NATIONAL ENERGY POLICY

As Figure 5 shows, the dominant energy carrier in the Netherlands is natural gas. Natural gas is used extensively in the residential, industrial, and commercial sectors. Oil is mainly used in transport, refineries, and the petrochemical industry. Coal is mainly used in the iron and steel industry and in electricity production.

Figure 6: Netherlands Total Primary Energy Demand for 1996 (CBS, 1996)

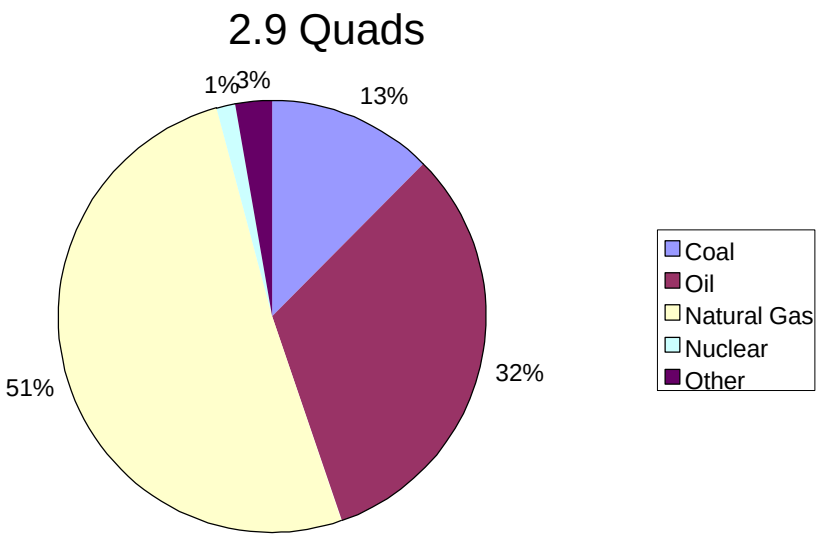

Table 1: 1996 Energy Snapshot[1]

Dependence on energy imports: 68%	Carbon emissions [1995][2]: CO_2: 48 million tons of carbon All GHG's: 58 million tons of carbon Equivalent
Energy Consumption per capita: 188 million Btu/capita (198 GJ/capita)	Carbon emissions per unit GDP [1995]: CO_2: 0.16 kg carbon/$ (0.07 kg carbon/fl) All GHG's: 0.19 kg carbon (eq.)/$ (0.09 carbon (eq.)/fl)
Energy Consumption per unit GDP (EI): 9.2 thousand Btu/$ (4.7 MJ/fl)	Carbon emissions per capita: CO_2: 3.1 tons carbon/capita All GHG's: 3.7 tons carbon (eq.)/capita
"Kyoto commitment": 6% reduction in GHG emissions from 1990 levels by 2008-2012	Fossil fuel import dependence Oil: 98% Gas: 56% Coal: 98%

Energy Policy

Since the oil crises of the 1970s and 1980s, the general objective of Dutch energy policy has been to provide the Netherlands with adequate supplies of reliable, affordable and clean energy. The

[1] Energy data from (CBS, 1996).
[2] CO_2-emission data from (CBS, 1997).

Dutch energy policy, as formulated in the most recent White Paper on Energy Policy (December 1995), has two pillars. The first aim is a gradual liberalization of the Dutch electricity and gas markets. The second is to achieve a 33% energy efficiency improvement (with respect to a base year of 1995) and a 10% share of renewable energy in total primary energy consumption by the year 2020.

Liberalization - Under the White Paper's proposals, the number of "captive consumers" in both electricity and natural gas markets will be steadily reduced. The basic nature of the market will be thus transformed from being supply-driven to being more demand-driven. In principle, third-party access to the electricity and natural gas grids must be provided on a non-discriminatory basis. Contracts with end-users will replace central planning. Previously the electricity production market in the Netherlands was heavily regulated under the Electricity Act of 1989. However, in July 1998 a new Electricity Act was adopted, mandating the complete liberalization of the electricity generation sector by 2007. This liberalization also extends to the import and export of electricity. Large consumers (33% of the market) will be free to choose their suppliers starting in 1999. A second group, constituting an additional 29% of the market, will be allowed to choose its suppliers as of 2002. Small consumers, making up some 38% of the market, will be allowed to choose their electricity providers only in 2007. The traditional roles of electricity production companies and electricity distribution companies are also being redefined. The Act also includes regulations regarding the introduction of renewable energy.[3]

Government regulation also has a significant influence on the market organization and production of natural gas. However, in contrast to the electricity market, large natural gas consumers[4] are already free to choose their suppliers. The import and export of natural gas are also largely unregulated at this point. Because of European Union regulations that were adopted in 1994,[5] producers are no longer obliged to sell natural gas solely to Gasunie, formerly the Netherlands' monopoly gas producer (Ministry of Economic Affairs, 1995).[6] A revised Gas Act will likely be introduced in the Second Chamber of Parliament in 1999.[7] The revised Gas Act is expected to provide for a further deregulation of the natural gas market that would parallel the deregulation of the electricity market, i.e., consumers would be allowed to choose their supplier of natural gas when they are allowed to choose their electricity supplier. The revised Gas Act will also likely include requirements for the further promotion of energy efficiency. Mining legislation is expected to continue regulating the exploration and production of natural gas in the liberalized market.

