# Renewable heating and cooling in the Netherlands

### D3 of WP2 from the RES-H Policy project

### A report prepared as part of the IEE project "Policy development for improving RES-H/C penetration in European Member States (RES-H Policy)"

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## The RES-H Policy project

The project "Policy development for improving RES-H/C penetration in European Member States (RES-H Policy)" aims at assisting Member State governments in preparing for the implementation of the forthcoming Directive on Renewables as far as aspects related to renewable heating and cooling (RES-H/C) are concerned. Member States are supported in setting up national sector specific 2020/2030 RES-H/C targets. Moreover the project initiates participatory National Policy Processes in which selected policy options to support RES-H/C are qualitatively and quantitatively assessed. Based on this assessment the project develops tailor made policy options and recommendations as to how to best design a support framework for increased RES-H/C penetration in national heating and cooling markets.

The target countries/regions of the project comprise Austria, Greece, Lithuania, The Netherlands, Poland and UK – countries that represent a variety in regard of the framework conditions for RES-H/C. On the European level the projects assesses options for coordinating and harmonising national policy approaches. This results in common design criteria for a general EU framework for RES-H/C policies and an overview of costs and benefits of different harmonised strategies.

## This report

This report provides an overview of the current situation in one of these target countries/regions, specifically the Netherlands. It describes the structure and current state of the market for heating and cooling in the Netherlands and the levels of penetration of renewable heating and cooling technologies. Furthermore, policy and regulatory efforts adopted in support of RES-H/C are described and the associated levels of success are assessed.

Similar reports have also been prepared relating to the other countries/regions targeted within this project.

# Summary

## S.1 Introduction

ECN is a partner in the European research project 'RES-H Policy', an Intelligent Europe (IEE) project. The project aims to arrive at an interactive process for shaping a coherent and effective package of policy measures for enhancing the share of renewable heating and cooling in the national energy systems of a number of countries. This report is part of the results of the project, addressing the state of affairs of renewable heating and cooling in the Netherlands, i.e. the current share, expectations for the near future and experiences with policy.

## S.2 The share of renewable heating and cooling

Total energy consumption in the Netherlands amounts to 3232 $PJ_{prim}$ in 2006, which is used for the production of electricity and heat, as fuel for transport and as raw material. 1224 PJ of the total energy consumption, which is a share of nearly 40%, is used for heating. Heat demand is mainly covered by natural gas and heat from cogeneration. Heat demand can be calculated by making assumptions about the efficiency of the conversion into heat. In 2006, total final heat demand amounted to 1093 PJth. Nearly half of this amount was used for heat demand from industry and refineries, 25% for households, 20% for non residential building and 8% for agriculture.

The Dutch renewable heat production amounted to approximately 20 PJ in 2006, thus covering 1.8% of total heat demand. The updated reference scenario Energy and Emissions 2008-2030 of ECN and PBL (Daniëls, 2009) anticipates a renewable heat production increase to 30 PJ in 2020 (see Table S.1). The Dutch target for renewable energy (20% in 2020) is higher than the requirements from Brussels (14%). There is no separate target for renewable heating and cooling.

*Table 1 Current development of renewable heat production (2006) and expected development for 2020 based on currently known policy*[1]

| | Renewable heat production [$PJ_{th}$] | |
|---|---|---|
| | 2006 | 2020 |
| Solar thermal | 0.6 | 1.3 |
| Heat pumps | 2.2 | 7 |
| Heat/cold storage | 0.5 | 1.7 |

1 Deep geothermal is not included in Table 1 as it entails only 1 realized project after 2006 in greenhouse horticulture with a heat production of approximately 0.1 $PJ_{th}$.

| | Renewable heat production [$PJ_{th}$] | |
|---|---|---|
| Energy from waste | 3.5 | 7 |
| Co-firing biomass | 0.5 | 0 |
| Wood stoves | 7.1 | 7 |
| Other biomass combustion | 3.1 | 0.6 |
| Digestion | 2.4 | 6 |
| Total | 19.9 | 30.6 |

*Source: Statistics Netherlands, 2008; Daniels, 2009*

## S.3 State of affairs of various options and experiences with policy

This report describes the state of affairs of various options and the experiences with policy instruments used to incentivise renewable heating and cooling. By means of literature research and interviews ECN has mapped the experiences.

*Solar thermal*

Outside the Netherlands solar thermal systems are often custom made, but in the Netherlands they are factory made. The Dutch market focuses on small systems, standardization and economic optimization. Solar boilers have a long payback time of more than 15 years. Since 1998, policy has been implemented by means of grants, promotional campaigns and covenants. Grants are based on heat production, not on collector surface area, which is done to stimulate efficient systems. Grants have always had a temporary nature and were sometimes terminated abruptly in the past, as in the case of the Energy premium scheme. As a result of these developments the market is sitting on the fence. The covenants were successful in lowering the cost price, but not in upscaling the market. An imortant lesson learned is that marketing is very important. Installers have little eperience with solar boilers and hence will not recommend them right away. It was expected that energy performance standards for new housing would lead to an increase in solar boilers and heat pumps but the current standards are still feasible with less costly measures.

*Heat pumps*

Heat pumps entail various kinds of technology with respect to heat source, type of heat pump and delivery system. Parties consider each project to be made-to-measure and there are few standard solutions, which leads to high engineering costs. Suppliers of heat pumps are small businesses and heat pumps are only part of their portfolio. Integrating a heat pump in a building concept is crucial, because the capacity of the heat pumps will fall short if the quality of the building leaves much to be desired. As of 1995, policy focused on incentivising heat pumps by means of grants, public information and demonstration projects. Many installers are still unfamiliar with the technique. Selling points of the heat pump are: comfort (cooling, constant temperature), energy saving and a healthy indoor climate (air quality).

A new development in this area is the combination of a heat pump with a gas-fired high efficiency boiler, a hybrid system which holds a large potential in existing buildings. One advantage is the fact that ground source heat exchangers are not needed, as air is used as heat source. Large manufacturers with large R&D budgets are involved in this development.

*Heat/cold storage*

The market is characterized by a limited number of companies, which makes knowledge transfer easier. The branch is well-organized. Underground heat/cold storage is applied in large construction projects with few actors. Heat/cold storage is an efficient technique for large buildings with sufficient cooling demand. Several demonstration projects have been started since 1993. Policy has only subsidized feasibility studies. The only bottleneck is constituted by permit granting, which involves many management layers with demands that are not harmonized. The current groundwater act does not take heat/cold storage into account. Open systems require permits, whereas closed systems don't. The branch would prefer an obligatory permit for all systems, which is adjusted to the degree of complexity of a project. A taskforce on heat/cold storage is putting effort into reaching consensus to solve bottlenecks in legislation.

*Biomass*

Renewable heat from biomass involves several very different options: energy from waste, biomass co-firing in coal-fired plants, wood stoves in households and businesses, small-scale biomass combustion and digestion. Electricity production from biomass is incentivised by means of MEP (Environmental quality of electricity production) and SDE (renewable energy incentive scheme). In recent years there was no attention for heat utilization. SDE grants for new applications for new installations in 2009 will depend on heat utilization. Heat sales from waste and biomass plants require long-term planning. If heat buyers are not contacted in the planning stage, there will not be a market for heat by the time the installation enters into operation. As for digestion, there is little net heat supply from plants. In digestion in sewage water purification plants 50% of heat production is needed to keep the digestion process going. In manure digestion, heat utilization is limited to approximately 1% of all extracted biogas. Experience has taught that biomass combustion in a local integrated concept is difficult to achieve. Handling and process management of fuel flows other than clean wood (energy crops, pruning waste) is complex and difficult and not efficient with the current scale size and market prices. If demand for biomass increases, prices may also increase. A long-term option is the large-scale production of Substitute Natural Gas (SNG) from gasification of solid biomass flows (bio-SNG), but this will not be possible on a large scale and commercial basis until 2020. Before 2020 several pilot projects will most likely be conducted. .

*Renewable heating and cooling in industry*

Due to the heat demand profile in industry, the role of solar thermal is marginal; the temperature level and the power density are too low and the imtermittent character of solar heat supply makes this option less reliable. Because natural gas is amply available at the moment, there is no reason for industry to deploy biomass. There are some residual flows of biogenic nature, but these currents are more profitable if sold via routes other than energy generation. Opportunities lie in the integrated business areas. The main problem, however, is that industrial parties are not happy about the (energy) dependency that is thus created. Deep geothermal is an interesting option for industry: the temperature level and security of supply could be high. This option could be deployed for processes with a heat demand that is lower than 150°C, but it will have to compete with (fossil) residual heat.

