illustrate the extent of these:

Table 24: Selected Norwegian government bills on climate and environment

Government Bills on Climate and Environment	Year
Act No. 63 relating to nature conservation (The nature conservation act)	1970
Act No.82 relating to motor traffic on uncultivated land and in watercourses	1977
Act No. 50 concerning the cultural heritage (The cultural heritage act)	1978
Act No. 6 concerning protection against pollution and concerning waste (The pollution control act)	1981
Act No. 31 relating to environmental information (Environmental information act)	2003

Integration of EU environmental laws

The EU has produced more than 400 environmental laws which the members states are obligated to follow. Through the EEA agreement[45], the EU is responsible for 80–90 per cent of Norway's environmental legislation. Since 1994, Norway has integrated 152 EU environmental laws into national legislation. The EEA agreement basically gives Norway the same limitations as EU member states within the areas covered by the agreement. At the same time, not being part of the EU, Norway has little or no influence on the EU and EEA environmental policies. The implementation of EU environmental laws through the EEA agreement has led to a general strengthening of Norwegian environmental regulation, even though there are important exceptions. Norwegian legislation and management has been strengthened in areas like phasing-out ozone-depleting substances, environmental impact assessment, and air and drinking water quality. Concerning food additives, Norway has had to lower its level of protection. Norway has implemented extensive environmental legislation on chemicals and biocides, which it would have been difficult for Norway to draft on its own due to lack of resources.

Key actors and institutions

Figure 15 illustrates the policy context of energy in Norway is dominated by the Ministry of Petroleum and Energy first and foremost, but the Ministry of Education and Research and the Ministry of Trade and Industry also allocate funds to education, research and innovation which is energy related. The main financial stream flows through the Research Council of Norway, but ENOVA and the Norwegian Water Resources and Directorate also administrate some funds.

[45] http://secretariat.efta.int/Web/EuropeanEconomicArea/EEAAgreement/EEAAgreement

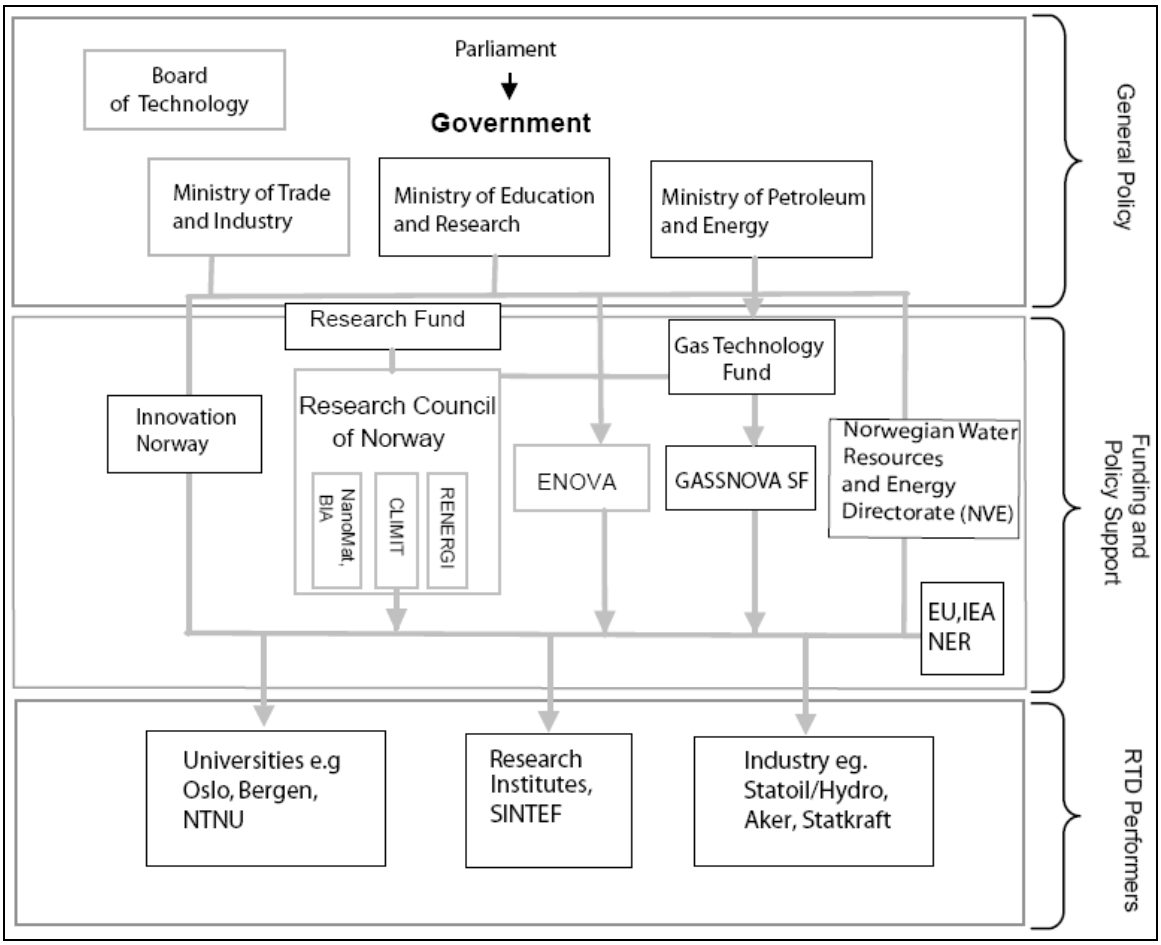

Figure 15: The Norwegian Energy Policy System. Source: NIFU STEP

Government organisations

As mentioned, Norwegian energy production is institutionalised mainly in the large activity areas oil and gas and hydroelectric power. The Ministry of Petroleum and Energy is responsible for achieving a coordinated and integrated energy policy. The Ministry for Petroleum and Energy was established in 1997 based on the part of the former Industry and Energy Ministry that was responsible for energy issues. In the period 1978-1992 the energy sector was governed by an own ministry.

The current Ministry of Petroleum and Energy has several departments: the Oil and gas department, the Energy and water resources department and Climate, industry and technology department.

In the latter is the Research and technology section, which is responsible for the Ministry's research and development activities and R&D programmes in the energy and petroleum sectors, such as Gassnova, the Gas Technology Fund, and the participation in the Carbon Sequestration Leadership Forum and the International Partnership for the Hydrogen Economy. The section is also responsible for participating in the Government's and the ministries Research Committee and for following up OG21 and the Energi 21 R&D-strategy on renewable energy that has been published in February 2008.

The Ministry of Petroleum and Energy has a broad range of agencies dealing with special tasks in the field of energy policy:

- The Norwegian Petroleum Directorate

The Norwegian Petroleum Directorate (NPD) shall contribute to creating the greatest possible values for society from the oil and gas activities by means of prudent resource management based on safety, emergency preparedness and safeguarding of external environment.

- The Norwegian Water Resources and Energy Directorate

The Norwegian Water Resources and Energy Directorate (NVE) was established in 1921 and is subordinate to the Ministry of Petroleum and Energy, and is responsible for the administration of Norway's water and energy resources.

- Enova SF

ENOVA is a public enterprise owned by the Ministry of Petroleum and Energy with the aim of contributing to environmentally sound and rational use and production of energy, relying on financial instruments and incentives to stimulate market actors and mechanisms to achieve national energy policy goals.

- Gassco

Gassco is the responsible operator for the transport of the gas from the Norwegian continental shelf to Europe. Gassco has several R&D programmes that focus on areas connected to its core tasks: increased transport capacity, increased gas processing capacity, pipeline design and integrity, pipeline intervention, energy efficiency and emission control, trace Component detection and control and next-generation gas transport management system.

- Gassnova SF

Gassnova SF is the government centre of CCS expertise. It was established in 2007 to manage and support technology development in CCS – capture, transport, injection and storage of CO_2. The main focus is on environmentally-friendly gas power technology due to the huge gas reservoirs on the Norwegian shelf.

- Statnett SF

Statnett SF is the public enterprise owned by the Ministry of Petroleum and Energy. Statnett has as its main aim provision of a reliable and efficient network infrastructure for the transfer and distribution of electricity in Norway.

- StatoilHydro ASA

StatoilHydro ASA is an integrated oil and gas company with significant international activity. It is owned by 62,5% by the Norwegian State and the Ministry of Petroleum and Energy.

- Statkraft AS

The Statkraft Group is a leading player in Europe within renewable energy. The Group generates hydropower, wind power and district heating and constructs gas power plants in Norway and Germany. Statkraft is a major player on the European energy exchanges.

Public research organisations

Universities

NTNU – Norwegian University of Science and Technology

The NTNU has several departments engaged in energy-related R&D: the Department of Energy and Process Engineering, the Department of Hydraulic and Environmental Engineering and the Department of Petroleum Engineering and Applied Geophysics at the Faculty of Engineering Science and Technology, and the Department of Electric Power Engineering at the Faculty of Information Technology, Mathematics and Electrical Engineering. A bibliometric analysis revealed excellent positions in CCS-related R&D, very strong positions in hydropower and wind energy R&D and good results in solar photovolatics and second generation biofuels. In collaboration with the SINTEF Group, NTNU has prioritised several strategic areas – one of them is Energy and Petroleum, Resources and Environment. The strategic area is based on several research centres:

- Centre for Renewable Energy

The Centre is a virtual research centre and a result of collaboration between the NTNU, SINTEF and the Institute for Energy Technology. The Centre focuses on the following research areas:[46]

- Solar energy – production of power (solar cell silicon) and heat
- Small-scale hydropower
- Wind energy (onshore and offshore)
- Bio energy
- Energy from the ocean (wave, tidal, salt gradients)
- Ambient heat (utilized by heat pumps to cover low value heating demand)
- Geothermal energy
- Hydrogen technology for energy storage and conversion
- Energy system integration
- Social, economical and political issues.

- Gas Technology Centre

The Gas Technology Centre of NTNU-SINTEF in Trondheim, Norway, is an academic research centre established in 2003, whose activities are mainly funded by the Research Council of Norway and Norwegian industry. The centre handles technology in the entire value chain from source to end-user. The centre has the following research areas:[47]

- CO2 management and value chain
- LNG and gas to liquids for the world market
- Offshore fields development including sub sea technology

[46] Strategic Area Energy and Petroleum – Resources and Environment: Annual report 2006. p. 4 http://www.ntnu.no/eksternweb/multimedia/archive/00023/06_EPRM_AnnualReport_23168a.pdf

[47] Strategic Area Energy and Petroleum – Resources and Environment: Annual report 2006. p. 5

- Industrial gas processing and gas products
- Production, storage and use of hydrogen
- Gas engines
- Infrastructure and techno-economic optimization of gas value creation.

- Centre for Smart Energy Efficient Buildings
- Centre for Better Resource Utilization
- Centre for Electric Energy and Energy Systems
- Centre for Energy and Society

University of Oslo
The University of Oslo is especially strong in basic science related to material science and chemistry. The bibliometric analysis revealed excellent positions in solar photovoltaics related R&D, very strong positions in hydropower R&D and good results in wind energy and hydrogen related R&D. Especially relevant for energy research is the FUNMAT@UiO, a cross-disciplinary research unit coordinating and sponsoring R&D activities on functional materials and nanotechnology. The activities of this unit are coordinated with the national FUNMAT consortium (together with NTNU, IFE and SINTEF).

University of Bergen
The University of Bergen has several units actively engaged in energy-related R&D, including the Bjerknes Centre for Climate Research, the Centre for Integrated Petroleum Research, the Department for Chemistry with a research group in petroleum chemistry, and the Department of Physics and Technology with a research group petroleum and process technology – both at the Faculty of Mathematics and Natural Sciences and the Christian Michelsen Centre for Industrial Measurement Science and Technology (CMR), a limited company owned by the university. CMR has two subsidiaries: Prototech AS and GexCon AS. Prototech is engaged in engineering RD&D and GexCon is specialised in gas and dust explosion safety.
The bibliometric analysis revealed very strong positions in wind energy and CCS R&D, but has also activities related to bioenergy.

University for Environment and Bioscience (UMB)
The UMB in Ås is an important R&D organisation specialised in bioenergy and second generation biofuels R&D. The Department of Ecology and Natural Resource Management (INA) is specialised in forest-based bioenergy.

Research institutes

SINTEF GROUP
The SINTEF Group is the largest independent research organisation in Scandinavia. The group consists of several units and some of which are particularly engaged in energy related research:
- SINTEF Energy Research

R&D is focused on power production, energy conversion, transmission, distribution and the use of energy, including industrial processes and products.

- SINTEF Petroleum and Energy

R&D is focused on exploration technology for petroleum resources, reservoir and well technology, well-stream technology, energy systems, thermal energy processes and electric power technology.

- SINTEF Petroleum Research

R&D is focused on exploration and production of petroleum resources.

- SINTEF Building and Infrastructure

R&D is focused on environmentally friendly, cost effective products and solutions in the construction industry, water treatment and materials technology, energy conservation and more efficient management, and operation and maintenance of buildings and infrastructure.

Institute for Energy Technology (IFE)
The Institute for Energy Technology in Norway is an independent foundation established in 1948 with departments at Kjeller and in Halden. With a staff of about 550, IFE is an international research centre for nuclear and energy technology. The institute collaborates with SINTEF and NTNU for the Centre for Renewable Energy (see more details under NTNU).

Paper and Fibre Research Institute (PFI)
The PFI in Trondheim has R&D activities in bioenergy.

WNRI - Western Norway Research Institute
WNRI is a Norwegian research institute doing research in the areas of sustainable development and environment.

TOI - Institute of Transport Economics, Norwegian Centre for Transport Research
TOI is a national institution for transport research and development. The Institute was set up in 1958, firstly as a government secretariat and later (from 1964) as a separate research institution under the auspices of the Royal Norwegian Council for Scientific and Industrial Research (NTNF), now incorporated into the Research Council of Norway). In 1986 the Institute became a private, independent research foundation. The Institute receives its annual base funding from the Research Council of Norway, Division of Culture and Society.

The main objectives of the Institute are to carry out applied research on issues connected with transport and to promote the application of research results by advising the authorities, the transport industry and the public at large. Its sphere of activity includes most of the current major issues in road, rail, sea and air transport. The Institute is also involved in international cooperation within the transport sector.

Polytec Research Foundation
Polytec is an independent R&D institute whose objective is to conduct research and development within the sphere of gas technology, energy, environment, quality and safety. Polytec is located in Haugesund, Rogaland, Norway’s principal oil and gas region.

The overall objective of Polytec is to provide value added to the local community on a not-for-profit basis, and to be a local centre of expertise within the key activity areas of the institute.

Polytec conducts early phase studies and applied research in areas where there is a potential for innovation. Development of new products and a higher degree of refinement within existing local enterprises is one objective of Polytec. Through highly qualified staff with interdisciplinary competence, Polytec constitutes a dynamic and exciting R&D environment.

Firms

Evidently, the involvement of the Norwegian state in the energy sector is deeply rooted in the natural resources and the political will to exploit them on behalf of the nation state. Consequently, many of the largest actors in the energy sector Have a share capital of which 50 per cent or more is owned by the state. This includes for example, StatoilHydro ASA, and Statkraft AS. An important group of actors comprises the regionally and locally based energy companies that were established to exploit the available hydropower. Some of them are pure distributors of electricity and heating; others own most of the value chain from hydropower generation to distribution. The ten largest energy distributors are:

- Hafslund, Fjordkraft, Los, Lyse, Nord-Trøndelag Energiverk, Eidsiva Energi, Fortum, NorgesEnergi (owned by Hafslund), Troms Kraft, Trondheim Energiverk

These 10 firms control around 75% of the electricity market in Norway. In most cases regional authorities and municipalities are strongly involved as owners.

Important industrial projects are:

- Saline Aquifer CO_2 Storage (SACS) Demonstration and monitoring project on the Sleipner field

Unwanted carbon dioxide from Statoil's Sleipner West field in the Norwegian North Sea is being stored 1000 metres beneath the seabed. This solution to the CO_2 problem won the Chief Executive's Health, Safety and Environmental Carbon Dioxide Storage Prize for 2000.

- Statoil – Snøhvit – The World's Northernmost LNG Project

Snøhvit-field – Snøhvit embraces the first export facility for liquefied natural gas (LNG) in Norway and Europe. Huge volumes of gas deep beneath the Barents Sea will be piped ashore, cooled down and shipped by special carrier to Spain and the USA.

Norsk Energi is the Norwegian Association of Energy Users and Suppliers.
The analysis of the R&D firm data gathered in this project gives on overview of the most important industry actors in selected energy technologies (Table 25). Some of the listed companies are active in several fields, like Norsk Hydro ASA, StatoilHydro ASA, Statkraft and Hammerfest Energi, while most of the companies are specialised in one field. We have rather strong clusters in photovoltaics and hydroelectric power, while the activities in second generation biofuels are still rather limited. Hydroelectric power has

long traditions in Norway, and R&D there has been transferred to R&D in wave and tidal power. R&D in wind power in Norway has been influenced by the experiences with big offshore constructions on the Norwegian oil and gas fields. Companies active in CCS R&D are often heavily engaged in oil and gas recovery.

Table 25: R&D based companies in Norway active in selected fields of energy technology*

Firm name	Photo-voltaics	Wind	Hydro-electric power	Wave / tidal power	Second Generation Biofuels	CCS
AkerKværner						X
Borregaard					X	
CAMBI AS					X	
Det Norske Veritas		X				X
ELKEM ASA	X					
ELKEM SOLAR AS	X					
ExxonMobil		X				
Geco Prakla						X
Hammerfest Energi			X	X		X
Hydra Tidal Energy Technology AS				X		
Industrikraft Midt-Norge AS						X
Metallkraft AS	X					
Miljø-Produkter AS				X		
MPU ENTPR AS Norway		X				
Naturkraft AS						X
NAVAL DYNAMICS AS				X		
NORPROPELLER AS			X			
NORSK HYDRO ASA Norway		X	X		X	X
NORSKE SHELL						X
Norske Skog					X	
NorSun AS	X					
ORKLA ENGINEEERING						X
OWEC TOWER AS		X				
POWER VISION AS				X		
Promeks AS	X					
REC ScanWafer AS	X					
REC SILICON	X					
Sargas AS						X
Scatec AS	X					
Sensonor ASA	X					
Skagerak Energi AS						X
Small Turbine Partner AS			X			
Statkraft		X	X			
StatoilHydro ASA		X			X	X
Sway AS		X				
TEEKAY NORWAY AS						X
Thermtech AS					X	
TIDETEC AS			X	X		
TROMS KRAFT PRODUKSJON AS			X			

Water Power Industries AS			X			
WAVE ENERGY AS				X		
Weiland AS					X	

* The selection criteria have been R&D activities documented in patent statistics, bibliometric statistics, R&D project funding by the EUFP5 or Nordic Energy Research and research reports.

1.5 Iceland

Policy and regulation framework conditions

Introduction to national energy technology and production

Systematic energy research by Icelandic government institutes started in the mid-1940s and has been carried out continuously ever since. The research and the activities of the Icelandic power industry have resulted in over 99% of electricity production and over 70% of total energy production currently comes from hydropower and geothermal energy sources. According to the National Energy Authority, one of the main driving forces behind Iceland's economic growth in the last years can be attributed to the successful exploitation of the geothermal energy and hydropower, which has also contributed to attract foreign investments to the country, mainly in power intensive industries.[48]

The long-term goal of the Icelandic government is to replace all fossil fuels with indigenous renewable energy as far as possible. Hydrogen is a central feature in both policy and priorities in this vision. Inn 1998, the government made a clear policy statement towards making Iceland a hydrogen economy. Importance was particularly attached to replacing fossil fuels in the country's transport sector and fishing fleet, which are the two sectors in Iceland responsible for most part of fossil fuel consumption and CO_2 emissions.