The Netherlands has been neither a laggard nor a leader among industrialized countries in liberalizing their energy markets. The United States, Canada and the United Kingdom are a step ahead; Germany is approximately at the same stage in the process, while other countries appear to be lagging behind. The government believes that in addition to reducing prices, liberalization will also improve the delivery of energy services to consumers (Ministry of Economic Affairs, 1995). That said, the government is still uncertain how deregulation will affect existing voluntary agreements with the utilities to strive to meet certain efficiency goals.

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[3] See Ministry of Economic Affairs, 1996 and the text of the Electricity Act 1998 , July 2, 1998.
[4] Large natural gas consumers are defined as consuming more than 10 million m^3/year. Large natural gas consumers account for about 46% of the market (Ministry of Economic Affairs, 1995).
[5] RL 94/22/EG, PB. 1994, L164.
[6] Gasunie is a gas trading and transmission company. Its primary activities are buying, carrying, and selling natural gas destined for the Dutch and export markets. Gasunie is owned 50% by the Government, 25% by Shell (gas and oil firm), and 25% by Esso (gas and oil firm).
[7] Press release by the Ministry of Economic Affairs (02-11-1998).

Energy Efficiency and Renewable Energy - The second major aim of Dutch energy policy is to continue the implementation of energy efficiency policy as formulated in 1990 and 1993 (Ministry of Economic Affairs, 1990 and 1993) and to pursue an active policy to realize 10% share of renewable energy in total primary energy consumption by the year 2020 (see Table 2). Policy to stimulate energy efficiency and renewable energy was further developed in April 1998 and March 1997 respectively

Since 1990, Dutch energy efficiency policy has not only been motivated by a desire to reduce the country's dependence on energy from OPEC countries but also by a desire to protect and improve the environment. Given that climate change is believed to be caused by the use of fossil fuels, policy measures designed to combat climate change are, to a large extent, formulated within Dutch energy policy.

The Ministry of Economic Affairs reformulated its energy efficiency policy in the aftermath of the Kyoto Climate Change Conference. Both the agreements made in Kyoto and the high economic growth in The Netherlands over the past few years necessitated the upward revision of the national energy efficiency target from 1.6% to 2.0% per year.

In a recent Memorandum on Energy Saving (1998) (which is currently a non-binding consultation document), the Ministry suggested that meeting this increased energy efficiency goal required considerable investments by the Dutch economy (about $1.5 to $2 billion a year) and that the government's contribution to the effort will be $300 million per year. The Memorandum also emphasized the need for more active measures to stimulate energy efficiency (Ministry of Economic Affairs, April 1998a). For example, in the past energy efficiency improvements were largely the result of Voluntary Agreements and self-regulation. In the future, Dutch energy policy will, in addition to the line of Voluntary Agreements, adopt performance standards, regulation, and fiscal stimulation to encourage further energy efficiency improvements. The government envisions targeted programs for different sectors of the Dutch economy (e.g., households, commercial buildings, agricultural sector, industry, SME's, transport, and the energy sector). Besides ideas such as benchmarking to stimulate industrial energy efficiency, an increasing focus on industrial areas, and stricter performance standards for energy efficiency in houses and utility buildings, RD&D also has a role to play. For example, the government will support RD&D for energy efficiency demonstration projects in the built environment, R&D for the horticultural sector (e.g., to support cogeneration projects), and R&D for industrial energy efficiency "breakthrough technologies" (creating step-function improvements in energy efficiency) (Ministry of Economic Affairs, 1998a).

As suggested in the White Paper, the Action Programme for Renewable Energy (1997-2000) was launched early in 1997 (Ministry of Economic Affairs, March 1997). The Action Programme is addressing three lines of thought: improving the price-performance ratio of renewable energy technologies through research, stimulating the market penetration of renewable energy technologies, and tackling administrative bottlenecks that frustrate the deployment of these technologies. In addition to increasing various subsidies and other fiscal stimulation measures designed to speed the market introduction of renewable energy technologies,[8] the renewable energy R&D budget of the Ministry of Economic Affairs increased considerably between 1996 and 1997 (see Table 3). A specific initiative mentioned in the White Paper is the establishment of

[8] Some of the fiscal stimulation measures for renewable energy technologies include the Energy Tax for Small Households and SME's (January 1, 1996), the Accelerated Depreciation of Environmental Investments (VAMIL), the Green Funds (started in 1995), and the Energy Investment Relief Scheme (IEA).

a Project Agency for Renewable Energy that would comprise EnergieNed,[9] the four Dutch energy production companies,[10] industrial partners, and the Ministry of Economic Affairs. This Project Agency is currently being established and is intended to play a catalyzing role in realizing renewable energy projects (located in Arnhem).