## S.4 Conclusions

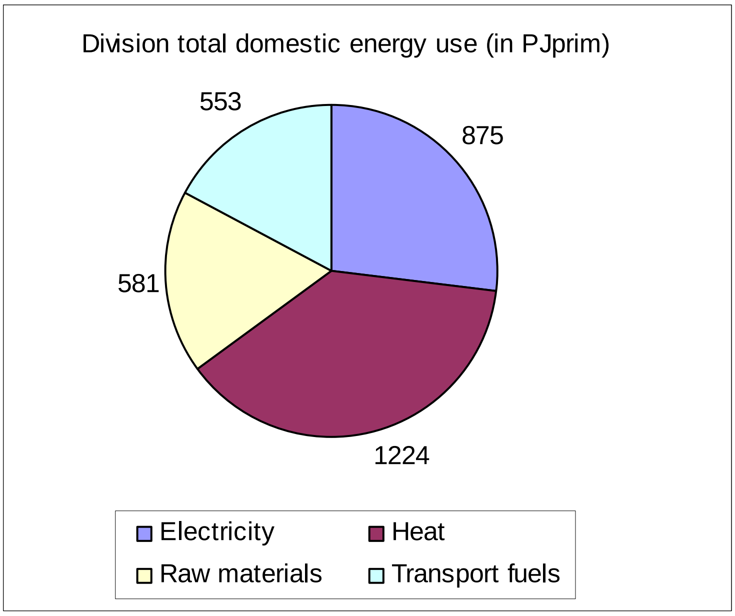
Experience has shown that stop-and-go policy is not good for the market, which needs stability of demand and market security. Standardization is a prerequisite for succes. A mix of policy and necessary conditions is needed. It takes more than good policy measures: all prerequisites must be favourable. In 2008, the Dutch cabinet presented the first integral policy programme for making heating and cooling demand more renewable (‘Warmte op stoom’ [‘Heat full steam ahead’], 2008). Although the memo only contained an elaboration of previously announced policy, the fact that renewable heating and cooling has been put on the agenda is beneficial.

# 1 Context/Introduction

## 1.1 Share of heat in total energy use

Total energy use in the Netherlands amounted to 3232 PJ in 2006. This energy was used for the production of electricity and heat, as a fuel for transport and as feedstock. Almost 1224 PJ, which is nearly 40%, was used for heating (see Figure 1.1.). Heat supply is the largest energy user in the Netherlands. Conservation, increasing sustainability of energy and efficient use of fossil fuels for heat supply thus have a large impact on total energy consumption and $CO_2$ emissions.

*Figure 1 Total domestic energy use for 2006 (3232 $PJ_{prim}$) distributed into deployment of energy carriers*




*Source: Statistics Netherlands (CBS) in consultation with the Expertise Centre for Heat SenterNovem*

## 1.2 Distribution of heat demand according to sector

In order to establish the potential for sustainable heating and cooling it is also important to establish the distribution of heat demand into sectors. In their energy statistics, CBS (Statistics Netherlands) only reports on final energy use of the various energy carriers such as natural gas, coal and oil to end users and the supply of heat from cogeneration. The Energy research Centre of the Netherlands (ECN) has calculated final heat demand for various sectors by adopting assumptions on the average efficiency of conversion into heat (see Appendix A).

In 2006, total final heat demand amounted to approximately 1093 PJ heat. Nearly half of this amount consists of heat demand for industry and refineries, 25% for households, 20% for non-residential buildings and 8% for agriculture.

Table 1 shows the total final heat demand in the Netherlands in 2006, including their $CO_2$ emission

*Table 2 Total heat demand in the Netherlands in 2006 and corresponding $CO_2$ emissions, calculated based on assumptions regarding conversion techniques used (see Appendix A)*

| | Heat demand [$PJ_{th}$] | $CO_2$ emissions [Mton] |
|---|---|---|
| Industry | 413 | 29 |
| *for the chemical industry* | *245* | *16* |
| *for the metal industry* | *52* | *5* |
| *For other industries* | *117* | *7* |
| Households | 280 | 19 |
| Agriculture | 89 | 6 |
| Non-residential buildings[1] | 206 | 14 |
| Refineries | 105 | 8 |
| TOTAL | 1093 | 74 |

[1] *Non-residential buildings is defined as the use in services (including environmental services) and construction.*

In Table 3, heat demand is broken down according to temperature levels. The largest share of heat demand is taken up by the category lower than 100°C (57%). This is mainly used for space heating in households and services (44% of total). Agriculture and horticulture take up 8% of total heat demand. Heat in this temperature range is usually generated with gas-fired boilers or CHP plants. From a technical viewpoint, heat pumps and deep geothermal could also be used in this segment. Heat demand in the segment 100-250°C only occurs in industry and is catered for by boilers and CHP plants. The next temperature level, 250-500°C, only occurs in industry and is generated by direct under-boiler firing and gas turbines. Temperatures above 500°C only occur in industry. All of these could also be generated with biomass.

*Table 3 Final heat demand in the Netherlands for the year 2006, broken down into sector and temperature level*

| Final heat demand [PJ] / Temperature in °C | Industry | *For Chemical Ind.* | *For Metal Industry* | *For Other Industry* | Households | Agriculture | Services | Refinery | Total |
|---|---|---|---|---|---|---|---|---|---|
| <100 | 53 | *12* | *8* | *33* | 280 | 89 | 206 | 0 | 628 |
| 100-250 | 71 | *27* | *0* | *44* | 0 | 0 | 0 | 0 | 71 |
| 250-500 | 84 | *66* | *3* | *15* | 0 | 0 | 0 | 45 | 129 |
| 500-750 | 51 | *51* | *0* | *0* | 0 | 0 | 0 | 49 | 100 |
| 750-1000 | 69 | *64* | *5* | *0* | 0 | 0 | 0 | 0 | 69 |
| >1000 | 85 | *25* | *36* | *24* | 0 | 0 | 0 | 11 | 97 |
| Total | 413 | *245* | *52* | *117* | 280 | 89 | 206 | 105 | 1093 |

*Source: Estimate ECN*

## 1.3 Cooling demand

*Households*

Only 6% of all dwellings has an air conditioning system (airco) (Van Holsteijn and Kemna, 2008), approximately 1% has a split airco (900W, 320 hours of operation), 5% has a single portable unit (450W, 184 hours of operation). According to estimates, they use 1000 million kWh of electricity in total (i.e. 0.4PJ electricity). The actual cooling demand is probably higher but is not yet provided for. The coefficient of performance (COP) is approximately 3, with a cooling demand of 1 PJ.

In addition, households use on average an estimated 600 kWh of electricity for cooling and freezing equipment (Van Holsteijn and Kemna, 2008). With 7 million households this amounts to a total use of 4200 million kWh, i.e. 15 PJ electricity. With a COP of 3 this amounts to 45 PJ for cooling.

*Non residential building*

In non residential building the number of cooling installations is much higher, varying from 22% in education to 81% in hospitals (see Table 4).

Space cooling in non-residential buildings takes up approximately 13 PJ electricity and 3 PJ natural gas and total cooling demand is 54 PJ (source: model ECN SAVE Utiliteit 2005). In addition, 5 PJ electricity is used for product cooling in supermarkets, which leads to a cooling demand of 15 PJ.

*Table 4 Ownership of cooling units non-residential buildings*

| | Ownership cooling units 2007 |
|---|---|
| Office buildings | 58% |
| Education | 22% |
| Shops | 47% |
| Hospitals | 81% |
| Nursing and care | 33% |

*Source SenterNovem Energiedata Utiliteitsbouw 2007*

*Industry*

Industry only has cooling demand in specific sectors such as the dairy industry, which is part of the food and luxury foods industry. 25% of total electricity demand in the dairy industry (3 to 4 PJ electricity) is used by cooling (1 PJ electricity); with a COP of 3, this means a cooling demand of approximately 3 PJ (Alsema, 2001).

*Greenhouse horticulture*

Despite the moderate Dutch climate, temperatures in greenhouses rise to adversely high levels in summer. In this situation the windows in the greenhouse are usually opened maximally and shadow screens, if present, will be shut. For most crops the adverse effects of the high temperatures are not significant enough to justify investing in cooling systems though.

Yet cooling demand is increasing in greenhouse horticulture. In the past, cooling was mainly used for cultivation of Freesias and Alstroemerias. These crops require ground cooling, leading to a cooling demand of 200 to 300 MJ per $m^2$ per year. Cooling is a prerequisite for being able to cultivate Freesias and Alstroemerias throughout the year (Zwart, 2004). Approximately 191 ha are dedicated to Freesia cultivation (data from 2004). With an electricity use of 300 MJ per $m^2$ cooling demand amounts to 0.6 PJ per year. If Alstroemerias cover the same area of cultivation, cooling demand will amount to 1 PJ.

In recent years greenhouse air cooling has been increasing. A concrete example of use is the Phalenopsis. In strawberry cultivation there is much interest in cooling greenhouse air at night. The largest need for cooling arises in closed greenhouses, which are currently under development and subjected to testing. In these situations, cooling demand amounts to approximately 2000 MJ ($m^2$ year). Cooling enables keeping the greenhouse closed, thus realizing a production increase of around 20%. An increase in closed greenhouses will therefore also imply an increase in cooling demand.

