HPT-Annex 46
Domestic Hot Water Heat Pumps

Annex 46

Task 1 Market Overview

Country Report Netherlands

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Technology Collaboration Program on Heat Pumping Technologies (TCP-HPT)

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Preface
This project was carried out within the International Energy Agency Technology Collaboration Program on Heat Pumping Technologies (HPT TCP).

The IEA
The IEA was established in 1974 within the framework of the Organization for Economic Cooperation and Development (OECD) to implement an International Energy Program. A basic aim of the IEA is to foster cooperation among the IEA participating countries to increase energy security through energy conservation, development of alternative energy sources, new energy technology and research and development (R&D). This is achieved, in part, through a Program of energy technology and R&D collaboration, currently within the framework of over 40 Implementing Agreements.

The Technology Collaboration Program on Heat Pumping Technologies (HPT TCP)
The Technology Collaboration Program on Heat Pumping Technologies (HPT TCP) forms the legal basis for a Program of research, development, demonstration and promotion of heat pumping technologies. Signatories of the TCP, called participating countries, are either governments or organizations designated by their respective governments to conduct. The Program is governed by an Executive Committee (ExCo), which monitors existing projects and identifies new areas where collaborative effort may be beneficial.

Annexes
The core of the TCP are the “Annexes”. Annexes are collaborative tasks conducted on a cost-sharing and/or task-sharing basis by experts from the participating countries. Annexes have specific topics and work plans and operate for a specified period, usually a number of years. The objectives range from information exchange to the development and implementation of heat pumping technologies. An Annex is in general coordinated by an expert from one country, acting as the Operating Agent (manager). This report presents the results of one Annex.

Triennial Heat Pump Conference
The IEA Heat Pump Conference is one of the three major products of the Technology Collaboration Program on Heat Pumping Technologies. The Executive Committee supervises the overall organization and its quality and selects from a tender procedure the host country to organize the Conference and establishes an International Organization Committee (IOC) to support the host country and the ExCo.

The Heat Pump Centre
The Heat Pump Centre (HPC) offers information services to support all those who can play a part in the implementation of heat pumping technologies. Activities of the HPC include the publication of the quarterly Heat Pumping Technologies Magazine and an additional newsletter three times per year, the HPT TCP website, the organization of workshops, an inquiry service and a promotion Program.
The HPC also publishes results from the Annexes under the TCP-HPT.
For further information about the Technology Collaboration Program on Heat Pumping Technologies (HPT TCP) and for inquiries on heat pump issues in general contact the Heat Pump Centre at the following address:
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The information and analysis contained within this document is developed to broadly inform on developments in the Netherlands. Whilst the information analysed was supplied by representatives from various companies and sources a number of assumptions, simplifications and transformations have been made in order to present information that is easily understood. Therefore, information should only be used as guidance.

The market of domestic hot water heat pumps (DHWHP) is developing fast and at the moment of publication some information can already be overtaken by new developments. There are some websites listed at the reference pages of the report.

In compiling, editing and writing this report I would like to thank mrs. Marion Bakker (RVO), mr. Charles Geelen (Infinitus), mr. Krijn Braber (Infinitus) and mr. Jacob van Berkel (ENTRY)

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Summary

The policy in the Netherlands is focusing on reducing the use of gas for heating in buildings applications (domestic and commercial) and in industry drastically. ‘Away from gas’ is the new approach stimulated by earth quakes in regions where gas is extracted from the underground. Several solutions in this approach are dominant, being low temperature district heating for densely populated areas and all-electric for other regions. And of course a mix of these. In this policy the awareness is growing that domestic hot water is an important factor to take into account.

When taking these in account scenarios of market developments have been developed in this report based upon an all-electric scenario for 2050 and the building growth/renovation scenario’s. Summing up the main tracks in the future developments until 2050 for the heating systems are:

Nearly Zero Energy for **single family buildings** will be all-electric for new buildings with electric double function heat pumps, medium capacity storage for domestic hot water, combined with solar photovoltaics and possibly solar thermal to reduce the overall demand. The system will be plug-and-play installed in new housing estates/districts and smart grid adapted. All newly built houses will be equipped:

- 60% with air source heat pumps
- 40% with ground source heat pumps

In the scenario it is not expected that this group of NZEB will be connected to a district heating system.

Nearly Zero Energy for new multi-family buildings, will be all electric with either:

- In 50% of the buildings, a collective system for space heating and a booster heat pump for domestic hot water, resulting in either one central heat pump per building or connection to low temperature district heating and one booster heat pump per dwelling.
- In 50% of the buildings, a collective high temperature heat pump, distributing heat for space heating and domestic hot water from a large storage tank.

An individual heating plug-and-play concept with a double function heat pump and a relatively small (150 litres) storage tank can be an alternative for collective systems. New direct flow technologies are also under development for this segment.

Renovation of privately owned single family buildings will be mainly fitted with hybrid heat pumps on the short term and later on in the process develop to all-electric systems. The peak of hybrid heat pumps will be in 2030 covering a max of 35% of the boiler replacements, seemingly only possible with new or adapted legislation. After that period the transition to all electric will take over this markets plug & play systems of renovation concepts become available. **Renovation of corporate owned single family houses** of which a large number will be renovated to the Nearly Zero Energy level and a number will be connected to the district heating grid. Being the front runner in the market

Renovation of corporate owned multifamily buildings has diverse technology directions:

- connection to the district heating grid and equipped with a booster heat pump,
- low temperature collective heat pump heating system and individually equipped with a booster heat pump
- individual plug & Play heat pump heating systems with a double function heat pump

The market in 2015 for high efficiency gas boilers for replacement of existing systems exists in almost all single family buildings and in 50% of the multifamily lodgings. In 2017 this numbered 400.000 per year and will decrease

to practically zero in 2050. A number of policy makers in Netherlands expect that District Heating for this type of renovation in densely populated areas will be the solution. **Low temperature district** heating will thus get to 15 - 25% of the overall heating market for buildings. Domestic hot water and sanitary hot water is then generated with a booster heat pump or new direct flow technologies which are under development for this segment.

Contents

Heat pump benefits

	2017	Potential*
Sales	25k	261k
Stock	115k	3.6m
Renewable energy produced	3 TWh	92 TWh
CO2 emissions saved	0.77 Mt	23.9 Mt
Final energy saved	3.7 TWh	116 TWh
Full time jobs provided	1 909 Jobs	59 486 Job

* The potential is calculated based on the method presented in chapter 4.6.

Key facts

Capital	Amsterdam	
GDP per capita	38 200 €	rank

Housing

Dwelling stock by category		
Total	7 459 694	% of tot
Single	4 726 666	63.4%
Two	250 607	3.4%
Multi	2 062 066	27.6%
Non residential	105 568	1.4%

Average energy consumption per m²	194 kWh/m²	
Space heating	123 kWh/m²	63.2%
Water heating	27.6 kWh/m²	14.2%
Other	43.7 kWh/m²	22.5%

Growth of new building permits	28.9%	

Renewable energy

Share of renewable energy of total consumption	-	
EU 2020 target for the share of renewable energy	14%	
National emission factor of electricity	404 g/kWh	

Energy consumption

Dwellings by energy source used for space heating		
Gas	5 976 240	85.5%
Oil	8 860	0.13%
Biomass	163 230	2.3%
District heating	795 470	11.4%
Electricity	43 030	0.62%
Coal	-	-

Final energy prices (euro cents per kWh of thermal energy)		
Electricity	0.16 €/kWh	
Gas	0.09 €/kWh	
Heating oil	0.13 €/kWh	
District heating	-	
Pellets	-	

Market overview [27]

1. The Dutch Policy framework

1.1 Introduction

The Netherlands have still a huge task in fulfilling its obligations related to the targets on use of renewable energy and energy consumption reduction as defined by the EU for 2020. To bridge this gap between the now achieved approx. 5.5% (Status 2015) renewable of the primary energy consumption, and the target of 14% in 2020 a nationwide energy agreement has been made. In 2013 more than 40 organisations, large companies, provinces and NGO's have signed the 'SER Energieakkoord' (the new energy coalition agreement) which implementation must lead us to the required 14% in 2020. The main agreements in this Energieakkoord are:

- Final energy savings of 1,5% per year
- Final energy savings of 100 PJ's in 2020 compared with 2012
- 14% renewable energy in 2020, 16% in 2023;
- 15.000 full time job creation in the energy savings sector

A major role in this agreement is foreseen for solar PV, wind power, off- and onshore, and biomass in large and small applications. These options sum up to 45% of the goal of 16% in 2023 for renewable energy. The rest being 186 PJ's will have to be filled in by other renewable options focusing on Renewable Heating and Cooling Technologies like solar thermal, heat pumps, bio-energy heating and geothermal are very diverse and often de-centralized influenced by many factors. Heat pumps are in this context recognised to be one of the key technologies in the building stock in domestic and commercial buildings, as well for greenhouses and industry. The ministry of Economic Affairs has developed for this goal its Heat-Vision, road mapping energy conservation, district heating and renewable heating and cooling for a long term. New policy instruments are proposed ranging from subsidies to legislation and programmatic support.

The Dutch government has a number of support mechanisms and programs to promote building renovation to increase their energy performance, which are mostly financial instruments, like

- Tax instruments and Reduced VAT
- Subsidy scheme for heat pumps and for housing corporations (year 2017 90 million)
- Loans
- Green Funds Scheme

Governmental policy, and foremost consistency in policy keeping are considered to be stronger drivers for the increase of use of renewables, besides the financial context. The Netherlands, a land with the most extensively spread gas network second to none, is in combination with the lowest prices for gas boilers in Europe, a challenging environment for the out roll of renewables. Clear and consistent policy making in this situation is crucial.

The biggest challenge in the transition in the Netherlands is to keep use of energy affordable and reliable while at the same time make the entire system more sustainable. The transition to a low-CO_2 energy requires a great effort from citizens, businesses and governments. The task is complex: Timely development and availability of sustainable alternatives, major investments including insulation (production) facilities and infrastructure and - in our densely populated country - continuous assessment of the spatial effects. Above all, the energy is a major social challenge: the transition is directly linked to daily life and the living environment of people. A transition of this magnitude takes place only when the energy supply affordable, reliable and remains safe.

The transition is thus more than just a change of energy, it becomes an (innovative) process that reinforces the strength of the Dutch economy and society. This requires a clear long-term perspective that offers security to companies that need to invest, to drivers who have to decide and to citizens who are faced with important choices. The security shall be until the year 2023 provided by the successful 'Energieakkoord' for sustainable growth.

1.2 Specific Policy for the Building Sector

In the 'Energieakkoord' the parties have reconfirmed their ambitious goals for the built environment:

- The goals are in line with the European Energy Efficiency Directive (EED), the recast of Energy Performance in Buildings (EPBD) and the Directive on the ECO-Design;
- 300.000 existing domestic houses and other buildings have to be renovated yearly by two label steps.
- Nearly Zero Energy Buildings is the standard for new buildings from 2020 onwards and in 2018 for governmental buildings;
- Rented existing domestic houses in 2020 have to be at an average of label B for housing corporations in the social renting sector and label C in 80% of the private renting sector.

Parallel to the Agreement new policy on reducing the energy use for heating and increasing the share of renewable heating was introduced by the Ministry of Economic Affairs in their Heat-vision. The package of measures proposed in the Heat Vision is divided into three specific areas of application: actions for specific building-based and area-based measures (collectively the built environment) and measures and actions for industry and agribusiness.

Highlights directly related to heat pumps are:

- Subsidy scheme for heat pumps and for housing corporations. In 2017 the budget is €90 million.
- Minimum requirements for the share of renewable energy for new construction and major renovation and provide valuation of bio-energy as renewable energy.
- A requirement for A + label devices for heating and hot water supply per 1-1-2018 (based on the eco-labels)
- Develop demand by raising awareness, building trust, certification etc.
- The elimination of inequalities in the tax on gas and electricity, to promote applications of renewable heat.
- Creating a financial investment support for small-scale renewable heat options that a level playing field with other options such as PV.
- Increase the deployment of District Heating Networks in densely populated areas and districts with a high concentrated energy demand.

Among the other measures are included as suggestions brought forward by the Association for Renewable Energy:

- The generic lowering the VAT rate for decentralized renewable options, as in some other EU countries.
- Use of tax instruments around property tax rates, transfer tax, etc based on level of use of renewable energy or energy performance of the building.
- New positioning for hybrid heating networks; lower temperature systems, adaptation rules for access to> 500 m for CHS; avoiding lock-in effects for fossil sources.
- Compensation Provision for phasing out older -fossil sources and pricing of network costs for hybrid networks

Parallel to this support programs for R&D for the built environment have been further developed under TKI-umbrella called TKI Urban Energy. In addition to R&D TKI Urban Energy is committed to the rapid dissemination and deployment of developed knowledge, techniques, social and institutional insights and implementations.

1.3 General trends in the transition

In addition to specific actions in the building sector a more general package of measures is having a relation to the built environment and is having an impact on it. A number of trends are relevant. These trends do impact the three goals (reliable, affordable and sustainable).

Examples:

- Increase of PV may cause problems in the distribution grid;
- Increased share of intermittent electricity recourses can reduce reliability of electricity supply.

Energy production changes:

- Increasing number of decentral producing source
- Increasing share of renewable energy
- Phase out of nuclear power (Fukushima, Atomausstieg) (Although the electricity generation from nuclear in the Netherlands is insignificantly small)
- Shale gas versus coal, low CO2 price and demise of ETS
- There is a trend in the Netherlands to choose for coal to generate electricity, because of rising natural gas price, lowering coal and ETS CO2 prices, to reverse this trend, the Dutch government has set an extra ‘coal tax’ is enforcing to closedown coal plants (see paragraph 1.5).

Energy consumption changes:

- Global increase of energy consumption
- Electrification of our energy system
- Electricity, gas and thermal energy merge to 1 grid i.e. 1 system

Effects of a free economy

- More small company in the role of providers
- Prosumers (Consumers who also act as producer)
- Local initiatives
- Freedom of choice

1.4 The need for support programs

The Energy agreement and Heat vision are a step forwards in reaching the goals but there are still a number of challenges:

Challenge: For the end user is unclear where and how to start with the purchase of a PV system, solar water heater, heat pump or bio-boiler/pellet burner. The consumer is not aware of the amount of renewable energy it can generate.

Solution: Setting up a portal that visitors inform objectively about:

- roadmap purchase & practical checklist
- yield calculations and examples
- arrangements
- conditions

- operating principles.

Challenge: There are nowadays not enough experienced installers to install all renewable energy systems.

Solution: Give prominence to the training system developed by sectors (such as Holland Solar) and UNETO VNI (Dutch installers). Challenge: For innovative techniques occurs as the regulations may hinder heat pump concepts for which the calculation methods that do not recognize techniques.

Solution: periodically adjusting calculation methods. Methods for standards based not only on existing techniques, but also proven innovative technologies. Equivalence statements provide more opportunity for innovative solutions.

1.5 Legislation – Building standards

This part describes the policy conditions for Energy performance of buildings and technical systems for Nearly Zero Energy Buildings for New Buildings and renovation.

- Current (2017-2018) development of the NTA 8800 – will replace NEN 7120 (Dutch EPBD)
- Energy labelling of buildings
- Product labels for Heat Pumping Technologies, like ECO-label or minimum requirements for efficiency of residential water heaters like in USA
- Test and rating procedures

1.5.1 Energy Zero in New Buildings

The EPBD recast states that all new buildings from 2020 have to be built at the level of nearly energy zero. This requirement already applies for government buildings starting from 2018.

The Dutch government introduced new standards on energy efficiency for residential and utility buildings in 2012. These standards, called Energy Performance of Buildings (EPG) combines a methodology for new and existing buildings, residential and non-residential, into one package. With the EPG, the Netherlands meets the requirements of the EPBD Recast. The standards for the EPG have been published as NEN 7120 on April 15th, 2011 with some updates – the latest one on June 22nd 2017.