The Third White Paper on Energy (1995) admits that the targets formulated for energy efficiency and renewable energy require both investments in the development of new technologies and fiscal stimulation (such as subsidies and tax breaks) for technology demonstration and deployment. The White Paper indicates industrial energy conservation, photovoltaics, biomass and wind energy as priorities for energy R&D. At the same time, the consequences of energy liberalization on the amount and the type of investments in energy R&D are uncertain (Ministry of Economic Affairs, 1995).

Table 2: Projected Renewable Energy Usage in the Netherlands (Ministry of Economic Affairs, 1995)

Contribution in PJ (saved primary energy)	2000	2007	2020
Wind energy	16	33	45
Photovoltaic energy	1	2	10
Thermal solar energy	2	5	10
Geothermal energy	-	-	2
Storage of heat and cold in aquifers	2	8	15
Heat pumps	7	50	65
Hydroelectric power	1	3	3
Energy from biomass and waste	54	85	120
Imported Norwegian hydroelectric power	-	18	18
Total (including import)	83	204	288

Energy R&D Policy – In line with the strategies formulated in "Knowledge in Action," the Ministry of Economic Affairs wants to increase the role of the energy sector in formulating energy R&D priorities. The government hopes that by increasing the private sector's consultative role and by encouraging private financial contributions to energy R&D projects, it will be better able to prioritize publicly funded energy research, guarantee an appropriate total level of energy R&D, and avoid the emergence of a gap between public and private R&D efforts (Ministry of Economic Affairs, 1995). To facilitate future involvement of the private sector in energy R&D priority setting, an extensive survey of the energy R&D supply and demand sides was performed preparatory to the White Paper (performed by Arthur D. Little and PA Consultancy, June 1997). The results of this survey are currently being used to improve the coordination among various elements of the "energy knowledge infrastructure."

This survey and the earlier-mentioned activities of a Strategic Foresight Committee resulted in the formulation of a public energy R&D policy (Ministry of Economic Affairs, April 1998b) (see also the section on Key Technology Areas).

[9] EnergieNed represents the interests of the Dutch utility distribution companies and is charged with implementing the Environmental Action Plan (MAP). It is supported by a small levy on electricity and natural gas consumption. This budget is used to support, among other things, the introduction of renewable energy technologies.
[10] UNA, EPZ, EPON and EZH.

A comparison of Tables 2 and 3 shows that photovoltaic energy is intended to receive the largest share of the energy R&D budget, while its contributions to the energy goals formulated are modest.

Table 3: Budget for Renewable Energy (Ministry of Economic Affairs, 1997)

Millions of US$ (1995 PPP)	1996	1997	1998	1999	2000
Research program: wind energy	4.1	7.7	7.7	7.7	7.7
Research program: photovoltaic energy	5.8	15.5	15.8	15.9	15.9
Research program: energy from biomass and waste	3.6	7.2	7.2	7.2	7.2
Research program: thermal solar energy	3.1	4.0	4.0	4.0	4.0
Program: heat pumps	2.5	3.8	3.8	3.8	3.8
Project Agency Renewable Energy	-	2.3	2.3	2.3	2.3
Basic / goal subsidy ECN	4.6	4.6	4.6	4.6	4.6
Goal subsidy TNO	0.7	0.7	0.7	0.7	0.7
"Economy, Ecology, Technology" Program[11]	4.7	4.7	4.7	4.7	4.7
Total (including subsidies)	33.8	53.3	50.7	50.7	50.7

CO_2 Emission Reductions – In addition to the Energy Policy, the Dutch government is pursuing activities within the framework of climate policy. The Dutch government recently announced a major initiative designed to reduce CO_2 emissions, exemplifying the government's attitude towards CO_2 emission reductions and investments in energy R&D. In 1997 the government allocated $750 million for intensifying climate policy to reduce CO_2 emissions.[12]

About $500 million is allocated to the "CO_2-reduction plan." The initiative focuses on large-scale investment projects that will substantially decrease CO_2-emissions. Twelve projects are currently supported. A second tender is currently open. Cost effectiveness in tonnes CO_2 emissions avoided is used as the explicit criterion for selecting projects. Areas of interest are the recovery of industrial waste heat, development of heat pumps and advanced cogeneration, membranes, energy infrastructure in horticultural and new residential areas and the realization of an offshore wind energy park.