*Table 5 Final cooling demand in the Netherlands for the year 2006, broken down into sector and temperature level*

| Final cooling demand [PJ]<br>Temperature in °C | Industry | Households | Agriculture | Non-residential building | Total |
|---|---|---|---|---|---|
| +10 to +15 | 0 | 1 | 1 | 54 | 56 |
| +10 to -30 | 3 | 45 | 0 | 15 | 63 |
| < -30 | 0 | 0 | 0 | 0 | 0 |
| Total | 3 | 46 | 1 | 69 | 119 |

*Source: Estimate ECN*

# 2 The heat market

## 2.1 Energy carriers and conversion techniques

Aspects that are important for the options of sustainable heating and cooling are also how current heat and cold demand is catered for, which energy carriers are used and which conversion techniques. Table 3 provides an overview of the primary energy consumption from the energy balance that can be attributed to heating. The first column concerns cogeneration and the other columns concern boilers.

Heat supply takes up a share of nearly 40% of energy consumption in the Netherlands. Remarkably, natural gas and cogeneration also play a large role.

*Table 6 Primary energy consumption for heat to energy carriers and conversion*

| | Heat from cogeneration | Biomass and waste and heat non-cogeneration | Coal | Natural gas | Oil | Total |
|---|---|---|---|---|---|---|
| Industry | 138 | 13 | 22 | 214 | 198 | 584 |
| Households | 3 | 14 | 0 | 302 | 4 | 323 |
| Agriculture | 16 | 0 | 0 | 67 | 2 | 84 |
| Non residential building | 6 | 21 | 0 | 201 | 3 | 232 |
| Total | 163 | 48 | 22 | 784 | 207 | 1224 |

## 2.2 Dwellings

The total number of dwellings in the Netherlands in 2006 amounted to 6.9 million, new housing delivers 70,000 dwellings per year, which is 1% of stock, and 20,000 dwellings are demolished every year. All dwellings built before 1980 are not insulated. After 1980 floor insulation (Rc-value=0.6), cavity wall insulation and roof insulation (Rc=1.3) were applied on a small scale. After 1995, the building shell became better insulated (Rc=2.5). It was not until after 1980 that new dwellings were provided with double glazed windows. In the mean time, previous construction year classes have partly been provided with double glazed windows. The average U-value amounts to 3.5, which means that approximately 20% of all dwellings still has single glazed windows and 80% has double glazed windows or HR glazing.

For space heating, 85% of all dwellings in 2006 is provided with an individual central heating system with a gas-fired boiler, 9% is connected to collective heating or district heating and 6% is heated with local heating from stoves (source: HOME 2007).

More than 70% has a combi-boiler which caters for both space heating and for warm tap water. In 5% of all dwellings an electric boiler is used for warm tap water for shower or bath. 10% of all dwellings also has an electric kitchen boiler. The remaining dwellings are provided with warm tap water via district heating or via gas-fired boilers or geysers.

*Table 7 Division of dwelling stock into type of dwelling and year of construction*

| Type of dwelling | Construction year class | Number |
|---|---|---|
| Detached | before 1930 | 226.306 |
| | 1931-1959 | 218.522 |
| | 1960-1980 | 237.553 |
| | 1981-1995 | 189.717 |
| | after 1995 | 148.418 |
| | Total | 1.020.516 |
| Semi detached/corner | before 1930 | 98.827 |
| | 1931-1959 | 178.608 |
| | 1960-1980 | 235.155 |
| | 1981-1995 | 221.233 |
| | after 1995 | 135.770 |
| | Total | 869.593 |
| Terraced house | before 1930 | 375.056 |
| | 1931-1959 | 535.553 |
| | 1960-1980 | 1.031.761 |
| | 1981-1995 | 757.959 |
| | na 1995 | 328.178 |
| | Total | 3.028.507 |
| Multiple family | before 1930 | 212.896 |
| | 1931-1959 | 443.748 |
| | 1960-1980 | 641.886 |
| | 1981-1995 | 428.876 |
| | na 1995 | 266.383 |
| | Total | 1.993.789 |
| Total | | 6.912.405 |

## 2.3 Non residential buildings

More than half of the dwelling stock consists of office buildings with a gross floor area of more than 5000 $m^2$. 81% of the 60,000 offices are let by institutional investors and real estate funds. These constitute a hard to reach target group because energy expenses are often transferred directly to the tenant. Contrary to dwellings, the lifespan of offices is often relatively short. Every 10 to 15 years, offices are refurbished to meet the demands of the tenant.

*Table 8 Number of buildings in Dutch non-residential building*

| Market segment non residential | No buildings | Remarks |
|---|---|---|
| Offices | 60.000 | 81% let |
| Education | 13.700 | |
| Hospitals | 128 | |
| Nursing and care | 1300 | |
| Shops | 144.000 | 79% let |
| Corporate hallways | 101.000 | |
| Indoor swimming pools/combi swimming pools | 490 | 36% managed by municipalities |
| Hotels/conference facilities | 2.400 | |
| Restaurants | 9.585 | |
| Indoor sports facilities | 2.160 | 46% managed by municipalities |

*Source: Ecofys (2007) Sustainable heat and cold 2008-2020: potential, barriers and policy [Duurzame warmte en koude 2008-2020: potentiëlen, barrières en beleid]*

Table 8 provides an overview of the techniques used for heating. About 80% of the buildings are heated with a gas-fired boiler, 4% are sustainable with heat/cold storage and heat pumps, 3% are connected to district heating, 5% have individual cogeneration and the remaining 8% is not heated or the conversion techniques are not identified. The applied techniques vary per type of building. 50% of all hospitals use cogeneration for their emergency power supply. The category 'shops food', includes buildings such as supermarkets, one one third do not have heating.

*Table 9 Techniques used for heating*

| How is the building heated? [%] | Hospitals | Nursing and care | Offices | Educa-tion | Shops food | Shops non food | Total |
|---|---|---|---|---|---|---|---|
| Via district heating | 5 | 3 | 4 | 4 | 3 | 3 | 3 |
| Only by means of boiler in building | 26 | 79 | 87 | 87 | 56 | 77 | 80 |
| Cogeneration is used | 44 | 9 | 2 | 1 | 0 | 2 | 4 |
| Heat/cold storage | 8 | 1 | 2 | 2 | 0 | 0 | 1 |
| via heat pump | 0 | 3 | 1 | 4 | 1 | 2 | 3 |
| Heat/cold storage and co-generation | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Cogeneration and heat pump | 5 | 3 | 0 | 0 | 3 | 0 | 1 |
| Building heated by other system | 5 | 0 | 2 | 0 | 3 | 9 | 3 |
| Building is not heated | 0 | 0 | 0 | 0 | 34 | 5 | 3 |
| Combinations | 8 | 0 | 1 | 2 | 0 | 3 | 2 |
| | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

*Source: SenterNovem Ubouw panel 2008*

## 2.4 Institutional set up of the market

The information in this paragraph is based on interviews with experts in heating in the Netherlands (see Appendix B).

Sustainable heat options serve only a small segment of the market. Installers will often advise against sustainable options because they have little or no experience with them.

Since the late 1980s the starting point was adopted that solar boilers are only an option when used for the production of warm tap water. The share of gas-fired combination boilers is already quite large and integration of the solar boilers with these gas-fired combination boilers becomes important. Large boiler manufacturers also become suppliers of solar boilers. A disadvantage is constituted by the fact that boiler manufacturers are competing for their market share by binding housing corporations and installers. Their consumer marketing is poor.

Outside the Netherlands, solar thermal systems are custom made; in the Netherlands they are factory made. The Dutch market has focused on small systems, standardization and economic optimization.

Heat pumps entail various technologies such as heat source, heat pump type and output system. Parties consider each project as tailor-made work and there are few standard solutions which lead to high engineering costs. There are no design guidelines or quality demands. The government does not consider this to be their responsibility. For many manufacturers, the heat pump is only a small part of their portfolio. The branch is subdivided and there are various platforms that support the interests of a certain type of heat pump. For existing construction, hybrid solutions (combination with high efficiency boiler) hold a large potential. The heat pump can also be added at a later stage. Among the manufacturers of hybrid systems, there are large foreign air conditioning manufacturers with large R&D budgets.

An important aspect for successful implementation of renewable energy in the built environment is the quality of construction. Especially in the case of heat pumps, a poor design or poor construction of a building or dwelling may lead to a high energy use and energy costs. This may constitute an implementation barrier (Egger 2009).. An interesting market initiative is the Groenwoning (Green dwelling), in which high quality is pursued by means of improved cooperation and monitoring during the various stages of construction and by influencing user choices, and certified if the performance is evident. This results in a healthy, comfortable and energy efficient dwelling with guaranteed performances (Groenwoning 2009). Many suppliers in the market advertise themselves as high quality builders. There are leading edge players, but the majority of the construction and installation branch are not that advanced.

