Regional Vision Parkstad Limburg

Opportunities for 5th generation district heating and cooling

CE Delft
Committed to the Environment

Interreg
North-West Europe
D2Grids
European Regional Development Fund

Regional Vision Parkstad Limburg

Opportunities for 5th generation district heating and cooling

This report was prepared by:
Benno Schepers, Marianne Teng, Marijke Meyer, Sinan Senel

Delft, CE Delft, November 2022

Publication code: 22.220182.162

Client: Open Universiteit
Your reference: MW100247

Publications of CE Delft are available from www.cedelft.eu

Further information on this study can be obtained from the contact person Benno Schepers (CE Delft)

Content

Summary

D2GRIDS is an Interreg North-West Europe project dedicated to increasing the share of renewable energy used for heating and cooling by accelerating the rollout of 5th generation district heating and cooling networks (5GDHC) in Europe. 5GDHC is an innovative, demand-driven form of district heating, operating at low temperatures. The D2GRIDS project has seven follower regions, as defined in the application form:
Parkstad Limburg (NL); North-East France; Luxembourg; Flanders (BE); Ruhr-area (DE); Scotland; East Midlands (UK). Mijnwater, a supplier of heating and cooling via a 5GDHC network in Parkstad Limburg in the Netherlands, is the lead partner of the D2GRIDS project. Each follower region will prepare a regional vision, describing its aspirations for contributing to the rollout of 5GDHC.

This vision describes the aspirations of Parkstad Limburg on how the region can contribute to the rollout of 5GDHC. The objective of the regional vision is to identify the most suitable potential regions for implementing 5GDHC.

Potential of implementing 5GDHC in Parkstad Limburg

Deciding on the regions where 5GDHC technology can be implemented is not straightforward. Many factors must be taken into account that play conflicting roles in determining where the technology is most suitable. These include financial, technical, spatial and social factors. A multi-criteria analysis was therefore used to resolve this multi-faceted problem. The multi-criteria analysis assesses all neighbourhoods in Parkstad Limburg to determine which neighbourhoods are most suitable for implementing 5GDHC technology.
Two regions have been selected based on the multi-criteria analysis; one in the proximity of the existing Mijnwater district heating and one further away from existing district heating. The selected regions are the Heerlen Centrum district, consisting of four neighbourhoods in the centre of Heerlen, and two neighbourhoods in Kerkrade (Rolduckerveld and Holz).
A local action plan will be prepared for these two regions.

Strengths and weaknesses

A SWOT analysis is conducted for 5GDHC in Parkstad Limburg. The region’s greatest strength is its experience with 5GDHC by Mijnwater. In addition, national and local plans for energy transition provide a good basis for identifying areas where it is feasible to implement district heating networks. The growing demand for cooling in the built environment in the Netherlands is another technical advantage for the implementation of 5GDHC.

The main weaknesses of the region are bureaucracy and achieving the participation needed for collective heating systems. We have identified the most important threats as the imbalance between heating and cooling demand and financial feasibility due to high investment costs. On the other hand, high energy prices due to the current energy crisis in Europe provide an opportunity for the implementation of 5GDHC.

Contextual information on 5GDHC in the Netherlands and Parkstad Limburg

For the implementation of 5GDHC technology in the Netherlands, particularly in Parkstad Limburg, we have compiled relevant contextual information.

The heating market in the Netherlands is rapidly changing due to energy transition (or gas phase-out), as we switch from fossil fuels to renewable energy. In the Netherlands, the most likely alternatives to conventional gas-fired boilers are hybrid heat pumps using renewable gas, all-electric heat pumps and collective district heating such as 5GDHC.
In the context of the energy transition, the government is providing various subsidy schemes for investments in insulation, heat pumps and district heating, which can also be used for 5GDHC. Although energy tariffs for district heating are strictly regulated in the Netherlands, there are no specific tariff regulations for 5GDHC.

Parkstad Limburg has several potential heating sources. The most promising sources are waste heat, solar thermal energy on repurposed agricultural land and the exchange of heat flows from different types of buildings. Furthermore, ground-coupled heat exchangers are allowed in most of Parkstad Limburg.

The region: Parkstad Limburg

This regional vision focusses on the Parkstad Limburg region. The Parkstad region is an administrative collaboration between seven municipalities in the province of Limburg, in the south of the Netherlands. The seven municipalities are Beekdaelen, Brunssum, Heerlen, Kerkrade, Landgraaf, Simpelveld and Voerendaal. Parkstad Limburg has 256,000 inhabitants and 126,000 households. It has a very high-population density of roughly 1,000 inhabitants per km^2. Most of the land in Parkstad Limburg is zoned for buildings and agriculture.
The western part of Parkstad is mainly covered by agricultural land, while urban areas predominate in the eastern part.

As is the case elsewhere in the Netherlands, most of the buildings in Parkstad Limburg are heated using natural gas-fired boilers. Some buildings are connected to the district heating network of Mijnwater. Mijnwater currently operates a 5GDHC network in Heerlen and Brunssum.

1 Introduction

The D2GRIDS is an Interreg North-West Europe project which aims to increase the share of renewable energy used for heating and cooling, through accelerating the rolling out of 5th generation urban heating and cooling networks (5GDHC) in Europe. 5GDHC is an innovative form of district heating which is characterised by the following principles:

- ultra-low temperatures close to end-user needs allowing the use of low-grade renewable heating sources;
- demand-driven temperature based on smart control, and decentralised installations enabling heating and cooling exchange between end-consumers thanks to a closed loop;
- integrated heat and power networks to reduce power peaks (Mijnwater, ongoing-c).

The D2GRIDS project has seven follower regions as defined in the application form: Parkstad Limburg (NL); North-East France; Luxembourg; Flanders (BE); Ruhr-area (DE); Scotland; East Midlands (UK) and involves five pilot sites in Bochum (DE), Brunssum (NL), Glasgow (UK), Nottingham (UK) and Paris-Saclay (FR). Mijnwater, a supplier of heating and cooling via 5GDHC in Parkstad Limburg in the Netherland, is the lead partner of the D2GRIDS project.

Within the D2GRIDS project the long-term work package aims to sustain roll out D2GRIDS outputs to a wide variety of target groups, including policy makers, financial investors, professionals, SMEs[1] and other companies in the DHC industry, as well as to new territories ('follower regions'). In this work package each follower region prepares a regional vision. This vision describes ambitions of each of the follower regions on how the region can contribute towards the goal of rolling out 5GDHC. To inform this regional vision, a preliminary feasibility assessment is conducted first. The goal of the feasibility assessment is to find the potential of deploying 5GDHC in the follower regions within five years after the project ends, as well as finding possible longer-term opportunities. This is done by mapping strengths, weaknesses, barriers and opportunities of 5GDHC for each of the follower regions. Mijnwater and the Open University asked CE Delft to perform the pre-feasibility assessment. This document contains the results in the form of the regional vision for Parkstad Limburg.