The continuing budget of $250 million is being used to support projects in several areas, including joint implementation (i.e., working with developing nations), reduction of greenhouse gases other than carbon dioxide, carbon sinks, breakthrough energy conservation technologies,[13] transportation research, and clean bio-fuels (see also Key Technology Area).

Lastly, with the recent installation of the new government in The Netherlands (August 1998), the stimulation of energy efficiency and renewable energy was again emphasized explicitly. The government's intention is to increase the current Ecotax. Of the total revenue generated by the Ecotax, the plan is to use 15% (about $250 million) for fiscal stimulation of energy efficiency. An additional $40 million will be allocated for renewable energy R&D during the period 1999-2002 (mainly photovoltaic solar energy)[14] (Regeerakkoord, 1998).

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[11] This figure represents an approximation of the share of the Economy-Ecology-Technology Programme's budget devoted to renewable energy.
[38] Personal communication, Mr. K.J. Koops, Ministry of Economic Affairs, November 1998.
[13] This budget might be used to implement many of the policy initiatives mentioned in the recent Memorandum on Energy Conservation (Ministry of Economic Affairs, April 1998).
[14] For the period 1999-2010, a total of $400 million is reserved for the promotion of renewable energy.

ENERGY TECHNOLOGY TRENDS

Except for the data covered in the science budgets (see Figures 3, 4, and 5), there are no robust time series data for either public or private energy R&D expenditures in the Netherlands.[15] However, with the increased attention being paid to energy R&D and the value of energy R&D in meeting certain national goals, a number of studies have recently been conducted that help to create some insight into Dutch energy R&D, its orientation, and its organization.[16]

A brief historical overview of changes in Dutch energy R&D activity and current priorities in energy R&D, which were recently formulated by the Ministry of Economic Affairs will be presented (Ministry of Economic Affairs, April 1998b), before a more detailed description of government energy R&D programs.

Historical Changes in Energy Priority Areas

Since the first oil crisis in 1973, the Netherlands government has funded RD&D in non-nuclear energy technologies (AER, July 1996). The first White Paper on Energy (1974) mentioned the need to reduce dependency on imported OPEC oil and environmental considerations as reasons why the government should support energy R&D.[17] In these early years of the Dutch energy R&D program, energy R&D priorities were (1) conservation (rational energy use in the building sector, transport and industry; possible ways to store energy; reductions in energy conversion losses); (2) diversification of energy supplies (reintroduction of coal and the introduction of nuclear power); and (3) the development of "national" domestic energy sources (e.g., solar energy, wind energy and geothermal energy). Dutch public energy R&D was coordinated by the Project Agency on Energy Research (PEO) until 1988 when Novem took over these responsibilities.[18] Table and 5 give an impression of the changes in priority areas for energy R&D in the Netherlands.

Even though PEO's and Novem's budgets do not fully represent the total energy R&D expenditure of the Dutch government (especially natural gas related research and nuclear research are missing from these programmatic budgets), they do give a rough indication of changes in priority for energy R&D. For example, the budget devoted to coal has been reduced substantially over time. Originally coal was seen as a significant option for diversifying the nation's energy supplies. However, because of environmental problems associated with coal combustion, the availability of large stocks of natural gas, and the successful implementation of gas-fueled combined heat power (CHP) in the Dutch energy system, coal has been replaced by natural gas as the dominant fuel.

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[15] The data historically submitted to the IEA (Paris) exhibit some systematic differences in recent yearly reports (data collected by M+I Consultancy (Amsterdam) and currently by Ecofys (Utrecht) (Personal communication, Mr. D. de Jager, Ecofys, February 1999).

[16] See, e.g., Weijnen, 1994; Wees and van Wijk, September 1995; OCV/VCE, February 1996; AER, July 1996; Arthur D. Little and PA Consultancy, June 1997; CBS, September 1997; Struker and de Jager, 1998; Senter, 1997; Ministry of Economic Affairs, April 1998b.

[17] Environmental considerations were the quality of air, soil, and water, and spatial planning.

[18] In 1988, Novem became the administrator of most of the non-nuclear governmental programs (covering research, development, market introduction, and knowledge transfer). The purpose of this public corporation is to contribute to improving the Netherlands' energy and environmental situation. Novem carries out a number of programs on research and dissemination of energy efficient technologies and renewable energy resources, which are commissioned by the Ministry of Economic Affairs (and increasingly are also cofunded by other institutions). Most of the programs are carried out on a cost-shared basis although the data above do not include these external contributions. Novem is not responsible for implementing the total energy RD&D budget.