Waste incineration plants (AVIs) are mainly designed for disposal of waste and are located near dumping sites, far away from urban areas. Biomass is co-combusted in coal-fired plants that are located near harbours for logistic purposes and not near urban area's either. Heat utilisation is therefore difficult.

Biomass incineration is often considered as sustainable energy generation that is incentivised via MEP (Environmental quality of electricity generation) or SDE (Renewable Energy Incentive Scheme) subsidies. Heat utilization is taken into account at a much later preparatory stage of a project.

Heat supply to households (district heating) is increasing, which is usually the result of expansion of existing heat grids, often on new housing locations and in accordance with long term contracts with electricity plants.

Ideas on sustainable heat from biomass originate from independent transition platforms, as for example the co-production of chemicals, transport fuels, electricity and heat and the production of SNG (synthetic natural gas) for the natural gas infrastructure. The platforms raise interest and stimulate research.

The standard for energy supply in the Netherlands is natural gas, offering many advantages: it is clean, requires only a low cost installation boiler and does not require a flue gas cleaning system. When deploying biomass, for instance, these characteristics do not apply. Therefore the industry does not have any reasons for using biomass instead of natural gas. Some residual flows are available in the biogenic industry, but these flows yield more when sold to other routes than the energy generation route. There are opportunities for integrated business areas. The problem of the energy dependence that is thus created, however, is that this is unwanted by the industrial parties.

# 3 The cold market

The information in this chapter is based on interviews with experts in the field of heating and cooling in the Netherlands (see Appendix B).

## 3.1 Cooling from sustainable sources

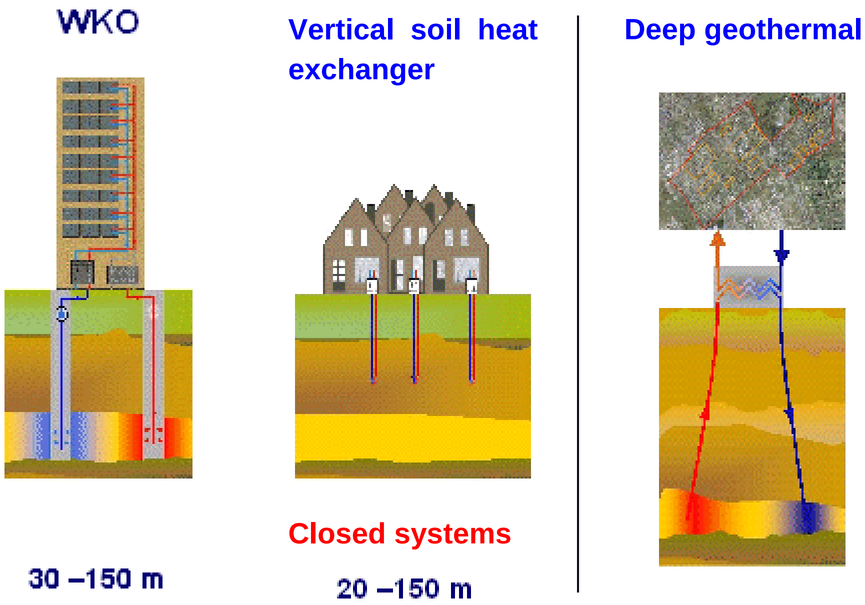
Generation of cooling from renewable sources in the Netherlands is usually done with two types of systems: heat and cold storage (HCS) and energy from surroundings via heat pumps. Other options are cooling via solar thermal energy or residual heat or free cooling using outside air. The first two options are barely used in the Netherlands. Cooling with outside air is a more regularly used option, but is not considered as renewable energy. This paragraph therefore focuses on heat and cold storage with heat pumps. Heat and cold storage and cooling by means of heat pumps make use of energy storage in the soil.

The principle of operation of energy storage in the soil is simple. Cold and/or heat are stored in an aquifer. By means of wells the groundwater from the aquifer can be pumped up and infiltrated back into the aquifer. In winter, cold is stored in a cold well at a temperature of approximately 8°C. In summer, cold groundwater is pumped up from the cold well and used for cooling buildings or processes. The groundwater absorbs heat from the cooling circuit in the building and is infiltrated in the warm well at a temperature of approximately 15 to 20 °C. The groundwater circuit and the building circuit are separated by means of a heat exchanger. Cooling with stored cold takes up only 10% of the capacity of a cooling machine. Combined with the electricity used for loading, cold savings of up to 40-80% in electricity use for cooling are possible, compared to a cooling machine. Heat/cold storage combined with a heat pump can lead to savings of up to 50% for heating and cooling compared to classic installations consisting of a boiler and cooling machine. From a technical viewpoint three types of systems are distinguished (see also Figure 2).

1) Open systems (heat/cold storage, heat/cold storage)
2) Vertical soil heat exchangers (closed system)
3) Deep geothermal

In system 1 (the open systems for heat/cold storage) groundwater is used as the energy carrier for heating and cooling. Afterwards, the groundwater is injected back into the soil. Closed systems or vertical soil heat exchangers (system 2) consist of pipes or tubes that are inserted into the soil for water circulation. Energy exchange between water in the pipes and the surrounding soil takes place by means of thermal conduction. In deep geothermal heat from groundwater at large depths is utilized. The temperature of ground water at depths of more than 2 kilometres varies from 40°C to 120°C.

*Figure 2 Various types of energy storage*




*Source: NVOE*

The table below compares several aspects of these three systems.

*Table 10 Overview of various systems with underground energy storage*

| | Heat/cold storage | Vertical soil heat exchangers | Deep geothermal |
|---|---|---|---|
| Type of application | Cooling or cooling and heating, often with heat pump | Heating and cooling with heat pump | Only heating |
| Market sectors | Non residential building, greenhouse horticulture, house-building | House-building, small non-residential building | House-building, greenhouse horticulture, industry |
| Minimal scale size | Building > 2.000 m2, 50 dwellings, cooling capacity >100 kW | 1 dwelling | 2500 dwellings, heat demand > 2 million m3 natural gas |
| Depth in the soil | 30-150 meter | 20-150 meter | 1500-5000 meters |
| License | Groundwater Act | License (not yet) required | Mining Act |
| Energy saving | 50-80% in cooling, 30-50% in heating, 50% in their combination | 30-50% in heating and cooling | 60-70% in heating |

*Source: NVOE*

## 3.2 Applied techniques for cooling

Only half of all non-residential buildings in the Netherlands have space cooling (see Table 10). Usually a compression cooling machine is used for this purpose. Only 3% of the non-residential buildings have a heat pump or heat and cold storage for cooling. The share of hot and cold storage is largest in hospitals (see Table 2). Various projects have started in this sector: hospitals manage their own buildings and managers are willing to try new techniques. When it became apparent that this was also efficient for large buildings, project developers started asking for it and the option was implemented in offices.

A limited number of companies are involved in the projects (IF technology, DWA, Haijtema) resulting in a small network and thus facilitating knowledge transfer. Moreover, large scale contruction projects are involved with a limited number of actors.

The branch is well organized, arranges its own trainings and has established quality requirements and design guidelines. Legislation and regulation is a major bottleneck. It is complicated because several management layers and departments are involved: the state, provinces, district water boards and both the Water Act and spatial planning play roles.

*Table 11 Type of cooling installation non-residential building*

| [%] | Hospitals | Nursing and care | Offices | Education | Shop food | Shop non food | Total |
|---|---|---|---|---|---|---|---|
| Compression cooling machine | 36 | 22 | 27 | 9 | 33 | 14 | 19 |
| Absorption cooling machine | 10 | 6 | 4 | 6 | 3 | 2 | 5 |
| Heat pump | 3 | 0 | 2 | 0 | 0 | 3 | 1 |
| Other | 5 | 6 | 11 | 5 | 3 | 4 | 6 |
| A combination | 18 | 2 | 6 | 2 | 0 | 3 | 3 |
| Unknown | 8 | 6 | 18 | 5 | 3 | 17 | 10 |
| Heat/cold storage | 10 | 2 | 2 | 2 | 0 | 0 | 2 |
| No cooling | 10 | 56 | 29 | 71 | 58 | 58 | 53 |
| | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

*Source: SenterNovem Utiliteitsbouw panel 2008*

# 4 Renewable heating and cooling (Current Status of Renewable Energy Sources of Heating and Cooling in territory)

## 4.1 Objective

Early in 2007, the current Dutch cabinet formulated ambitious targets for energy and climate policy in their Coalition Agreement. The intended reduction of greenhouse gases amounts to 30% in 2020 compared to 1990. Moreover, the pace of energy saving will be increased from 1% to 2% every year and the share of renewable energy will be increased from 2% to 20% in 2020. There is no separate target for renewable heating and cooling.

## 4.2 Current production of renewable heating and cooling.

Table 4 provides an overview of renewable heating production. Compared to total heat demand in the Netherlands this share is less than 2%.