Reading guide

Chapter 2 describes Parkstad Limburg. It gives a general description of the region as well as more detailed insight in the types of buildings and the current heating technologies. **Chapter 3** gives an overview of the Dutch heating markets and the developments in the Dutch energy transition in the built environment. **Chapter 4** examines the position of district heating in the Netherlands. It describes the regulatory framework, the stakeholders involved and the financing and subsidies. The available energy sources and storage are outlined in **Chapter 5.** This all comes together in the SWOT analysis in **Chapter 6.** A multi-criteria analysis shows which neighbourhoods are most suitable for 5GDHC in **Chapter 7.** This leads to the selection of two regions for the local action plans in **Chapter 8.**

[1] Small Medium Enterprise.

2 The region: Parkstad Limburg

2.1 Characterisation of the region

This regional vision focuses on the region Parkstad Limburg. The Parkstad region is an administrative collaboration between seven municipalities in the province Limburg, in the south of the Netherlands (see Figure 1). The seven municipalities are Beekdaelen, Brunssum, Heerlen, Kerkrade, Landgraaf, Simpelveld and Voerendaal.
The Parkstad region had 256,000 inhabitants and 126,000 households in 2021.
It has a very high-population density of roughly 1,000 inhabitants per km^2 (CBS, 2021).

Table 1 – An overview of the population in Parkstad Limburg and the Netherlands in 2021

	Parkstad Limburg	The Netherlands
Population (2021)	256,318	17,475,415
Number of households (2021)	126,263	8,043,443
Area	235 km^2	33,671 km^2
Population density	1,093/km^2	519/km^2
Average income per resident with income	€ 29,300	€ 33,300

Provinces, municipalities, districts and neighbourhoods

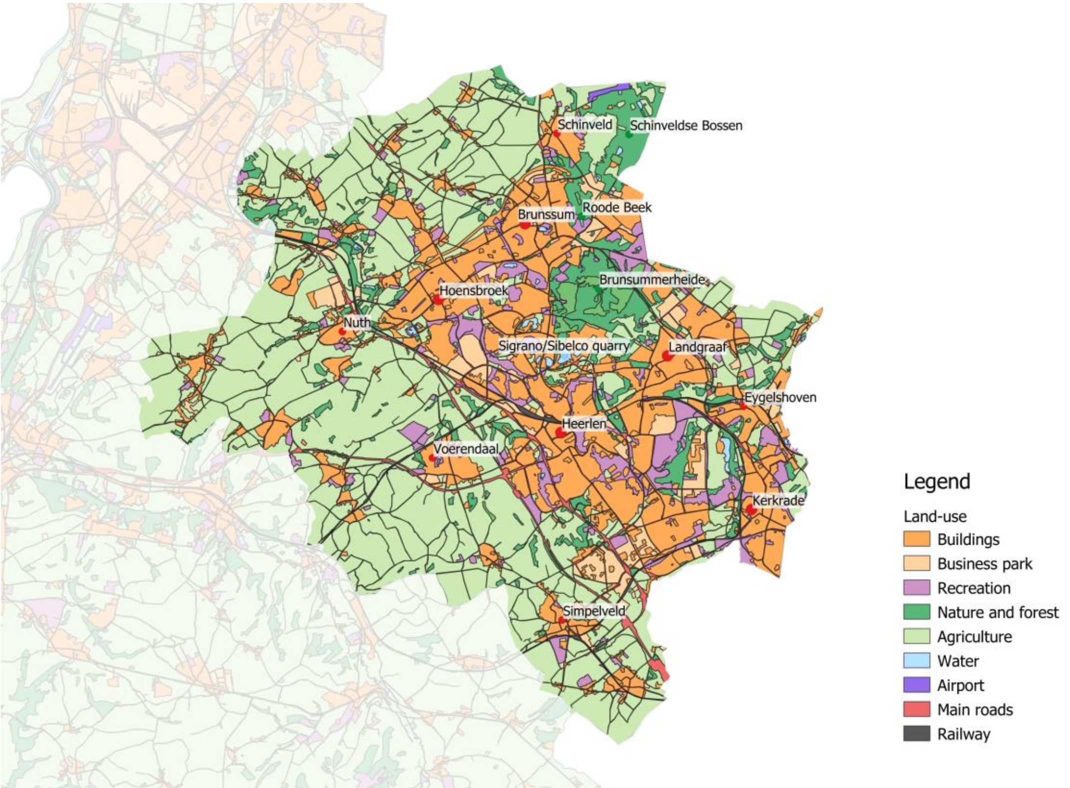
The Netherlands is divided in geographical regions on several scales (CBS, 2022a).
The largest division scale are the provinces. There are twelve provinces in the Netherlands. The provinces have administrative power over subjects such as spatial planning, transport, agriculture and nature and landscape. Within the provinces are the municipalities. Figure 1 on the left shows the 345 municipalities in the Netherlands. The municipalities are the third administrative layer in the Netherlands (after the national government and the provinces). Municipalities are responsible for a wide variety of public services, such as land-use planning, public housing, management and maintenance of local roads, waste management and social security. They are also responsible for a large part of the execution of the Energy transition. Within the municipalities there are districts (‘wijken’), and within the districts there are neighbourhoods (‘buurten’). There is no definition of the size of a neighbourhood. On average about 600 households live in a neighbourhood, however in some neighbourhoods there are 13,000 households and in some there are none. A district typically consists of two to fifteen neighbourhoods.

Figure 1 – Left: The municipalities of the Netherlands. The municipalities in yellow are the municipalities in the Parkstad region. Right: The seven municipalities of the Parkstad region

Landscape

Figure 2 shows the land-use of Parkstad Limburg. Most of the land-use is for buildings and for agricultural use. The western part of Parkstad is mainly agriculture, while the eastern part has more cities and villages. The largest cities (Heerlen, Kerkrade, Landgraaf, Brunssum and Hoensbroek) are fused together. There are some nature reserves: the Brunsummmerheide, Roode beek and Schinveldse bos. Limburg, and especially the south of Limburg, is hillier than the rest of the Netherlands.