This energy regulation in the Building Code is based upon an index, where the level of energy efficiency is expressed in the Energy Performance Coefficient (EPC). This index only includes building-related energy consumption, such as heating, domestic hot water use, ventilation and lighting. It is based on the typical meteorological reference year and a standard occupant behaviour. A standardized methodology to calculate the EPC has been formulated. The current EPC requirement from 2015 onwards is 0.4 and will be 0.0 in 2020 (energy-neutral). For new domestic buildings Dutch policy stands firm behind the EU-targets for Nearly Zero Energy in 2020.

However the existing standards do not fit well with the methodologies for NZEB and does not very well take into account renewable energy. Therefore the Building Code is going to adapt new to the new situation by defining requirements to:

- Maximum energy consumption in kWh/m2;
- Maximum primary energy consumption in kWh/m2;
- Minimum share of renewable energy in%.

The Government wants to ensure assessment methods for the requirements of nearly zero-energy buildings that are transparent and simple and will serve the needs of the consumer. While the determination method for BENG is not available yet, the above indicators are indicated for this moment. They are determined on the basis of (share) results of the EPC calculation according to NEN 7120. In this contribution the determination of the three indicators is defined and a spreadsheet is elaborated to calculate the BENG-indicators.

Many building companies already offer so called Nul-Op-de-Meter –buildings (Energy Costs Zero Houses) with a long term performance guarantee.

Building-related energy: use energy use directly dependent on how the building is built This means, for example, the energy use for heating and ventilation. The building-related energy use is measured with the energy performance coefficient (EPC). The lower the EPC, the better the building performs. The terms include:

- Energy neutral: the entire building-related energy use itself. EPC = 0 means the same thing as energy neutral.
- BENG: stands for 'Nearly Zero Energy Building'. Mandatory in year 2021 for new buildings
- Passive House: house with heavy reduced building-related energy use. Depending on whether the House itself also generates renewable energy, EPC between 0 and 0.4.

User related definitions: Zero on the Meter (NOM)- and Energy note-zero (ENN)

In addition to building-related energy use, is there also end user related use of energy.

- Zero as the user related-On-The-Meter (NOM): the net electricity meter is at the end of the year to zero. Over the year the house generates as many energy as used (both for the building as the users). The costs to the system operator electricity connection has still to be paid,. Because this tax credit is higher than the cost to connect the grid operator, these house earns € 100.0 annually-back!
- Energy note-zero (ENN): a house looks very much like a NOM apartment, but produces about 500 kWh less over the year. Instead of getting money back the final energy bill for homes and buildings remain 0 euro.

Other often used sustainability tools are GPR and BREEAM

The above mentioned assessment tools are all about the energy use of a building. In addition, there are also methods that bring more sustainability aspects, such as health of the users and environmental impact of the materials used. The two best known are the GPR (Municipal Practice directive) and the BREEAM (building Research Establishment Environmental Assessment Method). GPR is used more as a method to design and BREEAM more to a sustainable building according to international guidelines. In both methods, a score awarded on several sustainability themes, which merged to one sustainability score.

1.5.2 Renovation

For existing buildings, the Energy Index and related Energy Label is available since 1998. The Energy Index is calculated using an Energy Performance Advice (EPA). Only certified assessors may issue an EPA. Since 2008, it is mandatory for every building to have an energy label when it is sold or rent. Recent monitoring shows an implementation rate by 85%. For buildings with an area of 1,000 m^2 or more, an energy label is required at all time. From 2015 onwards the Energy Label for house owners will have consequences for the Taxes and value of their property.

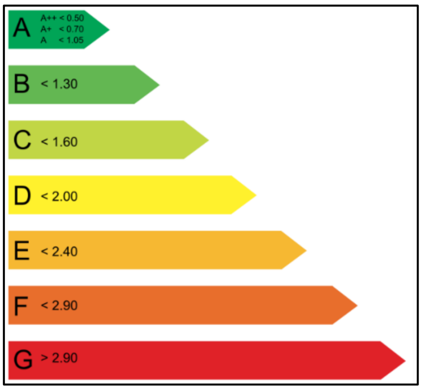


Figure 1.1: Energy label and energy index for residential buildings in the Netherlands

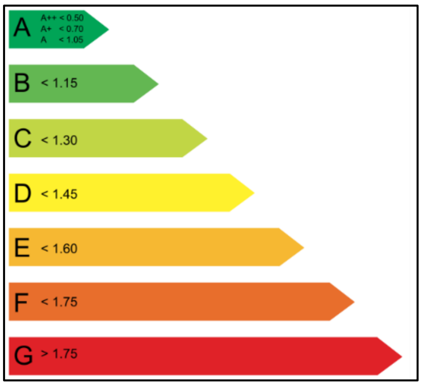


Figure 1.2: Energy label and energy index for utility buildings in the Netherlands.

Due to the stricter energy performance index in the Dutch Building Code (Bouwbesluit) heat pumps with a DHW storage tank became popular in larger building projects and after a learning curve accepted in the market. Summertime cooling is often offered in these projects.

Housing corporations committed themselves to an average energy label ‘B’ on their respective building stock. It is expected that in near future the whole housing stock will follow.

Utility buildings larger than 1,000 m2, need to have an energy label at all times. This energy label must be visibly displayed in the buildings. Utility buildings in renovation can be confronted with the Environmental Law (Dutch: Wet Milieubeheer). One of the starting points of this law is saving energy and resources. The permit authority can ask for an energy saving study, in which Best Available Technologies (BAT) for both the building and the installations are considered. If the BAT has a pay-back time of five years or less, the authority is privileged, based on the Environmental Law, to enforce the use of this technology. By 2023 the label C will be mandatory for every office building.

1.6 Legislation - Safety Issues

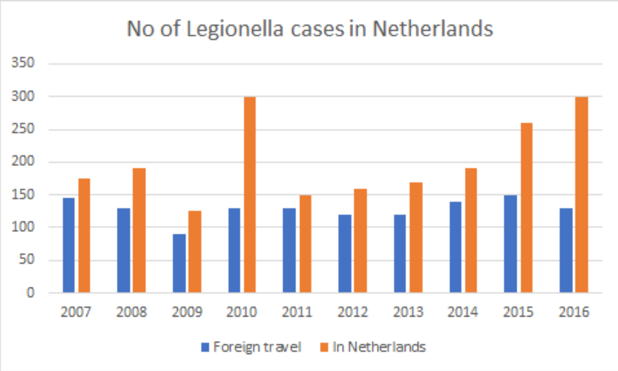
This describes the legislation and standards for heat pumps, ranging from:

- Installation guidelines and control
- Explosion, fire safety
- Health i.e. Legionella
- F-gas regulation

Question: Are legislative processes harmonized at international level and are there enforcement procedures?

Legionella

Legionella is a bacterium that can cause an acute infection of the airways (legionellosis). This condition has two known syndromes: legionella pneumonia (veterans disease), a severe form of pneumonia and Pontiac fever, a flu-like condition. Legionellosis is an infection by a bacterium. This bacterium is called Legionella. Most people do not become ill after exposure to this bacterium. Sometimes mild, flu-like symptoms (legionella flu or pontiac fever) develop. That will pass after a few days. Sometimes the legionella bacterium causes severe pneumonia: Legionnaire inflammation or legionella inflammation.



Most years there have been between 300 and 400 reports in the Netherlands of patients with legionella inflammation. In the summer, legionella inflammation occurs more often than in winter. In some years the number of reports is somewhat higher than usual. This usually depends on certain weather conditions. Especially in heavy rainfall after a relatively warm period, there is an increase in the number of patients. The actual number of patients is probably somewhat higher than the number of reports. Due to limitations in diagnostics, not all patients may be diagnosed.

Fig. 1.3 The current situation of Legionellosis in Netherlands

Tank thermostats are not a reliable guide to the internal temperature of the tank. Gas-fired water tanks may have no temperature calibration shown. An electric thermostat shows the temperature at the elevation of the thermostat, but water lower in the tank can be considerably cooler. An outlet thermometer is a better indication of water temperature.[17]

In the renewable energy industry (solar and heat pumps, in particular) the conflict between daily thermal Legionella control and high temperatures, which may drop system performance, is subject to heated debate. In a paper seeking a green exemption from normal Legionellos is safety standards, Europe's top CEN solar thermal technical committee TC 312 asserts that a 50% fall in performance would occur if solar water heating systems were heated to the base daily. However some solar simulator analysis work using Polysun 5 suggests that an 11% energy penalty is a more likely figure. Whatever the context, both energy efficiency and scalding safety requirements push in the direction of considerably lower water temperatures than the legionella pasteurization temperature of around 60 °C (140 °F).[citation needed]

According to NEN 1006 (drinking water quality), there is no minimum storage temperature required.

The main principles for preventing legionella are described as:

Level 1:

- Thermal management
- Physical management: UV-light, membrane filtration, pasteurization
- Photochemically: UV light in combination with titanium oxide

Level 2: Electro chemical, like Anodic oxidation

Level 3

- Chemical by using chlorine dioxide, monochloramine or hydrogen peroxide
- In determining what management level is applicable it is important to know
- the temperature of the cold water
- the hot water temperature;
- the presence of any unused parts of the distribution piping
- the use of the tapping points.

Mainly Thermal management. In collective domestic systems this is based upon four criteria:

- Temperature of cold water is lower than 25 ^{o}C

- Hot water temperature is at least 60 ^{o}C
- There are no unused pipes in the systems
- There is a weekly use of the taps

However, legionella can be safely and easily controlled with good design and engineering protocols. For instance raising the temperature of water heaters once a day or even once every few days to 55 °C (131 °F) at the coldest part of the water heater for 30 minutes effectively controls legionella. In all cases and in particular energy efficient applications, Legionnaires' disease is more often than not the result of engineering design issues that do not take into consideration the impact of stratification or low flow.

At this moment the Dutch regulation is not yet harmonized with the surrounding European countries. It is expected that in 2018 this will be the case and to get in line with the European Guidelines.

The European Guidelines for Control and Prevention of Travel Associated Legionnaires' Disease recommend that hot water should be stored at 60 °C (140 °F) and distributed such that a temperature of at least 50 °C (122 °F) and preferably 55 °C (131 °F). These temperatures are lower than according to the Dutch regulation offering more room for energy efficient systems.

2. Present market situation

2.1 Building stock (numbers and ownership)

The building stock in Netherlands is segmented in a number of groups with their own characteristics. A division for the domestic building sector can be made as:

- Single family houses, which can be detached, semi-detached, corner house or a terraced house.
- Multi Family Buildings, which is taken up in and counted in the statistics as apartment, which can be maisonettes, gallery flats, flats with an entrance hall and flats.

	Building Stock (number)			Average floor area (m2)		
Year of construction	Total	Single family building	Multi Family Building	Total	Single family building	Multi Family Building
	7 686 178	4 956 862	2 729 313	119	140	81
1000 - 1850	70 621	31 596	39 025	157	235	92
1850 - 1905	266 985	142 532	124 453	148	196	92
1905 - 1925	435 563	269 702	165 861	128	154	87
1925 - 1945	687 514	460 948	226 566	126	146	83
1945 - 1955	363 860	250 005	113 855	108	125	73
1955 - 1965	797 473	504 694	292 779	105	122	75
1965 - 1975	1 295 746	872 546	423 200	114	131	79
1975 - 1985	1 148 252	801 853	346 399	114	132	73
1985 - 1995	1 018 131	697 197	320 934	114	131	76
1995 - 2005	832 463	538 026	294 437	131	153	92
2005 - 2015	673 373	330 413	342 960	126	162	92
from 2015	96 180	57 336	38 844	114	143	70

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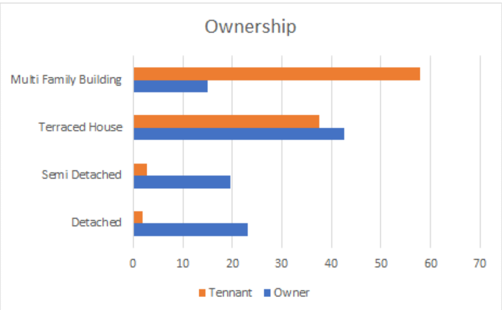
	number
Total	8.854.389
Domestic Building	7.727.225
Non Domestic Building	1.127.164
Event	60.999
Prison	57
Hospital	22.517
Industry	191.982
Office	97.471
Hotel	117.695
School	14.272
Sport	9.577
Shop	130.314
Other	482.280

All these categories have various architectural, energy and user characteristics. Especially the energy use depends on the age building and the type of ownership and of course on the number of occupants and their age. The number of newly built houses is growing again after the crisis. This not only as one family houses but also in the segment of Multi Family Buildings. The majority of single family houses was built in the period from 1985 – 1995, where it is interesting to notice that the number of newly built multifamily houses is about the same.

Next to the domestic sector the non-domestic sector is of interest for the application of sanitary hot water where hot water heat pumps can be applied. A typical already popular application is a niche market of farmhouse milk production where the condenser of the milk cooling is making hot water for cleaning purposes in over 6000 Dutch farms already. Hotels, guesthouses, prisons and other lodgings, hospitals, psychiatric institutions and care homes, schools, training institutes and universities, sport accommodations and other event buildings, all do have a significant need for hot water. This is more than often based upon a central hot water generator.



Of the domestic housing stock, 56 percent is a owner-occupied home, 30 percent is a rental property of a corporation and 13 percent is owned by other landlords[1]. The number of homes owned by housing corporations declined in 2014 by more than 9 thousand. There were a total of 2.3 million houses owned by housing corporations in the Netherlands on 1 January 2015. A

[1] Other landlords are private investment companies, private individuals and institutional investors

remarkable trend is that in 2015 the number of owner-occupied dwellings had increased by almost 29 thousand and the number of dwellings owned by other landlords increased by almost 25 thousand compared to 1 January 2014.

The decline of ownership by housing corporations is mainly due to a decrease in new construction and the sale of housing to other parties, such as companies, private individuals and institutional investors. In Rotterdam no less than 45 percent of the housing stock is held by housing corporations. The share of owner-occupied homes in the four major cities is much lower than the national average of 56 percent. In Amsterdam, only 29 percent of the housing stock consists of owner-occupied housing. The number of dwellings of other landlords also shows a completely different picture than the national average of 13 percent. In Amsterdam, that percentage is twice as high.

There are major differences in corporation ownership in the region. In the case of cities with a housing stock of at least 50 thousand homes, the share of housing corporations is generally above the national average of 30 percent. Only Haarlemmermeer with 22 percent, Almere with 27 percent and Apeldoorn with 29 percent are below the national average. The figure below shows the percentage of housing corporations' vis-à-vis the housing stock per municipality.

Single family houses which are for the larger part privately owned can be:

- Detached, free standing house/villa
- Semi-detached, which two-under-one-roof
- Corner house in a row of similar houses, which can be considered energy wise as a semi-detached house
- Terraced house, which a house in a row of houses between others.

	Single Family Building					
		Detached	Semi Detached	Corner	Terraced	Other
1998	5.799.000	954.000	755.000	865.000	1.829.000	.
1999	5.851.000	964.000	744.000	809.000	1.808.000	.
2000	5.948.000	957.000	788.000	836.000	1.871.000	.
2002	6.059.300	959.500	840.300	818.400	1.858.400	87.700
2006	6.255.400	1.020.500	840.100	837.300	1.836.500	87.900
2009	6.383.800	1.013.000	899.800	881.800	1.872.900	126.600
2012	6.547.200	1.003.800	891.800	882.500	1 926300	160.200

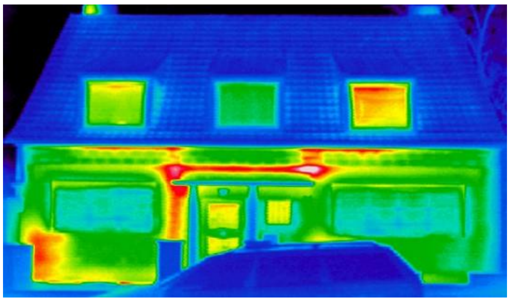
Where the average floor area has been 162m^2 in the period 2005/2015 this has decreased to 143m^2 after 2015.

Multi Family buildings are in existence in various types where dependent on the age it can a flat, apartment, gallery flat, storey apartment, upper and lower house, porch house or maisonette. For the energy use it is of importance to know that over 50% of the multifamily buildings have a high temperature central heating system supplying heat for space heating and domestic hot water to the individual apartment. Also ground floor and top floor apartments in the buildings built before 2000 do have significant higher energy use. A great number of multifamily buildings in cities like Rotterdam, Amsterdam and Utrecht are connected to the district heating grid.