Table 26: Iceland Country Summary Table. Sources: Eurostat (2007) Energy Yearly Statistics 2005

Demographical information	
Population (2007)	312 851
Land area	103 000 km²
Macroeconomic Information	
GDP per capita in PPS (2006)	130.3
Real GDP growth rate (2006)	4.2
EU Targets for the share of energy from RES	
RES share in 2005 (% of final consumption of energy)	n.a.
RES target 2020 (% of final consumption of energy)	n.a.
Biofuel target (2010)	n.a.
Electricity generation- total 2005 (GWh)	8 686
Hydro	7 019
Geothermal	1 658
Conventional thermal of which: - Hard coal - Petroleum products - Natural gas - Biomass	 - 5 - 4

[48] Icelandic National Energy Authority

Consumption	7799
Exports and imports	
Exports	-
Imports	-

Table 27: Renewables in Iceland in 2005. Source: IEA[49]

	Municipal Waste*	Industrial Waste	Primary Solid Biomass**	Biogas	Liquid Biofuels	Geothermal	Solar Thermal	Hydro	Solar Photo-voltaics	Tide, Wave, Ocean	Wind
Unit	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*
Gross Elec. Generation	**0**	**0**	**0**	**4**	**0**	**1658**	**0**	**7019**	**0**	**0**	**0**
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*				
Gross Heat Production	**56**	**0**	**0**	**0**	**0**	**8670**	**0**				
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*1000 tonnes*	*TJ*	*TJ*				
Production	70	0	0	42	0	85000	0				
Imports	0	0	0	0	0	0	0				
Exports	0	0	0	0	0	0	0				
Stock Changes	0	0	0	0	0	0	0				
Domestic Supply	**70**	**0**	**0**	**42**	**0**	**85000**	**0**				
Statistical Differences and Transfers	0	0	0	0	0	0	0				
Total Transformation	**70**	**0**	**0**	**42**	**0**	**60470**	**0**				
Electricity Plants	0	0	0	42	0	18324	0				
CHP Plants	0	0	0	0	0	40976	0				
Heat Plants	70	0	0	0	0	1170	0				
Other Transformation	0	0	0	0	0	0	0				
Energy Sector	**0**	**0**	**0**	**0**	**0**	**0**	**0**				
Distribution Losses	0	0	0	0	0	2930	0				
Total Final Consumption	**0**	**0**	**0**	**0**	**0**	**21600**	**0**				
Industry	0	0	0	0	0	1500	0				
Transport	0	0	0	0	0	0	0				
Residential	0	0	0	0	0	15800	0				
Commercial and Public Services	0	0	0	0	0	2000	0				
Agriculture / Forestry	0	0	0	0	0	2300	0				
Fishing	0	0	0	0	0	0	0				
Other Non-Specified	0	0	0	0	0	0	0				
Non-Energy Use	0	0	0	0	0	0	0				
- of which Petrochemical Feedstocks	0	0	0	0	0	0	0				

[49] http://www.iea.org/Textbase/stats/renewdata.asp?COUNTRY_CODE=IS&Submit=Submit

* Municipal Waste: the split for renewable and non-renewable waste is also available
** Primary Solid Biomass: data are also available for charcoal

Government energy action plans and strategy documents, in particular energy technology focus areas and priorities

The present Science and Technology Policy Council (STPC) established in 2003, and reconstituted in 2006, is the strategic body in charge of setting broad policy orientations for science and technology. These orientations go beyond science and technology in the strict sense, and extend to a much broader range of societal issues to which science and technology are relevant. The work of this Council, under the chairmanship of the prime minister, has helped to place R&D and innovation higher on the policy agenda. While the implementation of science, technology and innovation policy falls within the remit of the Ministries concerned.[50]

In November 2003, the Ministry of Industry and Commerce, the Icelandic Energy authority and VistOrka published a joint paper on hydrogen research. This document explains the government's ambition to make Iceland the world's first hydrogen society based wholly on a renewable energy chain.[51]

The national strategy for sustainable development was drawn up by the Icelandic government in 2002. This strategy was developed through broad consultation between ministries, with stakeholders and civil society. The strategy is intended as a general framework for policies set by authorities in the sustainable development field until 2020. The purpose of the strategy is to set up priorities, set long-term goals and to define and set up criteria to measure progress. Seventeen objectives are presented related to environmental issues. Under the section for sustainable use of resources one important objective mentioned is the increased use of renewable energy.[52]

One important objective of the government's Climate Change Strategy 2007–2050 is to further reduce the use of fossil fuels in favour of renewable energy sources and climate-friendly fuels. The strategy contains several provisions that promote research in various fields as part of government measures. The government has the intention to increase the carbon sequestration from the atmosphere and foster research and innovation in the fields related to climate change. The government intends to invest more in research to investigate the feasibility of pumping CO_2 from geothermal power plants back to the ground. The export of Icelandic expertise in the fields related to renewable energy technologies is considered to be the weightiest contribution that Iceland can make in the campaign against climate change. Further, the government wants to increase the R&D efforts regarding climate-friendly fuels. Research and development in the fields of hydrogen utilisation will be encouraged and the possibility of setting up a coordinated research and development plan concerning innovation in climate-related fields will be examined. The Ministry of Environment has compiled an overview of research conducted in Iceland related to climate change in a report for the Science and Technology Policy

[50] ERAWATCH Iceland, Basic characterisation of the research system
[51] Ministry of Industry and Commerce and VistOrka (2003),"Towards a Sustainable Hydrogen Economy", Iceland as an International Platform for Clean Energy Research.
[52] "Welfare for the Future. Iceland's National Strategy for Sustainable Development 2002-2020"

Council. The report indicates numerous research fields of special interest for future investigations, such as sequestration of CO_2 and climate-friendly technology, innovation and promotion.[53]

Iceland's Fourth National Communication on Climate Change under the United Nations Framework Convention on Climate Change was published in March 2006 by the Ministry for the Environment. Also in this document the government stresses the importance of continuing research on fuel cells and hydrogen as energy carrier.[54]

Electricity Act

The purpose of this legislative Act is to develop an economic electricity system and thereby strengthen Icelandic industries as well as regional development in Iceland. To this end, the Act states:
1. A competitive environment shall be ensured for the generation and trade of electricity, with such restrictions as may prove necessary for the security of supply and other public interests.
2. Effectiveness and efficiency in the transmission and distribution of electricity shall be promoted.
3. The security of the electricity supply system and consumer protection shall be ensured.
4. The use of renewable energy sources and observance of other environmental criteria shall be promoted.[55]

Table 28: Selected Icelandic government bills on energy

Government Bills on Energy	Year
Act On Landsvirkjun No. 42	1983
Act No 13 On prospecting, exploration and production of hydrocarbons as amended by Act No. 49/2007	2001
Rules No. 553 governing the granting of licenses to prospect for hydrocarbons	2001
Electricity Act No. 65	2003
Law On the Establishment of Landsnet hf. No. 75	2004

Environmental laws and regulations

The Act on Research and Utilisation of Underground Resources applies to licences for the investigation and research into energy sources in preparation for electricity generation. In addition to the conditions listed therein, applicants for research licences shall submit an evaluation on how a proposed power plant may be connected to Iceland's electricity supply system.

Table 29: Selected Icelandic government bills on climate and environment

Government Bills on Climate and Environment	**Year**
Planning and Building Act No.73	1997

[53] Ministry for the Environment (February 2007), Iceland's Climate Change Strategy 2007-2050
[54] Iceland's Fourth National Communication on climate Change under the United Nations Framework Convention on climate Change (2006)
[55] Electricity Act Article 1, *Purpose*

Act on Research and Utilisation of Underground Resources	1998
Public Health and Pollution Control Act	1998
Nature Conservation Act No. 44	1999
Environmental Impact Assessment Act No. 106	2000
Emissions of Greenhouse Gases Act No. 65	2007

Important R&D and innovation policy instruments

In 2005, R&D expenditure in Iceland amounted to 28 billion ISK (approximately €335m). As a share of the Gross Domestic Product (GDP), R&D expenditure accounted for 2.8%.

Iceland is ranked 5th among OECD countries for the R&D/GDP ratio. More than half of the expenditure on R&D is generated from the private sector (approximately 168 MEUR). In 2005, approximately 3 per cent of the total R&D expenditure was dedicated to the energy field (compare Figure 16).[56] Iceland is among the countries with the highest primary energy and electricity consumptions per capita in the world. Despite its high energy consumption Iceland is obtaining some 70 per cent of its energy from renewable sources. [57]

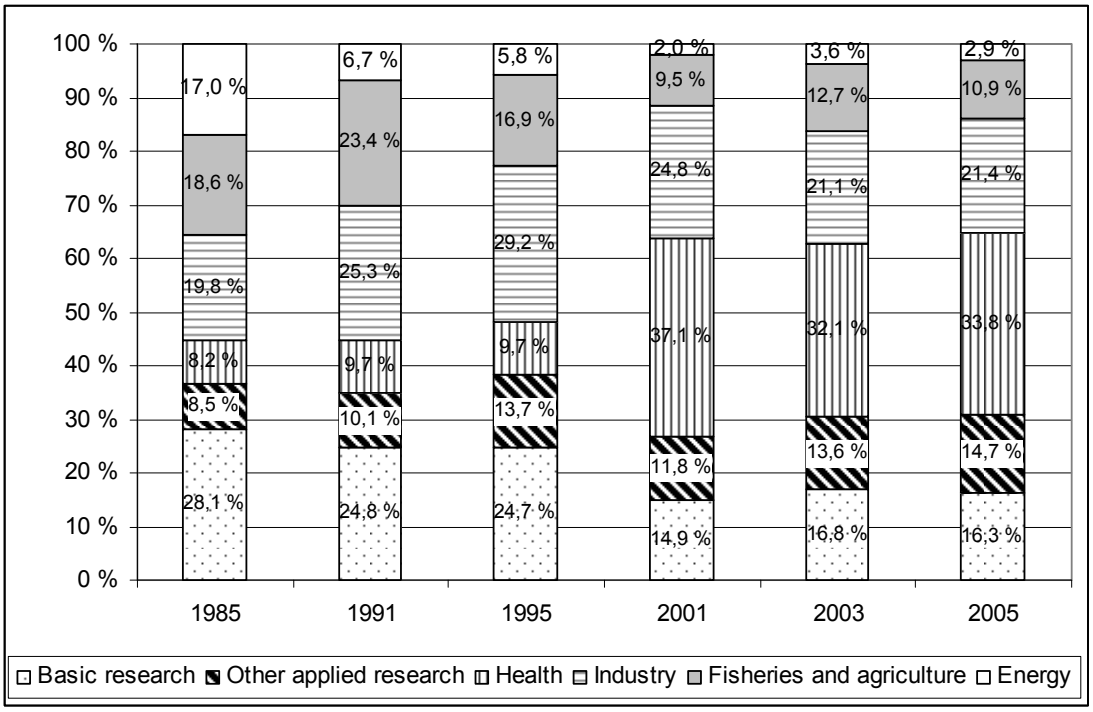

Figure 16: Expenditure on R&D in Iceland by theme from 1985 to 2005 (%). Source RANNIS

[56] Rannis statistics

[57] Ministry for the Environment (2002) Welfare for the future, Iceland's National Strategy for Sustainable Development. Statistical Indicators 2006.

Research on the production of synthetic fuels from hydrogen has been conducted for more than three decades at the University of Iceland. A dedicated company, Icelandic New Energy, was established to support further research and development in the field of hydrogen. Increased international cooperation in the field of energy research is an important priority. [58]

Unlike most of the other Nordic countires there are currently no support schemes for electricity generation in Iceland.[59]

In 2006, Reykjavík Energy and all universities in Iceland's capital established i an autonomous Environmental and Energy Research Fund which is intended to become a venue for collaboration in energy and environmental research. The initial capital contribution is ISK100m, and the goal is that Reykjavík Energy will annually contribute approximately 5% of its revenues towards the Fund.

The Environmental and Energy Research Fund is owned by Orkuveita Reykjavíkur-Reykjavík Energy which, along with all seven universities located in the Company's service area, bears professional responsibility for the Fund. The universities are: Háskóli Íslands (University of Iceland), Háskólinn í Reykjavík (Reykjavík University), Listaháskóli Íslands (Iceland Academy of the Arts), Kennaraháskóli Íslands (The Iceland University of Education), Landbúnaðarháskóli Íslands (The Agricultural University of Iceland), Háskólinn á Bifröst (Bifröst School of Business) and Jarðhitaskóli Háskóla Sameinuðu þjóðanna (The United Nations University Geothermal Training Programme).[60]

New Icelandic Energy is carrying out several projects on renewable energy technologies. Several projects are carried out under the EU research framework programme and the focus is mainly on hydrogen. Some of the projects include:

ECTOS – Demonstration project, EU funded hydrogen project: The Ecological Transport City System (ECTOS) project, supported by the EUFP5, was launched in March 2001, thereafter managed by Icelandic New Energy. The ECTOS project introduced the first hydrogen buses that have now been operating in Reykjavik since 2003. The project had a budget of €7m and was supported by the European Commission DG-Research "City of Tomorrow and Cultural Heritage".

Create Acceptance: assessing and promoting societal acceptance of clean energy technologies.

HyApproval: Icelandic New Energy is one of 26 partners taking part in this EU-supported project. The aim of the project is to make a "handbook for approval of Hydrogen refuelling stations" which will be used to certify public hydrogen filling stations in Europe. This handbook will be issued to hydrogen refuelling station operators and local authorities.

NEEDS: New Energy Externalities Development for Sustainability or "NEEDS" is an EC funded project which aims at estimating all costs (environmental and social as well as

[58] Towards a Sustainable Hydrogen Economy
[59] Support Schemes for renewable energy in the Nordic countries, chap. 9 in Ten Perspectives on Nordic Energy (2006)
[60] http://www.or.is/Forsida/UOOR/English/AbouttheFund/

direct costs) of various energy systems for the future. Among the technologies under consideration are wind power, solar power, advanced fossil fuels, and hydrogen technologies. INE's role will be to provide LCA studies on Hydrogen production via electrolysis and suggest future opportunities to produce and use hydrogen as well as to suggest methods of measuring external costs from using renewable energy sources.

Roads2HyCom (R2H) is a project supported by EUFP6. Its purpose is to assess and monitor Hydrogen and Fuel Cell technologies for stationary and mobile energy applications. This is done by considering what the technology is capable of relative to current and future hydrogen infrastructures and energy resources, and the needs of communities that may be early adopters of the technology. By doing this, the project will support the Commission and stakeholders in planning future research activities.

SUGRE (Sustainable Green Fleets) is an accompanying measure within EUFP6 that promotes alternative propulsion and mainly focuses on captive fleets, but not only regarding land transport. The main objective is to promote and support the conversion of fleets to alternative propulsion (ranging from bio-fuels, methane as fuel to hybrid systems comprised of combustion engines and electric propulsion systems) and the energy efficient usage of them.

The Icelandic hydrogen team is launching the next learning phase towards a hydrogen future, **the SMART–H_2** (Sustainable Marine and Road Transport, Hydrogen in Iceland). The SMART–H_2 has three main paths; testing hydrogen passenger cars; designing and using fuel cell equipment as auxiliary power unit (APU) on board a ship and a research path based on the data collected in the bus project as well as the upcoming demonstrations. VistOrka (a cooperation platform for hydrogen) will provide at least USD3.5m to the SMART-H_2, a project with the total budget of USD7–8m. The funding will be used to provide incentives for available hydrogen vehicles preferably fuel cell cars. VistOrka has also the intention to evaluate other alternative fuel sources and vehicles with the goal of at least 30 hydrogen vehicles operating by mid-2009.[61]

"Vetnistæknimiðstöð" – Hydrogen Energy Technology Centre
Currently the key academic and research institutes in Iceland along with private companies like INE, are creating a joint forum for hydrogen activities. The key is to establish a forum for all hydrogen research as spin-offs from activities like the ECTOS project are setting the scene for new industries, i.e. 139 technology industry. This new industry could create new high-tech jobs in the near future.

61
http://www.newenergy.is/en/news/?ew_news_onlyarea=UserArea&ew_news_onlyposition=0&cat_id=22164&ew_0_a_id=284045

Key actors and institutions

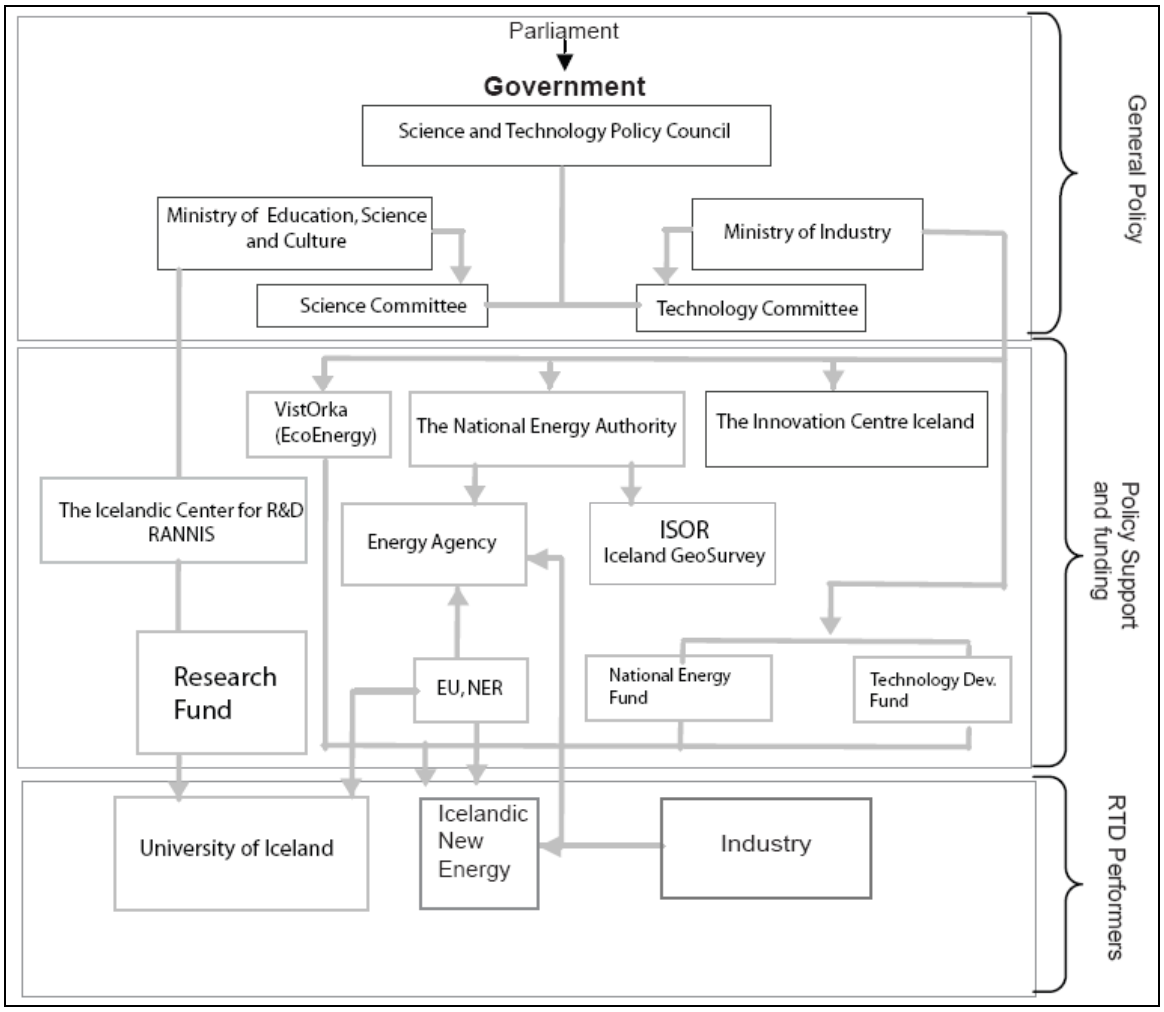

Figure 17: The Iceland Energy Policy System. Source: NIFU STEP

Government organisation

Ministries

The Ministry of Industry and Commerce is in charge of promoting and operating Icelandic government policy on energy and hydrogen in close cooperation with other ministries and stakeholders. The role of the Department of Energy and Environmental Affairs, an agency under the Ministry for Industry and Commerce, is to promote further and better utilization of energy resources and more efficient organisation of energy affairs. Iceland's energy companies are partly or wholly owned by the State or local municipalities. The ministry's Department of Energy and Environmental Affairs handles administrative dealings with those companies.

Governmental Agencies

The National Energy Authority (Orkustofnun) is an administrative and regulatory agency and has been engaged in research on hydropower, geothermal energy and assessing Iceland's energy potential for many decades. The main areas of responsibility are to:

- Conduct research on energy issues, accumulates information, and maintain a database of knowledge on energy resources.
- Collect basic data on hydrological conditions, on the hydrological budget of Iceland's freshwater and geothermal resources, as well as data on various natural and environmental processes.
- Disseminate knowledge on the exploration and exploitation of geothermal resources to developing nations.
- Execute administrative functions on behalf of the Icelandic government, and serve as a governmental advisor on energy issues.

Orkustofnun is also involved in assessing the potential of hydrogen production of energy in Iceland. Orkustofnun works closely with several international organisations including the International Energy Agency, the EU and Nordic Energy Research.[62]

Orkusetur, the first energy agency in Iceland was formally opened in the end of 2006 and is located in the town of Akureyri in North-Iceland. The main role of the agency is to increase awareness about energy efficiency in households and industry. Creation and introduction of education material about different energy issues will also fall under the main agenda of the agency. The agency is fully autonomous and will work as a link between the public, private companies, institutions and the authorities. During a trial period of 3 years the activity is partially financed by *Intelligent Energy – Europe* (IEE), an initiative of converting EU policy for smart energy use and more renewables into action on the ground, addressing today's energy challenges and promoting business opportunities and new technologies. The agency is managed by the management board and politically supervised by the Icelandic Government. [63]

RANNIS - The Icelandic Centre for Research was established in 2003 and replaced the office of the earlier Icelandic Research Council operating since 1994. RANNIS reports to the Ministry of Education, Science and Culture and its mission is to provide professional assistance to the preparation and implementation of science and technology policy in Iceland.[64]

The main functions of RANNIS are the following.