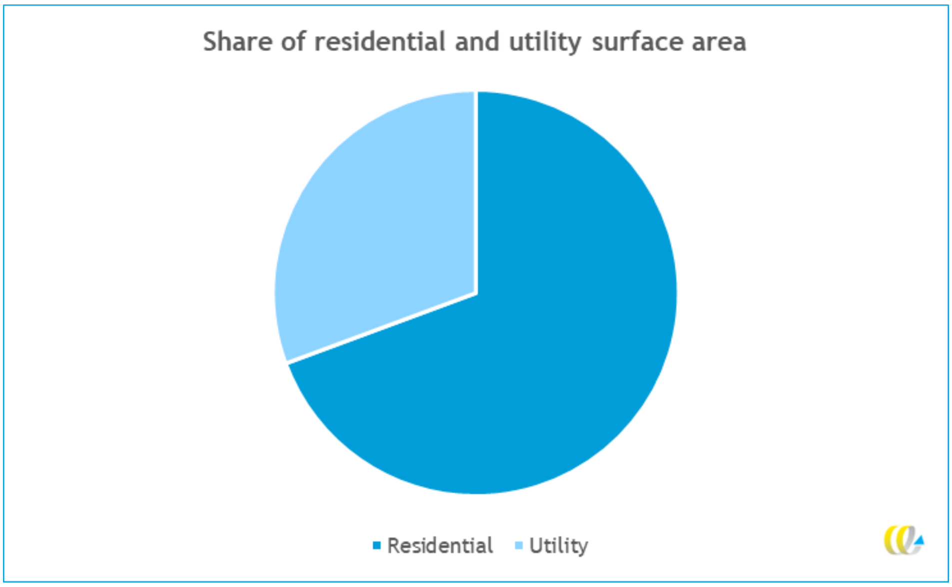
Figure 2 – Land-use in Parkstad Limburg



2.2 The built environment in Parkstad

In 2020 there were almost 130,000 dwellings and over 13,000 utility buildings in Parkstad Limburg. Utility buildings are all non-residential buildings such as schools, offices, hospitals et cetera. Figure 3 shows that roughly two third of the building surface area is residential.

Figure 3 - Share of residential and utility surface area in Parkstad Limburg (Kadaster, ongoing-b)



Dwellings

The average surface area of a dwelling in Parkstad Limburg is 130 m^2. This is larger than the average Dutch home, which has an average surface area of 120 m^2 (CBS, 2022b). Figure 4 shows the distribution of dwelling types in Parkstad Limburg. Almost half of the dwellings are terraced houses (mid-terrace and end of terrace), about 30% are stacked dwellings and almost a fourth of dwellings are detached or semi-detached. In general, the detached and semi-detached houses have the larges surface area, and the stacked dwellings have the smallest surface area.

Figure 5 shows the distribution of dwellings over six categories of building years. Dwellings built in the same period have roughly the same building characteristics. For example, most dwellings built before 1945 are often poorly insulated and lack cavity walls, which makes insulation challenging, while dwellings built after 1945 do have a cavity wall which can be insulated.
Figure 5 shows that the number of dwellings is fairly evenly distributed over the different periods.

Figure 4 – Distribution of dwelling types in Parkstad Limburg (Kadaster, ongoing-b)

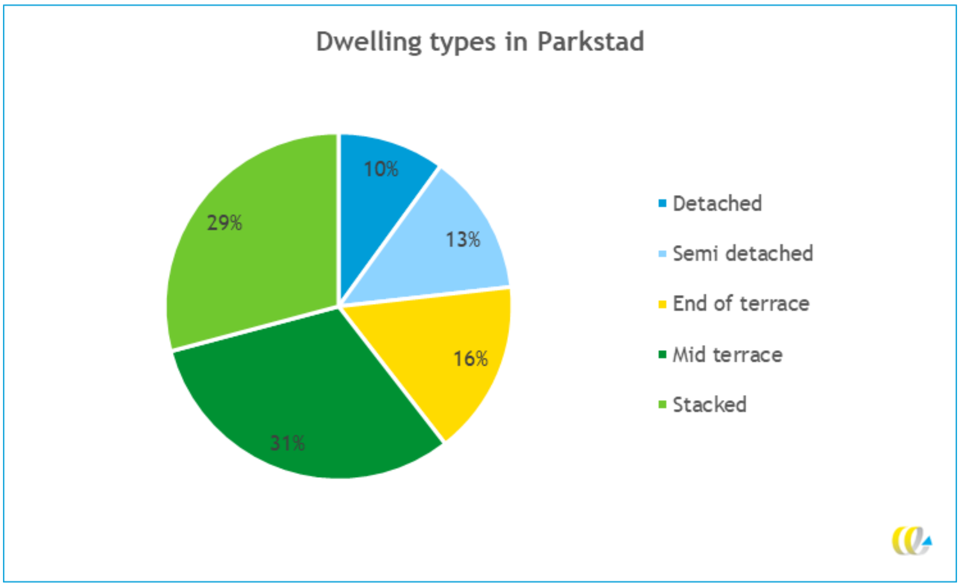
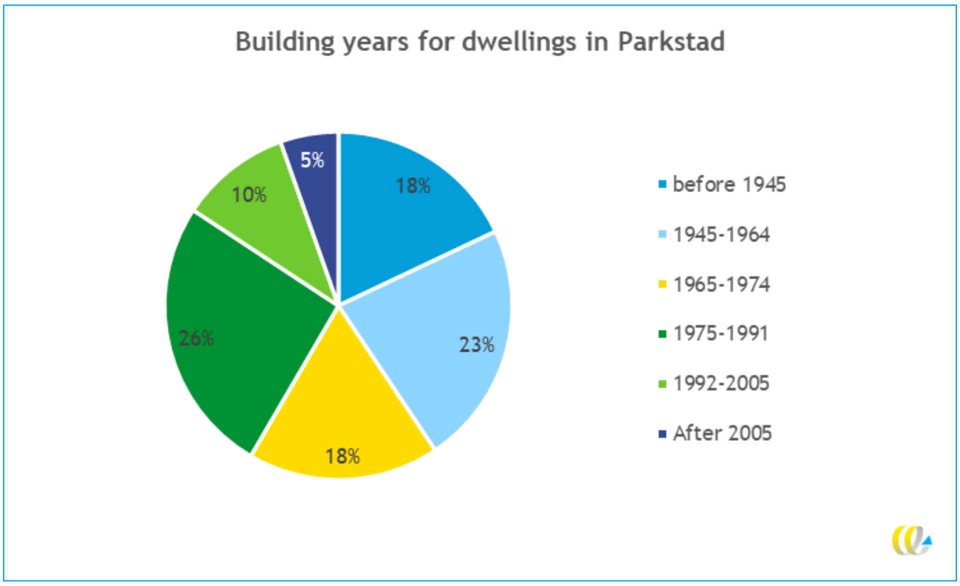
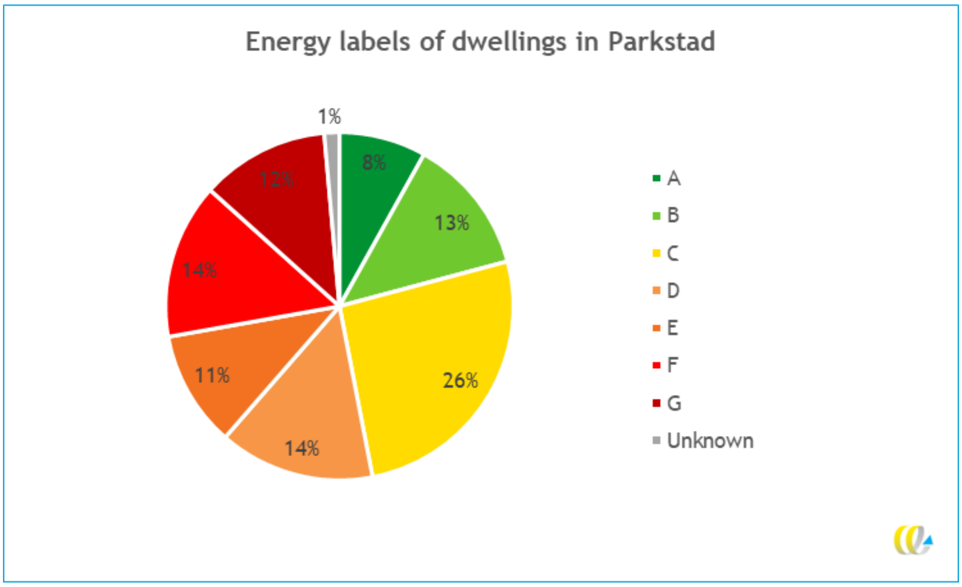