Table 4: Cumulative Spending on Non-Nuclear Energy R&D (PEO) 1973-1986[19]

Energy R&D Area	[$ million] 1995 US $	% of budget
Coal	70	25 %
Wind energy	64	22 %
Solar energy	33	12 %
Reuse of waste	8	3 %
Geothermal energy	5	2 %
Rational use of energy building sector	31	11 %
Rational use of energy industry	11	4 %
Rational use of energy transport	11	4 %
Energy saving appliances (e.g., heat pumps, fuel cells, also boilers)	36	13 %
Other	14	5 %
Total	~ 284	

The budget devoted to energy efficiency R&D (whether industrial, residential, or transport) has increased substantially over time. By now, it is the dominant area of public and private energy RD&D in the Netherlands (Struker and de Jager, 1998; Senter, 1997).

The Netherlands has a long history of supporting renewable energy projects. Wind energy was the first renewable option that received substantial support from the government. The first National Research Programme started in 1976 (1976-1981). R&D in wind is however decreasing lately.

A national research program on solar energy (only thermal solar energy) started in 1978. Stimulation of photovoltaic solar energy started in the 1980s. The budget available for PV is growing recently (see also Table 3). Biomass is the most recent renewable energy option to receive growing interest. This biomass research started mainly in the waste area (e.g., co-combustion, cleaning of flue gasses, conversion efficiencies of waste incinerators, availability of waste material) and shifted its focus more and more towards biomass (e.g., different conversion routes, gasification etc.). Although modest in budget, geothermal energy has received attention since the initiation of the Dutch public sector R&D effort.

Since 1990, Dutch energy conservation programs and programs designed to explore and exploit domestic energy sources (e.g., renewable energy and natural gas) are increasingly motivated by environmental arguments as opposed to the previous decades' rationale of reducing the dependency on OPEC countries. The development of "national" domestic energy sources (e.g., solar energy, wind energy and geothermal energy) was continued under a changed argument.

Energy research has received increasing attention since the early 1990s, for example, through the activities of the Strategic Foresight Committee in 1992 (OCV, February 1996 and June 1996). In Appendix 1 the current organization of energy R&D programming and financing is shown. The committee concluded that publicly financed energy R&D should facilitate a change towards an energy system that supports "sustainable development." Both energy efficiency and the introduction of renewable technologies (solar energy, wind energy, and biomass) were favored

[19] About half of the total governmental spending on energy R&D in this period ($560 million) was implemented through the Project Agency on Energy Research (PEO, 1987). All data are taken from PEO 1987.

for the long term. The expanded and more efficient use of natural gas is seen as a suitable option in the transition towards a sustainable energy system.

Table 5: Novem Programme Budget[20]

	1986	1987	1990	1992	1995	1997
Programme budget [millions of US$ (1995 PPP)]	41	50	160	149 [155][21]	94 [103]	111 [125]
Rational energy use in industry	14 %	10 %	25 %	35 %	33 %	38 %
Rational energy use in transport	5 %	3 %	-	2 %	4 %	4 %
Rational energy use in the building sector	9 %	10 %	9 %	7 %	8 %	10 %
Appliances (e.g. heat pumps, fuel cells, CHP) / Long term technologies	15 %	7 %	11 %	9 %	9%	7 %
Coal (& Energy supply)	20 %	20 %	7 %	5 %	3 %	6 %
Wind energy	12 %	26 %	10 %	20 %	21 %	6 %
Solar energy	6 %	8 %	13 %	5 %	7 %	13 %
Reuse of waste heat	11 %	7 %	6 %	3 %	3 %	1 %
Energy from waste and biomass			6 %	2 %	4 %	5 %
Geothermal energy and heat storage in aquifers	6 %	8 %	1 %	1 %	< 1 %	< 1%
Environmental technology	-	-	4 %	3 %	2 %	3 %
De-Nox / low NOx turbines and motors	-	-	5 %	4 %	-	-
Measurement methods	-	-	-	-	1 %	1 %
Policy studies	4 %	2 %	3 %	3 %	5%	6 %

As mentioned earlier, the Committee Report and the White Paper on Energy induced an extensive analysis of the supply and demand side of Dutch energy R&D (Arthur D. Little and PA Consultancy, June 1997). The main conclusions stemming from this analysis are embodied in a Memorandum to the government on energy R&D priorities published by the Ministry of Economic Affairs (April 1998b):

- The quality of energy R&D in the Netherlands is generally good. However, both the efficiency of energy R&D and the "sustainable" character of the activities performed can be increased. The government believes (1) the organization of energy R&D should be improved, (2) the priorities in energy R&D should be formulated clearly to anticipate international agreements to reduce CO_2 emissions, (3) energy R&D programs should take into account the liberalization of the energy markets, and (4) the administration of energy R&D programs should facilitate decision-making in "buying" or "developing" new technologies.