	Multi Family Building				
		Ground Floor	1st/2nd Floor	3rd/4th Floor	5th Floor & higher
1998	1.957.000	299.000	1.073.000	401.000	184.000
1999	2.118.000	323.000	1.179.000	422.000	193.000
2000	2.053.000	276.000	1.123.000	446.000	207.000
2002	2.062.400	310.900	1.123.000	433.000	195.700
2006	2.178.300	344.200	1.160.000	474.600	199.000
2009	2.202.300	307.500	1.223.000	459.600	212.200
2012	2.276.200	347.000	1.236.000	470.000	224.000

There has been a period between 1990 and 2005 that the government stimulated the energy renovation of these older central heating systems by replacing these for individual high efficiency gas boilers.

Statistics show that the quality of newly built houses increases after the seventies, still leaving a considerable potential for renovation in the houses built in the period from 1945 onwards. From 1960/65 onwards most newly built domestic houses became equipped with a central hydronic gas fired heating system for space heating. Often these systems were equipped for domestic hot water with a small gas-boiler in the kitchen or an electric storage water heater, supplied by the energy company on rental basis. The energy companies did this for the storage capacity and peak shaving.

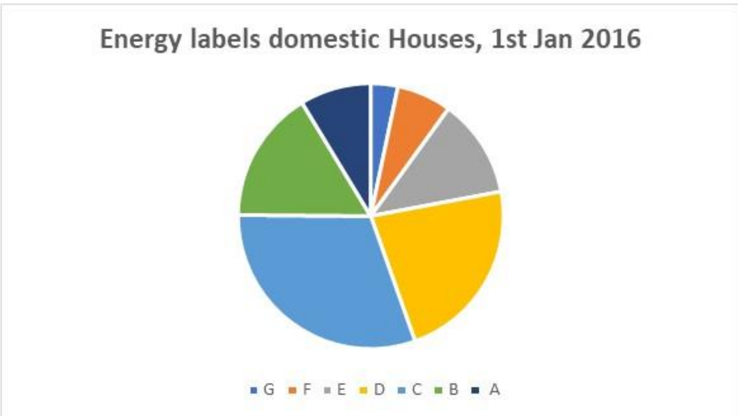


By the seventies legislation enforced the insulation of newly built houses. This mostly carelessly done by putting glass fibre blankets between the cavity walls.

Statistics show that it can be estimated that the majority of domestic buildings are insulated. However it also can be expected that the quality of insulation of buildings insulated before 2006 is insufficient. Especially small cracks in the insulation can have a big effect on the peak demand which can increase the heat demand in peak periods beyond the capacity of standard available heat pumps, designed on the average load.

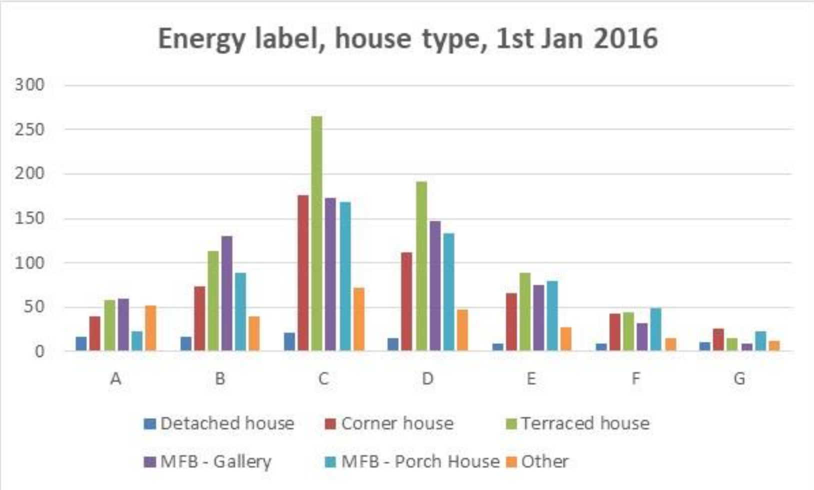
Hybrid heat pumps therewith have a large potential as the gas boiler can cover the peak demands.

Statistics on the avarage energy use dependent on housing characteristics for 2015 show as can be expeced detached houses have the highest average energy use and appartment the lowest.



Due to legislation in line with the European Energy Label modern housing, as may be expected have a significant smaller overall energy use, while renovation of existing housing has its effect.

The Energy Performance of Buildings Directive - EPBD (EU Directive 2002/91 / EC) obliges European member states to regulate the energy certification of buildings. A recast of this directive was published in 2010 (Directive 2010/31 EU). In the Netherlands, this is laid down in the Energy Performance of Buildings Decree (BEG), the Energy Performance of Buildings Regulation (REG) and the Activities Decree (installation inspections). Homeowners must have provided their home with an energy performance certificate on the sale of the home since 1 January 2008. This certificate, later also referred to as an energy label, is based on an inspection of the house.



The label has been renewed in 2010. Although the energy label was mandatory for sale or rental, it lacked sanctions in the event of default. To this end, the European Commission started legal proceedings against the Netherlands in 2012. The Minister for Housing and the Central Government Department introduced a simplified label at the beginning of 2015, with sanctioning options. In 2015, no sanctions have yet been imposed. All houses without a label have been assigned a provisional label at the end of 2014 as part of the simplified system, which, however, has no formal status. As of 1 January 2016, nearly 2.9 million homes were provided with an energy label. Approximately 9% of the homes have an A label, 16% a B label. Most homes have energy label C (31%). The energy label for homes and buildings has been around since 2007. This label provides a quick indication of the energy consumption of a home. Of the more than seven million homes in the Netherlands, approximately 2.9 million homes have been provided with an energy label as of 1 January 2016.

The majority of homes have a C or D label (31% and 23%). Approximately 25% of the homes have a green label (A and B). Nearly nine percent of the issued labels are the very energy-efficient class A.

Most energy labels have been issued so far in 2009 (see third figure). Many housing corporations then had their housing files screened. If a house later - for example after taking saving measures - receives a new label, the old label will be 'overwritten'. Thus double counting is prevented. In 2015 there are also many recordings. This may be due to the simplification of the label request, which has reduced the costs. Also in 2015 sanctions came into effect on the lack of a label when selling or renting the home.

In 2007, 12% of the recordings resulted in a green label (A or B), in 2015 this was 36%. The share of energy-inefficient labels E, F and G declined from 37% in 2007 to 21% in 2015. The recordings are not representative of the entire housing stock. There are still more than four million houses without a formal energy label. Recordings for an energy label are performed relatively often at new-build and rental homes. The figures come from the RVO (formerly NL Agency) and concern the inventories up to and including 2015.

The differences between the housing types are small. The highest percentage of green label (A and B) can be found in the 'other' category (35%). These are maisonettes and other flats. This percentage is also high for detached houses (34%). The lowest is this percentage for corner houses and two under one roof (21%). In detached houses, there are also many 'red' labels (E, F and G, together 29%). In contrast, intermediate houses are often mid-motor vehicles (C and D, 59%).

Market developments

In the Netherlands, space heating is mainly provided for by burning natural gas in central heating boilers. Due to stricter regulations and the goals to get to energy zero more and more newly built houses are constructed as Nearly Zero Energy and Energy Costs Zero houses. According to Government Policy no new housing districts are to be connected to the traditional gas grid, where two options are given:

- Connection to a small local Low Temperature District Heating Grid
- All electric based upon Heat Pumping Technologies

In accordance with European Directive EPBD, in 2020 all new construction must be net-zero energy (Recast of the Energy Performance Building Directive (EPBD)).

Net-zero energy is a relatively simple concept based on the appropriate building physics combined with renewable energy. It's simple if the appropriate technologies are available and if they have been proved in conjunction with each other. The report under IEA HPP-Annex 32 [1] already indicated that the Netherlands has made significant progress in the area of net-zero energy, with a trend towards industrialization of the building process of low-energy homes. This has fulfilled a key condition for the qualitative control of the construction- and installation process which are considered to be a basic precondition in order to meet the net-zero energy requirements in 2020. With regard to the scale of the approach, the Netherlands are one of the frontrunners in Europe, as can be seen in the project examples below. However the majority of the building constructors are still in the learning curve. The additional costs might make new houses unsellable in a difficult market. Examples prove the other way around.

In principle most of those involved label as strategy the Trias Energetica as a starting point:

- *Reduction of the energy demand:* Reduction of the energy demand by a higher insulation grade of the outer shell (Rc outer shell ≥ 5 m²K/W), and the application of additional insulation glazing (double plus, HR or more). In Passive houses 3-layered glass is being used with a U-value ≤ 0.7W/m²K
- *Using sustainable energy:* Application of solar heat (solar boiler) and groundheat; on a larger scale bio mass on district heating as well.
- *Optimization of the energy supply – efficient use of the energy.* Application of high efficiency equipment, optimized controls and facilities for heat recovery for heating, ventilation and domestic hot water.

An energy concept is defined as a logical combination of design choices and installation facilities to achieve low energy consumption. This choice is made before the architectural design stage, so that from the very beginning an integral design can be realized whereby all facilities contribute optimally to the performance of the above-mentioned objectives.

The choice of the energy concepts however in a lot of cases is mainly the result of the choice of partners and the collaboration between these various partners and suppliers. In this collaboration experiences with and judgements about projects already realized (own projects and third party experiences) play an important role for innovations, rather than objective appraisal of concepts. Parties want to distinguish themselves from others, want to outdo the other parties in a different manner.

Thus in everyday practice however it is found that other considerations than only low energy consumption also play an important role in the choice for a package of measures. Because of the mutual influence of the three steps from the Trias Energetica it is sooner the case that an energy concept is chosen as a starting point which then will further be optimized.

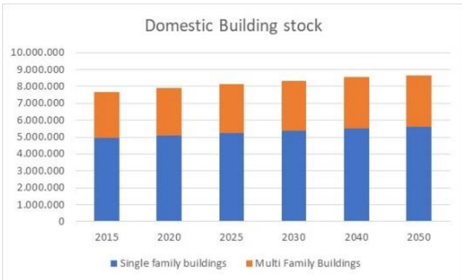
Dutch constructor VolkerWessels' believes that the 'zero energy bill home' will be standard within the next 5 years. 'In terms of free-market principles regarding zero energy concepts, the idea of zero energy bill homes is one step further in the process. The idea behind zero energy bill homes is so simple that it can be easily explained to consumers, and it has moved away from the EPC (Dutch energy regulation Building code law) way of thinking. Everyone understands what a household without an energy bill means'.

This trend of zero energy bill house concepts may turn the residential construction sector upside down: higher quality buildings at a lower price, interesting financial possibilities as energy cost no longer exist, a major change in the relationship between housing association and construction partners, possibility of significant savings on the overall housing foundation charges, etc.

Meanwhile, more and more good examples of both new constructions and renovations are known in the Netherlands. The concepts in this report show that the air-water or soil heat pump is often chosen, supported by solar PV to achieve energy neutrality.

For the new domestic buildings and some types of commercial building the road towards Energy Zero is resulted already in provable concepts. However the biggest challenge for net-zero energy concepts is to make it economically attractive and affordable, also for the renovation market. In the Netherlands a large campaign has started for the market introduction of zero energy buildings. Four constructors and six housing corporations signed a deal called “De Stroomversnelling” (or "The Rapids") on the 20th of June 2013. The goal of this collaboration: to refurbish 111.000 homes to zero-energy, starting with 11.000 homes and ten organisations. The deal was signed by the contractors VolkerWessels, BAM, Ballast Nedam and Dura Vermeer.

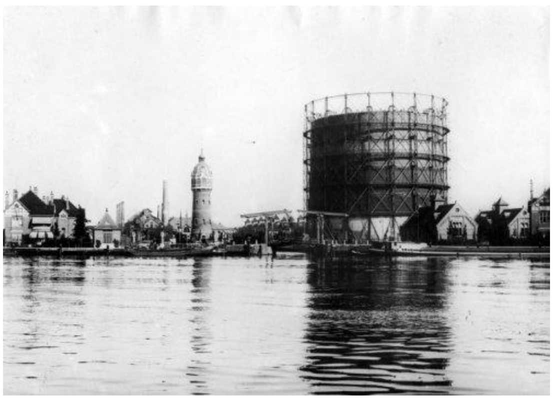
	Total	Single family buildings	Multi Family Buildings
2015	7.686.178	4.956.862	2.729.313
2020	7.888.000	5.088.046	2.799.951
2025	8.148.000	5.257.046	2.890.951
2030	8.335.000	5.378.596	2.956.401
2040	8.536.000	5.509.246	3.026.751
2050	8.657.000	5.587.896	3.069.101



2.2 Hot water Systems

This describes the momentary and often conventional market of hot water systems in the residential sector:

- Individual standalone water heaters
    - Instantaneous water heaters
    - Storage water heaters
- Individual combined heat generators for space heating and hot water (and cooling)
- Collective water heaters for multifamily applications or in district heating
- Innovative first applications



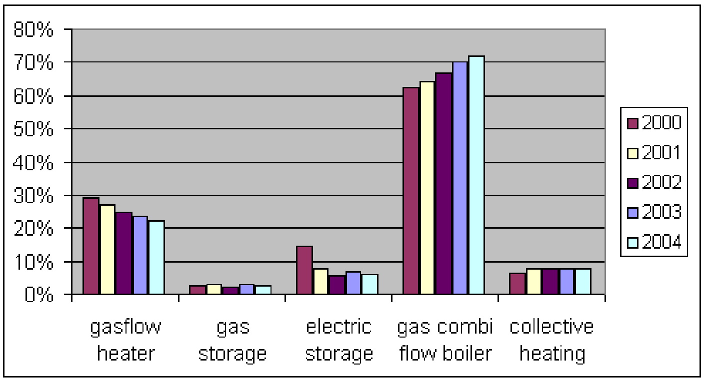
Although, especially for the single family buildings, the diversity is big, the heating systems have traditionally since the sixties been the same lay-out/design of an individual hydronic distribution system with a gas fired boiler in the top of the building. These gas fired boilers have developed from the expensive cast iron heavy weight boiler to the cheap mass-produced small high efficiency boilers. At an average year these high efficiency boilers are sold at 400.000+/year. As the capacity of these gas boilers grew up to 32kW’s there has never been the urgency to install a hot water storage tank next to the gas boiler.

After the discovery of large gas resources in the north of the country the gas fired central heating systems, as they are called in Netherlands, were broadly introduced in the market. An industry producing the gas boilers developed on this.

Gas was already in the market, produced on local level. Next to the water tower, the gas-holder was a familiar sight in the city landscapes. Although gas was available space heating in domestic houses was often based upon a coal fired stove in the living room. Hot water was then produced with a small capacity direct flow gas heater (so called geysers) or with a small electric storage water heater, sized between 50 – 80 litres at temperatures of 85ºC. Both were installed in the kitchen. Later on in this development also the individual space heating became gas fired. In multifamily buildings space heating was mostly done with a central collective gas fired heating system, while the domestic hot water often was generated with a geyser or an electric storage water heater, similar as in the old style single family houses.

Fig: typically fifties and sixties, left: Kitchen with a geyser and right: Kitchen with electric storage water heater

With the broader introduction, the central gas fired hydronic heating system became the standard for single family buildings. The installations for tap water heating therewith showed a market development from individual geysers towards combi flow through gas boilers.



The combination of space heating and DHW in one heat generator like a high efficiency condensing gas boiler for which the capacity is chosen on the instantaneous demand for high comfort DHW (being 32kW), is no longer the obvious solution as the peak demand for space heating decreases to 4kW and lower. Low capacity systems combined with water storage tanks for DHW get more interesting.

Seperate concepts

With separate concepts, the appliances are specially and only intended for preparing hot water. These devices are often close to the tapping point. Roughly, separate concepts distinguish between flow-through water heaters (including geysers) and storage water heaters (tanks).