*Table 12 Production of renewable heat in 2006*

| | Renewable heat* [TJ] |
|---|---|
| Solar thermal | 599 |
| Heat pumps | 2240 |
| Underground storage of heat/cold | 547* |
| Energy from Waste (EfW) | 3537** |
| Biomass co-firing in large plants | 469 |
| Biomass stove in households | 5191 |
| Biomass boiler in industry | 1930 |
| Other biomass combustion | 3078 |
| Biogas from digestion | 2370 |
| Total | 19961* |

* *Includes cooling for underground storage of heat/cold*

** *This figure refers to the biodegradable share, which is 47% of total EfW*

*Source: Statistics Netherlands, CBS*

**Expected market developments**

In the Updated Reference projections energy and emission 2008-2020, ECN (Daniels, 2008) indicates which developments in renewable heating and cooling production are anticipated based on current policy (see Table 13).

*Table 13 Development of sustainable heating and cooling production according to the update of the projections*

| Heating production in PJ | 2006 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| solar thermal | 0.6 | 0.9 | 1.1 | 1.3 |
| heat pumps | 2 | 4 | 5 | 7 |
| heat/cold storage | 0.5 | 1 | 1.3 | 1.7 |
| Biomass total | 17 | 28 | 30 | 20 |
| Energy from Waste (EfW) | 3.5 | 7 | 7 | 7 |
| co-firing biomass | 0.5 | 0.7 | 0 | 0 |
| wood stoves | 7 | 7 | 7 | 7 |
| Other biomass combustion | 3 | 1.8 | 2.0 | 0.6 |
| digestion | 2 | 12 | 14 | 6 |
| **Total** | **20** | **34** | **37** | **30** |

*Source: (2006 data provided by Statistics Netherlands (CBS), 2010-2020 data provided by ECN)*

The number of solar boilers in households continues to increase at the same pace as in the period 2000-2005. An additional 50,000 solar boilers are to be subsidized by the renewable heating grant scheme in the period 2008-2011. The number of heat pumps in new housing is planned to increase (from 1% to 6% of new houses in the period 2012-2020). The projections do not anticipate an increase in heat pumps in existing buildings. A trend wise growth is assumed for heat/cold storage, including cooling production.

Energy from waste provides a large contribution to heat production from biomass. Before 2010 a new waste incineration plant will be put in operation, after which the capacity and heat supply of waste incineration plants remains constant. Biomass co-firing in coal-fired plants was incentivised by means of the MEP (Environmental quality of electricity production), but no longer in the current SDE (renewable energy incentive scheme). When the MEP comes to an end in the period 2010-2015 grant budget will no longer be available. The update of the projections assumes that co-firing of biomass in coal-fired plants will no longer be cost-effective. Compulsory biomass co-firing is considered as a policy instrument, but has not been included in the update of projections. There is little information on wood stoves in households and industry. The reference projections assume a constant heat production. A distinction should be made between domestic fireplaces and wood stoves in businesses as for example in the wood and furniture industry (increased between 2005 and 2006). Only industrial wood stoves can be regarded as truly sustainable and are worth incentivising.

Small scale biomass incineration and manure digestion are subsidized by the MEP. After 2015, when the scheme ends, these projects will no longer receive grants. IN the update of the projections ECN has assumed that the lack of budget for new SDE projects in the period 2015-2020 will shift grants to cheaper options such as offshore wind. In digestion, landfill gas production will also decrease because no new combustible waste will be dumped.

The Statistics Netherlands data for 2006 already indicate 3 PJ of heat production from small scale biomass combustion. The ECN projections update assumes 0 PJ, because only the MEP and SDE schemes were considered. The biomass combustion that is observed by Statistics Netherlands concerns projects that are probably conducted without MEP or SDE grants, as for example installations that produce only heat.

Beside Daniëls et al (2009) other references can be found that make statements about the future development of renewable heating and cooling in the Netherlands. However, all these reports assume intensification of policy, which will lead to extensive growth of renewable heating and cooling. Because this section only provides an indication of the development based on current policy other sources of literature are not discussed here. Within the framework of the RES-H Policy project another report lists all available studies for the Netherlands (Kranzl, 2009).

# 5 Historical and ongoing policies that have been applied to the support of RES-H and RES-C

## 5.1 Solar thermal

In 2006 the installed collector surface area amounted to 646,000 $m^2$. Solar boilers are the best known application, but the market for large systems for swimming pools is larger with regard to collector surface area. The number of additionally installed [bijgeplaatste] solar boilers increased from 500 in 1990 to 10,000 anually in 2002, but dropped to 5600 in 2006. The additonally installed collector surface area of large systems increased from 2000 $m^2$ in 1990 to 28000 $m^2$ per year in 2002, after which it dropped to 13000 $m^2$ in 2006.

Below an overview is provided of implemented policy for solar thermal systems:

**1988: start of the first grant scheme for solar boilers**

The grant amounted to a maximum of 40% of the investment with an annual budget of 7 million Dutch guilders. As of 1991, the grant amounted to 700 Dutch guilders per installed collector surface area with a maximum of 4 $m^2$.

**1990: Target solar boilers in the Memoradum on Energy Conservation**

The Memorandum on Energy Conservation contains a target of 300,000 solar boilers in 2010. The Dutch Ministry of Economic Affairs did not see the need for further study of solar thermal and did not make any finance available. The Novem programme Solar thermal should specifically concentrate on market introduction. Based on this starting point, Novem developed a marketing strategy for the period until 1994. In 1991, the Solar Boiler Campaign was launched.

**1991: Start of the Solar Boiler Campaign**

The main targets were the recently established new distribution companies. In the framework of the MAP (Environmental Action Plan) these companies agreed with the Dutch Ministry of Economic Affairs to make a contribution to the environment and the solar boiler was one of the options. In the following years, energy companies accounted for 80% of the annual sales of solar boilers and are thus the largest group of buyers of solar boilers.

**1993/1994: Stabilisation of the market**

Althought the number of installed solar boilers increased from several hundreds in the early 1990s to more than 2000 annually, a stabilisation occurred in 1993 and 1994. The main reason was that budgets were running out increasingly earlier. The Dutch Cabinet planned on cancelling the grant. In 1993 and 1994 the BSET (The energy conservation and technologies grant scheme ) for solar boilers was continued but with increasingly lower amounts per $m^2$.

### 1994: Long term Agreement solar boilers signed

On February 3rd 1994, EnergieNed, five distribution companies, the solar energy industry, the Dutch Ministry of Economic Affairs, Novem and Holland Solar signed a long term agreement in which the industry promises to work on lowering the cost price (incl. installation, excl. VAT) of a solar boiler from 3850 guilders in 1991 to 2350 guilders in 1997. The distribution companies strive to increase the installation speed from 1800 to 14000 per year. Novem will provide financial support for involved energy companies in the framework of the National Research Programme Solar energy. Novem and Holland Solar jointly continue the solar boiler campaign. In addition, a quality certificate is developed. Up to 1997, the Dutch Ministry of Economic Affairs provides an annual amount of 7 million guilders for subsidizing the purchase of solar boilers. Afterwards, the solar boiler is expected to pull its own weight on the market. As of 1995, the grant is related to energy efficiency instead of the collector surface area of the solar boiler. Due to growing demand, increasing efficiency of production methods and product innovation, the prices of solar boilers decreased. In 1991, the price of an installed solar boiler amounts to 3800 guilder; by the end of 1995 it is already less than 2900 guilders. The solar boiler manufacturers thus seem to be ahead of the agreements that were made in the framework of the long term agreement. A further decrease of the price of solar boilers is necessary, though. As of 1998, the solar boilers must be put on the market in large quantities without grants from the Dutch Ministry of Economic Affairs.

### 1995: Third Energy memorandum published

The publication of the Third Energy memorandum results in renewed attention for renewable energy. Indicative targets are increasing: 80,000 solar boilers in 2000 and 400,000 in 2010. The grant for buying solar boilers, which was to end in 1997, will be continued until the end of 2000. As of 1998, the Dutch Ministry of Ecnonmic Affairs increased this grant scheme from 6 million to 8 million guilders per year. However, as the extension of the grant scheme was not published until November 1998, the amount of subsidy applied for in 1998 amounted to 2 million guilders only.

### 1999: Long term agreement becomes covenant solar boilers

Together with the Dutch Ministries of Economic Affairs and Housing, Spatial Planning and the Environment, more than thirty parties commit themselves to the application of solar boilers in the Netherlands by signing the Covenant Solar Boilers. The Covenant is a successor to the Long Term agreement Solar Boilers that ended in 1997. The signing of the Covenant took place a year later than planned, because it took great effort to bring it in to accordance with the competitive trading act and European legislation. Thirteen producers of solar boilers dedicate themselves to improving the quality of the boilers, whereas the Netherlands Association of Installation Companies VNI will focus on the quality of the installation. Thirteen affiliated energy companies have an obligation of best intent to install 40,000 solar boilers in 2000 and nearly 65,000 until 2002. The covenant runs to 2001 with the option of extension to 2007. Ultimately, a solar boiler market will have to emerge that will make the target of 400,000 solar boilers in 2010 feasible.