Figure 5 – Distribution of dwellings over six building year periods (Kadaster, ongoing-a)



The energy performance of dwellings is indicated with a letter from A++++ to G (A being the best and G being the worst). The energy label is based on the fossil energy use in kWh/m^2/yr. Energy labels are required for all homes that are being built, sold or rented. As of January 2020, approximately 50% of homes in the Netherlands had an energy label, of which almost 40% have the best-performing label A or B (Rijksoverheid, 2020). As all newly built homes have energy labels, the national share of well-insulated homes is expected to be lower.

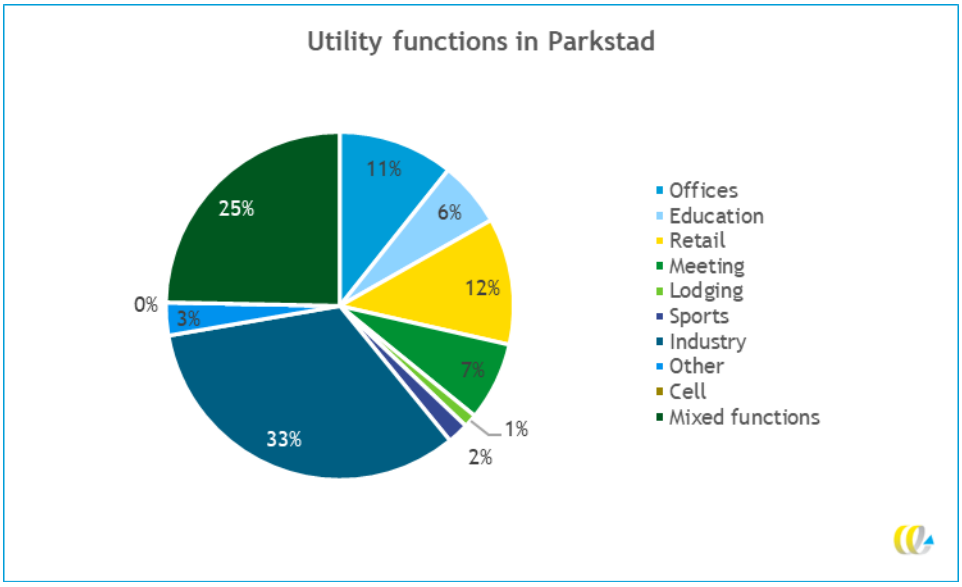
Figure 6 - Energy labels of dwellings in Parkstad Limbug. Labels A to A++++ are in the A category



Utility

Figure 7 shows the utility functions and their share in Parkstad Limburg. Common utility functions such as offices, education, retail and meeting seem to have a relatively small share. However, there are many buildings with these functions, but their surface area is not as large as the industry buildings. About 25% of utility has mixed functions, this can be a mix of industry and offices for example.

Figure 7 - Utility in Parkstad Limburg by function. The share of a utility function is based on the surface area of buildings with this function



2.3 Current dominant heating technology

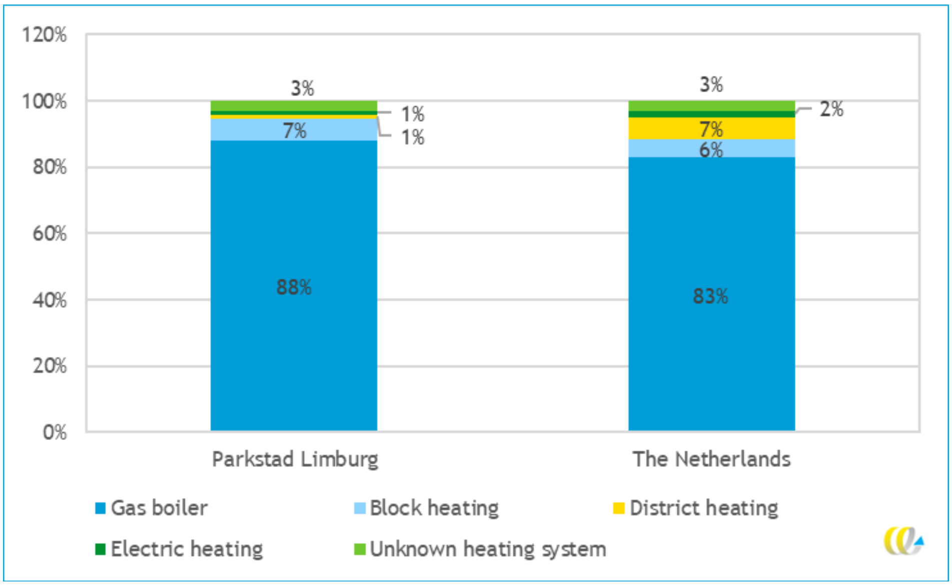
Most buildings are heated using natural gas

Natural gas is the most important energy carrier in the Dutch heating system. Most buildings use gas boilers for heating, and district heating systems are primarily powered using natural gas. This dependency on natural gas is attributable to the presence of a very large natural gas field in the north of the Netherlands. The country's energy system has developed around natural gas since its discovery in the 1960s.

Figure 8 shows the main heating technologies for dwellings in Parkstad and in the Netherlands. It is clear from this figure that in Parkstad, like in all of the Netherlands, the gas boiler is by far the technology most often used in dwellings. In Parkstad only 1% of the dwellings was heated with district heating in 2020. The average home in Parkstad Limburg uses 1,222 m^3 of gas per year (CBS, 2020).

It is not known how many homes have a cooling system, but estimations lie between 2 and 11% of homes. The general expectancy is that the number of homes with a cooling system will increase, but by how much is very uncertain (W/E Adviseurs, 2018).

Figure 8 - Main heating technology for dwellings in Parkstad Limburg and in the Netherlands in 2020. Block heating and district heating in the Netherlands are primarily powered by natural gas (CBS, 2022d)



District heating in Parkstad

Some regions in Parkstad Limburg already have district heating. Mijnwater has a 5th generation district heating and cooling (5GDHC) network in Heerlen and Brunssum.
The Oranje Nassau Mine is the main heating source in the network in Heerlen.
The city office and the APG datacentre are supporting heating sources (Warmtenetwerk, 2022). Another heating company, Ennatuurlijk, exploits a small high-temperature district heating network in the centre of Heerlen (Warmtenetwerk, 2022).