Flow-through devices: In flow through devices the water flows through the appliance and is immediately heated to the operating temperature. Depending on the desired tap comfort, a relatively large capacity (more than 15 kW's) is required to bring the flow of water to the tapping temperature sufficiently quickly. Due to the nature of this appliance, the amount of hot water available is unlimited in quantity. A small gas fired boiler (called geyser) is a well-known Dutch example of a flow-through device. Lesser applied in Netherlands are the electric flow through heaters as the electric grid in average domestic applications is too weak.

Storage concepts: In the appliance, a supply of water is kept at a constant temperature in a well-insulated storage tank. In the sixties and seventies the electric storage water heater was a popular water heater, rented by the energy companies for night storage of overcapacity in power generation. Storage tank sizes of 50 – 120 litres were installed.

Water heaters are available in many shapes and sizes. Characteristic of a storage water heater is that the supply of hot water is finite. So when the tank is 'empty', cold water flows from the draw-off points. It will take some time before hot water is available again. The waiting time depends on the available generating capacity and the size of the tank. The use of the water heater is therefore strongly determinative of the required content: a small volume in the kitchen water heater, a large capacity storage tank that can be used to quickly fill a bath and for a large family.

However, too large a volume also means unnecessarily large standstill losses because there is always (too) much water to be kept at temperature, even if it is not necessary. For optimum efficiency of a storage device, it is essential that the content and the generating capacity in combination with the tap water requirement are well matched.

	Energy source	Capacity	Comfort	
		kWh	ltr/min	size
Heat Pump WH	Electricity	2 to 3	12 to 15	150 ltr
Solar thermal + Gasboiler	Solar + Gas	6 to 20	12 to 15	150 - 300 ltr
Solar thermal + electric back up	Solar + Electricity	2 to 3	12 to 15	150 - 300 ltr
Storage WH indirect	Gas	20,00	12 to 15	80
Gas boiler for bath	Gas	20,00	5,5	
Electric flow heater	Electricity	3 to 15	4	
Gas boiler for kitchen	Gas	10,00	3	
Electric Kitchen Storage WH	Electricity	2,00	12 to 15	10
Electric Storage WH	Electricity	2 to 3	12 to 15	80 - 150 ltr
Gas fired Stoage WH	Gas	6 to 8	12 to 15	80 - 150 ltr

	Storage size/pp
Frequent shower	25 ltrs
Frequent Bath	45 ltrs
Heating Capacity > 15 kW	30 ltrs
Heating Capacity < 15 kW	40 - 50 ltrs

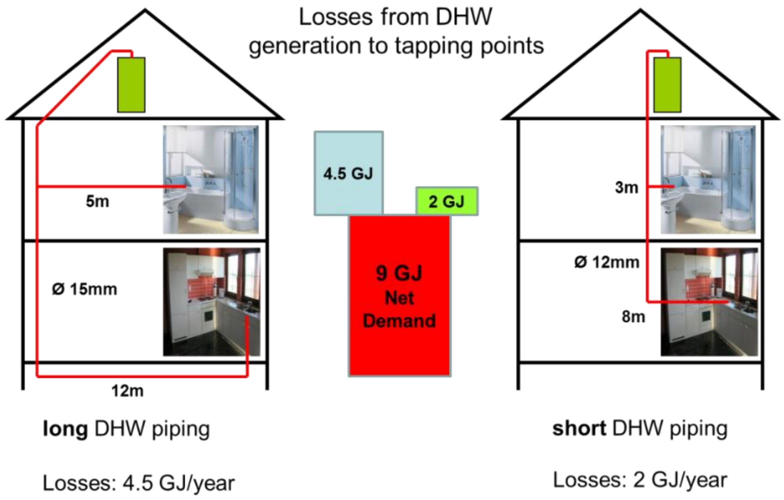
For storage WH, the selected generating capacity is often lower than for through-flow devices (order of magnitude of 1-3 kW). This applies in particular to appliances that are designed to heat the tap water at night (night-water heaters).

Legionella is an important point of attention for storage devices, especially if they have not been at the operating temperature (from 55 to 60˚C) for a long time. In paragraph 7.4 the Legionella aspects are explained in more detail.

Combination concepts

In combi-concepts, the appliances have a dual function, being space heating and heating of domestic hot water. Combi high efficiency boilers are the most used appliances in residential buildings. Combi concepts come both as a flow-through variant (most combi-boilers) and in combination with a storage tank. The power of especially the flow-combi concepts is mainly determined by the required hot water comfort. Often the capacity of this type of equipment is at least 20 kW with a trend to increasingly higher capacities due to the increased comfort requirements for hot water. With the combi-concepts with storage water tanks, the capacity is usually lower.

In contrast to separate concepts, 'combi-generators' are linked to a central hydronic system and located at the top of the building. This can be at (large) distance from tapping points like kitchen and bath. The greater distance from the appliance to the tapping point (and the pipe thickness in between) has a considerable influence on the final chain efficiency. This is still relatively limited for long-term taps (showers and baths), but in the many short-term taps in the kitchen in particular, the pipe losses can have a major impact on the chain efficiency and, in part, negate a very good appliance efficiency. The tapering behaviour of the users is very decisive here. Small kitchen storage water heaters are popular.



In table 3.2 below some essential characteristics and performances of combi-concepts for domestic hot water.

		Capacity	Comfort	
		kW	ltr/min	Storage size
Combi - EHP ground source	Electricity	5 to 15	12 to 15	150 - 300
Combi - EHP air source	Electricity	5 to 15	12 to 15	150 - 300
Combi AHP	Gas	4	12 to 15	150 - 300
Micro CHP	Gas	20	5.5	
HE - Gas boiler	Gas	32	7	
Gas boiler	Gas	20	5.5	
HE - Gas boiler + storage	Gas	25	12 to 15	80 - 150 ltr
Gas boiler + Storage	Gas	20	12 to 15	80 - 150 ltr

Collective concepts

In collective concepts, the tap water is heated collectively for several households. This can be done, for example, by connecting (a complex) housing to district heating, a collective central heating boiler in a central boiler house or a large wood-burning stove with tap water supply. These concepts often occur in blocks of flats (block heating from a collective boiler house) or areas / residential areas with a relatively high building density (many terraced houses) and thus a high heat demand density (district heating with site pipelines, possibly partly due to the crawl spaces). In most cases, the homes each have a delivery set with a heat meter and a heat exchanger for the preparation of hot tap water.

In the case of collective concepts, forced circulation and / or distribution pipelines occur. These heat distribution pipes (outside the building) must be kept at a temperature to provide the users with hot water quickly enough. High system losses are therefore a characteristic consequence of collective tap water systems. In addition, these systems contribute to the internal heat load of a building. Another issue for collective systems is Legionella prevention (see section 7.4).

Most common types of heating systems are:

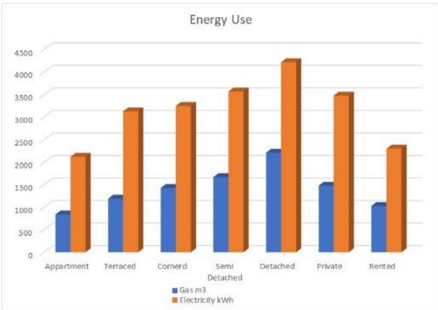
- In single-floor apartments in large buildings:
  - Block heating (central boilers) with central DHW-production/storage;
  - Block heating (central boilers) with individual instant DHW-production (“geiser”);
  - Block heating (central boilers) with individual electrical storage water heaters;
  - Individual Combi boilers (SH and DHW delivered by the same (HE-) boiler).
- In two-floor apartments (“maisonettes”):
  - Individual Combi boilers (SH and DHW delivered by the same (HE-) boiler).

2.3 Energy use for space heating and domestic hot water

This research into the energy consumption has shown that the actual energy consumption does not correspond to the theoretically calculated energy consumption. Especially in gas consumption the difference between the energy labels is smaller than calculated in advance. This study, which has analysed the energy consumption of 558 homes, showed that homes with energy label A consume an average of 38% more gas than calculated in advance, while homes with energy label F consume 20% less gas. There are also large differences in energy consumption per energy label. A spread of 9 m3 of gas per m2 of living space was observed for the homes with energy label B that were tested.

With energy label C this is even 19 m3 per m2. This difference per energy label shows that the resident behaviour has more influence on gas consumption in energy-poor housing. In the case of energetically better homes equipped with floor heating the thermostat is often set at a ‘much’ higher temperature than according to the calculation in the standard.

Energy Use in 2015			
	Gas	Electricity	District Heating
HousingCharacteristics	m3	kWh	%
Overall	1250	2980	5.5
Appartment	840	2120	.
Terraced	1190	3130	.
Cornerd	1430	3250	.
Semi Detached	1670	3570	.
Detached	2210	4220	.
Private	1480	3480	.
Rented	1030	2300	.



In the figures for energy consumption there is no clear distinction made in the energy use for space heating and domestic hot water. It is assumed that the energy use for domestic hot water is between 300 – 450 m^3 of gas (10 – 15 GJ). However that is the energy use, when having a high efficiency gas boiler Based upon the theoretical assumption that a high efficiency gas boiler has an energy efficiency of 87% the energy need for hot water as being 9 – 14 GJ is an estimate which is not supported by practice as the real energy need for hot water.

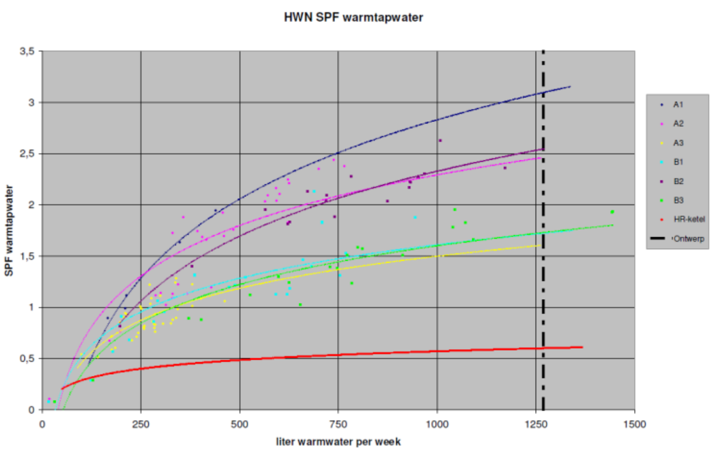
For the condensing boilers, an HR combi boiler has been used, using the average efficiency measured for high efficiency boilers in the field tests (Energy Matters, 2014). The practical efficiency for space heating is between 90 and 95% on top value. We take 90% at insulation level low, and 95% at insulation level Medium or High. Because the central heating and return temperature in a home with poorer insulation must be higher, the high efficiency boiler will be less in condensing operation, which means the yield is lower. The practical efficiency of a high efficiency gas boiler for hot water is 54% with a hot water demand of 4.3 kWh per day. It is assumed that an HR boiler can produce tap water with an efficiency of 87%, means that the practical return is a factor of 62% lower due to downtime losses. With a high insulation level and a hybrid heat pump, it is assumed that a boiler with an increased DHW efficiency of 62% is used.

a. Statistics on hot water use

This report uses an average heat demand pattern for hot tap water per dwelling. This pattern of functional tap water demand is the same for all housing types. The idea behind this is that the tap water demand does not depend on the type of dwelling, but on the household size. The associated energy demand for hot water depends on the technique used. The total annual gas demand for the preparation of hot water is taken from measurements in the context of the HOME study (ECN, 2009) and amounts to 300 m3 (approximately 3000 kWh) of natural gas per year. This is an average, depending on the number of people in a household and their shower behaviour can be higher or lower.

	Aplication	KItchen (60° C) [liters/minute]	Shower (40° C) [liters/minute]	Bath (40° C) [max. minutes]
CW1	Kitchen	≥ 2.5	-	-
CW2	Kitchen or Shower	≥ 3.6	≥ 6	-
CW3	Kitchen or Shower or Bath (<100 liters)	≥ 6	≥ 10	≤ 12
CW4	Kitchen or Shower or Bath (120 liters)	≥ 7.5	≥ 12.5	≤ 11
CW5	Kitchen or Shower or Bath (150 liters)	≥ 7.5	≥ 12.5	≤ 10
CW6	Kiitchen and Shower and Bath (150 liters) or Bath (200 liters)	≥ 7.5	≥ 12,5	- ≤ 10 ≤ 10

The abbreviation CW stands for Comfort Hot Water. The number behind it indicates a class. The higher this value is, the more hot water the boiler can deliver per minute. This CW value has been determined by the Gaskeur Foundation. Below is an overview of how much hot water a CW3 to CW6 unit can deliver at different water temperatures. Why different temperatures for hot water are handled is described in detail on this page. A guideline: as a consumer you want to have warm water of about 38 degrees Celsius. So you need to use that temperature and hot water quantity to determine the desired CW value. In the column "tap water quantity at 38 ° Celsius in practice (average)" we looked at all current central heating boilers in that CW value class and took the average. This gives you a good grip on what you can expect in liters per minute from your shower or bath tap. You will see that the practice values are usually higher than prescribed by Gaskeur.



In general testing procedures are built upon tapping curves simulating the hot water use. In practice there is a great variety in water usage based upon human behaviour factors.

Water consumption has reduced in recent years. In 1969 the average was 190 liters per person per day. In 2013, the average declined to 119 liters per person per day. The decrease in water consumption is mainly because home appliances such as the dishwasher and the washing machine have improved considerably, being more energy efficient using less water. Nowadays most of the water is used for the daily shower on average 51 liters per shower and for the toilet on average 33 liters per day.

The graph above [07] shows the results of a field test. It becomes very clear that the overall efficiency has a strong relation with the demand of DHW (horizontal axis: liters of DHW per week – vertical axis: SPF).

- People in large cities shower more often than in the rest of the country.
- Average time spent under the shower is 8.1 minutes.
- 50% of the households have a water saving shower head. This can save up to 1.8 liters of water per minute.
- Comfort showers use two times more water than a standard shower and is becoming a trend, particularly popular with young adults (18-24 years).
- Outdoor (sports, work, school) showering is at an average 3 minutes shorter than at home
- The use of the sink has remained the same in the past decade.

- The use of a bath has decreased significantly since the 1990s
- Less than 50% of the people wash hands after toilet visit.
- The washing machines are more economical. In 2001 used a machine 80.3 liters per wash, in 2010 55.6 liters per wash.
- At a hand washing dishes including pre-rinse 9.1 liters of water is consumed. At a modern dishwasher about 15.8 liters.

3. Brands and Associations

Netherlands has a number of Associations and has the Dutch Assocation for Renewable Energy (NVDE) as umbrella association with amongst its members heat pump manufacturers like Inventum and ITHO-Daalderop, but also Installers, Banks and Energy Companies and the Associations for Solar, Geothermal, Bio-Energy, Wind, Ground Sources and Heat Pumps. The Dutch Heat Pump Association (DHPA) is representing heat pump manufacturers and suppliers.

The objective of the Dutch Heat Pump Association (DHPA) is to systematically and structurally promote the application of sustainable energy systems in residential and utility buildings (new and existing), both fully electrically implemented and in combination with existing infrastructure and existing gas-fired installations. In its organization two main segments exists, being:

- Domestic buildings
- Commercial buildings

The Dutch heat pump manufacturers are among the most innovative in the European market and have many years of experience in developing the technology for various applications. Triggered by the stiff competition of cheap gas boilers and focusing on the mass market of middle priced privately owned houses as well as the enormous renovation market in the segment of rented houses and apartments. More and more these companies are involved in building projects for new NZEB as well as renovation to the level of NZEB. By this direct one-to-one contact with the building constructors, housing corporations and occupants or owners, new integrated products have been developed. This ranging from Plug & Play systems avoiding intermediaries like installers and consultants, to advanced smart control systems to monitor and maintain the system as well as giving the grid operators a valuable tool

This competition and the weak electric infrastructure lead to the development of the Hybrid Heat Pump for renovation. The challenge of multifamily buildings triggered the development of Booster Heat Pumps for Domestic Hot Water.

Although there are no real OEM's amongst these manufacturers and suppliers the particular strength of the Dutch heat pump industry lies in the production of heat pumps for the capacity range smaller than 10 kW's, even down to 3,5kW's. On the other side of the spectrum for commercial buildings and industries manufacturers build and supply systems up to 6MW's. Of particular relevance are air / water systems, which, in contrast to most other heat source systems, have been posting strong sales increases since 2014. Dutch heat pump manufacturers have recognized this trend in good time and invested accordingly in this technology.