- RANNIS operates the competitive financial public support system for research and technological development. This includes the Research Fund, the Fund for Research Equipment and the Graduate Research Fund under the Ministry of Education, and the

[62] http://www.os.is/page/english/
[63] http://www.orkusetur.is/
[64] http://www.rannis.is/english/

Technology Development Fund under the Ministry of Industry. Each of the funds is governed by a Board of Directors, the allocation of grants being subject to an extensive peer review process.

- RANNIS actively provides the Science and Technology Policy Council and its subcommittees with information on scientific research and technology development nationally and internationally as a basis for the policy-making process.

The Science and Technology Policy Council was established in 2003 when the Icelandic Research Council was abolished. The Council has 14 members representing the science and technology community and the social partners plus five ministers, and is chaired by the prime minister. The role of the Science and Technology Policy Council of Iceland is to promote scientific research and research training in the sciences and to encourage technological progress in Iceland, for the purpose of strengthening the foundation of the country's culture and boosting the competitive capacity of its economy. The principal function of scientific and technological policy is to express the priorities set by the government and inform of the improvements to be made in the support structure for research and development. It also serves to guide those who participate in implementing the policy in selecting appropriate strategies towards established goals. The Council's second and current policy statement was adopted in June 2006 and covers the period 2006–2009.

Public research organisations

Universities and Higher Education Institutions

The University of Iceland is conducting extensive research programmes on the storage and production of hydrogen, hydrogen systems analysis and the socio-economic implications of the use of hydrogen as energy carrier.[65]

The Institute for Sustainable development at the University of Iceland (UI- ISD) takes part in a variety of research project, where alternative energy is one of the main fields of investigation.

The School for Renewable Energy Science is a new private higher education institution established in April 2007. The training programme offered at the school is run in cooperation with two public universities in Iceland, University of Iceland and University of Akureyri, as well as in partnership with a number of leading technical universities in Europe. Available courses are: renewable energy science, geothermal energy, fuel cells systems and technologies and biofuels and bio-energy.[66]

Research Institutes

The Innovation Centre Iceland is a leading institution in technological R&D in Iceland. Its areas of expertise are mainly nanotechnology and environmental energy, concrete

[65] http://www2.hi.is/page/hi_is_english_frontpage
[66] http://res.is/?m=page&f=viewPage&id=3

research and building technology. Projects include applied research and testing, basic research in key areas, consultation and technology transfer. The staff does fundamental technical work in close cooperation with clients to find technical and development solutions.

The Centre was established in August 2007 as a result of the merger of the Technical Institute of Iceland (IceTec) and the Icelandic Building Research Institute (IBRI). It operates under the Ministry of Industry and receives revenue from both the public and private sectors. An important goal of the Centre is to excel in technology research, product development, analysis and testing.

The Innovation Centre has three main departments: Human Resources and Services, Entrepreneurs and SME Services, and Icelandic Technological Research. The latter deals specifically with energy issues and focuses on:

- production, processes and energy;
- materials, biotechnology and energy.[67]

ÍSOR, Iceland GeoSurvey, was established on July 2003. ÍSOR is a service and research institute providing specialist services to the Icelandic power industry, the Icelandic government and foreign companies, in particular in the field of geothermal sciences and utilisation. When it was established, ÍSOR took over all responsibilities of the former GeoScience Division of the National Energy Authority of Iceland. ÍSOR is a self-financed, non-profit governmental institution which operates on the free market like a private company. The annual turnover is close to €4.5m.[68]

Firms

VistOrka is a cooperation platform for hydrogen, engaged in developing the vision of creating the country's first hydrogen-powered society, VistOrka's primary function lies in its role as local partner to Icelandic New Energy, a company in which it holds a share of around 51%. Through its structure, VistOrka brings together investment funds, academic and research institutions, private enterprises, Iceland's largest energy companies and the government with the goal of creating the world's first hydrogen society.[69]

Icelandic New Energy was established in 1999 as a spin-off from the research activities at the University of Iceland. The mission is to investigate the potential for the eventual replacement of fossil fuels in Iceland with hydrogen based fuels. The owners are VistOrka, Hydro, Shell Hydrogen and DaimlerChrysler.[70]

Varmaraf ehf was founded in 2000 around applications of thermoelectricity in harnessing geothermal power, which is abundant in Iceland where the company is based. Varmaraf has recently introduced globally unique thermoelectric generators as a result of an extensive product development effort. Varmaraf is also active in development of

[67] http://www.nmi.is/
[68] http://www.isor.is/page/profile
[69] http://www.ectos.is/newenergy/en/icelandic%5Fnew%5Fenergy/owners/vistorka/
[70] http://www.ectos.is/newenergy/en/

hydrogen storage devices where some of the novel features of its thermoelectric generators are introduced into conventional storage designs using metal hydrides. This is an important step for the company into technology development for the massive global transition to hydrogen as energy carrier.

Landsvirkjun is the national electricity company. Its purpose is to produce and provide electricity to heavy industry and to sell electricity to smaller providers, such as Reykjavik Energy and Iceland State Electricity (RARIK). Landsvirkjun has eleven power plants, mainly hydropower and steam power plants. Currently the largest hydropower plant in Iceland, the Kárahnjúkar Hydropower Project is being built by Landsvirkjun. The finished plant will provide power to an aluminum smelter industry. The plant has been heavily criticized for its environmental and economic impact in the region. There are five main district heating companies in Iceland, the biggest one being the geothermal plant Orkuveita Reykjavikur.

Other energy companies in Iceland are:

- Akureyri Municipal Water and Power Company (Norðurorka)
- Hitaveita Suðurnesja
- Húsavík Energy (Orkuveita Húsavíkur)
- Landsvirkjun National Power Company
- Westfjord Power Company (Orkubú Vestfjarða)

2. The Baltic countries

The energy combination of the Baltic States is quite diverse. In Estonia, oil shale is the dominant energy resource. Hydro resources and nuclear energy complemented with imported natural gas and oil products are important in Latvia and in Lithuania respectively.
The Baltic States have no direct connection to the power systems of Central Europe, which creates the problem of being dependent on gas supply from a single source, namely Russia.

Since the beginning of the 1990s, the Baltic Council of Ministers is responsible for the overall coordination of matters regarding the Baltic cooperation, including energy issues. The Committee of Energy is responsible for the Baltic States cooperation within the energy sector. An agreement on cooperation between the three Ministries of Economy in the energy sector was signed in Riga on October 29th 1998.[71]

The CO_2 emissions from the Baltic countries are below the level for the OECD as a whole (in 2005 11.02 t CO_2 per capita). Estonia had the highest emission rates in 2005 – both in absolute numbers and per capita (Figure 18). The comparably higher emission levels in Estonia can be explained by the extensive use of oil shale that is the dominant energy source in the country.

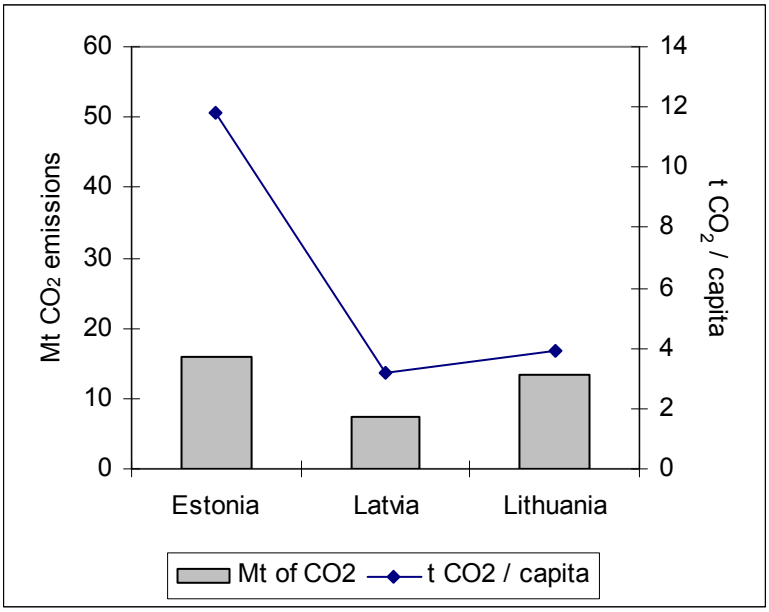

Figure 18: CO_2 emissions by country in 2005 – absolute numbers and per capita for the Baltic countries. Source: IEA Key World Energy Statistics 2007, p. 48ff.

Since 1 May 2004, Estonia, Latvia and Lithuania have been full Members of the European Union. The harmonisation with the EU policies and standards has created favourable conditions in the Baltic States for closer cooperation, also in the energy sector.

[71] Baltic Council of Ministers, Energy Committee, Baltic Energy Strategy 1999

In the light of the common challenges facing the three states such as rapid economic growth, increase in oil and gas prices, dependency on gas supply from a single supplier and the challenges relative to nuclear power, the Baltic States adopted a new common Baltic Energy Strategy in 2007. In order to meet the requirements and provisions in the Treaty of Accession to the EU, Energy Charter Treaty, EU legislation and the Green Paper the Baltic States has set up six strategic objectives:

1. To integrate power and gas supply systems into the energy system and energy markets of the EU;
2. To diversify primary energy sources and supplies, and increase the contribution of renewable and local resources;
3. To increase the energy efficiency at the demand side and in the energy transformation sector;
4. To develop the transit routes for energy products, including electricity;
5. To strengthen education, research and development in the energy sector;
6. To elaborate and implement a common policy on energy imports from non- EU countries.

The strategy also concludes on the need to build a new nuclear power plant in Lithuania. The countries also stress the need for a common strategy for the development of a transmission system that can integrate the Baltic power systems into Central European and Nordic energy systems.[72]

When considering total installed electricity capacity from the beginning of the 1990s to 2005, we see that this has been at a quite stable in Latvia, with only a marginal increase since 2002. Estonia experienced a fall in 1995 and the installed electricity capacity has since then continued to decline and in 2005 was at the same level as Latvia. Lithuania had had a relatively stable electricity capacity during this period until late 2004 when levels fell drastically, mainly due to the decommissioning of the Ignalina nuclear power plant (Figure 19).

Between 1995 and 2005 the electricity produced from renewable energy sources was close to zero in Estonia, which can be explained by the extensive use of oil shale. Lithuanian levels were slightly higher than the Estonian levels. By contrast, Latvia has had much higher renewable electricity production, mainly because of the electricity produced from hydro power (Figure 20).

The Baltic countries have been engaged in collaborative energy research: the Inter-Baltic Energy Research Programme was in place from 1996 to 2000. The main topics of this programme were energy policies at pre-integration to the EU accession and Baltic energy networks.[73] Renewable energy sources were not in the focus of this programme (cf. Egle).

[72] Baltic Energy Strategy 2007
[73] Latvian Academy of Science: Inter-Baltic Energy Research Programme: http://www.lza.lv/news/bn96_6.htm

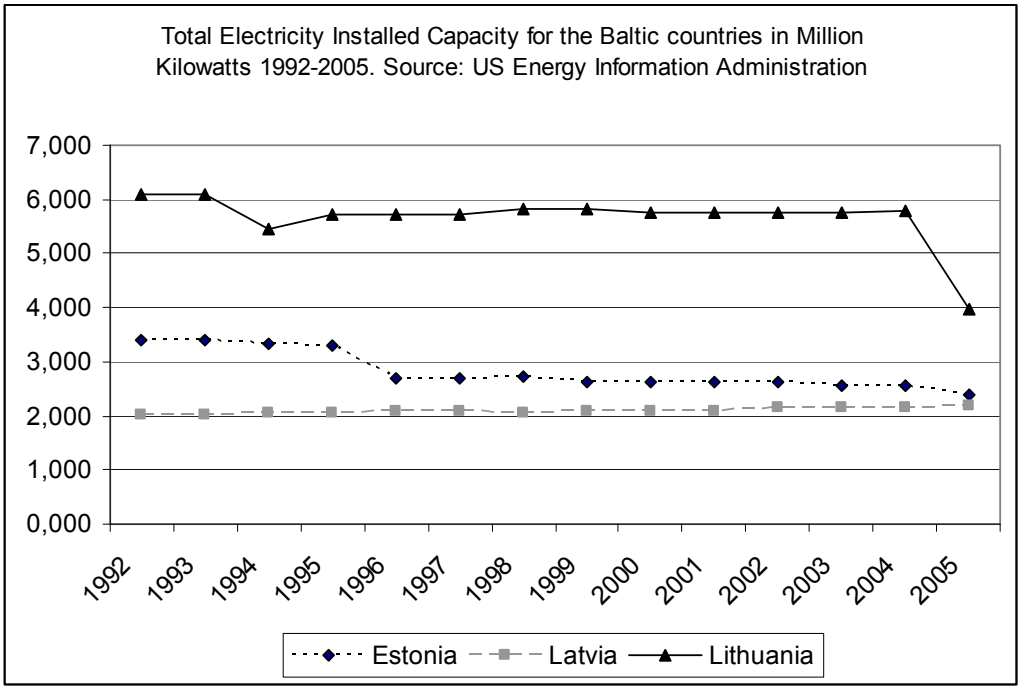

Figure 19: Total Electricity Installed Capacity for the Baltic countries in million Kilowatts 1992-2005. Source: US Energy Information Administration

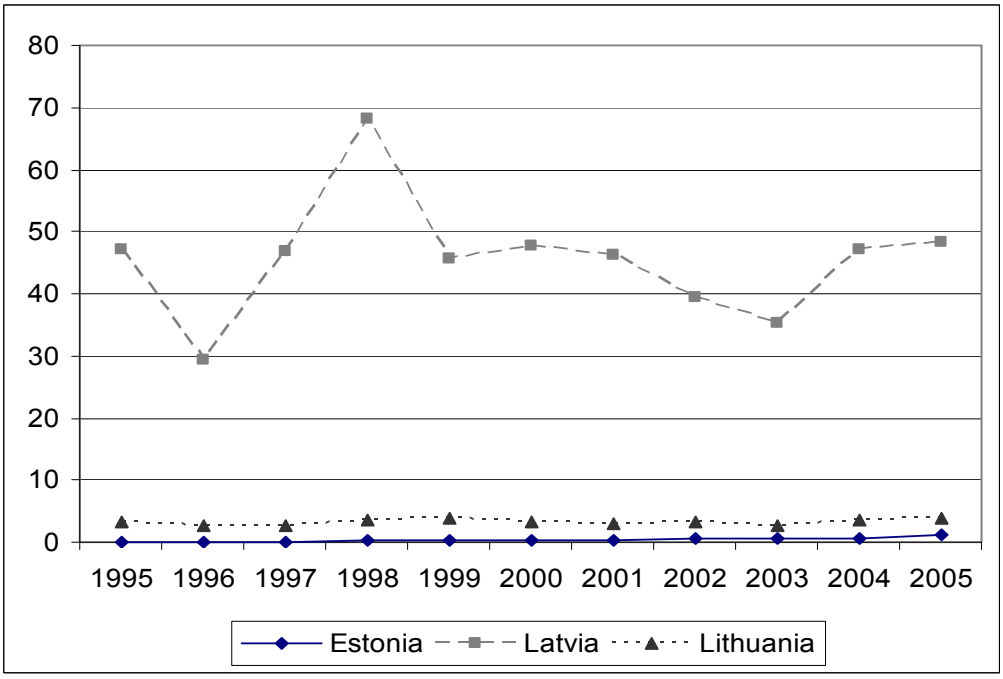

Figure 20: Ratio between the electricity produced from renewable energy sources and the gross national electricity consumption for the Baltic countries. 1995-2005. Source: Eurostat

2.1 Estonia

Policy and regulation framework conditions

General framework conditions

Estonia became fully independent in 1918, was occupied by the Soviet in 1940, and regained its independence in 1991. Since its formation, the parliamentary government has pursued policies of economic reform to increase transparency in all sectors by emphasizing market-oriented mechanisms. Subsequently, Estonia has been able to form one of the more stable economies of the former soviet states. Consistent growth in GDP has been observed since 1995, accompanied by inflation, decreasing into single-digit figures. As a result of its extensive reform efforts and growing economy, Estonia was accepted into the WTO in 1999, and joined the EU in 2004.

Introduction to national energy technology and production

Eesti Energia (Estonian Energy) is the dominant player in the Estonian power sector, as it has responsibilities for the bulk of the country's power-generating units and its distribution networks. Estonia has approximately 3.3 GW of installed electric-generating capacity, 99.7 per cent of which comes from thermal power plants. The Estonian Power Station and the Baltic Power Station, both fuelled by oil shale, together account for nearly 95 per cent of Estonia’s electricity production. The remainder of the electricity is generated by other oil shale plants and combined heat and power plants. Oil shale treatment and technology has a very long tradition in Estonia.

There are indications that the Estonian renewable energy targets have been set unrealistically high. Table 25 shows that the official target of renewable energy sources in final consumption of energy was 18% for 2005. The 18%-target was evidently too ambitious. As we write (summer 2008) Estonia obtains around 1 per cent of its power from renewable sources. Under a deal with the European Union, Estonia will have to raise that percentage to 5.1 per cent by 2010 as it moves away from oil-shale-fired electricity. The target for 2020 is 25%. With the current configuration of activity in Estonia, it seems that the target set for 2020 is ambitious.

The government has sought to increase efficiency in the use of energy, reliable electricity generation and distribution, by seeking outside investment where applicable for infrastructure improvements, and by facilitating competition and diversity within energy industries. To this end, the government began a phased-in liberalization of the electricity sector in 2001. Tariffs were established to allow all customers to choose their electricity supplier. However, at this time only customers whose annual consumption exceeds 40 GWh can choose their electricity supplier. These financial reforms come on the heels of the unbundling of the energy sector into a grid operator, Eesti Energia, generation companies, and distribution networks. The two largest generating stations, Eesti Elektrijaam and Balti Electrijaam, were purchased by US based NRG Energy, Inc. in 2000 and 2001, respectively. Additionally, two of the regional distribution companies have been sold to international investors.

Table 30: Estonia Country Summary Table.
Sources: Eurostat (2007) Energy Yearly Statistics 2005; European Commission (2003b) Biofuels Directive; European Commission (2008) Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources COM (2008)

General information	
Population (2006)	1 343 547
Land area	45,226 km^2
Macroeconomic Information	
GDP per capita in PPS (2006)	68.5
Real GDP growth rate (2006)	11.2
EU Targets for the share of energy from RES	
RES target in 2005 (% of final consumption of energy)*	18.0
RES target 2020 (% of final consumption of energy)*	25
Biofuel target (2010)	n.a.
Electricity generation – total 2005 (GWh)	*10 205*
Hydro	22
Wind	54
Nuclear	-
Conventional thermal of which: - Hard coal - Lignite and peat - Petroleum products - Natural gas - Biomass - Industrial wastes	10 129 9 302 32 760 21 14
Consumption	*6 023*
Exports and imports	
Exports	1 953
Imports	354

*European Commission (2008)

Table 31: Renewables in Estonia in 2005[74]

	Municipal Waste*	Industrial Waste	Primary Solid Bio-mass**	Biogas	Liquid Biofuels	Geothermal	Solar Thermal	Hydro	Solar Photo-voltaics	Tide, Wave, Ocean	Wind
Unit	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*
Gross Elec. Generation	**0**	**0**	**21**	**14**	**0**	**0**	**0**	**22**	**0**	**0**	**54**
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*				
Gross Heat Production	**0**	**0**	**3812**	**43**	**0**	**0**	**0**				
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*1000 tonnes*	*TJ*	*TJ*				
Production	0	0	29551	149	0	0	0				
Imports	0	0	0	0	0	0	0				
Exports	0	0	-3893	0	0	0	0				
Stock Changes	0	0	61	0	0	0	0				
Domestic Supply	**0**	**0**	**25719**	**149**	**0**	**0**	**0**				
Statistical Differences and Transfers	0	0	-1256	0	0	0	0				
Total Transformation	**0**	**0**	**5418**	**127**	**0**	**0**	**0**				
Electricity Plants	0	0	16	16	0	0	0				
CHP Plants	0	0	181	104	0	0	0				
Heat Plants	0	0	5221	7	0	0	0				
Other Transformation	0	0	0	0	0	0	0				
Energy Sector	**0**	**0**	**97**	**0**	**0**	**0**	**0**				
Distribution Losses	0	0	0	0	0	0	0				
Total Final Consumption	**0**	**0**	**18948**	**22**	**0**	**0**	**0**				
Industry	0	0	5707	0	0	0	0				
Transport	0	0	0	0	0	0	0				
Residential	0	0	12342	0	0	0	0				
Commercial and Public Services	0	0	689	22	0	0	0				
Agriculture / Forestry	0	0	210	0	0	0	0				
Fishing	0	0	0	0	0	0	0				
Other Non-Specified	0	0	0	0	0	0	0				
Non-Energy Use	0	0	0	0	0	0	0				
- of which	0	0	0	0	0	0	0				
Petrochemical Feedstocks											

* Municipal Waste: the split for renewable and non-renewable waste is also available

** Primary Solid Biomass: data are also available for charcoal

[74] IEA: http://www.iea.org/Textbase/stats/renewdata.asp?COUNTRY_CODE=EE&Submit=Submit

Government energy action plans and strategy documents, in particular energy technology focus areas and priorities

Energy policy in Estonia is based on the following strategic documents:

1. Long-term Public Fuel and Energy Sector Development Plan until 2015 (2004)
2. Electricity Market Act (2003)

The Long-term National Development Plan for the Fuel and Energy Sector is based on the Sustainable Development Act (RT^2 I 1995, 31, 384; 1997, 48, 772; 1999, 29, 398; 2000, 54, 348) and directs the development of the Estonian fuel and energy sector until 2015. It is an update of the plan from 1997. The document defines the current situation in the sector, presents issues set out in the EU accession treaty, prognoses developments in the energy consumption, states the strategic development objectives for the energy sector, the development principles and the extent of the necessary investments. The plan describes the problems that require further analysis and the functions of the state relating to supervision and regulation.