2.4 Regional visions of municipalities in Parkstad

All Dutch municipalities have drawn up regional visions[2] for the heating transition. In a regional vision the municipalities describe where they are going to start with the heating transition in their municipality (see the following frame for more information about the regional visions). For the potential of 5GDHC in Parkstad it is important to know the plans of the municipalities. Upscaling 5GDHC will be more successful when local governments are on board with the plans. It is desired to incorporate the municipalities' regional visions within the plans for Mijnwater.

The Dutch Climate Agreement states that all municipalities in the Netherlands have to a regional vision. The deadline for these vision documents was the end of 2021. In the regional vision the municipalities give direction to their approach of insulating buildings and the natural gas phase-out in the built environment. They have to make a timeline for the gas phase-out in their municipality. The Dutch Climate Agreement says that a regional vision should at least contain:

- the number of dwellings and other buildings that will be insulated or heated without natural gas by 2030;
- the promising alternative heating technologies;
- the heating alternative with lowest national costs (PAW, lopend).

Conclusions of regional visions in Parkstad

The seven regional visions for the municipalities in the Parkstad region use the same template and the same method. They use the results of the 'Startanalyse'[3] for the analysis on national costs[4] for the promising alternative heating solutions, which are

- an all-electric heat pump;
- district heating with a high-, mid- or low-temperature sources;
- boilers on renewable gas.

Besides national costs, the regional vision uses several criteria to determine the most suitable neighbourhoods to start with the gas phase-out:

- support from inhabitants and the presence of citizen initiatives make a neighbourhood more suitable;
- a large share of housing association property makes a neighbourhood more suitable;
- a large share of government buildings makes a neighbourhood more suitable;
- homogeneity makes a neighbourhood more suitable;
- neighbourhoods with a large share of monumental buildings are less suitable;
- the possibility to combine the gas phase-out with other infrastructure maintenance[5] makes a neighbourhood more suitable.

The regional visions do not give the results of this criteria analysis. Also, none of the municipalities in Parkstad Limburg have appointed neighbourhoods that will be heated without natural gas in the near future. They state in the regional visions that the analysis they have done so far is not detailed enough to make definite choices for districts and neighbourhoods.

[2] Transitievisie Warmte (TVW) in Dutch.

[3] The Startanalyse is an analysis done by the Netherlands Environmental Assessment Agency (PBL). In the analysis they have calculated the national costs for five natural gas-free heating strategies for each neighbourhood in the Netherlands. For three scenarios the Startanlyse indicates the heating strategy with lowest costs for each neighbourhood. For more information see https://themasites.pbl.nl/leidraad-warmte/2020/#.

[4] National costs for a heating system are all costs associated with that heating system, independent of who has to pay for it. National costs also include costs that are socialised, such as electricity and gas infrastructure costs.

[5] In Dutch this is often referred to as '*koppelkansen*'.

3 The Dutch heating market and energy transition

This chapter describes the Dutch heating market and the developments in it. The heating market is rapidly changing due to the energy transition, where we move from fossil fuels to renewable energy. We describe the main stakeholders and their roles in the process. This chapter also describes the most important policies in the energy transition.

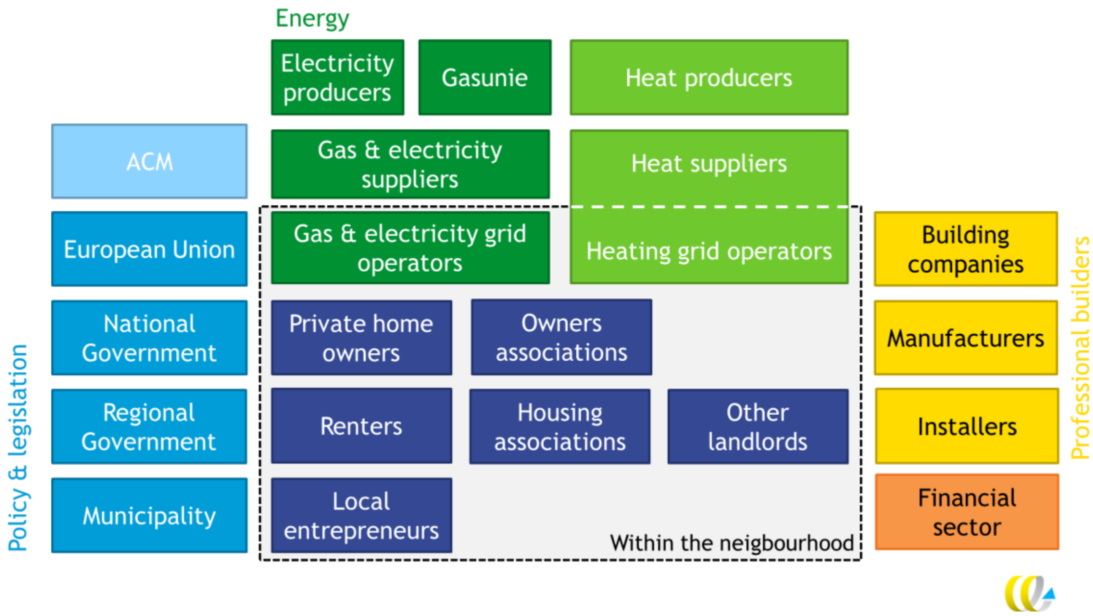
3.1 Main actors in the current heating regime

Figure 9 provides an overview of the main actors in the heating market in the Netherlands. Central in the heating market are the citizens with buildings that need to be heated (shown in blue in Figure 9).

The energy sector is shown at the top (in green). Grid operator companies and energy supply companies are separate entities. The Dutch Energy Act regulates the responsibilities and permitted activities of grid operators as they have a monopoly in their region. National and local governments legislate, subsidise and oversee the heating market, as shown on the left. The Authority for Consumers and Markets (ACM) ensures fair competition between businesses and protects consumer interests. ACM regulates energy tariffs.

The professional builders, shown on the right, are involved when physical changes need to be made. They are especially relevant in the energy transition. Builders are rarely part of the debate on energy transition, but many buildings will have to be renovated and infrastructure will have to be changed to make it happen. The capacity of builders is, however, limited and the current shortage of building materials limits the pace of the transition. Finally, the figure shows the financial sector, which is essential to finance the transition.

Figure 9 - Overview of main actors in the Dutch heating market



3.2 Policy measures for the energy transition

Several policy measures can be identified that significantly contributed to progress in the gas phase-out. Broadly speaking there are five categories of measures:

- regulation: minimum energy requirements for new construction and, to a lesser extent, existing buildings;
- pricing: taxation of energy use;
- district-oriented approach with municipalities taking the lead;
- voluntary and binding agreements with housing associations;
- incentivisation of consumers through positive price signals, such as subsidies and loans.

Regulation: Requirements for new construction

Since July 2018, all new construction has to be built without a gas connection (Ministerie van BZK & Ministerie EZK, 2018). This was enacted by a change in the Gas Act (‘*Gaswet*’). While electricity and gas grid operators were previously obliged to connect all consumers to the grid, in 2018 gas DSOs (Distribution System Operators) were prohibited from connecting new construction, with some exceptions (Ministerie van BZK & Ministerie EZK, 2018).
In 2019, 70-80% of new homes were built without a gas connection; in 2020, this was 87% (Netbeheer Nederland, 2021).