3.1 Dutch heat pump manufacturers and suppliers

The supply of heat pumps for domestic application is from a various number of suppliers of which a number consists of manufacturers and a number of importers. For this Annex the most relevant suppliers seem to be the Dutch manufacturers, however some interesting concepts appear from the other suppliers too.

The Dutch manufacturers focusing on smaller domestic applications are:

- ATAG, as part of the Ariston Thermo Group, is starting to distribute heat pumps by mid-2018. The main speciality is being a manufacturer of gas boilers and solar thermal installations
- Inventum, originally a manufacturer of storage water heaters, supplies a number of heat pump ranges for space heating and domestic hot water. The Ecolution ventilation heat pump is one of the innovations.

Inventum supplies storage tanks and heat pumps also for other suppliers. Next to heat pumps Inventum supplies a large range of electric storage water heaters[2].

- ITHO-Daalderop, originally a manufacturer of storage water heaters, supplies a number of heat pump ranges for space heating and domestic hot water. The air to water heat pump can be installed as mono or hybrid with storage water heater, whereas ITHO-Daalderop has been one of the first to have fully integrated hybrid heat pump based upon ventilation air. Furthermore their concepts for Energy Zero are installed in a number of projects like Rijswijk Buiten. This latter project based upon their WPU4 double function heat pump, also supplying cooling in summertime. Developed by the company of ECOON the booster heat pump was introduced by ITHO-Daalderop. The company is one of the main suppliers of the 2nd Skin project focusing on plug & play concept for the renovation of existing domestic buildings.
- Nefit, as part of the Bosch group, manufactures gas boilers and combine these with heat pump technologies from the Bosh group. Both ventilation (VentiLine), air source and ground source heat pumps are sold, potentially in combination with solar thermal and/or pv.
- NRGTeq is Dutch manufacturer of a large range of heat pumps. A special High Temperature range has been developed for renovation projects in Multi Family Buildings. Their TNG series ranges from 4 – 250kWs and has DHW tanks added to the concept.
- Remeha, as part of the De Dietrich group, manufactures mainly gas boilers to combine these with technological know-how from De Dietrich. The main heat pump products are the hybrid Tzerra combined with a gas boiler and storage tanks ranging from 50 – 350 litres.
- Techneco, manufactures a wide range of heat pumps for the domestic market, having ELGA as the first Hybrid Heat Pump on the market and TOROS as a plug & Play Concept. For the hybrid ELGA heat pump an air source unit from Toshiba is used. The larger systems are Aquatop with capacities up to 45kW. Techneco is also representing as a supplier ROBUR in the Dutch market. As manufacturer and supplier of heat pumps, in addition to supplying the heat pump, Techneco can also supply the integral system with a closed loop ground source and low temperature floor heating system in the house.

A number of Dutch suppliers for large heat pump manufacturers develop their own market approach with technologies based upon the heat pumps from their mother company. To enter these markets a competitive advantage is in developing a number of plug & play concepts.

- Alklima, as supplier of a broad range Mitsubishi technology developed a successful approach for the NZEB market developing plug and play concepts for new buildings and renovation of multifamily buildings. One of these is the WATTZ approach where Alklima offers renovation concepts. Together with Zehnder and ABB another plug&play concept is marketed. For renovation Alklima works together with large construction companies like Dura Vermeer in pilots.
- Daikin, together with the European Development Centre in Ostend in Belgium have developed the Daikin Altherma LT Integrated Solar Unit, to be installed in NZEB in Europe and first to be demonstrated as example project under Annex 46. This unit is based upon the smart domestic hot water storage unit. Together with Dutch Intergas gas boiler manufacturer Daikin is market the integrated hybrid heat pump unit, sold in Germany by Rotex.
- Dutch Heat Pump Solutions have based upon Panasonic technology developed the Hydrotop and the Hydrowall as a plug and play concepts for existing and new domestic buildings. A special integrated unit has been developed combining heat pump technologies with solar energy.
- Nathan as supplier of Alfa Innotec is primarily active as system integrator in the building sector, supplying a number of heat pumps, designing and drilling ground sources. A booster heat pump designed by Nathan appeared on the market and is monitored in a pilot project in Sophiastaete. Furthermore Nathan developed an Energiemodule as a plug & play concept and applied the concept of an NZEB building for a related company in the NATHAN Group.
- Thercon is the supplier of Fujitsu heat pumps and has a interesting website monitoring installed heat pumps.

[2] The author of this report has been working for Inventum for eight years at the development of water heaters.

- Valliant Group together with AWB, has developed for the Dutch market a small hybrid heat pump preferably combined with the UNISTOR storage tank for DHW. Special combinations are applied in NZEB projects and examples like in Amersfoort can be found on the website.

Next to manufacturers and suppliers for smaller domestic application there are manufacturers and suppliers for larger collective systems and commercial buildings:

- Carrier with their Dutch support unit and French development is one of the important players in the Dutch market mainly active in larger projects in commercial buildings and agriculture.
- Coolmark is supplying the high temperature Q-ton heat pump developed by Mitsubishi Heavy Industries
- ETP, is a company mainly active in the market for commercial buildings supplying heat pump project up to 10Mws as turn-key projects based upon standardized procedures. Their care is including ground sources, monitoring, reporting and maintenance. Together with a large energy company a new product for domestic hot water is tested in a pilot project.
- Grenco is part of the German GEA company, producing as OEM screw compressors. GEA-Grenco mainly supply their heat pumps for industrial applications.
- Linthorst Techniek, manufactures large capacity high temperature heat pump TT68 with an interesting application at a multifamily building in Leiden. The heat pump was developed under the R&D program TKI-Urban Energy.
- Reduses, manufactures as part of the Installect Group, gas engine driven heat pumps ranging from 100 – 500 kW. These heat pumps supply high temperatures and are fit for renovation in multifamily buildings and for medical applications.
- Triple Aqua is a manufacturer of a heat pump developed in Netherlands using propane as refrigerant. This development has already won numerous awards such as the Eneco Dutch Innovation Award at the 12^{th} IEA Heat Pump Conference. Typically Triple Aqua heat pumps are applied in commercial buildings. The heat pumps are marketed by suppliers like Beijer and Coolmark
- OSH is a system integrator supplying and installing plug & play concepts for commercial as well as collective domestic buildings based upon heat pumps by Waterkotte. OSH claim to install these systems in one day and guarantee the performance on the longer term. An interesting example is the system installed at Clarissenhof in the city of Tilburg, which is one of the example projects under this Annex. For individual single family buildings the One@home plug & play concept is developed.

Innovation is a major topic in the industry.

The majority of the Dutch manufacturers are no Original Equipment Manufacturer (OEM). Compressors, expansion valves, evaporators are almost all manufactured outside of the Netherlands. Thus the development within the manufacturing companies almost always focuses on the strengths of the company. Companies like Inventum and ITHO-Daalderop typically have always been manufacturers of storage water heaters, while Nefit, Remeha and Intergas are experienced in Gas-technologies and Grenco is a manufacturer of refrigeration equipment and screw compressors. The others are relatively 'new' as manufacturers, combining in a smart and innovative way technologies with expert knowledge of the market.

The survey of companies according to their strengths also shows that motivated employees who have been working in the company for years, as well as a high level of customer satisfaction, are the central strengths of the national industry. Another strength is the positive corporate development. Nearly half of the companies have seen steadily rising sales over the last three years; to a further 36%, this development is largely true. These figures are consistent with the steadily rising sales figures in the Dutch heat pump market.

4. Market trends and scenario's

In this part the reporter analyses the figures, policies, trends and technology developments and describes the expectations for the market until 2020 - 2030.

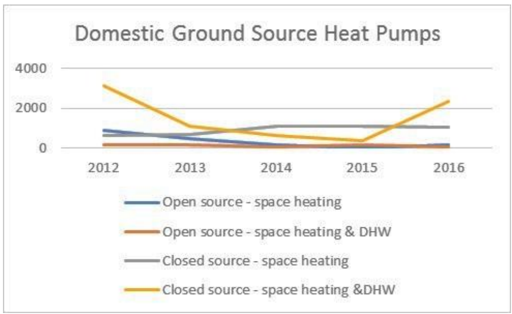
4.1 Market development (history)

At this moment the Dutch heat pump market is a small but growing market. The use of ground sources increases steadily: in 2015 and 2016, it grew by six percent. In new commercial buildings, it is an almost standard technology which is relatively cost-effective. In addition to a heat demand, these buildings have a cooling demand using the same ground source for the heat pumps as passive cooling. Often open ground source systems are used for which in 2015 a total of 251 million m^3 of water was pumped. The number of domestic houses on open ground sources is dropping. These often large collective systems.

GROUND SOURCE HEAT PUMPS

	Numbers					Capacity MW				
DOMESTIC Buildings	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Open source - space heating	875	502	190	7	171	10	6	3	0	2
Open source - space heating & DHW	185	157	52	148	73	1	1	0	1	1
Closed source - space heating	656	688	1125	1112	1031	12	7	10	14	16
Closed source - space heating &DHW	3129	1095	643	381	2363	16	5	4	2	13
	4845	2442	2010	1648	3638	39	19	17	17	32
COMMERCIAL Buildings	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Open source	398	433	300	302	337	58	70	64	64	51
Closed source	545	197	200	136	90	16	21	14	10	4
	943	630	500	438	427	74	91	78	74	55

source CBS



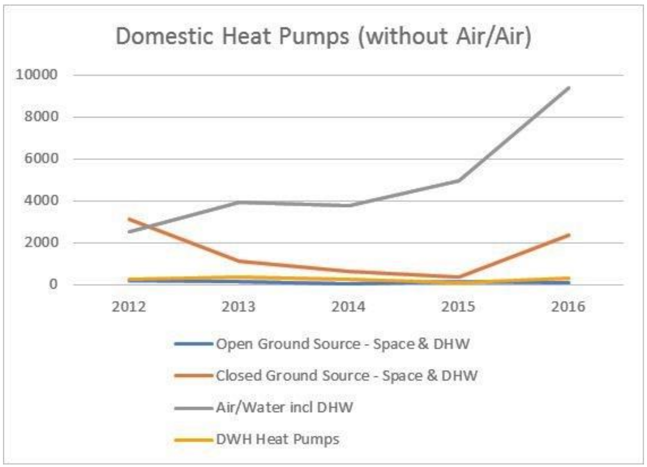
By 2016, the building of new domestic housing shows some recovery after a crisis period of reduced activity. The sale of heat pumps also increased in units sold, but the overall new installed capacity dropped. This seems to indicate a trend to the lower demand of space heating for newly built houses, also indicating that the majority of ground source heat pumps are installed in the market segment. Heat pumps for space heating and DHW are combi-type of heat pumps installed in larger building projects of which a number of projects is in all electric housing quarters not connected to the gas grid. Often these houses are already of the Energy Zero Category or even the Energy Costs Zero Category. This is a fast growing market already. Unclear in this CBS-statistics is the market for space heating only ground source heat pumps. It could be the category sold to private owned houses. RVO gives figures of the heat pumps supported with the ISDE grant, which shows that in 2016 about six thousand heat pumps were installed by private house owners, where 25% were ground source heat pumps.

AIR SOURCE HEAT PUMPS

	Numbers					Capacity MW				
DOMESTIC Buildings	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Air/Air	11.514	10.039	13.338	16.265	24.254	48	46	68	80	118
Air/Water incl DHW	2.536	3.905	3.744	4.925	9.374	12	21	20	24	53
DWH Heat Pumps	270	373	231	88	322	0	1	0	9	1
	14.320	14.317	17.313	21.278	33.950	12	22	20	33	54
COMMERCIAL Buildings	2.012	2.013	2.014	2.015	2.016	2012	2013	2014	2015	2016
Air/Air	22.221	22.814	26.191	27.276	34.362	184	188	219	214	254
Air/Water	418	255	524	622	1.430	19	17	26	36	47
	36.959	37.386	44.028	49.176	69.742					

source CBS

The use air source heat pumps is steadily growing. By 2015 more than 350 MWs and in 2016 about 474 MWs was installed with nearly 70.000 installations. Most of these (almost 60 thousand) are air-air heat pumps, the others is linked to hydronic heating systems. Air source heat pumps can be installed relatively cheap in a new building. Although the sale of heat pumps, due to the reduced construction activity, remained fairly high until 2016. The increased new building activities for domestic and commercial buildings in 2016 has contributed to the steep increase in sales. In addition, the increasingly stringent energy standards for new buildings is a tipping point in the choice between a traditional installation and a heat pump. It is apparently preferred to choose an air source heat pump rather than a ground source heat pump. In addition, the ISDE scheme has given some impetus for the sale of heat pumps. An analysis of an RVO data file containing data on numbers of heat pumps purchased with ISDE subsidy shows that in 2016 about six thousand heat pumps were purchased by private house owners.

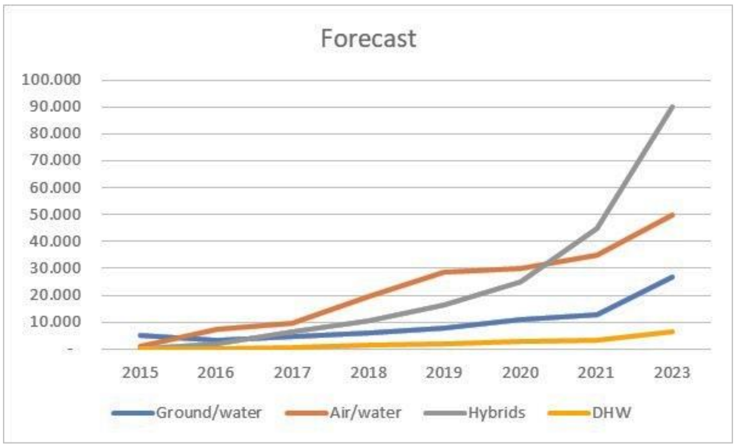


It is striking that the avoided CO_2-emissions of air source heat pumps are negative for the recent years, but the avoided consumption of fossil primary energy is positive. The explanation is that the savings of these heat pumps depend on the difference between the avoided natural gas consumption with the related emissions and the additional consumption of electricity with the related emissions of power stations. Electricity generation according to current references has higher CO_2 emissions per unit of energy consumed than heat generation in a gas boiler. Moreover, it is important to know that both the avoided primary energy consumption and the CO_2 emissions are strongly dependent on the energy performance factor of the heat pumps. This value for this factor has been taken over from a European Commission Guideline (see RVO.nl and CBS, 2015), but in practice, very little is known about the performance of outdoor heat pumps in practice.

4.2 Market development (short term)

The statistics given by CBS do not split the air source heat pumps in the domestic sector in single use and hybrid systems. This is being done by DHPA for the years starting in 2015 with an estimate of the market growth

	2015	2016	2017	2018	2019	2020	2021	2023
Ground/water	5.013	3.394	4.500	6.000	8.000	11.000	13.000	27.000
Air/water	1.293	7.486	9.500	19.500	28.500	30.000	35.000	50.000
Hybrids	200	2.200	6.500	10.500	16.500	25.000	45.000	90.000
DHW	88	322	750	1.500	2.000	3.000	3.500	6.500
Total	6.594	13.402	21.250	37.500	55.000	69.000	96.500	173.500



The market developments given are based upon expected growth rates from manufacturers and suppliers based upon existing governmental and local policies and existing legislation.

4.3 Scenario's (longer term)

Long term government policy (horizon: 2030) for the building sector focuses on:

1. No gas grids in newly built housing estates and districts.
2. Renovation of 200.000 domestic apartments/houses per year.
3. Introduction of low temperature district heating in densely populated areas with a high heating demand/profile.

Electrification of end-use services in the transportation, buildings, and industrial sectors, coupled with decarbonisation of electricity generation, has been identified as one of the key pathways for achieving a low-carbon future. By lowering the carbon intensity of electricity generation and substituting electricity for higher-emission fossil fuels, significant reductions in carbon dioxide emissions can be achieved. Next to a significant reduction of energy needs, one of the major boundary conditions is the development of a smart infrastructure with more and diverse power suppliers and a lower and more flexible tariff for electricity. In this smart infrastructure storage of energy, heat pumps and domestic hot water play important roles.