**2000: Government target not achieved**

The target for 2000 (80,000 solar boilers) is not achieved. It was expected that the energy performance standard for new housing would automatically lead to their installation. Moreover, the MAP contribution that was used by distribution companies to finance solar boilers was stopped in 2000. In addition, the high efficiency boiler has become a significant competitor for the solar boiler.

**2001: Dutch Ministry of Economic Affairs opts for biomass and wind, 2002 end of covenant**

In their explanation of the national budget for 2002, the Dutch Ministry of Economic Affairs describe their ‘new strategy’ for renewable energy. This is the result of a “reconsideration” of the government targets in view of factors influencing renewable energy. The target entails 10% renewable energy in 2020, with an intermediate target of 5% in 2010. As for Dutch electricity use, a share of 9% in 2010 and 6% in 2005 is envisaged.

This new strategy means that national policy will have to give more priority to renewable energy options that can provide the largest contribution to the 10% target in 2020. According to the ministry these are electricity from offshore wind and biomass. Concretely, the ministry will be in control of the development of wind parks at sea and various biomass options will be examined, with an unabatedly important role for co-firing of biomass in coal-fired plants.

According to the ministry other renewable sources such as solar boilers, photovoltaic cells and heat pumps are not expected to make a substantial contribution until after 2020. This means that these sources will no longer receive specific support. The covenants for the market introduction of these sources between government and market parties will not be continued after they expire “in view of their limited effectivity in terms of people/resources”. In 2002 the covenant for solar boilers is terminated.

**2001-2003: Energy premium scheme**

As of 1 January 2001 the energy premium scheme (EPR) is expanded. Apart from energy saving measures, the scheme also entails measures for renewable energy for domestic use, such as PV systems, solar boilers and heat pump boilers. In 2003, the EPR grant is terminated. The effect for the solar boiler market is limited, because new housing could not use the EPR and they constitute the main segment of the market for solar boilers. After the EPR is terminated the market relapses: the Netherlands are the only country with a decreasing market for solar boilers. The temporary arrangement for $CO_2$ reduction for the built environment led to only a limited effect on the market. The tighteng of the Energy Performance Coefficient (EPC) to 0.8 also has little effect on the market. The main reason is that the EPC of 0.8 can easily be achieved with less costly techniques.

**2008: Clean and efficient**

In the framework of the energy and climate targets of the current cabinet, as described in the working programme ‘Clean and Efficient’, a new grant scheme for solar boilers in existing housing started in September 2008). In the first year for small solar boilers with a collector surface area of up to six square metres the grant will amount to 200 euro per GJ calculated on projected output.. For larger solar boilers the grant amounts to 180 euro per GJ. For the most common solar boiler this results in an average grant of 600 to 1000 euro. There is sufficient grant budget to subsidize between 50,000 and 60,000 solar boilers in four years time.

## 5.2 Heat pumps

In 2006 the installed capacity amounted to 831 $MW_{th}$. The number of heat pumps increased by more than 10,000 to 50,000 in total. 6400 of these 10,000 pumps are reversible heat pumps in non residential building and agriculture, which are mainly purchased because of their ability of cooling. Moreover, 2000 heat pump boilers are used in households and 500 heat pumps for heat recovery in milk cooling. The rest (more than 3000, with 2500 in dwellings) concern heat pumps for space heating. Below is an overview is provided of policy for heat pumps:

**1995 Start of Programme for Heat Pumps**

In 1995 the Novem Programme Heat pumps is started. The programme envisages an increasing involvement of suppliers and installers as well as potential users. Moreover, strengthening, putting into operation and exchanging knowledge and experiences are also pursued, among others by means of demonstration projects and information provision. Furthermore, several bottlenecks in the market will need to be resolved. Some examples of these bottlenecks are limited familiarity, installers’ lack of experience with heat pumps, a lack of serial production, limited knowledge and high investment cost. Even the fine gas infrastructure and the tariff relation of gas versus electricity curbs the introduction of heat pumps. By the end of 1996, the grant facility for heat pumps is terminated.

**1995 Third Energy Memorandum**

In the third Energy Memorandum high targets are set for heat pumps: capacity sufficient to generate 2 PJ in 1995, 7 PJ in 2000, 50 PJ in 2007 and 65 PJ in 2020 in all sectors: houses, non residential building, greenhouse horticulture and industry. The number of heat pumps would also increase significantly in the second half of the 1990, but at the same time the heat pump as a type of renewable energy technology was subjected to pressure. After long discussions it was decided that heat pumps are no longer considered as renewable in industry as they operate with residual heat of fossil energy carriers.

**Current policy**

As of September 2008 the new grant scheme for sustainable heating enters into operation: for water/water-heat pumps up to and including 10 $kW_{th}$ (heat capacity) the grant amounts to 500 euro per $kW_{th}$ in the first year. Above 10 $kW_{th}$ the grant amounts to 250 euro per KWth. An investment of 20,000 per dwelling results in a grant of 5,000 euro. For air/water heat pumps the grant amounts to 500 euro per $kW_{th}$ with a maximum of 1,000 euro (the cost of an air/water heat pump including high efficiency boilers costs amounts to approximately 7,000 euro). The grant scheme covers about 20 to 25% of the investment. Up to 2011 approximately 7000 heat pumps can be subsidized with the available budget. Incentivisation of long term research of heat pumps is conducted via EOS (energy research grant) and UKR (Unique Opportunities Scheme).

## 5.3 Heat/cold storage

In 2006, the installed thermal capacity of heat/cold storage increased by 150 $MW_{th}$ to 743 $MW_{th}$. The largest part of the heat/cold production (70%) involves systems in non residential building but storage in greenhouse horticulture is also starting to develop with 20% new installed capacity in 2006. The overview below adresses policy for heat/cold storage:

**1994 Market introduction energy storage aquifers (MEA)**

After grants for feasibility studies were provided by SenterNovem, several projects with cold storage are realised in 1993. The Dutch Ministry of Economic Affairs concluded that an investment grant was not needed, but they did start up the MEA programme. This is a programme of SenterNovem in support of feasibility studies and investments and projects. This programme was able to provide tailor-made work and was therefore much more effective than current generic schemes.

**Current policy**

At this moment there is no incentivisation scheme for heat/cold storage, except tax relief measures such as the Energy Investment Deduction/Allowance (EIA). Heat/cold storage is profitable for large buildings with large cooling demand. The branch is well-organized, arranges its own training and established quality requirements and design guidelines. The main bottlenecks are legislation and regulation. The current groundwater act does not take heat/cold storage into account. Open systems require permits, but closed systems don't. Each municipality establishes its own regulation, also with respect to monitoring, which makes automation of the permit trajectory impossible. The permit trajectory takes up approximatly 9 months. The Dutch Association for Underground Thermal Energy Storage Systems (NVOE) came up with a proposal to harmonise and simplify permits for heat and cold storage in the Intergal Water Act. This proposal was accepted by the Dutch Lower House as an amendment, but in real life, nothing has changed so far. Currently, the Task Force Heat and Cold Storage is examining the bottlenecks.

**Biomass**

Renewable heat from biomass includes various options:

- Heat supply from waste incineration plants (energy from waste - AVIs).
- Heat supply from plants with direct or indirect co-firing of biomass.
- Wood stoves in businesses and households.
- Heat production from other types of biomass combustion: combustion of paper sludge, animal fat, or other biogenic residual flows outside plants.
- Landfill gas
- Biogas from sewage purification plants.
- Other biogas, e.g. from agricultural businesses through manure digestion.

**Waste incineration plants**

Heat production from waste incineration plants remains more or less constant , with a few minor expansions. The waste incineration plants and energy recovery from waste are the result of waste policy.

**1979 Motion Lansink, 1996 dumping prohibition waste**

In 1979, the Dutch Lower House adopted the motion by Lansink, which introduced order of ranking in the desired method for handling waste products: prevention; recycling; incineration possibly combined with energy recovery and finally dumping. In real life, this mainly resulted in the cleaning up of dumping grounds and the construction of waste incineration plants in the 1980s. In 1996, dumping combustible waste became completely prohibited.

**1999 Covenant Energy from waste**

In 1999 the waste incineration plants enter into a covenant with the government to increase energy production from waste incineration by 23%. As of 1 August 1999, the waste incineration plants received an allowance per kilowatt-hour from the Regulating Energy Tax (REB), which was the usual allowance for the generation of renewable energy from the REB funds. The 50% equals the organic (kitchen and garden waste) content of averagely produced waste in the Netherlands (in 2007 this percentage was 47%). The covenant and the producer allowance were terminated by the Dutch Cabinet as of 1 August 2002.

**2003 MEP allowance for electricity production**

As of 2003 electricity from waste incineration plants receives a MEP allowance (environmental quality of electricity production) and as of 2008 an SDE allowance (renewable energy incentivisation scheme). This allowance is thus an incentive for electricity production, but not for heat supply.