Since January 2021, all new construction must meet the NZEB (Nearly Zero Energy Buildings) requirements. These requirements were legislated through the European Energy Performance of Buildings Directive (EPBD). The NZEB requirements define strict maximum values for energy demand and primary fossil energy consumption, as well as a minimum percentage of renewable energy use. The exact values vary, based on the type of building and its compactness. The exact requirements were defined in partnership with the construction industry.

Regulation: Energy performance of buildings

A system of applying energy labels to buildings has been used in the EU since 2002. These labels, ranging from G (worst-performing) to A (best-performing) indicate how energy efficient buildings are. Attributes such as fossil energy use and renewable energy production are also attributes used in determining the label of a building.

All existing office buildings in the Netherlands are required to have energy label C by 2023, which translates into a maximum total energy use of 225 kWh/m^2 (20.9 kWh/ft^2) per year. Furthermore, a predecessor of the Climate Agreement states the portfolio of homes owned by housing associations should have an average energy label B by 2021. This is considered to be sufficient for heating with an all-electric heat pump. This means a portion of these homes will be sufficiently insulated for gas-free heating ('gas-free-ready'), but others will still need additional insulation.

Existing privately-owned homes currently have no energy performance requirements. There are, however, guidelines which inform homeowners which insulation level is regarded to be futureproof in switching away from natural gas. These levels were developed in 2021 in a follow-up to the Climate Agreement and are referred to as the 'Insulation Standard'. The recommended insulation levels should ensure that heating with a temperature of 50°C is possible in homes built after 1945 and 70°C in homes built before 1945. While these guidelines are currently only a communication instrument, the introduction of more binding instruments is under consideration (Ministerie van BZK, 2021)

Pricing: Energy tax

The Dutch energy taxation rates are used as an instrument to incentivise energy savings. Gas and electricity have separate tax rates and both taxation systems have five tax brackets based on the amount of energy users consume. Low-volume consumers (households and low-volume commercial customers) pay higher rates than high-volume users, such as industry and horticulture.

In the Climate Agreement, it was decided to increase the rate for gas incrementally between 2020 and 2026 by € 0.10 per m^3 (€ 3.00 per MMBTU) in total, while decreasing the tax on electricity (Rijksoverheid, 2019) by € 0.05 per kWh. For an average household, this results in a € 124 increase in gas taxes and a € 137 reduction in electricity taxes annually by 2026. In this way, households and businesses are incentivised to move away from natural gas.

District-oriented approach with municipalities taking the lead

The phase-out of natural gas in existing buildings is built around what is called a district-oriented approach. In this approach, municipalities take the lead in the heating transition.

Programme for Natural Gas-Free Districts

A national programme (PAW, Programme for Natural Gas-Free Districts) was created in 2018 to support the first districts that make the transition towards natural gas-free heating. Through this programme, municipalities can apply for additional funds to support the transition. Additionally, municipalities can apply their general instruments, i.e., provide funds themselves, receive extra funds from the national government or issue loans with favourable conditions for energy efficiency measures.

Besides a funding scheme, the PAW has played a key role in gaining experience for coordinating large-scale building renovations. In this way, practical barriers to going gas-free (such as legal, financial, organisational, capacity-related issues) are identified, lessons learned can be shared and signalled to the national government. The evaluation of the scheme concludes that municipalities did learn a lot about the complexity of the task, which they will take with them in future projects (KWINK & Rebel, 2020). The evaluation identified several improvement points for the learning aspect of the programme. In the future, regional governments will provide more support to smaller municipalities to ensure higher success rates.

Local heating plans

As described in Section 2.4, municipalities are obliged to develop a vision of the local heating transition[6]. In this document, the municipalities, together with stakeholders such as district heating companies, housing corporations and utility companies, develop an indicative time path for realising alternative (natural gas-free) heating, neighbourhood by neighbourhood. For those neighbourhoods where the gas phase-out will take place before 2030, the municipalities indicate the most suitable alternative to gas. From the beginning of 2020 onwards, each municipality was obliged to prepare and submit such a plan before January 1st, 2022.

After these local heating visions, municipalities are obliged to develop individual neighbourhood execution plans[7], in which they commit to a timeline and heating technology. Citizen participation is widely regarded as an important part of the execution plans.

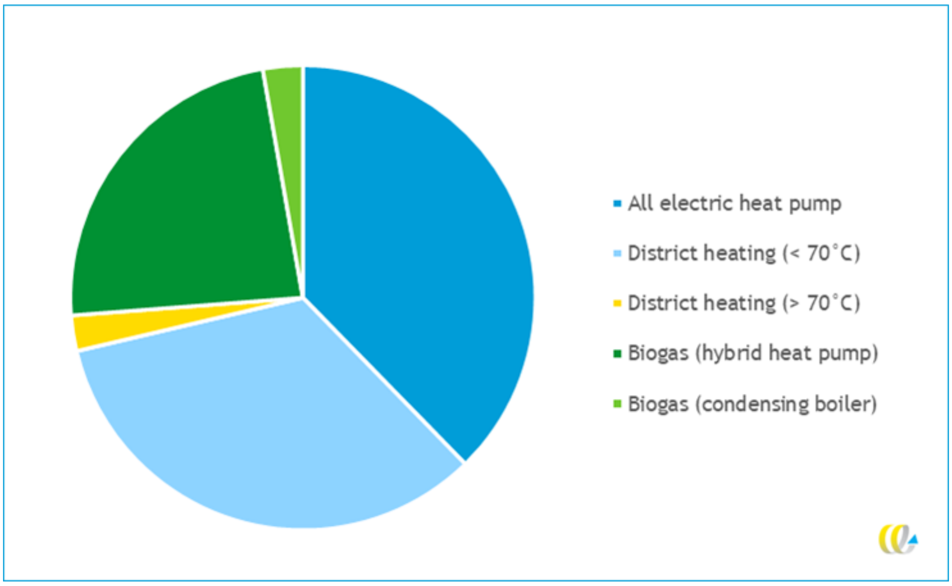
In both the local heating visions and the neighbourhood execution plans, the technical alternatives must be based on the lowest cost (according to the affordability principle). Different parties, including the Netherlands Environmental Assessment Agency (PBL), have developed projections of lowest-cost scenarios based on modelling of the built environment.

The calculations of PBL result in a natural gas-free technique with the lowest total cost for each neighbourhood (an area with on average around 600 houses). Figure 10 shows the distribution of techniques for all buildings in the Netherlands according to the lowest-cost scenario modelling.

[6] Transitievisie Warmte (TVW) in Dutch.

[7] Wijkuitvoeringsplannen (WUP) in Dutch.