The ambition by government to get toward Energy Zero by 2050 means an average of 200.000 – 300.000 new and/or renovated houses/apartments per year to be fitted with renewable and sustainable technologies. In effect this means:

- Suppliers and manufacturers will have to be able to make the right numbers of sustainable technologies,
- Installation branches will have to increase with a factor 4 – 6 of high quality installers with the know-how to install heat pumps and other technologies that are more complex than 'simple' gas boilers.
- Simple technologies have to be introduced into the domestic market to achieve these goals.

The solution for this challenge seems to be an increasing deployment of plug & play and smart solutions needing a less high qualified workforce. This not only for the installation but also for maintenance.

For single family buildings, mainly privately owned, this will have to focus for the homeowner to become with the energy system independent from intermediaries who make money from their services. This with a system that gives the desired quality in the living environment, as much as possible maintenance-free and without worries and additional costs. For new Energy Zero houses these are standardised concepts, already appearing in the market, with ground source heat pumps and an individual closed loop ground sources, or air source heat pumps. For ground source and air source heat pumps it will in almost all cases be a double function heat pump with a storage tank for domestic hot water. For existing domestic houses the hybrid heat pump will be the first solution for the majority of the house owners, where domestic hot water is primarily be made with the supporting gas-boiler. For rented single family buildings the same options are available, where as it can be expected that for renovation projects the choice of systems will focus on the all-electric solution and maybe in densely populated areas on district heating. The latter not being the optimal choice as it makes the occupants of the house dependent of the district heating company.

For multifamily buildings, mainly owned in the inner cities by housing corporations, the options of individual solutions are more complex. Collective systems maintained, optimized outside of the apartments in the building seems to be an interesting solution. Optimisation will have to be found outside of the front door of the apartment. Domestic hot water can be supplied centrally by a heat pump with a small heat exchanger in the apartment. A solution for potential legionella will have to be found. Another solution is to split space heating and domestic hot water and install a booster heat pump in the apartment. Major obstacle in that will be the lack of space for such a booster heat pump with storage tank in the apartment. District heating, fed with sustainable energy options at low temperatures, is another option.

4.3.1 No gas grids in new housing estates and districts

New construction ‘must’ be built off the gas grid as a standard solution. It’s up to local authorities to decide whether to choose for all-electric or district heating. As new buildings must be, according to the Building Regulation, Energy Zero from 2020 onwards, district heating yields far less CO_2 reduction than for existing buildings, so all electric for these houses is the obvious choice. Basic assumptions for the ‘no gas grids’-scenario are:

- The number of individual households will rise from 7.27 million in 2013 to 8.0 million in 2020 and 8.4 million in 2030. It is expected that almost every household in new houses will have its own individual space heating and hot water supply.
- The energy demand in new housing will drop further as after 2020 newly built houses will be Energy Zero. Basically this is mainly for space heating while the demand DHW will increase.
- New housing in the period up until 2020, expected to be 40,000-45,000/year. This will be on average 30% rental premises and 70% for the private sector. In the period of 2020-2030, there will likely be a stronger growth in new residences for the rental sector mainly multifamily buildings, partially due to the aging of the population.

The expected development of the all-electric solutions and types of heat pumps for single family buildings is:

- The standard will be the double function (combi) heat pumps for space heating and domestic hot water, potentially combined with thermal solar energy and always combined with solar photovoltaics.
- Increased share of air-source heat pumps compared to the ground source systems
- A further development and deployment of packaged plug and play units in an industrialized building process
- Smart grid solutions and control by the grid operators as mayor market player.

For Multi Family Buildings (MFB) there is a number of solutions, being either collective or individual. About 50% of the existing multifamily buildings is equipped with a collective heating system. Collective solutions for MFB can be:

- A collective high temperature heat pump with a large thermal buffer for domestic/sanitary hot water, comparable with systems that are installed in hotels or lodging premises. Hot water is distributed directly from the storage tank.
- A collective high temperature heat pump with (decentral) hot water generating sets in individual apartments.

- A collective low temperature heat pump for space heating, used as a source for (decentral) booster heat pumps with storage tanks installed in the individual apartments.

The major challenges in this market are not so much technical regarding the used technology of heat pumps, domestic hot water or solar energy but more on:

- Network management and network load for the energy infrastructure becoming all-electric
- Knowledge - and therefore the support - for smart grids is missing, but slowly developing
- Further development of control technology between central systems

These challenges are on local political level in a relation with the grid operators, the system suppliers and the building constructors.

4.3.2 Renovation of 200.000 houses per year

The application of technologies to reduce the energy demand of a house with insulation (HR ++ glass, cavity wall insulation, floor insulation, roof insulation) or heat recovery is the first step towards sustainability. Irrespective of the heat source of the household (boiler, heat pump, hybrid heat pump or district heating network), reducing energy demand is the first step in reducing CO2 emissions and reducing energy bills. It is important to realize that the initial choice for an option like a hybrid heat pump does not mean "lock in". Other options like district heating do so.

Single family buildings

The majority of single family buildings are privately owned, whereas hybrid heat pump technology has the largest potential to replace gas boilers. It is difficult to transform existing houses to an all-electric house. The originally on 90/70 dimensioned radiators in a vast part of the domestic housing stock often operate at lower supply/return temperatures, due to the reduced transmission value of the building as a result of massive insulation programs. This opened huge market opportunities for heat pumps – especially hybrid heat pumps - in the existing building stock. The rise of hybrid systems slow down electrification and inhibits the reduction of gas consumption.

A hybrid heat pump avoids the requirement of expensive interventions which are often needed to apply an all-electric heat pump in existing buildings. A hybrid heat pump consists in most cases of an electrically driven heat pump delivering approximately 75% of the yearly space heating, with outside air or ventilation air as a source. The small capacity of the heat pump can generally not provide sufficient heat in peak demand at extremely cold days. In this situation, the hybrid heat pump switches from the heat pump to the gas boiler when outside temperatures get below -4°C; the last time this occurred in the Netherlands was in 2013. So in practice there can be long periods that the heat pump covers 100% of the demand. With the latest technology air source heat pumps can even deliver a sufficient capacity at temperatures lower than -10°C. However the electricity grid in large number of districts can often not handle this peak demand.

With the hybrid heat pump domestic hot water is produced by the gas boiler, as more than often no storage tank has been installed next to a hybrid heat pump. Hybrid heat pumps offer a major and affordable step towards sustainability in existing houses, and it is a good step forward towards all-electric. Further research is needed to develop cheaper and compacter storage solutions, plug & play solutions which can be easily installed and super insulation in existing buildings.

The number of hybrid heat pumps in the Netherlands is still limited (+ / 20,000) compared to gas-fired boilers, of which approximately 400,000 are sold every year, mainly for existing buildings. In a positive scenario an ever-larger proportion of those 400,000 gas-fired boilers will be replaced by hybrid heat pumps, with expectations of 90.000 hybrids/year in 2023.

For perhaps two-thirds of the housing stock, the hybrid heat pump is currently a possible or even obvious choice. Old houses, with a construction year to about 1950, have the highest heat demand and are difficult to insulate. For these homes, hybrid systems can also offer a solution in the long term.

Newer homes (year of construction roughly between 1950 and 2000) can be provided with a hybrid system and switch to all-electric options in the future. The hybrid heat pump can make a significant contribution to CO2 emission reduction and the goals of the Energy Agreement, in the built environment this is possible even without the use of green gas. However, the potential of the hybrid heat pump was not included in the recent National Energy Outlook or the governmental Energy Agreement.

Multi Family Buildings

In an agreement with the Government, housing corporations have planned to step up the renovation rate of flats and dwellings in city quarters over the next years to about 10% per year. This will result in 300.000 renovations per year. It is expected that due to market demands the more fundamental types of renovation will be the focus of corporations.

One of the main barriers for the implementation of energy-saving measures, especially in rented apartments, is the divergence in interests of the tenant and the owner/investor. Whereas the owners of houses (e.g. housing associations) invest in energy-saving measures, the tenants benefit from the reduction of energy costs. Opportunities to increase the rent often are (legally) limited, or the return on investment is extended over a long period of time.

Most of the tenants enjoy rent protection. Low income tenants can apply for a social rent house with a low rent that is bound to a legal maximum. The rent does include the heating and hot water systems, but does not include the energy bill. So corporations who plan to invest in energy efficient equipment will not reap the benefits. To work around this problem, corporations can raise the rent under a guarantee that the energy costs will decrease by at least the same amount. This cannot be done in social rent houses, as the rent is bound to a maximum.

The possibilities for financing for existing housing appears to be more restricted than for new buildings. Options like credit from suppliers, leasing of systems or design/build/maintain constructions are hardly used. In large renovation projects, corporations can reach price reductions from suppliers. The large scale also facilitates engineering and the development of solutions for specific situations.

Challenges regarding the renovation process

Five major challenges are:

- Dutch consumers have relatively little knowledge in general of energy systems. This can be greatly improved.
- Costs of heat pumps are considerably higher than for high-efficiency boilers. The new installation must initially be financed by the end user who is not aware of the life time costs which are favourable by the changing energy taxes and the subsidies.
- Although heat pumps are mature and reliable, the market penetration is still small. Partly because the installation of a heat pump in a house is not a standard job. For the HR boiler, large-scale projects for housing corporations have led to quicker and easier installation procedures. This is not yet fully the case for (hybrid) heat pumps in renovation, where a plug & play standardized module should become available.
- Energy conservation in existing buildings is hardly legally enforced, but necessary for getting the energy label which is needed for selling a house.
- As a result of the above points, the demand for heat pumps is limited and the knowledge of installers is poorly developed.

- Voor bestaande woningen zijn er geen verplichtingen omtrent verduurzaming, ook zijn er geen eisen voor de toekomst gesteld. Er zijn geen extra incentives gecreëerd voor de bestaande bouw.
- Finances: incentives for housing corporations (as tenants benefit while corporations invest)

4.3.3 Low temperature district heating

According to the Governmental Policy Paper 'Heat Vision', connection of buildings to collective heating networks, such as district heating, produces up to 75 percent less CO2 emissions than heating with central heating boilers. This particularly appeals to local authorities (municipalities and provinces) who want to take major steps in tackling climate change. CO2 targets are converted into targets for connections to heat networks. The national government has indicated that it wants to facilitate the roll-out of heating networks. District heating is often proposed as the only sustainable solution with a CO2 reduction of at least 50%.

Some 70 municipalities in Netherlands have indicated they want to become free from the gas grid. It is often suggested that the gas distribution grids can be replacing by heat grids. By removing gas networks to be renovated, investments can be made in district heating networks. That sounds wonderful, but district heating is limited in its potential. The claim that we can become gas-free with heating networks is only partially feasible. With district heating, a considerable amount of gas is indirectly consumed in auxiliary gas-boilers and power plants (which have to compensate for the lost electricity). This means that CO2 reduction of district heating of electricity and waste incineration plants will be lower in practice than in theory and the calculation models used for the Energy Performance models. Compared to district heating with residual heat from electricity and waste incinerators (most common in the Netherlands), energy conservation and (hybrid) heat pump always are a better option.

In the comparison of district heating with alternative options, an adverse effect of district heating has not yet been taken into account. With district heating, a building requires less energy-saving measures than the same building on gas. When using measures outside buildings, the efficiency of the heat supply can be determined with NEN 7125. The efficiency of district heating can increase to more than 100 percent, so less energy-saving measures have to be implemented. This method is called the 'stepped requirement'. It allows the EPC of a district heating connected house to be 0.532, compared to 0.4 for a house with a heat pump. This means that the heat consumption of a home on district heating can be 33 percent higher! This requirement supports the deployment of district heating networks, making them more economic viable because of the higher energy demand. But it also leads to extra CO2 emissions.

High temperature district heating networks are not sustainable and won't offer CO2 reductions on the long term.

Still heat networks could offer a valuable solution contributing to the preservation of heat, provided that sustainable heat is used as the source. Where historically the temperature in heating networks was around or even above 100 ° C, there are more and more nets in which the temperature is much lower. These low temperature (LT) heating networks are interesting because of two important developments:

- On the supply side, CO2 emission targets lead to the phasing out of coal and gas power plants in the coming decades. This also applies to the availability of heat from the incineration of waste in waste incineration plants (AVIs). More efficient waste processing and recycling leads to a reduction in waste flows. In the industry, efficiency improvements ensure that not only the amount of available residual heat decreases, but also the temperature of the residual heat. It is a challenge to use these sources in the most effective way.
- On the user side, the demand for heat per home for space heating is greatly reduced by energy saving measures such as insulation and heat recovery. This lower heat demand makes it possible to heat at a lower temperature and to use low temperature heat sources. In contrast to the decreasing demand for space heating, the demand for hot tap water increases in absolute terms. This is partly because people shower more often per day and use more hot water per shower. However, the expectation is that this trend will level off again.

Challenges

These developments on both the supply and demand sides make low temperature heating networks more attractive compared to high temperature networks. In new heating networks, the temperature regime can already be taken into account in the design. While the experience with low temperature heat grids in the Netherlands is still limited, it is clear that the main challenges in the transition is not so much of a technical nature, but particularly organizationally and financially. Organizationally, because coordinated measures are necessary at both the generation, distribution, and the end-user. Financially, in particular because the cost of modifications to existing homes are considerable. Achieving social acceptance and support is essential, because of the more radical changes in existing buildings.

The 4th generation of district heating can expect to gain a relatively small market share of 15 - 25% of the overall buildings stock in 2040. The main challenge in that type of district heating is the sufficient and safe generation of sanitary and domestic hot water. At this moment, booster heat pumps seem to be the only direct available solution.

4.3.4 Smart Grids

According to the final HPT-Annex 42 report, the need for flexibility is recognised in the Netherlands, particularly for managing grid congestion in the medium-term. However, similarly to the UK, the market share of heat pumps is less than 1 % of the heating market, and there are challenges regarding lack of space for storage. The flexibility potential from HPs is therefore quite low – hybrids could be key to unlocking flexibility here.

On the technical side, the basic principles of heat pumps in smart grids are quite well understood. There is, however, still a lack of understanding on how to tap into the thermal storage potential of existing houses. This storage potential is not limited by the availability of storage tanks, it also strongly depends on the thermal characteristics (insulation & thermal mass) of the building stock. Other barriers include the design and implementation of the communication infrastructure and standards, as well as insight into the availability and feasibility of demand side response in real life applications.

The heat pump market is mature in terms of product research and optimization. Through years of experience with heating applications and air conditioning units, heat pumps are extremely reliable appliances. Yearly sales reach nearly 100 million units per year (including air conditioning). On the product reliability side, no major breakthroughs should be expected within the near future. Several research developments, however, indicate that significant gains in efficiency may still be obtained, especially if heat pumps are explicitly optimised for their intended application regimes (e.g. climate, heat demand pattern, source type). While the product-related technical understanding is presently in good shape, there are still several issues to be tackled when applying heat pumps in smart grids. These issues are not directly related to heat pump quality and reliability itself, but rather arise from the integration of several components into a single smart energy system.

Storage capacity is of tantamount importance for smart heat pumps. Only by allowing heat pumps to shift their heating load it will be possible to offer flexibility at all. This does not mean that a storage vessel is always needed for proper functioning. Because of the thermal mass present within the buildings themselves, there is a 'free' amount of thermal storage available in all situations. Depending on the size of the building's thermal mass, a (very) small shift in the building's core temperature may allow for significant energy storage.

Several questions are related to this building thermal storage potential.

- How can thermal mass be reliably estimated in new and existing buildings? And how can this storage be optimally used in conjunction with the insulation characteristics of the building?
- What is the potential of using building thermal mass for large-scale flexibility offerings?
- What is the effect on user comfort when using building thermal mass storage?

Limited storage Limited physical space for storage tanks is a widespread problem in most markets

- What opportunities are there to capture flexibility with limited storage?
- What role will hybrid systems play?
- What can be learned from the use of modulation to capture flexibility from air/air HPs?