**Landfill gas**

Landfill gas is biogas that originates from dumping grounds. Most of the captured landfill gas is converted into electricity. At a few dumping sites natural gas is produced and additionally some landfill gas is used directly for heat production. Landfill gas is burned off when it cannot be utilised in a profitable manner. The extraction of landfill gas has been decreasing since 2003, because the amount of dumped waste decreases.

After several pollution scandals (e.g. Lekkerker, 1979) environmental constraints are enforced upon dumping grounds as of 1993, one of them being the obligation to cover the top of the dumping ground. This more or less necessitated the extraction of landfill gas and eventually a legal obligation for extraction of landfill gas was implemented. In 1992, the Advisory centre landfill gas (ACS) was founded by Novem, EnergieNed and the VVAV (the Dutch Waste Processing Association). ACS offers advice and information provision to operators of dumping grounds and energy companies. The intention of ACTS was to conduct a feasibility study at each dumping ground and to stimulate a dialogue between the operators and the energy companies.

**Heat supply from coal-fired plants**

Various types of biomass are used for co-firing in electricity plants. Some examples are agricultural residual flows and wood pellets in coal-fired plants and palm oil in gas-fired plants. After initial strong growth from 2003-2005, co-firing of biomass decreased somewhat in 2006. The growth of co-firing was caused by the the fact that several technical adjustments became available in 2004 and 2005, which made it possible to co-fire larger quantities of biomass. Moreover, in 2005 the grant tariffs were apparently more than sufficient to cover the additional cost of biomass. In May 2005, the Dutch Ministry of Economic Affairs terminated the grant scheme for new co-firing projects. The grant for existing co-firing projects was lowered significantly as of 1 July 2006. Combined with the societal discussion on the sustainability of palm oil, this has probably contributed to the halt in growth.

As for co-firing of biomass in coal-fired plants, policy has focused only on electricity production until now. There are plans to differentiate the tarif per kWh according to the amount of heat that is sold, but this only applies to installations that apply for a grant from 2009 onwards, not for existing obligations. Whether or not co-firing of biomass should receive grants or whether it should be made obligatory is still under discussion. The obligations cover the co-firing of biomass, not the heat utilisation. An obligation for co-firing of biomass may increase heat production from biomass, because in situations where a coal-fired plant supplies heat to a heat grid, the heat production will be more sustainable.

**Domestic wood stoves**

The contribution of wood stoves to more renewable heating has been kept constant by Statistics Netherlands in the last few years, because new data are not available. The stoves include fireplaces, insert stoves and freestanding fireplaces. The total number is estimated to be 800,000. There is no incentivisation scheme.

**Wood stoves businesses**

Heat production from wood stoves in businesses increased in 2005 and 2006 due to smaller stoves in agricultural businesses. Most wood stoves are located in the wood industry and the furniture industry for combustion of waste wood. There is no incentivisation scheme.

**Other types of biomass combusion**

This involves biomass combustion outside plants. In total there are 20 projects, 13 of which generate electricity and heat and 7 produce only heat. Installations that generate electricity are supported via the MEP grant or via the SDE scheme. For projects that apply for a grant as of 2009 the height of the SDE grant depends on heat utilisation.

**Biogas from sewage purification plants**

The production of biogas from sewage purification plants has remained more or less stable in recent years. A recent trend is that more biogas is converted into electricity and less is being used for direct combustion for other proccesses. MEP and SDE grants are available for electricity production with sewage purification plants. 50% of heat production is used to keep the temperature of the fermentation stable. This share cannot be accounted for as renewable heat production.

**Biogas at farms**

The biogas installations at farms, also called manure digesters, often use manure in combination with another type of vegetable material. The digestion of manure alone is less attractive from a technical-economic point of view. The environmental legislation made it very difficult to co-digest any other materials (co-subtrates) at first. A few years ago this changed and the government introduced a positive list. Another important condition is the grant for electricity from the MEP and SDE schemes. By the end of 2007, 53 farms owned a manure digester. The residual heat from the digestor can be used to dry the digestat (residual product after digestion). The agricultural value of digestat is higher than non digested slurry, which makes its use attractive. The heat utilisation (apart from the digester) is still limited to approximately 1% of all extracted biogas, which is realised by approximately one third of the manure digesters. This is often used for heating the stables.

**Other biogas application**

This mainly entails biogas that is extracted and used in the food industry. Via anaerobic waste water purification biogas is extracted and used for generation of electricity and/or process heat. Moreover, several projects with kitchen and garden waste and in the paper industry have been started.

## 5.4 Work programme 'Warmte op stoom'

In 2008 the first integral policy plan on heat supply is launched, the work programme 'Warmte op stoom' [Heat full steam ahead]. The work programme has three types of incentivisation measures:

- Developing and sharing knowledge.
- Enhancing cooperation
- Improving market conditions for increasing sustainability.

Below, an overview is provided of policy from the work programme that incentivises renewable heating and cooling.The work programme also contains policy measures for saving in heat demand and residual heat utilisation, but these are not included here.

*Knowledge development:*

- In January 2009, the Dutch Expertise Centre for Heat (Nationaal Expertisecentrum Warmte) is started. This centre will gather and disseminate information on making cooling and heating more sustainable. The centre focuses on parties that may influence investment decisions. Primary focus lies with municipalities. The expertise centre develops a uniform measuring rod for comparing different techniques. Moreover, the centre will start up various field tests in the coming years to examine performances of certain techniques in practise.
- As of 2009 demand and supply of heat is visualised on regional heat maps, as for example residual heat or options for geothermal. The Dutch Ministry of Economic Affairs subsidizes 50% of the costs and the provinces and TenneT provide the other half.
- In industry, the long term agreement is used to direct attention to sustainable energy generation.
- The programme 'Greenhouse as energy source' incentivises research, demonstration and knowledge exchange on making heat demand in greenhouse horticulture more sustainable.

*Enhancing cooperation:*

In the Spring Agreement on Energy Saving in New Housing agreements were made with the construction sector about improving the energy performance of buildings with 25% in 2011 and 50% in 2015 (compared to 2007). In 2008 the covenant "More with Less" [Meer met Minder] was signed, focusing on energy saving in existing buildings.

The Spring Agreement with the construction sector and the More with Less Covenant also aim at improving cooperation among parties to enhance renewable heat supply in the built environment. Another covenant was made with the agricultural sector in 2008.

*Improving market conditions:*

- The largest bottleneck for geothermal is the risk of faulty drilling. In April 2009 a guaranteeing facility is opened to cover the risks of geothermal drilling. The scheme is financed by government budget amounting to 10 million euros and premium revenues from submitters.
- Current legislation (the Mining Act), which provides the basis for permit granting for geothermal, is resulting in lengthy procedures in geothermal heat projects. In 2009, procedures will be reviewed in order to simplify and accelerate them.
- The production of electricity from biomass also generates heat, which is not always fully utilized. As of 2009, the SDE will calculate the grant amount based on the combination of electricity production and efficiently used heat.
- In September 2008, a grant scheme for sustainable energy production in dwellings was started with a budget of 66 million euros. This should lead to additional installation of 55,000 solar boilers, 5000 heat pumps and 10,000 micro CHPs in existing dwellings in 2011.
- The Dutch Minister of Housing, Spatial Planning and the Environment set up a Taskforce for heat-cold storage that will offer advice on acceleration of growth of heat-cold storage in the short term.

# 6 Conclusions

Below is a list of most important experiences with policy for the enhancement of renewable heating and cooling:

- Grants for solar boilers are based on projected heat production, not on the collector surface area, which is done to stimulate efficient systems. Experience has shown that stop-and-go policy is not good for the market, which needs clarity. Grants for solar boilers have always had a temporary nature and were sometimes abruptly terminated in the past, as in the case of the Energy premium scheme. As a result of these developments the market is sitting on the fence.
- It was expected that energy performance standards for new housing would lead to an increase in solar boilers and heat pumps but the current standards are still feasible with less costly measures.
- The long term agreement  and the covenants were successful in lowering the cost price, but not in upscaling the market. An imortant lesson learned is that marketing is very important. Marketing is difficult when a large group of private homeowners are involved. Installers are an important link, but they often have little experience with solar boilers and hence will not recommend them right away.
- Heat pumps entail various kinds of technology with respect to heat source, type of heat pump and delivery system. Parties consider each project to be made-to-measure and there are few standard solutions, which leads to high engineering costs. Integrating a heat pump in a building concept is crucial, because the capacity of the heat pumps will fall short if the quality of the building leaves much to be desired.
- Heat/cold storage is an efficient technique for large buildings with sufficient cooling demand. Several demonstration projects have been started since 1993. Policy has only subsidized feasibility studies. The only bottleneck is constituted by permit granting, which involves many management layers with demands that are not harmonized.
- Electricity production from biomass is incentivised by means of MEP (Environmental quality of electricity production) and SDE (renewable energy incentive scheme). In the last years there was no attention for heat utilization. SDE grants for new applications for new installations in 2009 will depend on heat utilization. Heat sales from waste and biomass plants require long-term planning. If heat buyers are not contacted in the planning stage, there will not be a market for heat by the time the installation enters into operation. As for digestion, there is little net heat production from plants. In digestion in sewage water purification plants 50% of heat production is needed to keep the digestion process going. In manure digestion, heat utilization is limited to approximately 1% of all extracted biogas.