As the environmental impact from the energy sector cannot be reduced to the required level without restructuring the use of energy sources, the major part of energy demand increase is projected to be met by natural gas resulting in doubling its share in primary energy supply in 10 – 15 years. Regarding the sustainable use of local resources, the wider deployment of renewable sources is planned, especially in the form of electricity and heat cogeneration based on these fuels.

Table 32: Selected Estonian government bills on energy

Government Bills on Energy	Year
Sustainable Development Act, amended in 1997, 1999, 2000	1995
District Heating Act, amended in 2004	2003
Electricity Market Act, amended in 2004	2003
Liquid Fuel Act, amended in 2004	2003
Natural Gas Act 2003	2003
Liquid Fuel Stocks Act	2005

The long-term public fuel and energy sector development plan until 2015 is supplemented by the development plan for the electricity sector based on the Electricity Market Act (RT I2003, 25, 153; 2004, 18, 131; 30, 208) and prepared in 2005. The Long-term Public Fuel and Energy Sector Development Plan sets a target to increase the share of renewables and peat in the primary energy supply by two-thirds in the period 1996–2010. It also provided that to implement the Plan, a *Target Programme Economically Feasible Implementation of Peat, Biofuels and Other Renewables in Energy Production* shall be developed. Concerning renewable sources, the plan presents the following indicators for the year 2010: the share of renewables in total primary energy supply 11–13% and in electricity production 5.1%.

Regarding international agreements, Estonia signed *The Energy Charter Treaty* (ECT) in 1994. The ECT, together with the *Protocol of Energy Charter on the More Efficient Energy Use and the Related Environmental Aspects,* was ratified by the Estonian parliament and entered into force in 1998. In December 1998, Estonia signed the *Kyoto Protocol of the United Nations Framework Convention on Climate Change*. One of the

main goals is to ensure the CO_2 emission level to be kept lower than limits fixed in Kyoto Protocol (in 2008–2012 the emission level has to be 8% lower than in 1990) by increasing the efficiency of energy production and transportation, by using environmentally friendly fuels and by reducing energy consumption in all sectors and households. Additionally, Estonia has ratified several international agreements, including the Convention on Long-Range Transboundary Air Pollution and its protocols, and Vienna Convention for the Protection of the Ozone Layer.

The target groups of the mentioned target programme are the following: Ministry of Economic Affairs and Communication, Ministry of Environmental Affairs, counties, local governments, energy companies and consumers of local heating. In the programme it is pointed out that the experience gained since the 1990s in expanding the use of biofuels and peat has indicated that the success depends on how well such projects are planned and prepared. Since exploiting renewable energy sources and peat is linked to regional development, regional employment, pricing policy of fuels and energy and financing opportunities, the preparation and launch of a national programme dealing with these issues is vitally important. Consequently, economically viable conditions of using renewable energy sources and peat are planned to be analysed, and environmental and regional aspects of corresponding projects are considered. The national programme should enable to outline the assessment to the potential of economic viability of exploiting peat and renewable energy sources both regionally and nationally. The national programme on economically viable use of renewable energy sources and peat would be the basis for applying for international aid for financing respective pilot projects through cooperation projects including European Union and Baltic Sea countries.

Energy policy priorities are indicated in the Electricity Market Act. This addresses the renewable energy sources – hydro, wind, solar, wave, tidal and geothermal energy sources, landfill gas, sewage treatment plant gas, biogases and biomass. In the Act, biomass is defined as the biodegradable fraction of products, waste and residues from agriculture (including vegetable and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste.
Summing up, the Estonian fuel and energy policy includes the following strategic objectives:[75]

- Ensure fuel and energy supply with the required quality and at optimal prices;
- Ensure the existence of local generating power to cover the domestic electricity consumption needs and the supply of liquid fuel in compliance with law;
- Ensure that by 2010 renewable electricity forms 5.1 per cent of the gross consumption;
- Ensure that by 2020 electricity produced in combined heat and power production stations forms 20 per cent of the gross consumption;
- Ensure that the power network is completely modernised in approximately every thirty years;

[75] Source: Long-Term Public Fuel and Energy Sector Development Plan Until 2015, based on the Estonian Sustainable Development Act (RT^2 I 1995, 31, 384; 1997, 48, 772; 1999, 29, 398; 2000, 54, 348). The Estonian Ministry of Economic Affairs and Communications (www.mkm.ee)

- Ensure that, under open market conditions, the competitiveness of the domestic market of oil shale production is preserved and its efficiency is increased, and apply modern technologies which reduce harmful environmental impact;
- Ensure compliance with the environmental requirements established by the state;
- Increase the efficiency of the energy consumption in the heat, energy and fuel sector;
- Until 2010, maintain the volume of primary energy consumption at the level of the year 2003;
- Develop measures which enable the use of renewable liquid fuels, particularly biodiesel, in the transport sector;
- Ensure that modern know-how and specialists are constantly available in all fields of the fuel and energy sector to promote technology development within the state and enable transfer of the modern energy technology;
- Establish preconditions for the establishment of connections with the energy systems of the Nordic countries and Central European countries.

The Estonian policy profile does not seem to be directed toward the Nordic area to any significant extent. However, the last objective in the list above illustrates that there is an Estonian consciousness towards the Nordic region. In turn, this particularly emphasised the relevance of studying relations between the Nordic countries' energy systems and that of Estonia.

Environmental laws and regulations

Estonian environmental policy is generally in accordance with European Union policy. The strategy document "Sustainable Estonia 21, Estonian National Strategy on Sustainable Development (2005)", lays down the general principles of further development.

Sustainable Estonia 21 (SE21) is a development strategy devised on the basis of the Terms of Reference approved by Government Resolution No. 33 of 24 July 2001 and set out in procurement contract No. 2-11- 13/146. According to the Terms of Reference, SE21 is *a strategy for developing the Estonian state and society until the year 2030 with the aim of integrating the success requirements arising from global competition with the principles of sustainable development and preservation of the traditional values of Estonia.*

The document is a proposal of goals and courses of action that aim at providing a foundation for public understanding on sustainable development of Estonia. It is a development programme covering all of societal life, and not a strategy focusing solely on ecological issues.

The proposed development goals of Estonia were derived from the following issues:
1. Common values. Development goals must express the most general objectives or common values whose achievement is important for the majority of the people of Estonia.
2. Persistence and continuity. An essential feature of development goals established in the context of sustainability is their orientation to ensuring persistence and continuity.

In that regard the goals may differ in their emphasis from those set in other general strategies (national development strategy, budget strategy, etc.).

3. Existing goals and objectives. Development goals cannot be "worked out" and imposed upon the society. They have to be existent in society itself and can only be formulated and specified (through discussions, debates). Both the essence and formulation of the development goals has to meet the expectations and notions of the majority of the Estonian society about the future of Estonia.
4. Bindingness. There is sense in setting goals only if the goals are important enough to become binding. In other words, agreement upon a goal implies also willingness to make efforts, to take action and spend resources to achieve the goal.

The four development goals for Estonia proposed by the experts of SE21 are presented and specified in the document. The goals are described through the following parts: essence of the goal, its components and indicators, threats to the achievement of the goal, expected target condition by the year 2030, key mechanisms for achieving the goal.

Table 33: Selected Estonian government bills on climate and environment

Government Bills on Climate and Environment	Year
Water Act, amended latest in 2004	1994
Waste Act, amended latest in 2003	1998
Forest Act, amended latest in 2004	1998
Environmental Monitoring Act, amended latest in 2004	1999
Sustainable Estonia 21	2001
Environmental Supervision Act, amended latest in 2002	2001
Environmental Impact Assessment and Environmental Management System Act	2005

Important R&D and innovation policy instruments

As one of the Member States in EU, Estonia enjoys possibilities for funding through the EU Structural funds, the Rural Development funds and by means of several EU subsidies. The Estonian state may use the following measures in order to implement the strategic objectives:

- regulative or legislative measures (including price formation mechanisms),
- the tax system,
- investment support,
- national programmes (including of education, research and technology development).

Research policy

Estonian research policy consists of a policy combination with many components. It is the overall objective to increase private investment in R&D, something which did not exist in the occupation period. Likewise it is the aim to put efforts into more effective and efficient public expenditure on R&D. Through its research policy, Estonia is working towards specific national targets for public and private investment in R&D. The policy includes grants to public sector research institutions. It is a specific objective to strengthen and create centres and networks of excellence, and to develop public–private

partnerships for R&D. These processes will certainly include international actors. By improving R&D cooperation, technology transfer can also be improved.

The research policy combination also focuses on the promotion of R&D services to enterprises (especially SMEs). Concerning the business sector, it is the objective to give grants to support business R&D, and R&D collaboration. In relation to the aim of increased business R&D there is need for increasing access to external sources of finance for R&D.

In the domains of personnel, education and skills, it is an outspoken objective to raise interest of the young in science and technology, and to reconfigure the relationship between teaching and research. It is also the aim to enhance the mobility of researchers.

Innovation policy

Ever since October 2005, when the European Commission emphasised the need for strengthening the links between research and innovation, Estonia has been working with a more sophisticated target-setting, acknowledging differences in innovation drivers and processes of key business sectors. This implies addressing the full research and innovation spectrum, including non-technological innovation. With its small population (about 1.5 million) Estonia is struggling in order to reach a critical mass. In the domains of research and innovation this is to be the result of integration of research and innovation effort via EU wide technology platforms and transnational cooperation.

While research policy is focusing more on developing new knowledge and its applications, Estonian innovation policy is focusing on transforming knowledge into economic value and commercial success. According to the Ministry of Economic Affairs and Communications in Estonia (which seems to rely on work done by consultants in the Innovation Policy Consultancy, Technopolis), a good innovation policy in Estonia is one that acknowledges the need for sectoral/thematic actions to support innovation in wider groups of enterprises. Consequently the current enterprise innovation financing measures need to be widened to include technology transfer and 'non-technological' innovation (design, marketing) issues. There is a need to increase investment in infrastructure and services for 'high-potential' firms (spin-offs, research intensive inward investment). Moreover, for Estonia as nation it is important to close the productivity gap through increased technology diffusion. This can be done by increasing exports of innovative products, and by improving networking and cooperation turning knowledge into innovation. At the overall policy governance level there is need to establish a knowledge base on which policy can be made, in particular by doing technology foresight, enterprise innovation studies, public procurement, and by adjusting the fiscal environment.

Still, according to the Ministry of Economic Affairs and Communications in Estonia, a proposal for a strategic framework for research and innovation shall have the overall vision:

- By 2013, Estonia will be recognised as Europe's most innovative and competitive small nation.
- Estonia shall be centred around 'human potential' as key *leitmotiv* for a knowledge economy.

The strategic objectives shall be:

- A skilled population open to new technologies, products and ideas
- Business leaders open to innovation and risk-taking in new technologies and markets
- Researchers working at the forefront of science, open to cooperation in order to create value from invention.

This is supposed to be done by means of four key priorities:

- A creative and innovative population;
- Attracting, creating and developing innovative enterprises;
- Investing in internationally competitive research;
- Future needs of Estonian research and innovation system.

As is evident from the above objectives for research and innovation policy, a sectoral approach, which obviously would capture and support research and innovation in the energy sector as well, seems to be long in coming in Estonia.

Concrete policy measures

The Estonian Science Foundation (EstSF), established on July 1990 by the Estonian Government, is an expert research funding organisation. Its main goal is to support the most promising research initiatives in all fields of basic and applied research. The EstSF uses state budget appropriations to award peer-reviewed research grants to individuals and research groups on a competitive basis. Grants awarded for research and development in the field of renewable energy sources in the period 2000–2007 are presented in the table below.

Table 34: Grants awarded for research and development in the field of renewable energy sources. Source: Renewable Energy Policy Review, Estonia. European Renewable Energy Council, Brussels 2004

Grant name	Grant holder and university	Period
Production Ecology of Willow Short Rotation Forests and Combined Use of RSF as Vegetation Filters and Renewable Energy Recourses	Katrin Heinsoo, Institute of Zoology and Botany at Estonian Agricultural University	2001-2004
Production Ecology of Willow Short Rotation Forests and Combined Use of RSF as Vegetation Filters and Renewable Energy Resources	Koppel, A. Institute of Zoology and Botany at Estonian Agricultural University	2001-2004
Radiation Regime, Architecture and Biomass Production of the Energy Forest (Willow and Grey Alder) in Estonia	Juhan Ross, Tartu Observatory	2001-2004
Improvement of Biofuels Grate Firing Technology	Ants Veski, Tallinn Technical University	2001-2003
Air distribution influence to the boiler efficiency at grate burning of biofuels	Ants Veski, Tallinn University of Technology	2004-2006
Engineering bases for producing hydroenergy on small rivers considering environmental requirements	Mare Pärnapuu, Tallinn Technical University	2003-2004
Estonian wind climate and wind energy resources	Ain Kull, University of Tartu	2003-2005
Possibilities and Efficiency of the Use of Wind Generators in Estonia	Olev Liik, Tallinn Technical University	2000-2002
Modelling of cooperation of wind turbines and power system	Olev Liik, Tallinn University of Technology	2004-2007
Definition of the Parameters for a Hot Water System and Solar Diffusive Radiation Model for the Estonian Conditions	Teolan Tomson, Estonian Energy Research Institute	2001-2003
Investigation on the Dynamics of the Estonian Wind Energy Resource and Arrangements	Teolan Tomson, Tallinn Technical University	2002-2004
Study of the efficiency of the two-step controlled solar collectors	Teolan Tomson, Tallinn University of Technology	2004-2005
Optical Coatings for Solar Cells	Tiit Varema - Tallinn Technical University	2002-2003
Contacts for Semiconductor Solar Cells	Tiit Varema - Tallinn University of Technology	2004-2005

In 2008, the Ministry of Economic Affairs and Communication probably will have launched by the time this is read, an Innovation studies programme for providing project funding for more academic research projects in order to increase the competitiveness and size of the innovation research community in Estonia, and create literature on emerging issues.

Another concrete policy measure that is recently established is the Estonian Development Fund**,** which became operational in 2007. The fund has two pillars: one early stage pillar of seed/venture capital investments into technology-based start-ups, and one piller on substantial resources for the development of shared vision to help to create basis for smarter and more effective long-term policies and investments.

We have to go to the Electricity Market Act to find some policy measures that are supporting the energy sector in general and renewable energy sources (RES) in particular:

- A network operator is obliged to buy electricity produced from renewables within the network, which he owns or processes.
- Feed in tariffs: A network operator pays the price for renewable electricity that equals the product of the coefficient 1.8 and weighted average price of the electricity sold in the previous calendar year by the producer processing over 500 MW capacity (AS Narva Power Plants is the only producer today which satisfies these conditions).
- Wind energy-based electricity shall be eligible for this feed-in tariff for 12 years. All support schemes to renewable energy will be terminated at the end of year 2015 which means that only wind power plants that came into operation at the beginning of 2004 will obtain maximum support.
- Feed in tariffs for bioenergy: 1) 7.35 € cent/kWh when selling to Eesti Energia or 2) 5.4 € cent/kWh when selling electricity to the market.
- The act defines the balance-sharing obligation of all electricity market players and stipulates that a market player has to enter into an open delivery contract with a respective seller. A market player that generates electricity from wind-power is not obliged to pay for the open delivery contract that he enters into with the network operator.
- Therefore, electricity generated by renewable resources (wind) can receive some financial support until end of year 2015.

International collaboration

In research and innovation policy international collaboration is formulated as a key objective, in particular because Estonia's small size and problems of establishing a critical mass. Estonia is participating in the FENCO ERA-NET for clean fossil energy technologies. The figure below is taken from a country report from the European Trend Chart in Innovation. It gives an overview of the most important actors and institutions in the Estonian National Innovation System. The two smaller coloured boxes indicate that EU R&D and investment programmes and foreign firms including foreign direct investment and cooperation are envisaged to play an important role in Estonia.

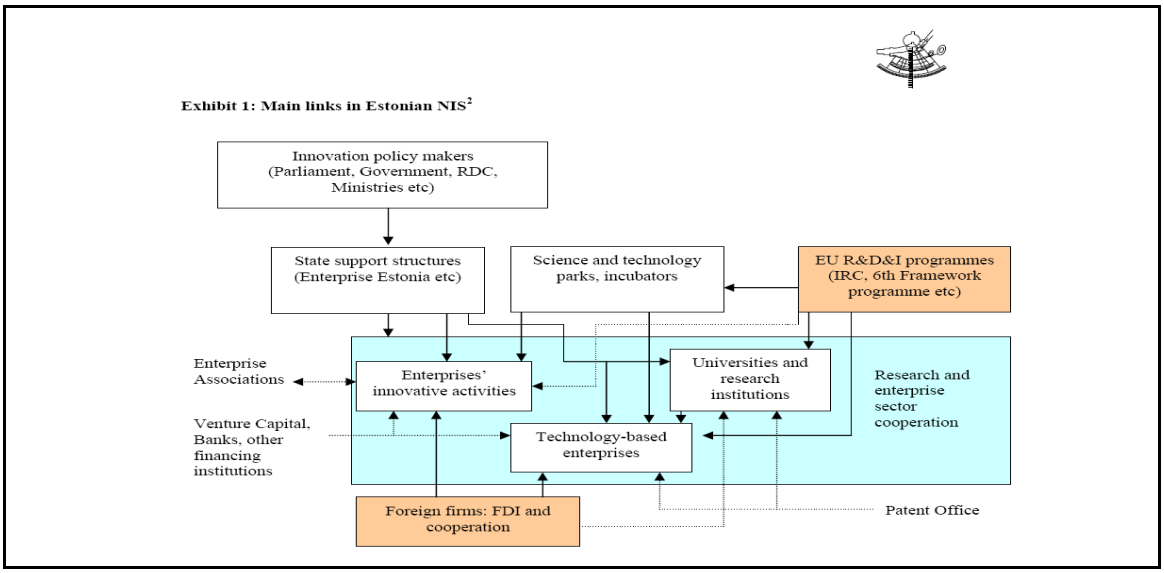

Figure 21: Main links in the Estonian national innovation system. Source: European Trend Chart in Innovation

Key actors and institutions

The size of Estonia makes it relatively simple to make an overview of central actors and institutions. This can be an advantage because people tend to know (about) each other and it simplifies communication. But as we have emphasised, it may also imply the problem of not being able to establish a critical mass in different domains.

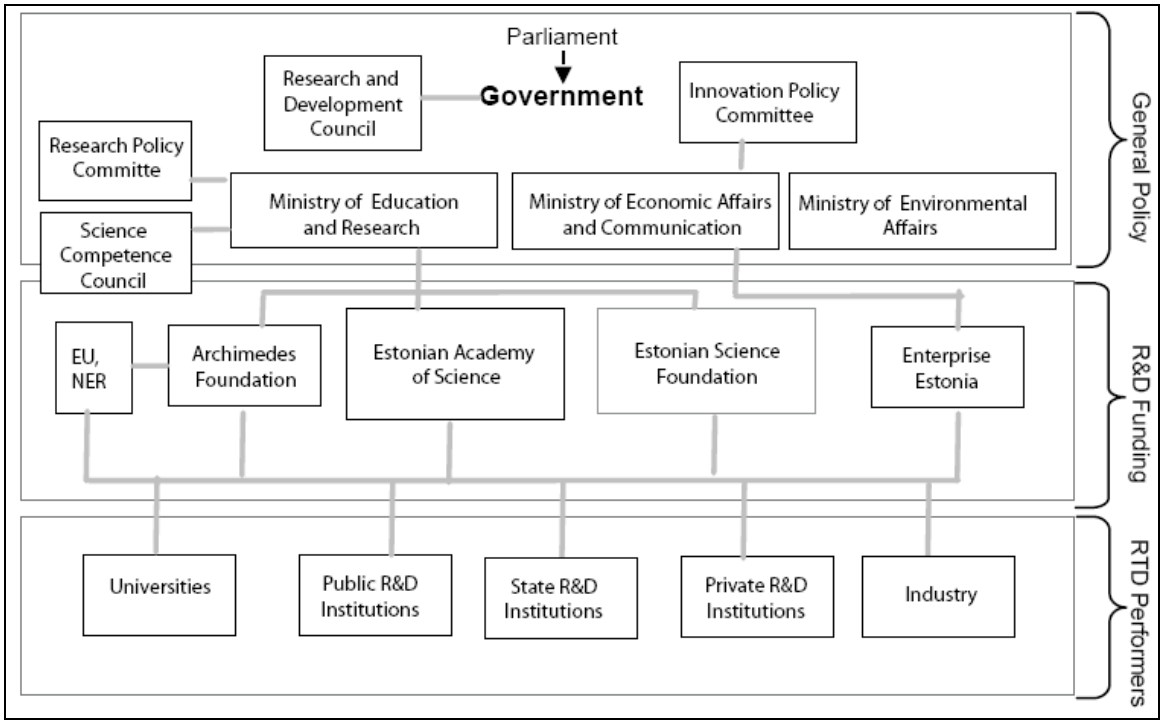

Figure 22: The Estonian Energy Policy system. Source: NIFU STEP

Government organisations

Of government organisations, it is the Ministry of Economic Affairs and Communications which is in charge of research, innovation and energy policy.