4.3.5 Scenario in numbers

Summing up the main tracks in the future developments until 2050 for the heating systems are:

Nearly Zero Energy for **single family buildings** will be all-electric for new buildings with electric double function heat pumps, medium capacity storage for domestic hot water, combined with solar photovoltaics and possibly solar thermal to reduce the overall demand. The system will be plug-and-play installed in new housing estates/districts and smart grid adapted. All newly built houses will be equipped:

- 60% with air source heat pumps
- 40% with ground source heat pumps

In the scenario it is not expected that this group of NZEB will be connected to a district heating system.

Nearly Zero Energy for new multi-family buildings, will be all electric with either:

- In 50% of the buildings, a collective system for space heating and a booster heat pump for domestic hot water, resulting in either one central heat pump per building or connection to low temperature district heating and one booster heat pump per dwelling.
- In 50% of the buildings, a collective high temperature heat pump, distributing heat for space heating and domestic hot water from a large storage tank.

An individual heating plug-and-play concept with a double function heat pump and a relatively small (150 litres) storage tank can be an alternative for collective systems. New direct flow technologies are also under development for this segment.

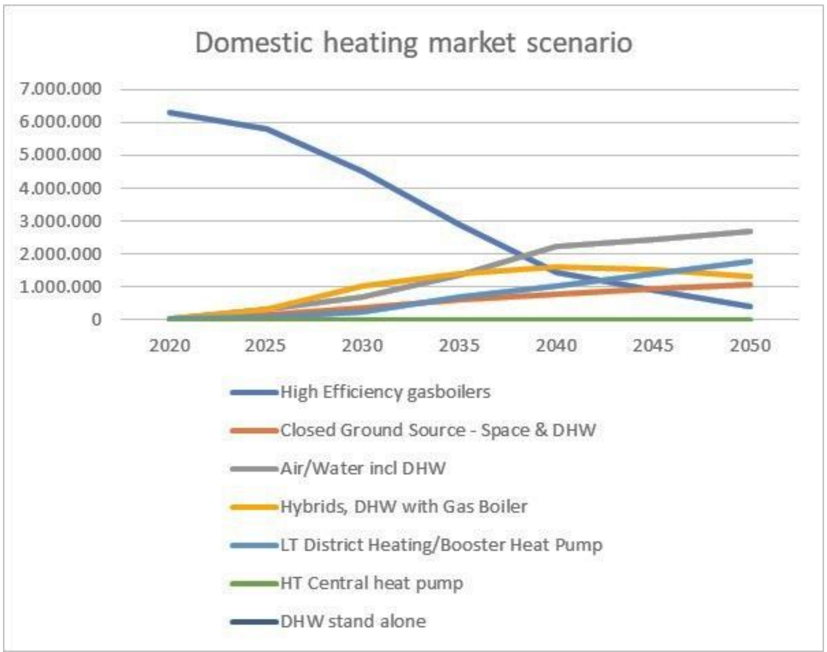
Renovation of privately owned single family buildings will be mainly fitted with hybrid heat pumps on the short term and later on in the process develop to all-electric systems. The peak of hybrid heat pumps will be in 2030 covering a max of 35% of the boiler replacements, seemingly only possible with new or adapted legislation. After that period the transition to all electric will take over this markets plug & play systems of renovation concepts become available. **Renovation of corporate owned single family houses** of which a large number will be renovated to the Nearly Zero Energy level and a number will be connected to the district heating grid. Being the front runner in the market

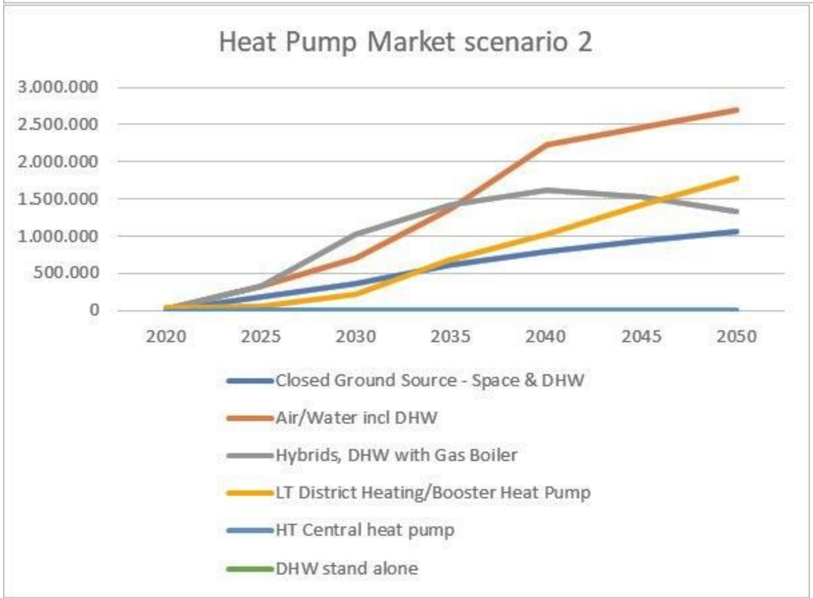
Renovation of corporate owned multifamily buildings has diverse technology directions:

- connection to the district heating grid and equipped with a booster heat pump,
- low temperature collective heat pump heating system and individually equipped with a booster heat pump
- individual plug & Play heat pump heating systems with a double function heat pump

The market in 2015 for high efficiency gas boilers for replacement of existing systems exists in almost all single family buildings and in 50% of the multifamily lodgings. In 2017 this numbered 400.000 per year and will decrease to practically zero in 2050. A number of policy makers in Netherlands expect that District Heating for this type of renovation in densely populated areas will be the solution. **Low temperature district** heating will thus get to 15 - 25% of the overall heating market for buildings. Domestic hot water and sanitary hot water is then generated with a booster heat pump or new direct flow technologies which are under development for this segment.

	2020	2025	2030	2035	2040	2045	2050
High Efficiency gasboilers	6.321.519	5.802.024	4.534.749	2.905.524	1.448.249	926.999	404.999
Closed Ground Source - Space & DHW	11.000	178.600	367.220	608.820	785.220	933.820	1.057.220
Air/Water incl DHW	30.000	331.400	704.330	1.366.730	2.221.330	2.464.230	2.699.330
Hybrids, DHW with Gas Boiler	25.000	325.000	1.025.000	1.425.000	1.625.000	1.525.000	1.325.000
LT District Heating/Booster Heat Pump	35.319	65.500	225.500	682.725	1.024.500	1.419.250	1.782.750
HT Central heat pump	1.766	4.041	5.677	7.077	8.302	9.265	10.052
DHW stand alone	3.000						
	101.319	900.500	2.322.050	4.083.275	5.656.050	6.342.300	6.864.300





5. Conclusion

Simple technologies have to be introduced into the market to achieve the goals. The ambition by government to get toward Energy Zero by 2050 means an average of 200.000 – 300.000 houses/apartments to be fitted with renewable and sustainable technologies. In effect this means an increase in jobs in the installation branches of a factor 4 – 6 of high quality installation know-how as heat pumps are more complex than ‘simple’ gas boilers. The solution for this challenge seems to be an increasing deployment of plug & play and smart solutions needing a less high qualified workforce. This not only for the installation but also for maintenance.

For terraced houses and single family buildings this will have to focus on straight forward system concepts, making the owner of the system as much as possible independent of intermediaries like energy companies and Esco’s. Ground source heat pumps with an individual closed loop ground source or air source heat pumps will in the all-electric solution be a double-function heat pump combining space heating/cooling with domestic hot water and a storage tank. The latter being of importance for a smart grid solution and the grid operator. Hybrid heat pumps with a gas boiler as support will be for a period up to 2030 2035 a temporary solution in the transition to all-electric. As the mostly air source heat pump part of this hybrid solution will become capable to heat with much lower outside temperatures it can be expected that more and more storage tanks will be installed for domestic hot water.

For multifamily buildings the option of collective and individual systems is a choice that can be made. Collective systems can be maintained, optimized outside of the apartments in a more complex technical solution. Then optimisation will have to be found outside of the front door where the occupants of the apartments will have a simple space saving installation inside. When individual systems are the choice, it can be an all-electric solution with a double function heat pump or a semi-individual with a booster heat pump.

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ADDENDUM 1 – Dutch Energy Policy

Aiming for CO2 reduction

In the transition to 2030 and 2050, the government sends one single goal: to reduce emissions of greenhouse gases, i.e. CO2 reduction. This is actually the most cost effective way to achieve the objective of the Climate Agreement of Paris.

It is clear that there must be wagered heavily on energy conservation and also large investments are needed to increase the share of renewable energy in the energy mix. Because of the great social, economic and technological uncertainties, it is impossible in advance to determine the optimal ratio between commitment to saving energy and commitment to renewable energy. By focusing on CO2 reduction is the most optimal and cost-effective mix of energy efficiency, renewable energy and other low-CO2 options in the market place. Aiming for CO2 reduction should be a central role in the European energy and climate policy.

The deployment of the Netherlands in Europe is directed there. The EU emissions trading system (ETS) is in principle a good tool to guide effective at reducing CO2 emissions. Currently, the CO_2 price in the ETS low due to the large supply of allowances in relation to demand. It is expected that this will remain so in the coming years. The ETS gives therewith insufficient incentive for the longer term in the European Union (EU) to achieve significant CO2 reduction. The government is committed to an ambitious strengthening of the ETS by strengthening the annual reduction rate and to reduce the surplus of allowances.

Need a gradual, so timely transition in Netherlands

Even if the CO_2-price increases by tightening of the ETS, the incentives will to contribute to CO2 reduction for the Dutch energy producers and energy intensive industry are currently limited to. This is because the power plants and companies in the Netherlands are very efficient at European level. The control from ETS gives all Member States the same goal, regardless of the baseline. Dutch companies are thus challenged to be one of the last in the EU in order to reduce their CO2 emissions. Without additional policy takes CO2 emissions in the Netherlands - especially in these sectors - therefore is not expected to make towards 2030. Expectation that these emissions in line even further increase with economic growth. The task therefore direction 2050 increases, while the time left to make the cover has been declining. A timely deployed and therefore more progressive energy other hand, can be positive for controlling the cost and also offers an opportunity to exploit the economic opportunities.

Netherlands therefore has an economic interest in a timely deployed and more gradual energy. This challenge is most pregnant with the functionalities within the ETS (power and light and high temperature heat). Also in the non-ETS sectors, low temperature heating and transport should be looked closely at the transition towards 2050. With a continuation of current policies, additional CO2 reduction Energy Agenda can be achieved in these sectors, although there are additional efforts needed realize the European proposed national target for 2030. The question is whether this aim is sufficient to convert the transition towards 2050 economically sensible way. These sectors have a major task and a long-term depreciation of investments. It is therefore advisable to also establish additional policies for these sectors and in the implementation of this supplementary policy to make choices aimed at a cost-effective implementation of the transition towards 2050. In this way also contributed to strengthening the social awareness around the energy and develop a good action perspective for citizens and businesses.

By shifting the perspective of the achievement of targets in the relatively short term (the targets in the Energy Accord in 2020 and 2023) to the desired necessary transition in 2050, is shown that the Netherlands has an economic interest in an accelerating pace in the transition. It is important that the investments that are to be done in the coming years with a low-CO2 economy in 2050, also to prevent disposals in the future. The necessary additional policy is thus not primarily prompted by global climate optics - the corresponding contribution of the Netherlands is limited - but from the desire to exploit economic opportunities and shocks to occur in the Dutch economy.

Due to the perspective in the long term it is obvious to focus more instruments on the transition to a low-CO2 energy supply in 2050. This greater emphasis on the policy of the (further) development of new technologies and the exploiting economic opportunities for the manual. it is necessary to launch a number of long-term, mission-driven innovation programs to effectively bet on innovation. Development of radical innovations requires much time. Therefore, it is important to better stimulate the development of relatively unknown, but potentially promising technologies in the context of CO2 reduction. This makes the transition to a low-CO2 energy is realistic, affordable, and potentially profitable. Efforts in research and innovation (such as the top sector policy) are therefore more focused on reducing CO2 emissions and long-term (2050). The government is committed to strategic international cooperation to bring promising international projects and research grants to the Netherlands.

?is for all sectors, temporary, elected for additional policies which consists of a mix of carrots (incentives) and sticks (standards and obligations) and that fits a gradual transition towards the 80% to 95% CO2 reduction by 2050. This policy stipulated in the so-called 'transition paths. The Energy Blog, these transition paths for the four functionalities drawn in outline. The government will in the first half of 2017 show further identify the cost of the transition towards a low-CO2 society by 2050. Based on these guidelines and on account of the costs, we will talk with citizens, businesses, research institutions, civil society organizations and local authorities. This ultimately ambitions and further elaborated transition paths by functionality towards 2030 and 2050 jointly determine. The innovation challenges will be an integral part of this transition paths.

The challenges towards 2050 by functionality

Power and Light. A significant reduction of CO2 emissions are foreseen in this market where three elements are central in the transition of the generation of power:

- CO2-neutral electricity generation;
- Improving the functionality of the European electricity market;
- Increase the flexibility of the electricity grid.

However, the ETS indicates expected to have insufficient incentives to continue to create sufficient momentum towards 2030 this functionality with the energy. Therefore additional policy measures are needed in the ETS:

- Promote renewable energy by continuing the successful incentive renewable energy (SDE +). In addition, expanding the scheme to other technologies.
- Collaboration with our North European neighbours, to avoid competition in grant instruments between countries.
- Large-scale deployment of offshore wind energy.
- Explore how the successful approach of offshore wind can also be used in the rollout of other forms of renewable energy on sea and land.
- Promote local renewable energy production.

High temperature Heat. The Netherlands has a large export-oriented and internationally competitive energy-intensive industries. The government sees prospects for maintaining this industry in the Netherlands, provided its production is low carbon. The energy-intensive industry is a large, complex transition task that requires a change in trend. As the ETS does not provide sufficient incentive to reduce CO2 emissions drastically it is expected that CO2 emissions from the industry will be increasing the next couple of years (decade). The industry needs to invest in CO2 reduction, but also retain its earning power and competitiveness. Therefore, the transition of the industry consists of a mix of incentives and standards and obligations. The main measures are:

- Preventing CO2 emissions through:
  - Ambitious goals on energy conservation, through continued commitment in the Multi Years Agreements for energy efficiency;
  - Developing and rolling out alternative heating options such as ultra-deep geothermal energy and better utilization of waste streams.
- Capture and storage of CO2 (CCS) in cases where no CO2-free alternatives are available.

Low Temperature Heat. In the built environment deployed drastic reduction of heat by energy savings and significant reduction of natural gas use by promoting and integrating low-CO2 electricity and heat. The first pillar for CO2 reduction in the built environment is energy conservation. The government is preparing legally binding measures, such as a minimum energy corporation for homes and offices. Explored is whether this is applicable to other property sectors. Furthermore continues and broadens the government encouraging savings through education, grants (such as the Energy Saving Incentive Homeowners), low-interest loans (such as the National Energy Saving Fund), and support innovative approaches.

The second pillar for CO2 reduction in this functionality is a strong reduction in the use of natural gas. To achieve this the government has decided to:

- Newly built housing districts will not have to be connected to the gas grid, so called gas-less areas being all-electric or connected to district heating Er worden in beginsel geen nieuwe gasnetten meer aangelegd in nieuwbouwwijken.

- Give local authorities more powers at local level, in collaboration with the grid operator, to decide on the local energy supply.
- Support the development of district heating grids

The transition from the low temperature heat supply takes place largely at the local level. A key role for local authorities and operators.

The responsibilities in the energy transition

Netherlands only realizes the transition if all parties - citizens, businesses, research institutions, civil society organizations, local authorities and central government - willing and able, each from their own responsibility and expertise, contribute to this. This requires good organization of the energy at European, national and regional levels. A truly effective climate - and an affordable low-CO2 energy - can only internationally are created. There should be about the implications of the Paris Climate Agreement and supplementary thereto need to work together closely in a Northwest European context created at European level agreements. This is necessary to prevent leakage, to ensure a level playing field and to make the most efficient choices. For example, we provide affordable energy and a sustainable competitive Europe.