[20] Data for this table are taken from Novem, various yearly reports.

[21] The figure in the bracket includes contributions from other public sources such as other Dutch ministries, by programs of the Paris-based International Energy Agency (e.g., Heat Pump Centre, GreenTie, CADDET Energy Efficiency) and the European Union.

- The Ministry of Economic Affairs will initiate foresight activities for new-long term energy R&D areas of interest.
- To stimulate energy R&D at universities (currently estimated at $35-40 million per year), the government will seek to foster greater coordination of university energy R&D (through NWO). The government intends to launch this "Stimulation Programme for University Energy R&D" early in 1999.
- Along these same lines, the government will seek to foster greater coordination among the semi-public energy research institutes. This is being done to reduce overlap and redundancies and to hopefully create synergy among the research projects carried out at these institutions. Even though the current liberalization of the energy sector is creating a rather dynamic and changing context for this industry, the Ministry of Economic Affairs is still attempting to formalize the role of the energy sector in setting priorities for energy R&D and in defining the role of semi-public and private research institutes that engage in energy R&D.
- The government will pay more attention to the non-technical – socioeconomic – aspects (so-called "gamma-research") of the deployment of new technologies (e.g., non-technical factors that influence diffusion of renewable energy technologies).
- Future energy efficiency R&D programs should emphasize more basic and more crosscutting research in areas such as advanced catalysts, biotechnology, advanced control of processes, and sensors.
- On the other hand, the increasingly decentralized and liberalized energy supply system implies that the focus of programs designed to commercialize energy technologies (e.g., renewable energy, energy efficiency, and energy infrastructure technologies) should shift from a component level to a system-level perspective.
- The government will step up its efforts to facilitate the introduction of (renewable) decentralized electricity generation and supporting technologies (e.g., grid stabilization, grid optimization, and storage).
- The government will initiate a new research program for the production and application of renewable synthetic gasses and fuels will be initiated (e.g., hydrogen, bio-gasses and bio-fuels/GAVE program). The budget for this new program will be approximately $20 million, supported out of the funds set aside for the intensification of climate policy initiative.
- The government will continue to support export-related activities for clean coal technologies, but will continue to reduce the budget for the further development of clean coal technologies.
- Although recognizing that a lack of public support makes it unlikely that the Dutch energy system will use nuclear power on any significant scale, the government will continue to support a level of nuclear R&D that will allow reintroduction of nuclear power if the need should arise.[22] The government will also continue to participate in international fusion research (application > 2050) for much the same reasons.
- The government will support a modest budget (approximately $2.5 million over the period 1998-2000) for supporting a private-public partnership for renewable energy.

[22] The government argues that it should maintain a nuclear energy R&D capability because of (1) the possible need to reintroduce nuclear power, (2) the possible occurrence of nuclear accidents elsewhere in Europe that would impact the Netherlands, (3) the obligation to take care of radioactive waste and the decommissioning of current nuclear plants, and (4) the spinoffs of nuclear energy R&D to medical research and pharmacology.

Quantitative Overview of Public Sector Energy R&D

Recently, two authoritative studies have mapped Dutch public and private sector energy R&D activities. These surveys help to shed light not only on the scale of the Dutch energy R&D effort, but also help describe who the major funders and performers of this energy R&D are.[23]

Table 6 shows the estimated support for energy RD&D from the Dutch national government, related EU contributions, and related contributions of the nongovernmental sector for 1995, 1996, 1997 (estimated).[24] Some interesting insights can be gleaned from Table 3 and from reports available on the state of Dutch energy R&D:

- Best available data suggest that the private sector's energy R&D investments are on par with the government's energy R&D budgets. The proportion is almost 50:50.
- The majority of the private sector's energy R&D investments are devoted to energy conservation.[25] Private sector investments also exceed those of the government in the area of power and storage technologies.
- In private R&D investments, 3.0% of the research was labeled energy R&D (CBS, September 1997).
- Private companies partner with another entity in over 30% of the energy R&D projects sponsored by the private firms; 90% of the time these private firms choose to partner with another private firm. However, the semi-public research institutes as TNO, KEMA, GasTec, ECN and NOVEM, as well as some of the larger national universities (Delft, Eindhoven, and Enschede) are also mentioned as significant partners for energy R&D projects (Senter, 1997).
- Funds from the EU comprise approximately 6% of the total energy R&D effort in the Netherlands (in 1997 approximately 10%). The EU's funds are largely concentrated in supporting fission-related research.
- Renewable Energy R&D, Nuclear Fission and Fusion, and the "Other" energy technology areas are predominantly financed by the public sector.