In addition to the Ministry of Economic Affairs and Communications, the Ministry of Environment and the Ministry of Education and Research are the most central in the Estonian domains for agenda-setting and policy design.

Public research organisations

Two universities and one applied higher educational institution have energy-related subjects included in their curricula. In the *Estonian Agricultural University* both the Institute of Agricultural Energy Engineering and the Institute of Forest Industry have courses in bio-energy related subjects – resources and technologies, theoretical and practical side.

Tallinn Technical University is the main centre of technical research and education. The Institute of Thermal Engineering in the Faculty of Mechanical Engineering provides education on fuels, boilers, combustion technologies, energy production, energy management etc.

An initiative for innovation has been launched by Tallinn Technical University – Development Centre of Power Engineering, with the following aims:

- Application of the newest achievements of science - new materials, renewable energy sources, new optimisation methods, energy storage devices, power electronics, intelligent electrical drives, information technology, productive equipment and technology - for reconstruction of Estonian electrical power system and consumption processes to ensure the sustainable and environment friendly development.
- Development and application of innovative products, technologies and services in mutually beneficial cooperation with companies in Estonia and abroad.
- Transfer of the newest achievements of world science and know-how of the top technologies of power electrical and mining technologies to Estonia, enhancement of development potential and creation of product development environment at Tallinn Technical University.

The centre may develop into a strong promoter of wider application of renewable energy sources, new sustainable and environmentally-friendly technologies and new research programmes.

Kehtna Economy and Technology School provides applied higher education since 1991, and production of local fuels since 1994, to which maintenance of energy equipment was added in 1997. They also cover organisation of heat production in small business and exploitation of boiler plants.

Non-governmental organisations

Estonian Wind Power Association, Tallinn

The aim of the Estonian Wind Power Association is, through extensive cooperation, to:

- provide a common voice for the wind power developers and related organisations Estonia and to provide a platform for joint activities;
- advance the wind energy application in Estonia and thereby contribute to the main objectives of energy policy in Estonia and Europe energy market liberalization, decentralization and security of energy supply through wider use of renewable energy;
- increase worldwide competitiveness of wind energy;
- improve legislation, governmental policies and business environment for wind power development in Estonia;
- represent its members in the relations with legislative and executive authorities, to stand for the rights of its members, and to represent the member organisations both in Estonia and abroad;
- ensure public understanding of the benefits of wind power application.

Estonian Biomass Association, EBA

The Estonian Biomass Association (EBA) is a non-profit association, founded in 1998. Today, EBA has 39 members including energy consultants, scientists, fuel suppliers, DH-companies, technology suppliers, energy service companies etc. The main fields of activity of the EBA are:

- Promotion of R & D on biomass and biogas applications
- Promotion of environmentally friendly technologies and energy conservation
- Promotion of cooperation with other interested partners home and abroad
- Information dissemination on biomass and biogas via local/regional/international seminars and information days and various publications, preparation of relevant training material
- Elaboration of suggestions from grass-root to national level for revision and improvement of energy related legislation in Estonia.

Rõuge Energy Centre

Rõuge Energy Park (Rõuge Energiapark) was established in 2001. The aim of the energy park is to promote the use of renewable energy and innovative solutions for energy production as well as to provide information about energy savings. The energy park is unique because old and new technologies have been combined. On the energy trail, one can see how it is possible to get energy from water, sun, wind as well as from the ground.

REC Estonia - Regional Energy Centres in Estonia Country Office

REC is a non-partisan, non-advocacy, not-for-profit international organization with a mission to assist in solving environmental problems in Central and Eastern Europe (CEE). The centre fulfils this mission by promoting cooperation among non-

governmental organizations, governments, businesses and other environmental stakeholders, and by supporting the free exchange of information and public participation in environmental decision-making.

Firms

The biggest energy company in Estonia, AS Eesti Energia, together with its associated companies Eesti Põlevkivi (Oil Shale) Ltd (extracts oil shale) and Narva Electric Power Plants Ltd (produces electricity and heat from oil shale) is 100 per cent state owned. Eesti Energia (Estonian Energy) is the dominant player in the Estonian power sector, as it has responsibilities for the bulk of the country's power-generating units and its distribution networks. The 100 per cent subsidiary, AS Narva Elektrijaamad, accounted for 97 per cent of the electricity production in Estonia in 2005. The only Estonian transmission network operator in Estonia and the main (85 per cent) distribution network operator are also 100 per cent subsidiaries of AS Eesti Energia.

A small number of smaller firms manufacture and sell different types of heating fuels. For example, DSD Trade OU offers ecologically appropriate biofuel-sunflower husk pellets (granules), and Goverlink Oy produces wood briquettes.

Renewable Energy Sources actors

AS Eesti Energia has established an alternative way to increase renewable energy production in Estonia. Electricity certificates for producers and customers are issued. A "Green Energy Producer Certificate" is issued to all the generators of alternative energy which sell their production to "Eesti Energia". Any company, government institution and residential customers having a contract with AS Eesti Energia may purchase electricity produced from RES and receive a "Green energy customer certificate". The price for this green electricity depends on the amount of purchased power. Each Green energy customer supports the Estonian Fund for Nature (ELF) through donations. ELF uses these funds to finance projects related to nature conservation, environmental education and sustainable development.

2.2 Latvia

Policy and regulation framework conditions

General framework conditions

Latvia is a transition economy – the country started the transformation from a centrally planned socialist economy towards liberal market economy in the late 1980s and early 1990s. At the beginning of the transformation process the country followed a neo-liberal economic policy, which focused on privatisation, deregulation and liberalisation. This has changed with the integration in the EU. On 1 May 2004, Latvia became a Member State of the EU. Integration into the EU has contributed to a change of attitudes regarding the belief in market forces and the role of the state: the government has to play an active role in the allocation of the EU pre-structural and structural funds. The government is using these funds for strengthening infrastructure, human resources and research, technology, development and innovation.

According to the "European Innovation Scoreboard for 2006" Latvia's innovation performance is well below the EU average, but Latvia has experienced some positive trends over time. Latvia had a very high level of youth education attainment, but the growth of the number of S&E graduates was only moderate, as at the EU25 average. Employment in high-tech services and business R&D expenditure showed quite a significant growth, but it's the level is still low.

As the Latvian Development Plan 2007–2013 (Latvian Government, 2006) and other political documents have stated, the level of expenditures on R&D is relatively low compared with other European countries. R&D expenditure as a proportion of GDP in 2005 was around 0.56 per cent, but the total amount increased from LVL21m in 2000 to LVL50.6m in 2005 (cf. Latvian Government, 2006a). The increased funding of R&D in the business sector (from LVL8.5m in 2000 to LVL20.6m in 2005) is mainly based on domestic enterprises' funding of R&D: foreign enterprises did not play an active role in this perspective. R&D expenditure by the government sector has almost doubled, mainly due to the increased funding by the government.

There is a high level of education, but employers experience a lack of a qualified workforce; academic personnel become older and the capacity of science is therefore limited. Latvia has human resources in education, but these potentials are not used, something which is reflected in the manufacture and service sector where low productivity and products with low added value are characteristic. After entering the EU, many Latvians migrated in order to enjoy better working and living conditions, causing a domestic labour shortage in several sectors (For more detail, see Kulinska, Bloch and Sproedt, 2007.)

Introduction to national energy technology and production

The Latvian energy sector is dependent on imported (natural and liquefied gas, oil products, coal) and local energy resources (wood and peat) for production of fuel,

electricity and heat (see Table 35). The imported fossil fuels (natural gas and oil) and local fuels (wood) are mainly used in heat generation (Table 36). Imports of energy resources come mostly from Russia (natural gas comprising 32.7%, heavy oil – 1.6%, other oil products – 26.6%, coal – 1.5%). Among local energy resources, wood is the most common (firewood, residue from woodworking – wood chips, wood briquettes and granules), and comprises 29.1% of total energy consumption (Ministry of Economics, 2006a, p. 46 ff.). The share of renewable consumption of gross final energy consumption was 34.9% in 2005; the target for 2020 is 42%.

Table 35: Latvia Country Summary Table.
Sources: Eurostat (2007) Energy Yearly Statistics 2005; European Commission (2003b) Biofuels Directive; European Commission (2008) Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources COM (2008)

General information	
Population, millions (2006)	2 287 948
Land area	64 589 km^2
Macroeconomic Information	
GDP per capita in PPS (2006)	54.2
Real GDP growth rate (2006)	11.9
EU Targets for the share of energy from RES	
RES target in 2005 (% of final consumption of energy)*	34.9
RES target 2020 (% of final consumption of energy)*	42
Biofuel target (2010)	
Electricity generation – total 2005 (GWh)	4 905
Hydro	3 325
Wind	47
Nuclear	-
Conventional thermal of which:	1 533
- Hard coal	-
- Lignite and peat	-
- Petroleum products	6
- Natural gas	1 486
- Biomass	42
Consumption	*5 701*
Exports and imports	
Exports	707
Imports	2 855

*European Commission (2008)

In Latvia, 67.8% of the *electricity* generation is provided by hydro power in 2005 (European Commission, 2008b). Electricity imports from Russia, Estonia and Lithuania play a substantial role in the electricity supply. In 2005 the state JSC Latvenergo generated 64.5% of the required electricity, 30.5% was supplied by other countries and 5% was purchased from small producers of electricity (see Table 37).

Table 36: Consumption of Energy Resources in Latvia1 (thousand tons of equivalent fuel – ktce2)

Consumption of energy resources	2000	2001	2002	2003	2004	2005
Energy resource consumption – total	**5259**	**5740**	**6466**	**6583**	**6764**	**6969**
of which:						
natural gas	1560	1980	1847	2138	2114	2155
light fuel products and other oil products	1366	1313	1610	1727	1798	1859
heavy oil, shale	406	269	233	166	132	113
firewood, peat, coke and other types of fuel	1267	1475	2084	1854	1987	2057
coal	94	123	99	90	87	107
electricity (HPPs, wind generators and imported from abroad)	566	580	593	608	646	678

[1] Source: CSB and the Ministry of Economics.
[2] 1 ktce = 0.02931 PJ.

The largest consumers of *natural gas* are combined heat and power plants (CHPs) and heat supply enterprises of Latvenergo (61%), industry (21%) and other consumers (18%). The Riga region accounts for 80% of the total natural gas consumption in Latvia. *Oil products* are used both as heating fuel and transport fuel. Prices in the oil product market are liberalised and competitive in regard to other types of heating fuel. Free market principles function in the area of oil product deliveries in Latvia. Oil products have an important place in Latvian market of energy resources (Ministry of Economics, 2006a, p. 46 ff.).

Solid fuels used in Latvia are coal imported from CIS, and local fuels (firewood and peat). The biggest consumers of firewood are households (48.7%), heat supply companies (24.8%), industry (mainly wood processing companies) and other consumers (29.5%). Use of peat in the energy sector has shown a continual decline in recent years.

Table 37: Electricity Supply in Latvia[1](billion kWh)

Components of electricity supply	2000	2001	2002	2003	2004	2005
Total electricity supply	**5.922**	**6.163**	**6.323**	**6.608**	**6.786**	**7.051**
Electricity generation – total	**4.136**	**4.280**	**3.975**	**3.975**	**4.689**	**4.903**
of which:						
HPP[2]	2.799	2.801	2.433	2.216	3.044	3.267
CHP[3]	1.163	1.246	1.238	1.363	1.225	1.278
other CHP	0.150	0.198	0.263	0.298	0.306	0.254
small HPS	0.020	0.032	0.030	0.050	0.065	0.058
wind generators	0.004	0.0034	0.011	0.048	0.049	0.046
Imports of electricity	**1.786**	**1.883**	**2.348**	**2.633**	**2.097**	**2.148**

[1] Source: State JSC Latvenergo, Ministry of Economics, CSB
[2] Daugava cascade and Aiviekste HPP (HPP of state JSC Latvenergo)
[3] CHP of state JSC Latvenergo

Table 38: Renewables in Latvia. Source: IEA[76]

	Municipal Waste*	Industrial Waste	Primary Solid Biomass**	Biogas	Liquid Biofuels	Geothermal	Solar Thermal	Hydro	Solar Photo-voltaics	Tide, Wave, Ocean	Wind
Unit	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*
Gross Elec. Generation	**0**	**0**	**5**	**36**	**0**	**0**	**0**	**3325**	**0**	**0**	**47**
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*				
Gross Heat Production	**0**	**0**	**4261**	**43**	**0**	**0**	**0**				
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*1000 tonnes*	*TJ*	*TJ*				
Production	0	184	83200	340	2	0	0				
Imports	0	0	195	0	2	0	0				
Exports	0	0	-24255	0	0	0	0				
Stock Changes	0	0	14	0	0	0	0				
Domestic Supply	**0**	**184**	**59154**	**340**	**4**	**0**	**0**				
Statistical Differences and Transfers	0	0	0	0	-1	0	0				
Total Transformation	**0**	**0**	**12878**	**264**	**0**	**0**	**0**				
Electricity Plants	0	0	0	19	0	0	0				
CHP Plants	0	0	1280	245	0	0	0				
Heat Plants	0	0	10740	0	0	0	0				
Other Transformation	0	0	858	0	0	0	0				
Energy Sector	**0**	**0**	**114**	**0**	**0**	**0**	**0**				
Distribution Losses	0	0	36	0	0	0	0				
Total Final Consumption	**0**	**184**	**46126**	**76**	**3**	**0**	**0**				
Industry	0	184	10640	0	0	0	0				
Transport	0	0	0	0	3	0	0				
Residential	0	0	28810	0	0	0	0				
Commercial and Public Services	0	0	5922	76	0	0	0				
Agriculture / Forestry	0	0	747	0	0	0	0				
Fishing	0	0	7	0	0	0	0				
Other Non-Specified	0	0	0	0	0	0	0				
Non-Energy Use	0	0	0	0	0	0	0				
- of which	0	0	0	0	0	0	0				
Petrochemical Feedstocks											

* Municipal Waste: the split for renewable and non-renewable waste is also available

** Primary Solid Biomass: data are also available for charcoal

[76] IEA: http://www.iea.org/Textbase/stats/renewdata.asp?COUNTRY_CODE=LV

Government energy action plans and strategy documents, in particular energy technology focus areas and priorities

The Ministry of Economics in cooperation with representatives of energy companies, scientists, economists and representatives of associations has drafted the policy planning document "Guidelines of Energy Sector Development for 2007-2016". The guidelines include government policy, development targets and priorities in the energy sector both in medium-term and in long-term. The main aims of energy policy in Latvia are the promotion of competition, raising the level of energetic independence, increasing the security of energy supply, encouraging the use of renewable and local energy resources, diversification of usable energy resources and environmental protection.

Regarding security of supply, Latvia will have to face the consequences of the diminishing opportunities to import electricity from its neighbouring countries. In fact, after 2009, the current excess capacity generated by energy systems of the Baltic Energy supply will diminish. The present development in Baltic energy supply indicates that an optimal future solution for basic capacities of electricity supply is represented by the planned construction of a new nuclear power plant unit in Lithuania (Ministry of Economics, 2006a, p. 121 ff.).

However, recently conducted studies on the security of Latvia's electricity supply indicate that the current co-generation plant projects or Latvia's participation in the construction of a nuclear power plant are insufficient for secure electricity supply of the country in longer term. The Ministry has therefore considered it necessary to diversify the energy supply structure of Latvia by building a new basic power plant that would use solid fuel (coal and biofuel).

One of the government's priorities is the creation of mechanisms for market operation in the electricity sector. This will be accomplished through approval by legal acts that ensure equal rights for all electricity users in Latvia to freely choose their electricity supplier and be qualitatively and securely supplied with energy in the necessary amount for lowest possible prices. At present, JSC "Latvijas Gāze" is the only merchant in the natural gas market in Latvia. "Latvijas Gāze" carries out transmission, distribution, storage and sale of natural gas.

Since 1 July 2007 all aspects of electricity distribution system operator have been taken over by JSC "Latvenergo Sadales tīkls" – fully owned by SJSC "Latvenergo". In addition, more than 100 small power plants and 15 licensed electricity distribution and sale companies are in operation.

As an EU Member State, Latvia has to ensure compliance with the common requirements laid down in EU legislation. In the electricity supply sector, this means that the electricity market in Latvia must be gradually opened up and operate in accordance with provisions of Directive 2003/54/EC of June 26, 2003 concerning common rules for the internal market in electricity. The creation of the sector's organisational structure correspondent to market conditions takes place in accordance with requirements of the new wording of Article 20.1 of the Energy Law and requirements of the Electricity Market Law.

Energy policy has been a target of legislation, as can be seen in the Energy Law and the Electricity Market Law which has been amended several times (Table 39).

Table 39: Selected Latvian government bills on energy

Government Bills on Energy	Year
Energy Law[77]	1998
Electricity Market Law	2005

Energy Law (1998)
The Energy law has as a policy objective to establish favourable conditions for the use of domestic, *renewable* and secondary energy resources and the diversified structure of the imported energy resources. Article 4 of the Act emphasised energy policy as a part of the national economy policy of the country. The implementation strategy has to be developed by the Cabinet of Ministers in the Latvian National Energy Programme for a 15 years period and shall be adjusted every five years. Amendments were made in 2000, 2001 and 2005. The EU Renewable Energy Directive has been transposed in Latvia trough the provisions in the Energy Law for obligatory purchase of electricity from renewable sources and the determination of higher purchase prices for different types of renewable energy.

National Energy Programme (1997)
The Energy Policy laid down in the National Energy Programme (adopted in 1997) until 2020 gives priority to the rational use of energy resources, the development of renewable energy sources, energy diversification and the restructuring of the sector.
The programme was developed in 1996–1997 and was approved by the Cabinet of Ministers in September 1997. The programme sets forth a set of measures for stable provision of Latvia with energy resources to match quality and quantity requirements of consumers and with minimal impact on the environment. It is planned to update the program every 5 years.

Structural policy on fuel and energy (1999)
The programme was financed by PHARE and evaluates available energy models in Latvia, analyzing previously developed energy programmes, legislative documents and technical data (energy balance, electricity and heat supply). It compares modelling, reference scenarios and scenarios based on different assumptions.

Energy Efficiency Strategy (2000)
The Latvian Ministry of Economy prepared the State Energy Efficiency Strategy in 2000 to identify possible measures for promoting energy efficiency which would help reduce the primary energy consumption by 25 per cent by 2010.

The Programme on renewable energy resources (2000)
The programme was financed by PHARE and aimed to prepare a medium and long-term strategy and action plan for the development of the use of renewable resources in Latvia.

Regional Baltic Wind Energy Programme

[77] Energy Law: http://www.ttc.lv/index.php?&id=10&tid=50&l=EN&seid=down&itid=13816
Amended: 3 August 2000; 10 May 2001; 17 March 2005; 26 May 2005.

The programme started in 1999 with funding from GEF, UNDP. This is a study of the potential of wind energy in Latvia.

National Programme for Production and Use of Bio-fuel in Latvia
The programme was launched by the Ministry of Agriculture in 2000 and analyses the possibility to produce bio-fuel from rapeseed oil as well as generation of biogas from industrial and household waste. The programme also analyses the environmental impact of these measures.

Climate Change Mitigation Programme for 2005-2010
The programme was developed in 2004–2005 and was accepted by the Cabinet of Ministers in 2005. The goal is to ensure that the total amount of GHG emissions does not exceed 92% of the 1990 level. This shall be achieved by activities in a broad range of policy areas. One target is an increased share of renewable energy sources in the energy balance. For implementing the climate change mitigation policy, possible activities have been analysed in more detail, like the promotion of biomass, biofuel and biogas use, the support for energy generation in small hydropower plants and wind power production, the promotion of solar energy use, the support for biofuel production, the processing of biologically degradable waste and the collection of biogas from municipal waste landfills.

Strategy of Utilization of Renewable Energy Sources 2006-2013
In October 2006 the strategy *of Utilization of Renewable Energy Sources* was accepted. This strategy reflects measures for rational usage of biomass, biogas and other renewable energy sources. The strategy emphasises the importance of combustible biomass and animal products, wind and solar energy.