Figure 10 - The results of the lowest cost scenario bases modelling of the built environment by PBL; shares of heating techniques for buildings



Incentivisation of consumers: subsidies and loans

Several subsidy schemes and loans exist to stimulate the energy transition in the Netherlands. The most important subsidies for the energy transition in the built environment are described below.

The **Energy Savings loan** is a loan with relatively low interests that can be used to finance energy saving measures. This loan is only for homeowners that also live in that house.
Stimulating Natural gas-free Rental Homes (SAH) scheme (RVO, ongoing-c). Housing associations and other landlords may receive a subsidy of a maximum of € 5,000 per rental house for the connection to an external heating network. The subsidy covers the adjustments in the dwellings to be able to connect to the district heating and the connection costs to the heating network.
Investment subsidy for sustainable energy (RVO, ongoing-a**)** is a subsidy that homeowners can get for insulation measures, the investment in a heat pump, the investment in a solar boiler and the connection to district heating.
Stimulating Sustainable Energy Production and Climate Transition Scheme (RVO, ongoing-b) is a subsidy scheme for the large-scale production of renewable energy.
The **Energy investment Allowance (EIA)** is a fiscal advantage for entrepreneurs when they invest in energy-efficient technologies and sustainable energy (RVO, 2022).
The **Environmental investment deduction (MIA)** and **Arbitrary depreciation of environmental investments (Vamil)** are fiscal advantages for entrepreneurs that invest in environmentally-friendly technology (RVO, 2021).

3.3 Recent developments

The Dutch Climate Agreement has been in effect since 2019, and in the past two years a diverse set of policy measures (as described in the previous section) have been implemented. The progress so far does not indicate that the 2030-goals for the built environment will be met. Additional measures will therefore be necessary. The new Dutch cabinet presented a coalition agreement on December 15th, 2021 (VVD et al., 2021).
This agreement proposes additional policy interventions that aim to increase the pace of emission reductions in the sector. The suggested interventions are especially relevant since they aim to address some key problematic areas that currently represent important barriers. These barriers specifically are cost, lack of skilled staff and not enough focus on insulation and hybrid heat pumps.

The coalition agreement suggests the following additional policy measures:
1. Organising large-scale insulation efforts through a ‘national insulation programme’.
2. Requiring and incentivising renters and private homeowners who live in poorly insulated houses to insulate.
3. Requiring heating installation suppliers to install an increasing number of (hybrid) heat pumps when replacing existing condensation boilers. From 2026 consumers that replace their gas boiler have to change to a more sustainable alternative, such as a hybrid heat pump or an all-electric heat pump (Rijksoverheid, 2022).
4. Requiring energy companies to blend green gas with natural gas to a minimum percentage.
5. Creation of an educational programme that aims to increase the availability of technical staff.
6. Creation of a large fund that provides subsidies for insulation, (hybrid) heat pumps, district heating and other interventions.
7. Subsidising currently unprofitable district heating network business cases.

Although not yet part of official government policy, the addition of these measures to existing policy will likely accelerate the move away from natural gas heating and towards a sustainable built environment.

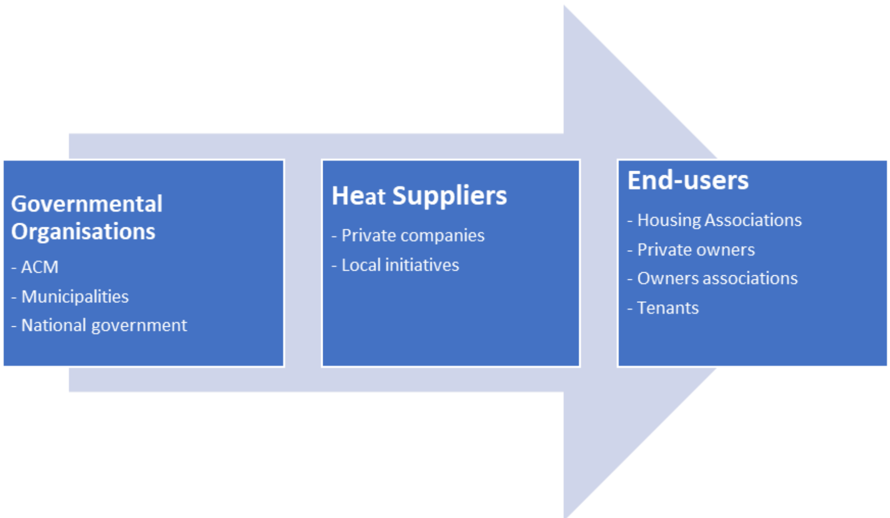
4 District heating in the Netherlands

In this section, the district heating technology is further studied in the context of the Netherlands. This analysis forms a framework for the implementation of 5th generation district heating and cooling (5GDHC) networks as they are in development. First, the value chain is presented with all stakeholders and their roles. It follows an analysis of the regulatory framework and existing price regulations for the district heating networks. Finally, financing and subsidy possibilities are listed that are available in the Netherlands for district heating specifically.

4.1 Stakeholders for district heating

The value chain of district heating in the Netherlands is shown in Figure 11.
There are three main players in the market, namely governmental bodies, heat suppliers and the end users.

Figure 11 - The value chain of district heating in the Netherlands



Governmental Organisations

Based on the plans and targets of the national government, municipalities prepare the heating transition and local action plans in which they pinpoint the suitable neighbourhoods to build a heating network. The new Dutch Heat Act ('Warmtewet 2') provides municipalities with the authority to set local rules for implementing the transition from natural gas to sustainable alternatives. According to the new law, the municipality can designate certain districts where an energy supply with sustainable energy becomes available to replace natural gas.

Municipalities can play four different roles in the implementation of district heating (DWA, 2020). Firstly, a municipality can become the owner and operator of the district heating network. In this case, the financial flows are running through the municipal budget. Secondly, a municipality forms a consortium and looks for partners to develop and operate the district heating. In this case, the municipality (co-)finances and/or provides guarantees to the market entity. The third option is that a municipality grants a concession to a third party for the development and operation of the heat supply and hereby grants guarantees to the concessionaire. Finally, if there is enough demand from building owners to connect to the district heating network, the municipality can function as a facilitator and helps the heat supplier to start delivering heat.

In the Netherlands, the Authority for Consumers & Markets (ACM) [8] regulates the energy market and thus the district heating market, see also Section 3.1 and 4.2.

Heating suppliers

According to the registry of ACM, as of September 2022, there are 35 licensed heat suppliers in the Netherlands. These are private companies and/or public private partnerships.

Local initiatives, such as those of owners associations or energy corporations, can also deliver heat without a licence obligation. According to the local energy monitor 2021, there are 87 local district heating initiatives in the Netherlands, 62 of which are actively working either on a feasibility study or on the realisation of a collective heating project. The rest of the local collective heating projects are no longer active after having worked on the policymaking or have completed a feasibility study with a negative conclusion (Hier opgewekt, 2021).

End-users

In the Netherlands, four types of end-users are identified in the built environment that are connected to the district heating network:
- housing Associations;
- private owners;
- owners associations;
- tenants.