At the national level requires the energy to have a clear vision and consistent policy. The Energy Blog has this vision, together with social partners will be further developed. Guaranteed to be the energy, as an unstoppable development, also continues to change of political colour of cabinets. Citizens, businesses and local authorities should feel the urgency and see the possibilities to take further steps in the transition to a low-CO2 energy supply.

Legal guarantee of goals, institutions or policy can contribute to this. It gives a signal of political commitment and stressed the necessity and urgency of the transition. However, the long-term climate objectives of energy policy are already enshrined legally through ratification of the Climate Agreement in Paris. EU, this translated into concrete objectives for 2030 and 2050. Allows these goals are already legally binding for the Netherlands.

Following the Energy Accord stands to reason to shape through a broad social agreement in the energy dialogue with local authorities, social organizations and businesses. Shaping in part or regional agreements with customized functionality per direction in 2030 and 2050 is an obvious strategy.

Realization of the energy takes place mainly at regional and local level. The challenge is to provide space for local authorities and regional and local social parties, and simultaneously at national level - through financial, material and spatial frameworks - to send in solutions that are better or more efficient at supra-regional or national scale. The government will continue in the coming months, according to the Energy Agenda in talks with parties on the details of institutions and transition paths, which also will look at the way of assurance.

ADDENDUM 2 - Some European Legislation (source EHPA)

3.3.1 Energy Efficiency Directive

The 2012 Energy Efficiency Directive (EED) establishes a set of measures to help the EU reach its 20% energy efficiency target by 2020. Under the Directive, all EU countries are required to use energy more efficiently at all stages of the energy chain from its production to its final consumption. This means that European households and industries need to become much more energy efficient. EU countries were required to transpose the Directive's provisions into their national laws by 5 June 2014.

According to the Energy Efficiency Communication of July 2014, the EU is expected to achieve energy savings of 18–19% by 2020 – missing the 20% target by 1–2%. The fact that the target is non-binding is often blamed for this. President Juncker described in the Political Guidelines for the new EC that he would like to significantly enhance energy efficiency beyond the 2020 objective. A review of the EED is foreseen for 2016.

3.3.2 Energy Performance of Buildings Directive

Annually, buildings are responsible for 40% of energy consumption and 36% of CO2 emissions in the EU. Currently, about 35% of the EU's buildings are over 50 years old. By improving the energy efficiency of buildings, total EU energy consumption could be reduced by 5– 6% and CO2 emissions could be lowered by about 5%. The Energy Performance of Buildings Directive (EPBD) (2010/31/EU) aims for high efficiency requirements for new buildings and deep renovations. It obliges the Member States that all new buildings in 2020 should be nearly Zero Energy Buildings (nZEBs). All new public buildings must be nearly zero-energy by 2018. The EPBD acknowledges heat pump applications in line with the RES Directive, and also explicitly mentions their reversible characteristic.

An EC progress report from 2013 found that EU countries had to significantly step up their efforts to take advantage of the opportunities presented by nearly zero energy buildings. 24 Member States missed the transposition deadline in 2012 and infringement procedures are ongoing. The review of the EPBD, including Smart Finance for Smart Buildings, which facilitates access to existing funding instruments, is foreseen for 2016. Also, the EC announced it would develop a 'Smart Financing for Smart Buildings'-initiative to make existing buildings more energy-efficient.

3.3.3 Energy labelling

The energy label is a benchmark for the end-consumer to see how economical, environmentally friendly and/or energy saving the product is. The success of the label has been a driver for innovative industry developments, with most of the products being in the top classes (A+++, A++, A+) today. Under the current legislation a maximum A++ on the product label is applicable from 26 September 2015. According to EC, the use of the A+++ label is not allowed at the moment. The energy label for heat pumps is based on the system's efficiency determined via ErP Lot 1, 2 and 10. The current situation makes difficult for consumers to distinguish the best performing products. Therefore the EC is reviewing the current energy-labeling scheme and a new proposal was presented in the summer of 2015. On the agenda are a few issues, such as the proposal for a rescaling from A to G and possible open top classes. The EC proposal will be sent to the European Parliament and the Council. When approved by the co-legislators, the EC will implement these changes for product groups that have an energy label within a period of five years for most products.

3.3.4 Ecodesign

The Ecodesign Directive for Energy-related Products (ErP) aims at reducing the environmental impact of products, including the energy consumption throughout their entire life cycle. This should benefit both businesses and consumers, by enhancing product quality and environmental protection and by facilitating free movement of goods across the EU. ErP regulations exist for the following HVAC appliances:

- space heaters up to 400 kW {gas and oil boilers, electric boilers, heat pumps (electrical and gas), cogeneration of heat and power appliances, integrated packages (space heater + supplementary space heater + solar thermal device + temperature control)};

- water heaters and hot water storage tanks up to 400 kW {gas or oil water heaters, electric water heaters, heat pump water heaters, solar thermal water heaters, storage tanks up to 2,000 litres, integrated packages (water heaters + solar thermal device)};
- air conditioners and air-to-air heat pumps up to 12 kW.

3.3.5 Ecolabel

The overall objective of the Ecolabel scheme is to promote products with reduced negative environmental impacts compared to similar products in the same product group, thus contributing to the efficient use of resources and a high level of environmental protection. The Ecolabel can be awarded to electrically driven, gas driven or gas absorption heat pumps with the purpose of space heating or the opposite process space cooling, with a maximum heating capacity of 100 kW. Heat pumps exclusively providing hot water for sanitary use, and those only extracting heat from a building are excluded.

Definition of Water heating:

Water heating is a thermodynamic process that uses an energy source to heat water above its initial temperature. Typical domestic uses of hot water include cooking, cleaning, bathing, and space heating. In industry, hot water and water heated to steam have many uses.

Domestically, water is traditionally heated in vessels known as water heaters, kettles, cauldrons, pots, or coppers. These metal vessels that heat a batch of water do not produce a continual supply of heated water at a preset temperature. Rarely, hot water occurs naturally, usually from natural hot springs. The temperature varies based on the consumption rate, becoming cooler as flow increases.

Appliances that provide a continual supply of hot water are called water heaters, hot water heaters, hot water tanks, boilers, heat exchangers, geysers, or calorifiers. These names depend on region, and whether they heat potable or non-potable water, are in domestic or industrial use, and their energy source. In domestic installations, potable water heated for uses other than space heating is also called domestic hot water (DHW).

Fossil fuels (natural gas, liquefied petroleum gas, oil), or solid fuels are commonly used for heating water. These may be consumed directly or may produce electricity that, in turn, heats water. Electricity to heat water may also come from any other electrical source, such as nuclear power or renewable energy. Alternative energy such as solar energy, heat pumps, hot water heat recycling, and geothermal heating can also heat water, often in combination with backup systems powered by fossil fuels or electricity.

Densely populated urban areas of some countries provide district heating of hot water. This is especially the case in Scandinavia and Finland. District heating systems supply energy for water heating and space heating from waste heat from industries, power plants, incinerators, geothermal heating, and central solar heating. Actual heating of tap water is performed in heat exchangers at the consumers' premises. Generally the consumer has no in-building backup system, due to the expected high availability of district heating systems.

ADDENDUM 3 - District heating

In the search for alternatives to fossil energy, a holy grail has recently emerged: heat networks. Municipalities in particular see this as an opportunity to realize their high sustainability ambitions. It sounds nice: residual heat that is (for example) released during the waste incineration can be used to heat homes and buildings. That heat would otherwise be lost, while more than half of Dutch energy demand is precisely determined by the need for heat. Each new heat connection is then a contribution to sustainability. The efficiency argument is added. A municipality that can build a heating network quickly achieving their goals, on paper. Your entire neighbourhood will get city heat! Easy, efficient and sustainable! Obviously, figures that support the latter claim follow. Like this: with every heat connection up to 75% cleaner energy is used. This is equivalent to the placement of 22 solar panels or 14,000 non-driven car kilometres.

But is that really so? And what do residents actually want themselves? Municipalities often pass easily by that question.

- How efficient is it actually to heat water up to 70 degrees or higher, then transport it and then heat a house up to 20 degrees?
- Dependency on the heat source, a source that could well disappear. The amount of waste becomes smaller and smaller in a circular economy. Ultimately, we will have to import more and more waste to enable its combustion. Cities like Amsterdam and Rotterdam are already importing waste. There are hardly any alternatives: there are few sustainable sources that can heat water up to 90 degrees, and natural gas also disappears from the menu.
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District heating makes the energy transition unnecessarily inefficient and expensive. Consumers pay a relatively large amount. There are enormous investments involved in the construction and maintenance of the heating networks, which will only be used temporarily.

When determining the CO2 reduction of district heating, the following components are important to consider:

Grid losses: For heat supply a pipeline network with insulated pipes is required. No independent investigation into the losses of heating networks has been done. The only known research7 comes at a loss of 15-40 percent for Dutch heating networks. In this memorandum, the number of 8 GJ per dwelling8 from the Uniform Measure is calculated. This is the average of high-rise and land-based homes. With the average gas consumption in the Netherlands this comes down to 15 percent, even though this seems only feasible in the optimal situation (good pipe insulation, high housing density).

Pump losses: Pumps are used to transport heat through the heat network. The energy consumption depends on the resistance in the system and this is largely determined by the distance from source to buildings. No independent research is known about pump losses in heat networks. This memorandum is based on the code number of 0.0018 MJ electricity / MJ heat per kilometer from NEN 71259. The pump loss in buildings is not included, as these are also in the reference situation (boiler).

Supplementation: In district heating, not all heat requirements are filled with residual heat. When no electricity is made, at peak times and in the event of malfunctions, heat is generated using auxiliary heat boilers that are fired with natural gas. The co-firing factor depends on the plant, the heat project and the tariff development in the electricity market. In general, the co-firing factor in heat projects is set at 20 percent, as in this note.

Degree of electricity: Because for district heating no real residual heat (45 oC) is used, but heat of 100-120 ° C, steam from the process must be used to make electricity. This allows the power station to make less electricity. This electricity must be generated elsewhere and processed in the calculation. The amount of energy depends mainly on the generation of steam in the power station and the required temperature at which the heat is disconnected. No independent studies are known about the inheritance factors for different projects. For this reason, the inheritance factor of the Uniform Standard is used in this document, being at least 0.18 GJelectricity / GJ heat. This factor is often not used in comparisons for district heating, while it has a major effect on the actual CO2 reduction.

The future of the electricity market

The electricity market is switching. By input of more sustainable electricity (for the time being via import from Germany) and the development of the electricity price Dutch power plants (mainly those on natural gas) are used less. Some important gas-fired power plants (STEG) also supply district heating. Because these power stations are used less, less residual heat is produced. In order to meet the heat demand, more co-firing is being done with the auxiliary heat boilers. This reduces the CO2 reduction even more. An example is the district heating in Utrecht. Because the power station (including Lage Weide) has produced less electricity since 2012, about 30 percent extra gas has been burned by the auxiliary boilers for district heating. In Almere, where district heating is supplied from the Diemen plant, this is also the order. To partially overcome the problem, a large buffer has been placed so that more residual heat can be stored. In the energy transition, storage has an important role to play in the application of sustainable energy. In this case it has a negative effect: the buffer gives extra losses because the charging temperature is even higher than the heating network needs. In addition, the buffer capacity is insufficient to store all the required heat. In spite of the buffer, extra gas is being added. The development of the electricity market will reveal a lock-in of district heating: auxiliary heat boilers must be used unintentionally to meet the heat demand. The expectation is that this development in the electricity market will continue.

Future waste incineration

At present, incineration of waste is inevitable and a better approach than landfill. With Dutch waste incineration plants, electricity is extracted as efficiently as possible from the incineration process, making it currently the best solution. However, developments in recycling have been rapid in recent years. With Van Afval Naar Grondstof (VANGG), the aim is to halve the residual waste to be incinerated in the Netherlands in 10 years. There is already an overcapacity at Dutch waste incineration plants that incinerate waste from abroad (in particular the UK) in compensation and increasingly. This is sustainable at EU level, because a lot of waste would (have to) be disposed of. These foreign volumes can fill the Dutch residual capacity in the next 6 years11. But how are things after that? The target formulated by the EU in 2015 for the Circular Economy12 is lagging behind the Dutch target in time for around 12-15 years. This allows a prognosis to be made for the decrease of the required waste incineration capacity. For the Dutch waste, the decrease has started in 2011. For Europe, the decrease will then start in about 2025. This means that the utilization rate of Dutch waste incineration plants for all waste over 10 years will actually decrease (and the overcapacity will increase). In other words, it will be desirable in 10 years to stop waste incineration, because otherwise valuable raw materials will be destroyed and unnecessary CO2 emissions will take place because raw materials will not be reused. In addition, it is impossible to predict how the waste incineration market will develop. Possibly, burning in the Netherlands is no longer attractive because of the price. Here too, a lock-in of district heating is visible. In about 20 years valuable raw materials13 may be burned unnecessarily or extra gas must be added to meet the heat requirement. These uncertainties are not included in the calculation. This means that the CO2 reduction of district heating of electricity and waste incineration plants will be even lower in practice.

Industrial residual heat

There is a great potential for residual heat from industry, especially in large regional clusters such as the Rijnmond, IJmond and Eemsmond. In district heating projects, it is not (yet) often used, because a director and investor are missing, the investments are uncertain, there are no return guarantees and several industrial sources on the (open or otherwise) grid are needed for reliable delivery. The same applies to residual heat from industrial processes as to residual heat from power plants. This is generally available at about 45 ° C. The district heating system requires disconnection at a temperature level of 100-120 ° C. Updating that difference requires extra energy that needs to be calculated. The amount of energy to be settled depends on the process / project and cannot be quantified in a general sense. As a starting point, we assume that industrial residual heat scores about the same as district heating with electricity production. Due to the distance between industrial business clusters and residential areas, small scale is not an obvious choice here. Even if residual heat with a higher temperature is available, the question is whether transport from a business cluster to a residential area is energetically useful. Before considering this option, the trias energetica first asks to look at the possibilities of upgrading and reuse within the company and heat exchange between companies within the cluster. It is also important that there are market-ready developments that can improve the energy efficiency of processes. Examples are steam recompression and high temperature heat pumps. The energy intensive industry in the Netherlands takes as a starting point that in 2050 there will be no residual heat14. A lock-in could be generated by linking residual heat from industrial processes to a district heating system. It is therefore not included in the comparison.

Biomass

Biomass can also be used as a source of energy for district heating. With the combustion of biomass, by definition no direct CO2 emissions occur (on balance). Sustainable biomass production

The condition for 0 emissions is that the biomass is produced sustainably. For example, through sustainable forestry, which does not harvest more biomass than the additional growth. In addition, other sustainability aspects are important, such as depletion of nutrients by production forestry. If another function is replaced by a new addition of biomass (eg old forest through production forest, food production by energy crops), this must be compensated for on another country. This gives one of the biggest uncertainties surrounding emissions from bio-energy. That is why the biomass must be certified.

Although there is no direct emission, indirect emissions are of importance for biomass16. Prune wood is limited in the Netherlands and insufficient for all district heating projects. That is why a comparison was made with Canadian wood pellets. A drawback of biomass combustion is the air emissions (NOx, SOx, PAHs, etc.). In addition, more and more high-value applications are available for wood as raw material (instead of incineration), so that there is also a great chance of a lock-in.

Geothermal energy

The perhaps ultimate heat source for district heating is (deep) geothermal energy. Water is pumped from 2 to 5 km deep, which is so warm that it can be used for heating and DHW heating. The deeper the source, the hotter the water. At 2 km depth, water of 70 ° C can be available that can be sufficient for the application. This would then have to be applied on a small scale (limitation of grid losses) so that the heating network does not require a higher temperature. Existing district heating systems, however, require a temperature level of 100-120 ° C, which requires deeper drilling (from 4 km). Little experience has yet been gained with residential areas. Whether geothermal energy in the places where district heating needs to be made available is sufficiently available determines whether it will become the obvious successor to conventional district heating. That availability becomes really clear after a bore. This makes projects insecure and complicated because it needs to be drilled deeper than is actually necessary. At this depth it will in any case be expensive.17 It is also important that geothermal energy can be extracted without problems. For example, it is not desirable that "fracking" should be used. Geothermal energy is calculated with a return (COP) of 10.

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