- Due to the heat demand profile in industry, the role of solar thermal is marginal; the temperature level and the power density are too low and the imtermittent character of solar heat supply makes this option less reliable. Because natural gas is amply available at the moment, there is no reason for industry to deploy biomass.

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# Appendix A Calculation of heat demand

The final heat demand was calculated by ECN on the basis of data from Statistics Netherlands on the use of energy carriers per sector (Statistics Netherlands, NEH 2006), see Table A.1. ECN has estimated the average conversion efficiency into heat per sector and per energy carrier, see Table A.2.

Multiplying the use of energy carriers with the conversion efficiency results in the heat demand per sector, see Table A.3. Every energy carrier has its own emission factor, see Table A.4. By multiplying heat consumption per sector and per energy carrier with the emission factor, the $CO_2$ emission resulting from heat consumption can be calculated, see Table A.5.

*Table A.1 Final consumption for energetic purposes 2006 [PJ]*

| Energy carrier | Industry | Chemical industry | Metal industry | Other industry | Households | Other buyers excl MWT | Refineries | Waste incineration | Extraction companies | Distribution companies | Transport | Mobile equipment | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coal total | 21.7 | | 19.4 | 2.3 | 0.2 | 0.3 | | | | | | | 22.2 |
| Cokes oven gas | 8.0 | | 8.0 | 0.0 | | | | | | | | | 8.0 |
| Blast furnace gas | 10.9 | | 10.9 | 0.0 | | | | | | | | | 10.9 |
| Coal other | 2.8 | 0.0 | 0.5 | 2.3 | 0.2 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | | | 3.3 |
| Oil total | 102.5 | 99.8 | 0.6 | 2.1 | 3.7 | 5.0 | 86.0 | 0.0 | 0.0 | 0.1 | 490.6 | 36.3 | 724.2 |
| Refinery gas | 2.0 | 2.0 | | 0.1 | | | 67.8 | | | | | | 69.8 |
| Chemical residual gas | 97.7 | 97.7 | | 0.0 | | | | | | | | | 97.7 |
| Oil Other | 2.8 | 0.1 | 0.6 | 2.0 | 3.7 | 5.0 | 18.2 | 0.0 | 0.0 | 0.1 | 490.6 | 36.3 | 556.7 |
| Natural gas | 173.3 | 61.1 | 32.3 | 79.9 | 301.5 | 267.2 | 13.4 | 0.6 | 25.8 | 1.8 | 0.0 | | 783.6 |
| Electricity | 118.5 | 35.9 | 28.6 | 54.0 | 87.2 | 140.4 | 9.6 | 0.1 | 8.7 | 19.0 | 5.8 | | 389.4 |

| Energy carrier | Industry | Chemical industry | Metal industry | Other industry | Households | Other buyers excl MWT | Refineries | Waste incineration | Extraction companies | Distribution companies | Transport | Mobile equipment | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Steam and/or warm water | 145.2 | 100.2 | 4.7 | 40.3 | 19.2 | 60.8 | 16.1 | 3.9 | 0.1 | 5.2 | | | 250.5 |
| Fermentation gas | 0.6 | 0.1 | | 0.5 | | 1.6 | | 0.0 | | 0.1 | | | 2.3 |
| TOTAL | 561.8 | 297.0 | 85.6 | 179.2 | 411.8 | 475.3 | 125.2 | 4.6 | 34.6 | 26.2 | 496.4 | 36.3 | 2172.2 |

*Table A.2 Conversion efficiencies (%)*

| Energy carrier | Industry | Chemical industry | Metal industry | Other | Households | Other buyers excl MWT | Refineries |
|---|---|---|---|---|---|---|---|
| Coal Other | 85.0 | 85.0 | 85.0 | 85.0 | 74.2 | 80.0 | 85.0 |
| Olie Other | 87.0 | 87.0 | 87.0 | 87.0 | 79.9 | 80.0 | 87.0 |
| Natural gas | 90.0 | 90.0 | 90.0 | 90.0 | 85.5 | 85.5 | 90.0 |
| Cokes oven gas | 90.0 | 90.0 | 90.0 | 90.0 | 85.5 | 85.5 | 90.0 |
| Blast furnace gas | 90.0 | 90.0 | 90.0 | 90.0 | 85.5 | 85.5 | 90.0 |
| Refinery gas | 90.0 | 90.0 | 90.0 | 90.0 | 85.5 | 85.5 | 90.0 |
| Chemical residual gas | 90.0 | 90.0 | 90.0 | 90.0 | 85.5 | 85.5 | 90.0 |
| Fermentation gas | 90.0 | 90.0 | 90.0 | 90.0 | 85.5 | 85.5 | 90.0 |
| Steam and orwarm water | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

*Source: estimate ECN*

*Table A.3 Useful heat consumption 2006 [$PJ_{th}$]*

| Energy carrier | Industry | Chemical industry | Metal industry | Other | Households | Other buyers excl MWT | Refineries | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Coal Other | 2.4 | 0.0 | 0.5 | 1.9 | 0.1 | 0.2 | 0.0 | 2.8 |
| Oil other | 2.4 | 0.1 | 0.5 | 1.8 | 3.0 | 4.0 | 15.9 | 25.3 |
| Natural gas | 156.0 | 55.0 | 29.1 | 71.9 | 257.8 | 228.5 | 12.1 | 654.3 |
| Cokes oven gas | 7.2 | 0.0 | 7.2 | 0.0 | 0.0 | 0.0 | 0.0 | 7.2 |
| Blast furnace gas | 9.8 | 0.0 | 9.8 | 0.0 | 0.0 | 0.0 | 0.0 | 9.8 |
| Refinery gas | 1.8 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 61.0 | 62.8 |
| Chemical residual gas | 87.9 | 87.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 87.9 |
| Fermentation gas | 0.5 | 0.1 | 0.0 | 0.5 | 0.0 | 1.4 | 0.0 | 1.9 |
| Steam and/or warm water | 145.2 | 100.2 | 4.7 | 40.3 | 19.2 | 60.8 | 16.1 | 241.3 |
| TOTAAL | 413.3 | 245.0 | 51.7 | 116.5 | 280.1 | 294.9 | 105.0 | 1093.3 |

*Table A.4 Emission factor per energy carrier*

| | Emission factor $CO_2$ [kton/PJ] |
|---|---|
| Coal other | 94.7 |
| Oil other | 73 |
| Natural gas | 56.8 |
| Cokes oven gas | 41.2 |
| Blast furnace gas | 237.1 |
| Refinery gas | 66.7 |
| Chemical residual gas | 62.6 |
| Fermentation gas | 0 |
| Steam and/or warm water | 63.1 |

*Table A.5 $CO_2$ emission from heat demand*

| Energy carrier | Industry | Chemical industry | Metal industry | Other | Households | Other buyers excl MWT | Refineries | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Coal other | 0.3 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.3 |
| Oil other | 0.2 | 0.0 | 0.0 | 0.1 | 0.3 | 0.4 | 1.3 | 2.2 |
| Natural gas | 9.8 | 3.5 | 1.8 | 4.5 | 17.1 | 15.2 | 0.8 | 42.9 |
| Cokes oven gas | 0.3 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| Blast furnace gas | 2.6 | 0.0 | 2.6 | 0.0 | 0.0 | 0.0 | 0.0 | 2.6 |
| Refinery gas | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 4.5 | 4.7 |
| Chemical residual gas | 6.1 | 6.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.1 |
| Fermentation gas | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Steam and/or warm water | 9.2 | 6.3 | 0.3 | 2.5 | 1.2 | 3.8 | 1.0 | 15.2 |
| TOTAL | 28.6 | 16.0 | 5.1 | 7.5 | 18.6 | 19.4 | 7.6 | 74.3 |

# Appendix B Interviews

In the framework of this report, interviews were held with the following persons:

- Gerard van Amerongen, Holland Solar (Dutch solar industry association)
- Ernst-Jan Bakker, ECN program Energy in the Built Environment
- Lex Bosselaar, SenterNovem, National Expertise centrum Heat (NEW)
- Hans Buitenhuis, DWA Installatie- en energieadvies, Dutch Association for Underground Thermal Energy Storage Systems (NVOE))
- Ad Schoof en Erik Wissema, Dutch Ministry of Economic Affaires
- Huib Visser, ECN program Energy in the Built Environment
- Rian Visser, ECN unit Biomass, Coal and Environmental Research
- Anton Wemmers, ECN unit Efficiency & Infrastructure (Heat Technology & Systems)