Table 6: Support for Energy RD&D in the Netherlands

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[23] The *first* survey, assessing Dutch governmental support to energy RD&D, was performed by Ecofys Energy & Environment (Utrecht). Novem financed the research project. All of the data in this section unless otherwise noted come from this first source (Struker and de Jager, 1998). It should be noted that these data cover *public* energy research, development and *demonstration* activities (RD&D). *Related* private and EU spending are also included. However, these categories are not complete. These data include a rather small amount of funding for technology deployment activities in addition to funds for R&D. Struker and de Jager (1998) estimate that approximately 95% of the total resources are spent on energy R&D activities; only 5% are devoted to demonstration projects. Most of the demonstration funds are spent in the energy conservation and renewable energy projects. The *second* data source was generated by Senter (Zwolle). Senter, one of the policy implementing agencies of the Ministry of Economic Affairs, has a database that tracks *private* R&D expenditures because of its role in implementing R&D fiscal stimulation programs (Senter, 1998). Both surveys *are currently being repeated (Personal communication, Mr. D. de Jager, Ecofys, February 1999).* It has yet to be determined the extent to which the energy RD&D projects covered in Ecofys' database are represented in Senter's database. A first explorative project is currently being performed to asses the overlap and/or the complementary character (Personal communication, Mrs. R. Bruel, Novem BV, February 1999).

[24] Research which is partly funded by government, induces expenditures of other sources. Nongovernmnetal expenditures are essentially private resources.

[25] This private sector dominance of energy efficiency R&D is also evident in the data collected by Senter. The Senter study reports that the private sector accounts for about 53% of all energy efficiency R&D in the Netherlands (Senter, 1997).

in millions of 1995 US Dollars[26]

	IEA – Energy Technology Classification	Public	Related EU	Related Private	Total
1995	A – Conservation	47.4	2.9	58.6	108.9
	B – Fossil Fuels	12.1	1.4	13.0	26.5
	C – Renewable Energy Sources	21.3	1.9	11.5	34.7
	D – Nuclear Fission and Fusion	19.1	4.3	3.4	26.8
	E – Power and Storage Technologies	14.2	2.4	18.8	35.4
	F – Other Cross-cutting Technology	16.6	1.9	10.6	29.1
	Total	**$130.7**	**$14.9**	**$115.7**	**$261.4**
1996	A – Conservation	50.5	2.8	79.3	132.6
	B – Fossil Fuels	12.6	0.9	11.4	24.9
	C – Renewable Energy Sources	21.6	2.8	14.2	38.7
	D – Nuclear Fission and Fusion	17.0	4.3	3.8	25.0
	E – Power and Storage Technologies	15.2	2.8	21.4	39.5
	F – Other Cross-cutting Technology	12.9	2.4	8.1	23.4
	Total	**$129.8**	**$16.1**	**$138.2**	**$284.1**
1997	A – Conservation	52.0	2.8	66.6	121.4
	B – Fossil Fuels	10.8	0.9	10.8	22.6
	C – Renewable Energy Sources	27.4	3.3	18.6	49.4
	D – Nuclear Fission and Fusion	18.0	4.7	2.8	25.6
	E – Power and Storage Technologies	14.4	2.8	22.0	39.3
	F – Other Cross-cutting Technology	14.7	3.3	10.3	28.3
	Total	**$137.4**	**$17.8**	**$131.3**	**$286.5**

Figure shows the distribution of governmental support to the major areas in 1997. The Struker and de Jager (April 1998) study help to shed light on how the government funds energy R&D (see also Figure 1 in Appendix 2).

- The Ministry of Economic Affairs finances approximately 65% of all publicly financed energy RD&D. The Ministry of Education, Culture, and Sciences funds 27% of Dutch public sector energy RD&D. The remaining 8% of public energy R&D support come from a number of other Ministries. The contributions of the different financiers of energy RD&D do not fluctuate very much over the three years covered (Struker and de Jager, April 1998).
- The vast majority of the energy R&D funds supplied by the Ministry of Education, Culture, and Sciences (22%) is used to support university based energy-research activities; 16% of the budget is funded directly, and 6% is channeled through NWO.
- Private sector entities perform approximately 30% of the publicly supported energy RD&D. Engineering and consultancy firms perform 5% of the public energy RD&D. Small to medium-sized firms (fewer than 500 FTEs) perform approximately 15%, while larger firms and utilities perform 7% and 3% respectively of the publicly supported research in the energy area.
- Novem distributed 46% of the public energy RD&D (Struker and de Jager, April 1998). In 1996, the largest share of Novem's program budget was allocated to small to medium sized industrial firms (<500 FTEs) (28%). Another 11% was allocated to larger firms (>500 FTEs). Respectively, 17% and 14% were allocated to semi-public research institutes (ECN

[26] Data are from Struker and de Jager, 1998. The figures for the European Union and the nongovernmental energy R&D programs represent figures related to the public spending on energy R&D and as such likely underestimate the energy R&D investments of these sectors.

and TNO) and to consultancies and engineering companies. Only 4% of Novem's budget is allocated to universities (Novem, 1997).