National Lisbon Programme of Latvia for 2005-2008
In the *National Lisbon Programme (*Latvian Government, 2005) the Latvian government stressed that the sustainability of resources is an important topic: "Several scientific research institutions and higher educational establishments are engaged in the analysis of technologies for the use of various renewable energy resources (biomass, sun and wind) as well as potential technological solutions of energy efficiency increase." The state budget programme, *Latvian Environmental Protection Fund,* has financed various research projects, but private firms have also financed relevant R&D in which they are interested. The National Lisbon Programme highlighted following measures:

- To encourage the use of renewable energy resources (responsible is the Ministry of Environment and Ministry of Economics):
- Setting up balanced volumes of compulsory procurement for new energy sources if renewable energy resources are used for energy generation;
- Test projects where energy would be generated from renewable energy resources less used in Latvia, including biogas (2005-2008);
- A strategy for the use of renewable energy resources, preparing policy planning documents in the field of development of environmental technologies (2006);
- Support schemes for promotion of bio fuel use in public transport, logging machinery, means of inland water transport (2005);

- Recommendations for "green procurement" in public administration as well as central and local government institutions (2006).

Latvian National Development Plan 2007 – 2013
In the Latvian National Development Plan 2007–2013 there is also a focus on the sustainable and efficient use of natural and energy resources (Ministry of Regional Development and Local Government, 2006). The plan has formulated the following tasks which are relevant for energy: the use of alternative and renewable energy resources for heating and energy production and the maintenance of agricultural land for the production of agricultural products as well as the increased production of raw materials for heating fuel and transport fuel.

Environmental laws and regulations

Several environmental laws and regulations are relevant for energy policy and especially for implementing energy production based on renewable energy resources (Table 40).

Table 40: Selected Latvian government bills on climate and environment

Government Bills on Climate and Environment	Year
United Nations Framework Convention on Climate Change	1995
Law on Pollution	2001
Emission trading Directive	2004
Law On Environmental Impact Assessment[78] with amendments of 2001	1998

Latvia's CO_2 emissions – both in absolute amounts and normalised per capita - are the lowest among the Baltic countries (see Figure 18). Latvia signed (1998) and ratified (2002) the Kyoto Protocol.

United Nations Framework Convention on Climate Change (UNFCCC; Convention)
Latvia signed the United Nations Framework Convention on Climate Change (UNFCCC; Convention) in 1992, and the Convention was ratified in 1995. The Latvian Environment Agency (LEA) is responsible for reporting on the GHG emissions and GHG reductions

Act on Pollution (2001)
The aim of the Act is to reduce damages for human health or life, property and environment caused by pollution and to eliminate consequences caused by such damages, and in general to eliminate or, where not possible, to *reduce the use of non-renewable resources and energy.* The *Emission Trading Directive* has been transposed in Latvia through the provisions in the Act on Pollution. The national emission allocation plan for Latvia has been prepared in 2004.

Act on Environmental Impact Assessment
The Act regulates the requirements and procedures for environmental impact assessments of proposed developments.

[78] Law On Environmental Impact Assessment: http://www.vidm.gov.lv/ivnvb/ivnvb/likumd/Eivn_lik.htm

Important R&D and innovation policy instruments

In 1998, the Latvian Council of Science approved the National Concept of the Republic of Latvia on Research development (Latvian Council of Science, 1998). The Concept has defined following priority areas of research development: information technology, material sciences, forestry and timber technology, organic synthesis, biotechnology, biomedicine and pharmacy and Letonics. Here energy was not listed as a priority area. In accordance with the EU Framework Programmes and the participation of Latvia's scientists in these programmes, the Ministry of Education and Science identified priority research directions in relation to Latvia's cooperation with the European Union: information technology and telematics, life sciences and biotechnology (biomedicine, drug construction, biotechnology), new materials and technologies, ecology and environmental protection, energy technologies, forestry and agriculture research, social and economic research, and any initiative for multilateral scientific and technological cooperation in compliance with the priority criteria. This means that energy technology has mainly been a priority because of the cooperation in the EU Framework programs.

The *Latvian Council of Science* provides funding to projects of fundamental and applied research to single research organisations and funds joint projects. The Council has funded projects in mechanics, mechanical and power engineering for around 350,000 euro per year. The share of *power engineering* for 2006 projects was 27% (94,750 Euro) (see Table 41).[ii] In addition the Council also funds projects in other fields which are relevant for energy research, but where only minor projects are funded.

The second larger funding stream goes to joint projects funded by the Council. Here are several projects that are based on collaboration of several Latvian institutions. In 2006, three joint projects received funding in this field with a total budget of 236,000 Euro (see Table 42). That means that the collaborative projects get much higher funding. And the focus of these projects is renewable energy sources and energy efficiency. In total we have for 2006 energy projects for 330,790 Euros (here are not included some minor basis science projects in fields outside power engineering).

Table 41: Latvian Council of Science: Projects of Fundamental and Applied Research in Power Engineering for the Year 2006[iii]

	2006	
	Number of grants	Funding
		Euro
Latvian University of Agriculture	1	1 728
University of Latvia	1	1 003
Institute of Physical Energetics, LAS	12	45 803
Riga Technical University	21	46 218
Total for Power Engineering	35	94 751
Total for Mechanics, Machine Engineering and Energetics		345 676

Table 42: Latvian Council of Science: Funding of joint projects in energy research for the Year 2006

Project title and responsible researchers	Funding per year in €
Non-Traditional Use of Biomass, 2006–2009	53 326
M. Beķers, Institute of Microbiology and Biotechnology, University of Latvia	

P. Šipkovs, Institute of Physical Energetics, Latvian Academy of Sciences	
M. Jure, Riga Technical University	
V. Kampars, Riga Technical University	
Scientific Backgrounds of the Complex Utilization of Renewable Raw Materials, 2006-2009	119 485
B. Andersons, Latvian State Institute of Wood Chemistry	
M. Kalniņš, Riga Technical University	
H. Tuherm, Latvian University of Agriculture	
L. Savenkova, Institute of Microbiology and Biotechnology, University of Latvia	
Promoting Energy Efficiency and Renewable Resources as the Basis for Secure Power and Fuel Supply and Sustainable Development of the Latvian Energy Sector, 2006–2009	63 224
J. Ekmanis, Institute of Physical Energetics, Latvian Academy of Sciences	
A. Krēsliņš, Riga Technical University	
U. Kanders, Institute of Solid State Physics, University of Latvia	
Sum of joint projects in energy research	*236 035*

International collaboration

Latvia's participation in the non-nuclear energy projects funded by EUFP5 was rather limited – the database revealed 16 projects and when counting only weighted shares of the projects the participation came down 3.6 projects. (See the chapter on size and scope of Non-nuclear energy research in the second part of our report). Especially active were the Institute of Physical Energy and the energy company Ekodoma. Nordic collaboration partners were mainly Denmark, Sweden and Finland.

Latvia collaborated actively in projects of the Organisations for the Promotion of Energy Technologies (OPET) related to renewable energy from 2000 to 2002.[79] OPET Latvia was based on following three R&D organisations:

- Riga Technical University Department of Energy, Systems and Environment
- Latvian Development Agency Energy Department
- Ekodoma Ltd.

The OPET network had the aim to spread the benefits of new, innovative energy technologies and foster market penetration of these technologies. OPET Latvia was involved in following projects: Trans-European biofuel transportation analyses, Promotion of dispersed energy solutions and Wood energy projects.

Latvia is collaborating in the FENCO ERA-NET for clean fossil energy technologies (see table on ERA-Net collaboration in section 3.3 Collaboration in ERA-NETets related to renewable energy). The Latvian Academy of Sciences has taken part in the Inter-Baltic Energy Research Programme (IBERP) which lasted from 1996 to 2000 (see Kristapsons, Martinson and Dagyte, 2003, and Egle (ed.)).

[79] OPET's homepage: http://cordis.europa.eu/opet/home.html

Key actors and institutions

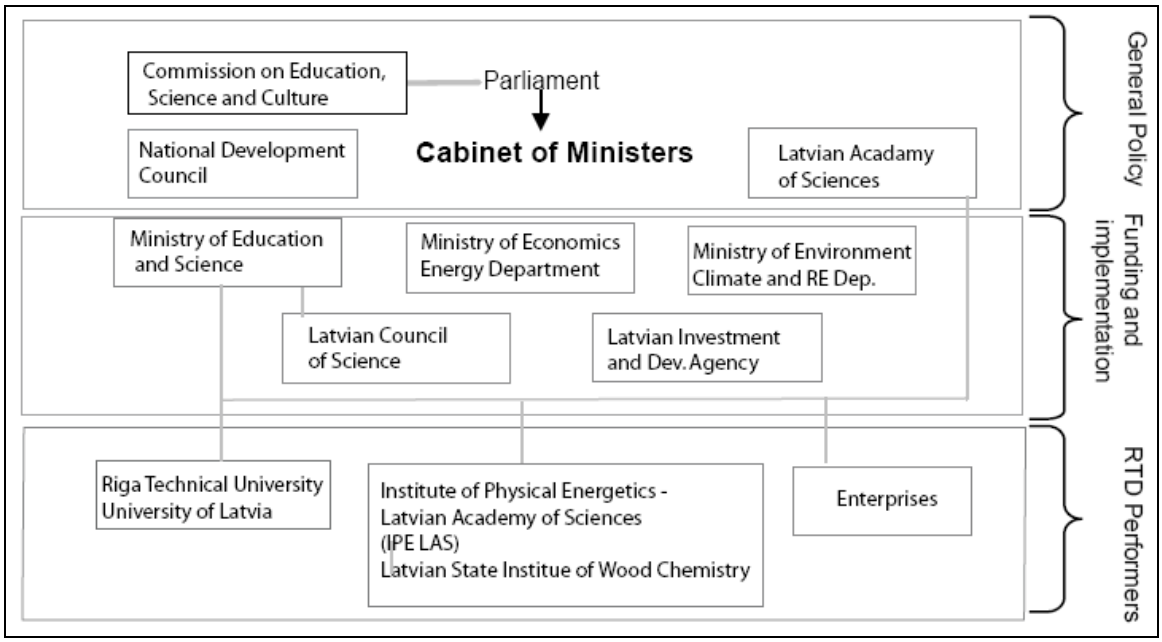

Figure 23: The Latvian Energy Policy System. Source: NIFU STEP

Government organisations

Ministries

Three ministries are relevant in the energy field.

Ministry of Economics

The Ministry of Economics has a special Energy Department dealing with energy issues. In cooperation with representatives of energy companies, scientists, economists and representatives of energy associations, the Ministry drafted the energy policy planning document "Guidelines of Energy Sector Development for 2007–2016". The department is responsible for energy policy, but energy policy is also integrated with other important national policies, for instance, environment, transport and agriculture policies.

Ministry of the Environment

The Ministry has a special Climate and Renewable Energy Department dealing with energy issues.[80] The Department has two divisions: Climate Policy Division and Pilot Projects Implementation Division.

The *Latvian Environment Agency* (LEA) is the governmental institution under the Ministry of Environment. The aim of the LEA is to implement governmental policy in the area of environmental data and information compilation, processing and dissemination.

[80] http://www.vidm.gov.lv/eng/par_ministriju/struktura/?info=21

Ministry of Education and Science[81]
This is the central state executive body responsible for the development and realisation of the state policy in the area of education, science and technology.

The Ministry of Education and Science of the Republic of Latvia has identified the priority research directions in relation to Latvia's cooperation with the European Union:
1. Information technology and telematics;
2. Life sciences and biotechnology (biomedicine, drug construction, biotechnology);
3. New materials and technologies;
4. Ecology and environmental protection.

For a sustainable development of the country the following directions are also relevant:
- Energy technologies
- Forestry and agriculture research
- Social and economic research
- Any initiative for multilateral scientific and technological cooperation in compliance with the priority criteria.

Public research organisations

Research institutes

Institute of Physical Energetics, Latvian Academy of Sciences
The Institute of Physical Energetics, Latvian Academy of Sciences (IPE LAS)[82] was established in 1946; over hundred researchers are working at 13 research laboratories and groups.
The main research areas are:
- Regional energy sector analysis and optimisation
- Energy saving management
- Energy - environmental policy studies
- Renewable energy resources
- Analysis of investment efficiency in electrical networks and electricity supply systems
- Electrical devices and machines
- Research into advanced materials and solid state physics problems.

IPE LAS is the leading institute in Latvia in the field of energy research. The main activities cover a wide field of energy research issues such as modelling and analysis of energy–environment interactions, energy–environmental policy studies, pricing and tariff policy in the energy sector, energy efficiency improvement and energy conservation programmes.

[81] http://www.izm.gov.lv/
[82] Homepage: http://www.innovation.lv/fei

Latvian State Institute of Wood Chemistry
The Latvian State Institute of Wood Chemistry (IWC),[83] the main centre of wood science in Latvia, founded in 1946, is an independent state non-profit organisation under supervisory of the Ministry of Education and Science Republic of Latvia.
Main research areas are:

- Characterisation of the structure, components composition, physical properties and chemical reactivity of the plant biomass in situ and its isolated components.
- Innovative technologies, products, materials and equipment for industrial applications. The main priorities here are:
  - Products from low-value wood (furfural, charcoal, polysaccharide derivatives, etc.)
  - Equipment for biotechnological processes, economic and ecological utilization of wood products and waste.
- Investigation of the behaviour of wood, wood-based materials and wood-derived products under conditions of their designed application and improvement of their properties.
- Development of the methodical approach and methods for investigation of the unchanged and transformed/modified wood complex and its components.

Latvian Academy of Sciences
The Latvian Academy of Sciences is a high-level honorary and advisory body. It has created a database over Latvian scientists active in energy research.[84]

Universities

Riga Technical University
Riga Technical University (RTU)[85] was founded in 1862 and today is one of the main higher education institutions in Latvia. It is the oldest and currently the second largest university in Latvia in student numbers. In 2006, RTU enrolled about 16,520 undergraduate students (of which 10,376 full-time students) and 350 PhD students. Regarding academic staff the RTU is the largest university in Latvia – in 2006 it had 1025 researchers and teachers including 200 professors.
The RTU has following research priorities: engineering sciences, ICT, organic chemistry, material sciences, architecture and engineering economics.[86] The University has eight faculties and 33 institutes: In the field of energy science and technology is the *Faculty of Power and Electrical Engineering* especially interesting. Main fields of research are:

- Development of functional algorithms of protective relaying systems
- Power system stability and quality of control
- Power system planning and optimization
- Energy efficiency
- Optimisation of district heating system

[83] Homepage for the IWC: http://www.kki.lv/
[84] http://www.lza.lv/Nozares/EnergyRes.htm
[85] Homepage for RTU: http://www.rtu.lv/
[86] Foreword at the homepage: http://omega.rtu.lv/en/zinf/foreword.pdf

- Energy systems and environmental aspects. Optimisation
- Control and regulation of electrical drives
- Direct frequency converters
- Simulation of electrical insulation ageing
- Semiconductor converters
- Special regimes of electrical machines
- Mathematical simulation of electromechanical elements.

The *Department of Energy Systems and Environment* in the ***Faculty of Power and Electrical Engineering*** is especially active in renewable energy resources (biomass, bio-hydrogen, solar), environmental issues, energy efficiency and rational use of energy. The Department is focussing on climate change policy, GHG reduction technologies and sustainable energy development.

Other universities are:
- The University of Latvia
- The Latvian University of Agriculture

Non-governmental organisations

Latvian Chamber of Commerce and Industry (LCCI)
Latvian Chamber of Commerce and Industry (LCCI)[87] is a non-governmental, voluntary organisation for Latvian companies in different industry sectors. The aim of the organisation is to create a favourable business environment, represent economic interests of Latvia's enterprises and offer business promotion services. LCCI represents business interests through a dialogue with national and local governments and participates in the drafting of commercial legislation in Latvia.

Other NGOs are:
- The Latvian Association of Energy Construction (LAEC)[88]
- The Latvian Bioenergy Association (Latbio)[89]

Firms

The Latvian energy sector is dominated by two large companies - Latvijas Gaze (Latvian Gas) and Latvenergo (Electrical Power Energy).

The leading electricity and heat generating and supply company in Latvia is *Latvenergo AS.*[90] Latvenergo generates most of electricity in hydropower plants. About 70% of electricity is generated from renewable and environmentally friendly resources. Latvenergo generates about 70% of heat for Rīga city, and 20% of the electricity consumed in Latvia in the Rīga combined heat and power plants (RCHPPs). Modernized

[87] Homepage of the chamber: http://www.chamber.lv/pub/
[88] LAEC's homepage: http://www.leba.lv/
[89] Latbio's homepage: http://www.latbio.lv/
[90] Latvenergo's homepage: http://www.latvenergo.lv

energy blocks supply the base load generation, while Latvenergo imports the rest of the needed electricity from Estonia, Lithuania, Russia and Finland.

Electricity supply structure in Latvia in 1996–2005:

- Daugava HPP - 45% (25%-65%)
- Rīga CHPPs - 20%
- Independent power producers - 5%
- Import - 30% (10%-50%)

Latvenergo is a member of Nord Pool Spot AS, the Nordic Power Exchange. Nord Pool Spot AS was founded in 1993 as an independent company. Latvenergo is establishing a subsidiary in Estonia - "Latvenergo Kaubandus" OÜ (Latvenergo tirdzniecība SIA (Latvenergo trade)) in order to participate in the formation of the Baltic regional electricity market.

Latvijas Gaze supplies the Latvian gas market, and offers a full range of services related to gas distribution. All the gas used in Latvia is imported from Russia's Gazprom. The privatisation of Latvian Gaze has been a relatively slow process. Today the private company is owned by leading gas companies of the world – German E.ON Ruhrgas International AG, Russian OAO Gazprom and the company SIA Itera Latvija.
Latvia has large underground natural gas storage facilities (third largest in Europe) located near Riga, with a capacity to cover the gas storage needs of all three Baltic countries and Pskov region of Russia.

An engineering consulting company with R&D activity in the energy field is *Ekodoma*.[91] Ekodoma was founded in 1992 by two professors from Riga Technical University. The company currently has 15 employees, working mainly in the areas in energy, environment and economics. Ekodoma participates in several international projects, focused on the implementation of international programs, such as OPET networking, PHARE, SAVE, and AIJ projects for the Swedish and Dutch government. It also co-operates with international and local ministries, agencies and companies of several European countries including Denmark, Germany, UK, Norway and the Netherlands. Ekodoma participates in the GreenLight Programme and has been funded by EUFP5 and Nordic Energy Research.

The Latvian company *Latekols* has conducted research on vertical axis windmills and has patented the invention internationally.

The Latvian Chamber of Commerce and Industry sorts companies by NACE code.[iv]

[91] Homepage for Ekodoma: http://www.ekodoma.lv/en/index.php

2.3 Lithuania

Policy and regulation framework conditions

General framework conditions

Lithuania is a transition economy – the country started the transformation from a centrally planned socialist economy towards a liberal market economy in the late 1980s and early 1990s. At the beginning of the transformation process, the country followed a neo-liberal economic policy, which focused on privatisation, deregulation and liberalisation. This changed following integration into the EU. On 1 May 2004, Lithuania became an EU Member State along with nine other states. The government is using the structural funds provided by the EU for strengthening infrastructure, human resources and research, technology, development and innovation.

According to the European Innovation Scoreboard Lithuania's innovation performance is well below the EU average. From recent available data a positive performance can be found in the level of youth education attainment: the number of science and engineering graduates (17.5% of population aged 20–29 compared to the European average of 12.7%), the share of the population with tertiary education and, again, youth education attainment (European Commission, 2007c).

The share of innovative SMEs collaborating with other firms or organisations (15% in 2004) and ICT expenditures is in line with the EU25 level. Performance in innovation output can be improved: exports of high-technology are only 2.7% of total exports (EU25 average 18.4% in 2004), and indicators related to intellectual property are well below the European average.

Trends

There are several positive trends in the innovation performance in the period 1998–2005 such as improved cooperation between SMEs on innovation, increased employment in high-tech services, higher sales of new-to-market products and numbers of US patents. Between 2003 and 2004, public R&D expenditure increased considerably and new community trademarks increased sharply (though the levels are still very far below the European level). A negative trend is the declining participation of the population in lifelong learning.

Introduction to national energy technology and production

Lithuania has a fairly strong energy sector, created in Soviet period to meet not just the needs in Lithuania but the Baltic region, and was mainly based on nuclear energy and imported fossil fuels (Table 43).