- In 1996 19% of Novem's program budget was allocated to policy and feasibility studies, 45% to technology development, 12 % to demonstration projects, and 24% to knowledge transfer and market introduction (Novem, 1997).

Figure 7: Distribution of Dutch Governmental Support to Energy RD&D by major Technology Area (1997)[27]

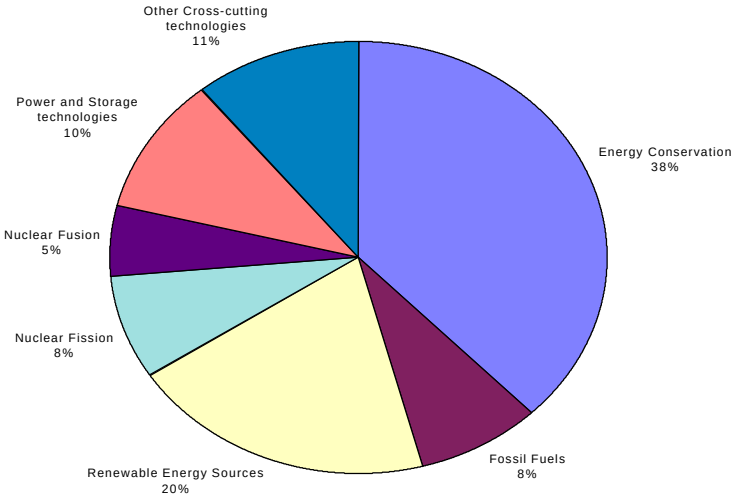

Table 5 shows the Dutch government's energy R&D investments over the past three years at a lower level of aggregation than what appears in Table 4. The data show that government support for energy RD&D increased from 1995 to 1997. Increases in the renewable energy R&D budget and in particular photovoltaic research largely account for this increase in the overall energy budget. The Dutch government's support for biomass and industrial energy efficiency research also received modest increases, while coal and light water reactor fission research saw reduced budgets.

Governmental support as reflected in these data has increased from 1995 to 1997. Renewable energy R&D is largely responsible for this.

[27] Data are from Struker and de Jager, April 1998.

Table 5: Support for Energy RD&D

	IEA – Energy technology classification [1995 US $]	1995 [million $]	1996 [million $]	1997 [million $]
1	Total conservation	47.4	50.5	51.6
1.1	Industry	28.2	32.7	31.7
1.2	Residential & services	7.0	7.5	8.3
1.3	Transportation	9.0	6.7	9.0
1.4	Other conservation	3.1	3.6	2.9
2	Total Oil and Gas	8.2	8.1	8.0
2.1	Enhanced oil and gas	3.5	3.4	3.4
2.2	Refining, transport and storage	2.6	2.6	2.6
2.3	Oil shale and tar sands	-	-	-
2.4	Other oil and gas	2.1	2.1	2.1
3	Total Coal	3.9	4.4	2.8
3.1	Production, preparation and	-	-	-
3.2	transport	1.1	1.8	0.3
3.3	Coal combustion	1.7	1.9	1.8
3.4	Coal conversion	1.1	0.8	0.8
	Other coal			
4	Total solar	11.2	11.8	15.8
4.1	Solar heating and cooling	1.0	0.3	0.4
4.2	Photo-electric	10.1	11.4	15.4
4.3	Solar thermal electric	-	-	-
5	Total wind	6.3	5.1	6.6
6	Total ocean	-	-	-
7	Total biomass	3.7	4.7	4.8
8	Total geothermal energy	0.05	0.05	0.1
9	Total hydro	0.05	-	-
10	Total nuclear fission	12.6	11.4	10.9
10.0	General	1.5	1.6	1.5
10.1	LWR	6.0	4.6	3.3
10.2	Other converter reactors	0.6	0.8	0.8
10.3	Fuel cycle	3.5	2.6	1.9
10.4	Nuclear supporting technology	1.0	2.0	3.4
11	Fusion	6.5	5.5	7.1
12	Total power and storage Technologies	14.2	15.2	14.4
12.1	Electric power conversion	10.7	10.8	10.4
12.2	Transportation, distribution and	3.3	4.2	3.8
12.3	storage	0.2	0.2	0.2
	Energy storage			
13	Total Other Crosscutting Techn. or Research	16.6	12.9	14.7
13.1	Energy systems analysis	6.4	7.0	7.1
13.2	Others	10.1	12.9	7.6
	Total	**130.7**	**129.8**	**137.4**