Table 43: Lithuania Country Summary Table.
Sources: Eurostat (2007) Energy Yearly Statistics 2005; European Commission (2003b) Biofuels Directive; European Commission (2008) Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources COM (2008)

General information	
Population (2006)	3 394 082
Land area	65 200 km^2
Macroeconomic Information	
GDP per capita in PPS (2006)	56.3
Real GDP growth rate (2006)	7.7
EU Targets for the share of energy from RES	
RES target in 2005 (% of final consumption of energy)*	15.0
RES target 2020 (% of final consumption of energy)*	23
Biofuel target (2010)	5.75%
Electricity generation – total 2005 (GWh)	14 782
Hydro	820
Wind	-
Nuclear	10 337
Conventional thermal of which:	3 625
- Hard coal	-
- Lignite and peat	-
- Petroleum products	401
- Natural gas	3 017
- Biomass	7
Consumption	*7 930*
Exports and imports	
Exports	8 607
Imports	5 641

*European Commission (2008)

According to the "Review of the economic and social situation in the Republic of Lithuania in 2006" (Ministry of Economy, 2007) the electricity generation in 2006 was 12.5 TWh, while the electricity consumption was 12.0 TWh. The major part of the generated electricity is coming from the nuclear power plant in Ignalina (in 2005, 10.3 TWh and in 2006, 8.7 TWh). A more detailed overview of the energy balance can be seen in Table 44 (from the same report):

Table 44: Electricity Balance in TWh. Source: Ministry of Economy, 2007

Production, demand, export	**2005**	**2006***
Gross production	14.8	12.5
Nuclear power plant	10.3	8.7
Thermal power plants	3.6	3.0
Hydro power plants	0.5	0.4

Pumped storage power plant	0.4	0.4
Import	1.1	1.5
Export	4.1	2.0
Gross consumption	11.8	12.0
Own needs of electricity producing companies	1.2	1.1
Water raising costs in pumped storage power plant	0.5	0.6
Transmission and distribution losses	1.2	1.1
Consumption in energy enterprises	0.9	0.9
Final consumption	8.0	8.3
Industry	2.8	2.9
Transport	0.1	0.1
Agriculture	0.2	0.2
Trade and services	2.7	2.8
Households	2.2	2.3

When analysing the particular profile for energy production and consumption based on *renewable energy sources*, it becomes clear that the proportion of renewable energy sources in electricity production is very low: for hydropower in 2006, 0.8 TWh. In heat production, the following can be noted: the use of primary solid biomass (with 4792 TJ in 2005), biogas (18 TJ in 2005) and geothermal energy (61 TJ in 2005) (compare Table 45). The values are rather stable when we compare with 2004.

According to the Energy Strategy 2007 the share of indigenous and renewable energy resources in 2005 was at ca. 10.8% (0.94 million toe) of the total primary energy balance. The main share of the produced heat based on primary solid biomass has been consumed in households (76%), followed by industry (18%) and commercial and public services (5%).

Table 45: Renewables and waste in Lithuania in 2005. Source: IEA Statistics[92]

	Municipal Waste*	Industrial Waste	Primary Solid Biomass**	Biogas	Liquid Biofuels	Geo-thermal	Solar Thermal	Hydro	Solar Photo-voltaics	Tide, Wave, Ocean	Wind
Unit	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*	*GWh*
Gross Elec. Generation	**0**	**0**	**3**	**4**	**0**	**0**	**0**	**820**	**0**	**0**	**2**
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*	*TJ*				
Gross Heat Production	**0**	**0**	**4792**	**18**	**0**	**61**	**0**				
Unit	*TJ*	*TJ*	*TJ*	*TJ*	*1000 tonnes*	*TJ*	*TJ*				
Production	0	0	30227	77	14	121	0				
Imports	0	0	727	0	0	0	0				
Exports	0	0	-710	0	-11	0	0				
Stock Changes	0	0	-482	0	1	0	0				
Domestic Supply	**0**	**0**	**29762**	**77**	**4**	**121**	**0**				

[92] http://www.iea.org/Textbase/stats/renewdata.asp?COUNTRY_CODE=LT&Submit=Submit

Statistical Differences and Transfers	0	0	457	0	0	0	0	
Total Trans-formation	**0**	**0**	**6337**	**43**	**0**	**121**	**0**	
Electricity Plants	0	0	0	0	0	0	0	
CHP Plants	0	0	191	27	0	0	0	
Heat Plants	0	0	6098	16	0	121	0	
Other Transformation	0	0	48	0	0	0	0	
Energy Sector	**0**	**0**	**13**	**0**	**0**	**0**	**0**	
Distribution Losses	0	0	4	0	0	0	0	
Total Final Consumption	**0**	**0**	**23865**	**34**	**4**	**0**	**0**	
Industry	0	0	4233	0	0	0	0	
Transport	0	0	0	0	4	0	0	
Residential	0	0	18099	0	0	0	0	
Commercial and Public Services	0	0	1278	23	0	0	0	
Agriculture / Forestry	0	0	255	11	0	0	0	
Fishing	0	0	0	0	0	0	0	
Other Non-Specified	0	0	0	0	0	0	0	
Non-Energy Use	0	0	0	0	0	0	0	
- of which	0	0	0	0	0	0	0	
Petrochemical Feedstocks								

* Municipal Waste: the split for renewable and non-renewable waste is also available
** Primary Solid Biomass: data are also available for charcoal

The current energy sector has its strengths and weaknesses. the SWOT analyses of the Lithuanian energy sector given in the national strategies are summarised in Table 46.

Table 46: Overview over strengths, weaknesses, opportunities and threats of the Lithuanian energy sector - mainly based on national energy strategies

Strengths	**Weaknesses**
• Energy capacities sufficiently developed (prior to the decommissioning of the NPP) • Primary energy balance is well-structured and dominated by natural gas, petroleum products and nuclear energy • Possibility to use different fuels in the majority of energy enterprises • Expertise in the production of biofuels • Highly qualified specialists in all sections of the energy sector • Restructuring of the electricity	• Available energy potential is not used to the full • Inefficient use of energy in public sector and old residential buildings • Electricity networks and substations, and gas pipelines are worn • Low share of renewable and indigenous energy resources (wood, peat, various combustible wastes, wind and hydro energy, etc.) in the primary energy balance • Slow transition to latest technologies in electricity and heat generation

economy and preparation for integration into a common Baltic electricity market completed	• No direct links of electricity and gas networks to the energy systems of Western Europe • Much radioactive waste and spent nuclear fuel has accumulated
Opportunities • Integration into the EU energy market will accelerate development of competitive energy market and reduce vulnerability to disruptions or decreases of energy supply • Energy efficiency measures contribute to lower energy demands and lower environmental impact • New transit gas pipeline from Russia to Western Europe across Lithuania can strengthen security of supply • Share of renewable and indigenous energy resources in the primary energy balance can further increase • Existing district heating system allows easily to use increasingly combined heat and power generation • Financial support by the European Commission for decommissioning of the NPP • Construction of new nuclear power plant based on Baltic collaboration and support from European private actors	**Threats** • Dependence on one supplier of fossil fuels • Early closure of the Ignalina NPP without financing from EU and international financial institutions is a heavy economic burden • Environmental disaster because of radioactive waste or accidents in the NPP • Slow modernisation of district heating system can cause economic and social problems • High dependency on the global energy resource market can lead to increased energy prices for consumers

Government energy action plans and strategy documents, in particular energy technology focus areas and priorities

Governmental energy strategies are regulated by law in Lithuania (Table 47). The Ministry of Energy is responsible for policies regarding the use of renewable and secondary energy resources according to the Act on Energy.

Table 47: Selected Lithuanian government bills on energy

Government Bills on Energy	Year
Law No. 169 On the Acceleration of Oil Production and Processing	1992
Law No. I-828 On Energy (amended 1996)	1995
Law No. I-1613 On Nuclear Energy	1996
Law No. VIII-1875 On Biofuel, Biofuels for Transport and Bio-oils	2000
Law No. IX-986 On State Stocks of Petroleum Products and Crude Oil	2002
Law No. IX-1999 On Biofuel, Biofuels for Transport and Bio-oils (new edition)	2004

Law No IX-2505 On Nuclear Energy	2004
Resolution No. 443 On the approval of the national energy efficiency programme for 2006-2010	2006
Law No. X-1329 On Heat Sector	2007

The *Act on Energy* defines the general provisions of energy activities, the basic principles of energy development, functioning and management and demands a revision of the Lithuania's *National Energy Strategy* every five years.

The first Strategy was approved by the government in *1994*.

Five years later, in October *1999*, the Seimas (Parliament) approved the second National Energy Strategy, which was due for a revision in *2004*. The Ministry of Economy developed the National Energy Strategy on the basis of studies, forecasts and calculations produced by the Lithuanian Energy Institute as well as on statistical information.

However, because of the accession to the European Union, it was necessary to revise the strategy two years earlier than anticipated in 2002. This was mainly to establish the precise dates for the final closure of both Ignalina Nuclear Power Plant reactors to meet European Union requirements. Decommissioning of this important facility has a great influence on the energy sector of Lithuania, thus making it necessary to revise the entire strategy for the period until 2020. The Strategy was prepared by the Lithuanian Energy Institute with support of the Danish Energy Agency.

The current energy strategy was approved in January *2007* by the Seimas (Seimas of the Republic of Lithuania, 2007 – hereafter, Energy Strategy 2007). *Energy Strategy 2007* has a strong focus on the problems in the field of energy security where several factors are particularly important:

- Energy security as a matter of national security
- Lithuania is still dependent on gas supplies from Russia
- Construction of a new gas pipeline from Russia to Europe under the Baltic Sea bypassing territory of the Baltic States
- Nuclear power plant Ignalina (installed capacity of 3000 MW) will be decommissioned in 2009
- Environmental requirements to reduce carbon dioxide emissions.

As a consequence of these key factors Energy Strategy 2007 has the goal of solving the endangered energy security by integrating Lithuania's energy system into the EU system and especially the EU energy market. A main target is the *construction of a new nuclear power plant* near by the site of the NPP Ignalina based on Baltic and European cooperation. (For further infrastructural challenges see the specific section in this report).

The Energy Strategy 2007 pointed also out the need to prepare a programme for the training of energy specialists, with a priority for specialists working in the new nuclear power plan.

The strategy pointed out following priority areas of R&D in the energy sector:

1. Thermonuclear and new generation nuclear reactors (by participating in respective international programmes)

2. Ensuring reliability and quality of electricity supply, vulnerability of power systems and optimisation of operating regimes
3. Nuclear energy safety, reliability and durability of energy equipment and systems, and ageing of construction materials
4. Management, storage and disposal of spent nuclear fuel and other radioactive materials
5. Hydrogen energy
6. Technologies for the use of indigenous and renewable energy resources
7. Distributed energy generation technologies. (Point 58 in the Energy Strategy 2007).

So far, the potentials of renewable energy resources have not been used sufficiently and receive relatively less attention compared to nuclear energy. These R&D priorities are, however, somewhat consistent with former strategies formulated in the National Energy Strategy from 2002, where nuclear energy was in focus, but also indigenous, waste energy resources and fuel cells had been highlighted along with energy saving and energy efficiency, environmental aspects of energy and energy economics.

Energy Strategy 2007 has set following *targets* regarding indigenous and renewable energy resources:

- Target for the share of renewable and indigenous energy resources for 2025 is about 2 million toe (out of this 0.45 million toe biofuel) or 20% of the primary energy balance
- Programme aiming at a more speedy use of biofuel for district heating and power generation based on:
  - use of logging waste (180 000 toe by 2025)
  - development of logistics for using straw in district heating (120 000 toe by 2025)
  - energy crop plantations (45 000 toe by 2015 and 70 000 toe by 2025)
  - constructing incineration facilities for municipal waste (replace 120 000 tons of fossil fuels)
  - replacement of ca. 450 000 tons of petroleum with biofuel, biodiesel and bioethanol using newest technologies,
- Implementation of the programme for the construction of wind power plants with the total capacity of 200 MW and drafting of a new long-term programme for using wind energy

The Act of 2000 on Biofuel, Biofuels for Transport and Bio-oils was revised in 2004. The Act has the objective to promote the production and use of biofuels, to diminish the dependency of the national energy sector on fossil fuels and imported raw materials; to increase the efficient use of local, renewable and alternative energy resources and the security energy supply; to reduce greenhouse gas emissions; and to implement the legal acts of the European Commission.

Environmental laws and regulations

Some of the Lithuanian environmental laws (Table 4) are also relevant also to the energy sector, where the Act on water regulating the use of water bodies for hydro-power

stations needs special mention. New and reconstructed hydropower stations have to follow the rules for facilitating fish migration defined by the Ministry of Environment.

Table 48: Selected Lithuanian government bills on climate and environment

Government Bills on Climate and Environment	Year
Law No. I-2223 On Environmental Protection	**1996**
Law No. VIII-474 On Water	**1997**
Law No. VIII-1190 On the Management of Radioactive Waste	**1999**
Law No. X-258 On the assessment of the impact of proposed economic activities on the environment[93]	**2005**

Important R&D and innovation policy instruments

The current situation regarding renewable energy technologies may be described as follows:

- relatively low level of investments in renewable energy technologies
- inadequate coordination between scientific and state governing institutions as well as companies active in the field on renewable energies
- the system of public research organisations does not focus on applied research and technological development.

The following programmes cover the utilization of local and renewable energy sources in Lithuania:

- *National programme on increasing the energy consumption efficiency (1999-2000).* The programme is titled "Consumption of local resources, waste and renewable energy sources". Part of the activities were funded by the state budget, and co-funded internationally, for example by the PHARE programme. The aim of the programme was to expand and to speed up the utilization of local and renewable energy resources in Lithuania.
- *Biofuel and bioenergy production and utilization programme:* The programme is financed by municipal budgets.
- *Science programme "Solar and others renewable energy sources for agriculture" (1996–1999)* which was coordinated by the Institute of Agricultural Engineering. The programme was funded by Lithuanian State Scientific and Study Fund.
- The *Lithuanian national solar programme 2000-2005*[94] has been developed with the goal of accelerating the development and deployment of renewable energy in Lithuania. The programme comprised not just solar photovoltaics, but also thermal technology, wind power, biomass energy (solid biofuel, biofuel, biogas) and geothermal energy. The programme planned to install 0.1MW wind, 8 MW small hydro, 0.05 MW photovoltaic power equipment, and more than 600 MW biomass power equipment, and 1000 m^2 of solar thermal collectors.
- *Lithuanian hydrogen storage programme* 2002-2004: projects were funded by the Department of Energy (USA) and the Lithuanian National Science and Studies Foundation. The main participant from Lithuania was the Lithuanian Energy Institute.

[93] Law text: http://www.am.lt/VI/en/VI/index.php#a/155
[94] Lithuanian national solar programme 2000-2005: http://saule.lms.lt/lnsp/lnsp_renew.html

- *National energy efficiency programme for 2006–2010:*
  The programme shall increase the efficiency of the use of energy resources and energy and the use of renewable energy resources in all sectors of the national economy. The programme will therefore fund applied scientific research, information and educational activities on issues related to efficient energy consumption and the use of renewable and waste energy resources. Both the Ministry of Economy and the Ministry of Education and Science are responsible for these tasks. In addition to these two ministries will also Ministry of Environment, the Ministry of Agriculture and Ministry of Transport and Communications support the cooperation with companies and PROs in EU research framework programmes related to energy efficiency and renewable energy resources.
  The programme is financed over the state budget, municipality funds, business sources, EU structural funds, and other international sources.

According to the Foresight Study conducted in 2006 for the EUFP6 project NENNET has Lithuania considerable strengths in fields such as energy research: hydrogen storage, fuel cells and photovoltaic cells (NENNET, 2006).

International collaboration

Lithuania's participation in the non-nuclear energy projects funded by EUFP5 was rather limited – the database revealed 17 projects and when counting only weighted shares of the projects, participation came down to less than 5 projects. (See the chapter on size and scope of Non-nuclear energy research in the second part of the report). Nordic collaboration partners were mainly Denmark, Sweden and Finland.

Collaboration in EUFP6 in the field of energy was concentrated on solar photovoltaics. Lithuania participated in the EUFP6 in the fields of nano and energy science with the project NENNET: High Quality Research Network on Nanosciences, Material and Energy Research in Lithuania (NENNET, 2006). The project consortium consisted of leading R&D organisations in nanosciences and energy research in Lithuania, the Semiconductor Physics Institute, the Lithuanian Energy Institute (LEI), the Vytautas Magnus University and the Institute of Lithuanian Scientific Society. It was assisted by experts from Germany and Ireland. NENNET has brought together researchers from distinct fields at the national level including nanosciences and nanotechnologies, photovoltaics, hydrogen and fuel cells. As a result, three national technology platforms have been established: Photovoltaics, Fuel Cells and Embedded Systems.

Researchers in hydrogen storage and SOFC collaborate with partners at Risø in Denmark and the University of Oslo in Norway.

Another EUFP6 project is the project SELFLEX - Demonstration of self-formation-based flexible solar cells manufacturing technology, coordinated by the Applied Research Institute for Prospective Technologies.

Since 2004, the Lithuanian Energy Institute has participated in the Marie Curie research training network HYTRAIN (Hydrogen storage research training network).

The Institute of Lithuanian Scientific Society coordinated the participation in the UNESCO programme "Development of the Lithuanian Solar Programme 2000–2005 and its implementation into the World Solar Program 1996–2005". This was funded by UNESCO.

Kaunas University of Technology (KTU) has a broad range of joint research projects with institutions from the Nordic Countries.[95] Main collaboration partners in energy research are:

- Yttrium Stabilizes Zirconium Oxide in fuel cells: Oslo University, NO; Risø National Laboratory, DK; KTU Department of Physics, LT.
- Utilisation of Surplus Energy in Lithuanian and Danish Industrial Enterprises: KTU Faculty of Mechanical Engineering, LT; Vilnius Gediminas Technical University, LT; Technical University of Denmark, DK; COWI, Consulting Engineers & Planners AS, DK.
- CO_2 sequestration: Chalmers University of Technology, SE; Norwegian University of Science and Technology, NO; Helsinki University of Technology, FI; Technical University of Denmark, DK; Tallinn Technical University, EE; KTU Department of Environmental Engineering, LT.

Key actors and institutions

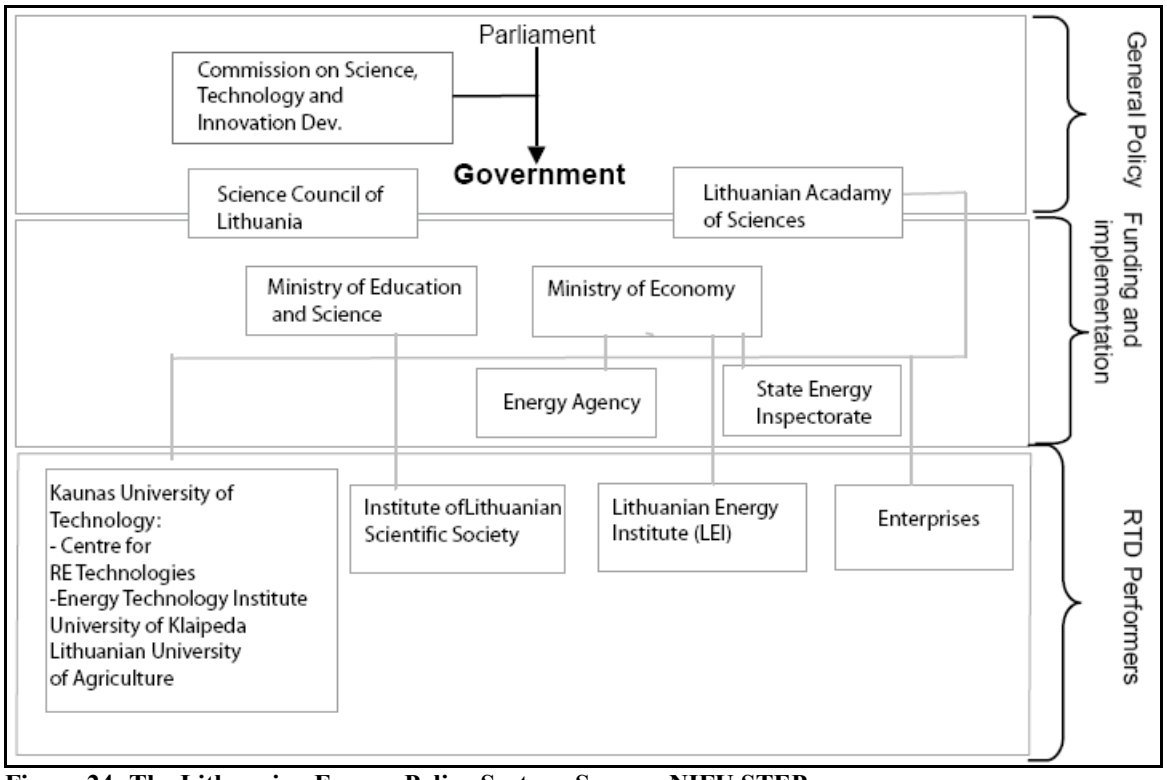

Figure 24: The Lithuanian Energy Policy System. Source: NIFU STEP

[95] Overview of KTU's joint research projects: http://internet.ktu.lt/en/index1.html

Government organisations

Ministries

Ministry of Economy[96]

The Ministry of Economy is responsible for the development of the national energy strategy. The ministry has several departments dealing with energy issues:

- The energy department – responsible for strategic energy projects, energy development and electricity and heat;
- The energy resources department – responsible for petroleum, gas and local resources;
- The nuclear energy and nuclear waste department, which is also responsible for the decommissioning of the Ignalina NPP.

Ministry of Education and Science[97]

The Ministry of Education and Science has three departments for education – general education, vocational training and continuing education, higher education - and one for science and technology. The Department of Science and Technology has a division for science and technology and a division for international research programmes. The ministry is responsible for higher education institutions and public research institutes financed over the state budget, and has initiated the development of five integrated science, study and business centres, two of them also related to renewable energy technologies.

Ministry of Environment[98]

The Ministry of Environment forms Lithuania's state policy for environmental protection, forestry, utilization of natural resources, geology and hydrometeorology, territorial planning, construction, provision of residents with housing, utilities and housing, as well as coordinates its implementation. The ministry is also responsible for the national strategies regarding climate change and is working with impact assessments of proposed economic activities.

Governmental Agencies

Energy Agency

The Energy Agency was founded in 1993 following the recommendations of foreign experts having participated in drafting the first National Energy Strategy and considering operation of analogous agencies in European countries. The Energy Agency falls under the jurisdiction of the Ministry of Economy. The Energy Agency deals with drafting the National Energy Strategy, other programs regarding the improvement of efficient use of energy resources and energy and use of local, renewable and waste energy resources; organisation of their implementation, updating and revision; preparation of legal,

[96] Homepage of Ministry of Economy: http://www.ukmin.lt/en/About/
[97] Homepage of Ministry of Education and Science: http://www.smm.lt/en/
[98] Homepage for Ministry of Environment: http://www.am.lt/VI/en/VI/index.php

economic and organizational energy efficiency measures for implementation of the national policy.

The Energy Agency is engaged in organising of international cooperation in the energy sector, coordination of foreign technical assistance to the energy sector in accordance with the National Energy Strategy and the National Energy Efficiency Programme, harmonisation of the Lithuanian legislation and the European Union legal requirements and participation in the integration processes of energy sectors of the Baltic States and Baltic Sea States.

Public research organisations[99]

Public research institutes

LEI - Lithuanian Energy Institute[100]

The most important public research organisation in the field of energy research is the Lithuanian Energy Institute, founded by the Lithuanian Academy of Sciences in 1948 (formerlythe Institute of Technical Sciences). The aim of the institute is to be the leading experise on issues of engineering, hydrology, metrology, nuclear safety, environment protection and economy, related to Lithuanian energy.
LEI has following strategic objectives:

- To perform fundamental and applied research in the fields of thermal physics, hydrodynamics, metrology, safety and reliability of energy objects, materials engineering, hydrology, and processes management.
- To prepare energy sector planning conceptual and methodological basis in state's policy energy sector.
- To prepare first-class specialists for energy and scientific research related to it.

The institute has a Laboratory of Renewable Energy with following main tasks:

- research of solid biomass usage for energy production;
- research of wind power parameters' change as well as wind power plants modelling taking into account local conditions;
- analysis of up-to-date technologies application using local and renewable energy sources (RES), – technical economical assessment of their usage, research of environmental issues;

The institute has also a large number of other laboratories which partly are relevant: Laboratories for Heat-Equipment Research and Testing, Combustion Processes, Nuclear Engineering, Material Research and Testing, Nuclear Installation Safety, Regional Energy Development, Systems Control, Automation and Energy Systems Research, Hydrology.

[99] Important source of information: Ministry of Education and Science (2004)
[100] Homepage for LEI: http://www.lei.lt/

Semiconductor Physics Institute[101]

The Semiconductor Physics Institute (SPI) was founded in 1967 as a scientific research institute of the Lithuanian Academy of Sciences. When Lithuania became independent in 1991, SPI was reorganized and became an independent State Research Institute. The institute has research priorities in material science and nanotechnology, including porous materials for applications in solar cells.

Universities

Kaunas University of Technology[102]

Faculty for Electrical and Control Engineering, Department for Electric Power Systems

Department for Electric Power Systems was founded in 1940 and has as one prioritised research area – electrical conversion of renewable energy. The Department has a research *Centre for Renewable Energy Technologies.*[103] The centre was founded in 2000. Its main activities include:

- Education at bachelor, master and doctorate levels
- Consultations, seminars and courses for specialists in industry and agriculture
- Education of society, formation of the right attitudes to the use of renewable energy sources and modern technologies of energy conversion
- Participation in national and international research programmes and projects of renewable energy technologies, especially in electrical conversion of renewable energy
- Cooperation with industrial and trade companies and other business organisations in demonstration and propagation of modern equipment for renewable and alternative energy use.

The centre has conducted research especially into solar photovoltaics, but also in more general issues regarding renewable energy:

- Solar and other renewable sources of energy for agriculture, 1996–1999
- Solar energy conversion and utilization, 2001–2004
- Self-formation research towards stairway to excellence in photovoltaic, project First Step of EUFP5, 2002–2005.
- The cycle of training and consultations in area of thrift and renewable energy in micro-region Ladruva (under the PHARE Partnership Programme), 1999–2000
- Teaching, propagation and training of renewable energy technologies (under the PHARE Programme), 2002–2003
- Partial alteration of nuclear energy by renewable and alternative energy in Utena region after the decommissioning the Ignalina Nuclear Power Plant, 2001–2003 (supported by German funds).

Faculty of fundamental science, Department of physics

The department is engaged in research on thin films and solid oxide fuel cells.

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[101] Homepage for SPI: http://www.pfi.lt/index_e.html
[102] Homepage for Kaunas University of Technology: http://internet.ktu.lt/en/index1.html
[103] Homepage for the Centre: http://www.aet.eaf.ktu.lt/eindex.php

Energy Technology Institute
The institute was founded in 2005. Research is concentrated on nuclear energy safety and power plant construction, energy economy and planning, power equipment reliability and oil industry equipment.
Integrated science, study and business centres
The Ministry of Education and Science has initiated the development of five integrated science, study and business centres, two of them, which also have relevance for renewable energy technology, will be established in Kaunas:

- "Santaka": centre in sustainable chemicals and pharmacy, mechatronics and related electronics, biomedical engineering, *future energy* and ICT
- "Nemunas": centre in agro biotechnologies, *bio energy* and forestry, food technologies, safety and health.

Vilnius University
The Department of radio physics at the Faculty of Physics specialises in intermediate-temperature solid oxide fuel cells (IT-SOFC).

Vytautas Magnus University[104]
The *Physics department* specialises in intermediate-temperature solid oxide fuel cells (IT-SOFC).

Klaipėda University
Faculty of Marine Technics
The most successful directions of R&D activities are concentrated on sustainable development of sea transport and logistics, the development of sustainable use of energy and the biodegradation of organic matter.

Lithuanian University of Agriculture
The university conducts R&D on renewable energy technologies mainly at the Institute of Agricultural Engineering; one R&D priority is the conversion of renewable energy resources, plant production and its waste into non-alimentary materials.

Non-governmental organisations

Institute of Lithuanian Scientific Society[105]
The institute is a non-governmental research institution established by the Lithuanian Scientific Society as an umbrella organisation for research activities of the members of ILSS. The R&D priorities are renewable energy, photovoltaics, ICT and future emerging technologies. Research activities of the Self-Formation Development Centre focus on self-formation of artificial systems theory and application in photovoltaic manufacturing and fuel cells technologies.

[104] Homepage of the university : www.vdu.lt
[105] Homepage of the ILSS: http://msi.lms.lt

Applied Research Institute for Prospective Technologies[106]
The Applied Research Institute for Prospective Technologies is a non-governmental, not-profit research institute founded in 2005 by research and business partners to create an environment for industrially oriented technologies development. The priorities of the Institute are: electronics, microelectronics and sensors, photovoltaic technologies ICT, and measurements and testing. The institute is working on photovoltaic technologies that are based on the principles of self-formation of artificial systems, silicon solar cells, their development and manufacturing technologies. The institute has coordinated a project under EUFP6 – SELFLEX: Demonstration of SELF-formation based FLEXible solar cells manufacturing technology.

The *Lithuanian Bioenergetics and Energy Economic Association* is working on biomass, photovoltaic, hydro power, solar thermal energy and wind.

Firms

According to the Database for Business and Public Administration,[107] 13 thermal electricity plants operate in Lithuania, in addition the Kruonis Hydro-Accumulative Power Plant, the Kaunas Hydro-electric Plant and 33 small power plants. The hydropower stations are organised in the Lithuanian Hydropower Association. For further information see also the overview at the Lithuanian Renewable energy server.[108] Lithuania's main source of electric power is the Ignalina Nuclear Power Plant, but the NPP will be decommissioned in 2009 and a new NPP will be built near the site of the old plant.

The deployment of *photovoltaics* is still rather limited in the Lithuanian energy sector. The development and deployment of solar energy technologies is hampered by very high costs per installed kilowatt that is several times higher than that of conventional electric energy. The joint venture company, *Saulës energija*, is a manufacturer of solar cells and in 1994–1998 installed some 3 kW overall power photovoltaic modules which are used for tourism or for feeding specific electronic devices. Low-power (25–100 W) equipment is already established or under construction. Saulës energija has been involved in R&D projects involving photovoltaics for Nordic Energy Research and the EUFP5.

The *Applied Research Institute for Prospective Technologies* offers commercial services in the field of photovoltaics, like technological audits, feasibility studies, technology market analysis, idea screening and forming of expert groups for implementing ideas.

A larger number of companies operate in the field of *bioenergy*, concentrating mainly on the use of biomass for heating and biofuel production. There are also several foreign companies operating in the biofuel market. StatoilHydro recently aquired a 42.5% share in a new biodiesel plant in Lithuania with a capacity of almost 100,000 tonnes biodiesel per year. Another international company is BIO-Fuel Europe.

[106] Homepage of the Applied Research Institute for Prospective Technologies: http://www.protechnology.lt/
[107] Database for business and public administration: http://www.balticdata.info/lithuania/lit_index.htm
[108] Lithuanian Renewable energy server: http://saule.lms.lt/main/hidro_e.html

Annex

Overview of methods applied by work packages

Table 49: Overview of methodology applied by work packages

	Quantitative analysis of EU indicators	Patent analysis	OECD study frame-work	Bibliometric analysis	Desktop analysis	Interviews with experts	Case study	SWOT-analysis	Project data (research council, EU FPs)	Reference group
WP 1.1	X	X		X	X	X				X
WP 1.2			X	X	X	X			X	X
WP 1.3								X		X
WP 2.1			X		X	X	X			X
WP 2.2	X				X	X				X
WP 3.1	X	X	X	X	X	X	X	X	X	X
WP 3.2								X		X

Endnotes

[i] List of energy companies in Finland:

Natural gas companies

- Gas importing company
- Gasum OY

Gas distribution companies and big gas consumers

- Anjalankosken Energia Oy
- Fortum Power and Heat Oy
- Gasum Paikallisjakelu Oy
- Gesterbyn Lämpö Oy
- Haminan Energia Oy
- Helsinki Energy
- Hyvinkään Lämpövoima Oy
- Imatran Lämpö
- J.M. Huber Finland Oy
- Karhu Voima Oy
- Keravan Energia Oy
- Kotkan Energia Oy
- Kuusankosken Aluelämmitys Oy
- Kyro Power Oy
- Lahti Energia Oy
- Lappeenrannan Energia Oy
- Lempäälän Lämpö Oy
- Leppäkosken Sähkö Oy
- M-real Oyj
- Myllykoski Paper Oy
- Neste Oil Oyj
- Orimattilan Lämpö Oy
- Paroc Oy Ab
- Pilkington Lahden Lasitehdas Oy
- Porvoon Energia Oy
- Pohjolan Voima, Nokian Lämpövoima Oy
- Raisio Oyj
- Rautaruukki Oyj
- Sandvik Mining and Construction Oy
- Stora Enso Oyj
- Tampere Power Utility
- UPM-Kymmene Oyj
- Valkeakaasu Oy
- Valkeakosken Energia Oy
- Vantaa Energy
- Vari Oy, Kouvola
- Vattenfall Kaukolämpö Oy

Companies selling gas appliances, equipment or services:

- Oy AGA Ab
- Alstom Finland Oy
- Gasum Energiapalvelut Oy
- JK Pajarinen & Co

- Justiflow Oy
- Kaasulaite Lennart Wikström Oy
- Kaasupörssi Oy
- Oy KWH Pipe Ab
- Naval Oy
- Oilon Oy
- Pöyry Energy Oy
- Sensorex Oy
- Siemens Osakeyhtiö
- Oy Soffco Ab
- Tieliikelaitos
- Uponor Suomi Oy
- Vexve 0y
- Wihuri Oy Witraktor, Power Systems
- WM-data Oy
- Wärtsilä Finland Oy
- YIT Industrial and Network Services

Windpower companies
Below a list of Finnish companies working with windpower in production and in supporting functions. The list is taken from the Finnish Windpower association's home page
Energy production, maintenance, operating experiences
- Suomen Hyötytuuli Oy
- Iin Energia Oy
- Kemin Energia Oy
- Kokkolan Energia
- Kotkan energia Oy
- Kuivaturve Oy
- Lumituuli Oy
- Pori Energia Oy
- Propel Voima Oy
- PVO-Innopower Oy
- Tunturituuli Oy
- Vattenfall
- Vapo Oy
- Oulun Seudun Sähkö
- Kansallistuuli Oy

Agents, importers, sellers, manufacturers
- Hafmex Windforce Oy
- Winwind Oy
- Windside Production Oy Ltd
- REPS Oy Ab
- Suomen Tuulienergia - FWT Oy
- Tuulivoimala.com Finland Oy
- Finnwind Oy
- MH-Metalli Heikkonen Ky
- MAATUULI

Wind turbine and component manufacturing
- Moventas Oy
- ABB Motors Oy

- The Switch
- Winwind Oy
- Small wind generators
- Windside Production Oy Ltd
- MH-Metalli Heikkonen Ky

Planning, consulting, and building and services and maintenance

- Cosphi One Oy Ltd.
- Ilmatieteen laitos, IL Energia
- YRJtechnology Oy
- Insinööritoimisto Erkki Haapanen Oy
- Micron Ky
- Suomen Tuulienergia -FWT Oy
- Windcraft
- Kemijoki Oy
- Empower Oy
- Empowerin huolto
- GreenStream Network Oy
- Kariniemi Transport
- WPD Finland Oy

[ii] Latvian Science Council: The development of number of grants and total funding in LVL per science field 200-2002 (http://www.lzp.lv/Fund 2001.htm and http://www.lzp.lv/Fund2003.htm)

Branch	2000		2001		2002	
	Number of grants	Funding (Ls)	Number of grants	Funding (Ls)	Number of grants	Funding (Ls)
1. Computer science	47	189 215	46	188 524	48	187 944
2. Mechanics, mechanical and power engineering	56	254 667	62	251 499	61	250 694
3. Physics, mathematics and astronomy	91	443 621	89	441 996	89	448 374
4. Chemistry	56	345 835	65	344 540	66	343 437
5. Scientific principles of technology: materials, chemistry, pharmacy	26	158 008	33	157 436	33	156 940
6. Biology, ecology, geography and geology	72	330 166	72	328 963	71	327 918
7. Molecular biology, microbiology and biotechnology	28	244 842	39	243 943	38	243 187
8. Medical sciences	74	351 801	100	350 488	101	349 396
9. Agricultural sciences	50	369 411	45	368 060	44	366 901
10. History (including history of culture)	9	102 788	14	102 423	14	102 102
11. Linguistics, history of literature and arts sciences	25	133 371	28	132 869	28	132 467

12. Philosophy, sociology psychology and pedagogic	50	208 079	55	207 312	56	206 661
13. Economics and law	23	198 440	33	197 715	33	197 101
14. Wood sciences	19	61 430	14	61 197	14	60 999
Total	626	3 391 674	695	3 376 965	696	3 374 121
Programs funding	22	1 402 585	25	1 417 294	25	1 467 888
Total	648	4 794 259	720	4 794 259	721	4 842 009

[iii] Latvian Science Council: Projects of Fundamental and Applied Research in Power Engineering for the Year 2006 in LVL (http://www.lzp.lv/Proj-2006/Proj06-2.htm)

3. Power Engineering			
Latvian University of Agriculture			
Šnīders A. 04.1077	Autonomous energy supply of waste water treatment units using biogas	1210	
Total for the Institution			1210
University of Latvia			
Jakovičs A. 04.1225	Complex diagnostics of heat losses and more accurate estimation of heat consumption in buildings – use of automated measuring- and hierarchically connected systems of mathematical models	702	
Total for the Institution			702
Institute of Physical Energetics, Latvian Academy of Sciences			
Bendere R. 05.1470	Organic waste as source of bioenergy, evaluation of the technical, economical and environmental responsibility factors of its usage	1210	
Klāvs G. 04.1163	Regulation of energy prices and tariffs in a liberalised energy market to ensure the implementation of a sustainable energy policy in Latvia	2057	
Krišāns Z. 04.1159	Approach to electrical network optimization under liberalized electricity market	5374	
Krišāns Z. 06.1943	Elaboration of the development dynamic model for system “Distribution Networks and Distribution Generation”	533	
Oļeiņikova I. 04.1160	Network reliability optimization under liberalized electricity market	1912	
Pugačevs V. 05.1471	Development of theoretical foundations for multiple variable reluctance machines	1162	
Šipkovs P. 05.1472	Methodological aspects and technical, economical and ecological challenges development of renewable energy resources utilization	1864	
Šipkovs P. 05.1473	Methodological investigations of the forecasting of fuel consumption structural changes while joining EU	1864	

Stabulnieks J. 04.1161	Theoretical principles and practical recommendations for automation and modernization of industry and transport based on the latest technology developments of power semiconductors, new materials and information processing	4357	
Tomsons E. 04.1164	Environment-compatible fuels in the energy balance of Latvia: possibilities of production and use	1210	
Zēbergs V. 05.1474	Latvian energy sector development strategy and its management process research by using simulation and optimisation methods	5180	
Zeltiņš N. 04.1162	Methodological research in the efficiency of energy economy for steady development of the national economy of Latvia using innovative technologies	5349	
Total for the Institution			32,072
Riga Technical University			
Barkāns J. 05.1675	Development of microprocessor-based arrangements for raising of electric network condition effectiveness	3945	
Blumberga A. 05.1677	Investigation and optimisation of regional GHG emission reduction by implementation of energy efficiency measures in buildings	605	
Blumberga D. 04.1181	Analysis of energy efficiency indicators of cleaner production in Latvian industry	920	
Čuvičins V. 05.1678	Operational features analysis for power system with distributed energy generation	2275	
Dirba J. 04.1184	Dynamic modes of electromechanical systems calculation methods and optimization of energy saving motors	920	
Dolgicers A. 04.1185	Power system relay protection performance testing	605	
Dzelzītis E. 06.2032	Development of control levels structure in building automation systems (BAS)	920	
Galkins I. 05.1679	Research and development of semiconductor reactive power compensation units and active filters	605	
Greivulis J. 04.1349	Solved electrical drives control	1210	
Krēsliņš A. 04.1187	Economic justification methods of building energy efficiency evaluation	702	
Krēsliņš A. 05.1680	Standardization of energy performance of buildings	3486	
Kuņicina N. 06.1964	Analysis of logistic multi-criterial decisions for electric power supply systems	557	
Levčenkovs A. 06.2033	Development of multi-agents systems for energy distribution	605	
Raņķis I. 04.1183	Synthesis and analysis of semiconductor converters with improved quality	1912	
Ribickis L. 05.1681	Power electronic converters and control systems with neural networks and fuzzy logic controllers	3147	

Ribickis L. 05.1682	Electrical drives system optimization and investigation of expert methods	1549
Rozenkrons J. 05.1683	Independent producer's power stations impact on reactive power balance in electric grid	920
Sauhats A. 04.1190	Utilisation of the global communication networks for power system relay protection and automation	4357
Turlajs D. 05.1684	Working out of more efficient and ecologically cleaner heat energy production technology	1477
Veidenbergs I. 04.1188	Investigation of adaptation of green energy technologies in Latvia. Prospects	920
Žiravecka A. 04.1189	Investigation and elaboration of operative electrical power converter systems	726
Total for the Institution		32,363
Total for Power Engineering		*66,347*

[iv] The Latvian Chamber of Commerce and Industry company database homepage (http://www.latvijas-talrunis.lv/pls/lt/lcci_start?part=N):

10 Mining of coal and lignite; extraction of peat

10.3 Extraction and agglomeration of peat

- BALTIC BOGS Ltd CESVAINES KŪDRA Ltd FLORABALT Ltd LAFLORA Ltd LĪVĀNU KŪDRAS FABRIKA Ltd OLAINES KŪDRA Stock Company PINDSTRUP LATVIA Ltd Peat Energy Llc RINGLA PLUS Ltd SEDA Joint-Stock Company STRUŽĀNU KŪDRAS FABRIKA Joint-Stock Company

23 Manufacture of coke, refined petroleum products and nuclear fuel

23.2 Manufacture of refined petroleum products

- CBR Joint-Stock Company AUTOHIM Ltd RĪGAS ASFALTBETONA RŪPNĪCA Ltd

40.1 Production and distribution of electricity

- ABULS CASCADE OF SMALL HYDROELECTRIC STATIONS Ltd LATVENERGO State Joint-Stock Company VEF State Joint-Stock Company

40.2 Manufacture of gas; distribution of gaseous fuels through mains

- AGA Ltd LATVIJAS GĀZE Joint-Stock Company

40.3 Steam and hot water supply

- KOMFORTS Joint-Stock Company LATVENERGO State Joint-Stock Company VATTENFALL LATVIA Ltd