The most significant role for the end-users is that they decide if they would like to connect to the heating network and they pay for the heat they use from the district heating network. Different from electricity and gas markets, small-scale users are not yet able to select their district heating supplier.

The current Heat Act aims to protect small-scale consumers by tariff regulation (maximum permitted rates), rules on connection and disconnection, compensation in case of failures etc. Since 1 July 2019, the Heat Act no longer applies to customers who receive heat from their landlord or by an owners association. The reason for this is that tenants and members of owners associations are also protected under the Civil Code.

The decision whether to connect a building to a heating network or make use of a different heating source for the building lies with the building owner.

[8] ACM is an independent regulator which protects the rights of both consumers and businesses by competition oversight, sector-specific regulation of several sectors, and enforcement of consumer protection laws. More information about ACM: [The Netherlands Authority for Consumers and Markets]

4.2 Regulatory Framework

The Dutch Heat Act assigns ACM for issuing licenses to district heating providers for small businesses up to 100 kW capacity. Providers which deliver at least more than 10,000 GJ heat per year to 10 consumers simultaneously are required to apply for a license at ACM.[9] After the revision of the Heat Act in 2019, lessors and homeowner associations are excluded from this obligation.[10]

ACM evaluates the district heating providers with regard to the set-up of a working administrative organisation and internal/external audits. The organisation is assessed on the following aspects[11]:

- conformity with laws and regulations;
- responsibility of every director/manager/employee at an energy supplier to act with integrity;
- controlling business processes (including risk management);
- segregation of duties for internal audits;
- information and relational check of purchase and sales figures,
- control of information, capacity and delivery;
- control of information, registers;
- security

As can be seen, the provider is assessed based on the audit procedures inside and outside the organisation, registers of client agreements and purchase/sales figures, procedures for complaints next to the processes for management of risks regarding the delivery and the purchase of heat.

4.2.1 District heating tariffs

ACM sets tariff caps for the heat suppliers based on the Not-More-Than-Else principle. Accordingly, the households that are connected to the district heating networks do not pay more than the households with conventional gas boilers.

The heating rate consists of a variable, i.e., usage-related part, and a fixed, i.e., usage-independent, part. The consumers pay the variable rate for the heat they use and this tariff cap for this rate is directly linked to gas prices. There is also a maximum price for connection, disconnection, rental of a delivery set and measuring consumption. When a house is connected to a heating network, there are five different cost components, namely:

- once-off connection costs;
- fixed costs (standing charge);
- rent delivery set;
- measurement costs;
- cost for the heat (GJ).

The rates for these cost components are (partly) regulated in the Heat Act and set by the Netherlands Authority for Consumers and Markets (ACM). The Heat Act was introduced to protect consumers against excessive prices for heating and hot water, unacceptable malfunctions and non-transparent suppliers.

The law states exactly how the variable rate must be calculated, and it is based on the gas prices that the ten largest gas suppliers charge on average. The price includes the tax on

[9] ACM: Ik wil warmte leveren. Wat moet ik doen? (only in Dutch)

[10] ACM: Revised Dutch Heat Act in effect

[11] ACM: Toelichting op het aanvraagformulier voor warmte (Only in Dutch)

gas and the Sustainable Energy Storage (ODE) in the rate. So, in the end the consumers of the district heating networks pay no more than what a consumer pays for gas, a central heating boiler and the standing charge for gas. The costs are those of an average household (incl. 21% VAT)

The New Dutch Heat Act ('Warmtewet 2'), which is expected to take effect before the end of 2022, changes the way how the heating rates are determined. The heating rates will no longer be dependent on the gas prices but depend on the costs incurred by a heat supplier to realise the heating network and keep it in operation. This will be implemented in three phases.

In the first phase, the gas price reference will still be used and corrected by the costs of the district heating network and a reasonable return rate. In this phase, the heat suppliers will keep track of their costs until enough information is available for Phase 2, which is estimated to take 3-5 years. In the second phase, the gas price reference is released, and ACM regulates the tariffs entirely based on costs. A periodic cost-based correction can be made on this. ACM's insight into the costs will become increasingly clear in this phase.
In the third phase, ACM uses a benchmark method that determines the permitted income of the heat suppliers. This phase will commence at a time to be determined by the minister. Within the three phases of the Heat Act, ACM is developing a better monitoring tool to gain insight into the costs of heating networks within individual plots.

No specific tariff regulations for 5GDHC

In the Netherlands, there is no specific regulation for the 5GDHC networks neither in the current Heat Act nor in the upcoming new Heat Act. Especially the heat discharge to the network by users would require a special arrangement for the operation of the heating network and the price determinations.

For cooling, tariffs are regulated in the Heat Act only in the case where it is used from a source to balance the heating load, for example from a ground water energy storage system (ATES). Small consumers pay only a standing charge whereas utility users often pay an amount per used amount (GJ or kWh) of cold. In the case of a cooling network with only a cooling source, it is also possible to pay per GJ for homes. The maximum standing charge for cold for small users of ATES systems has been set in 2020 at € 236.80 per year including VAT. The standing charge for large users depends on the capacity of the connection.
The GJ rate for large users varies per cooling network between € 11 and 21 excluding VAT (Vattenfall and Eneco, 2020 respectively) (TKI Urban Energy, lopend).

4.2.2 Ownership

In principle, there are three possible scenarios regarding the ownership of the district heating networks. Either private companies, local governments or private-public partnerships own and operate the district heating networks. This is determined case by case depending on the size of the district heating project and the risks associated with the development and operation of the network.
If there are uncertainties about the heating demand and the number of buildings that will be connected to the heating network, then the risks are too high for a commercial company to step in alone. This means then the municipality either takes up the ownership alone or it joins forces with a private party to form an entity ('entiteit' in Dutch) for developing and operating the heating network. See Section 4.1 for the roles that municipalities can play in this process.

Licenses are granted to operators of the district heating also when they do not have the economic or legal ownership of the heating network(s). With the introduction of the New Dutch Heat Act ('Warmtewet 2'), the Dutch Climate and Energy Minister is planning to transfer the ownership of the district heating networks from private companies to the public hands.[12] This means a drastic change to the current market in the Netherlands, as most heating networks are currently in the hands of heating companies.

4.3 Financing and subsidies

Section 3.2 already described the most important subsidies for the energy transition in the Netherlands. The subsidies that are relevant for district heating for both consumers and providers of heat are:

- SAH: Stimulating Natural gas-free Rental Homes. Housing associations and other landlords may receive a subsidy of a maximum of € 5,000 per rental house for the connection to an external heating network.
- ISDE: Investment subsidy for sustainable energy. Homeowners can get € 3,325 subsidy for the connection to district heating.
- SDE++: Stimulating Sustainable Energy Production and Climate Transition Scheme. This subsidy scheme is for the heat suppliers who will generate renewable or low-CO_2 heat, for example by renewable biomass, deep/shallow geothermal, solar thermal energy, residual heat, etc.

[12] Warmtenetwerk : Minister Jetten wil eigendom warmtenetten van privaat naar publiek

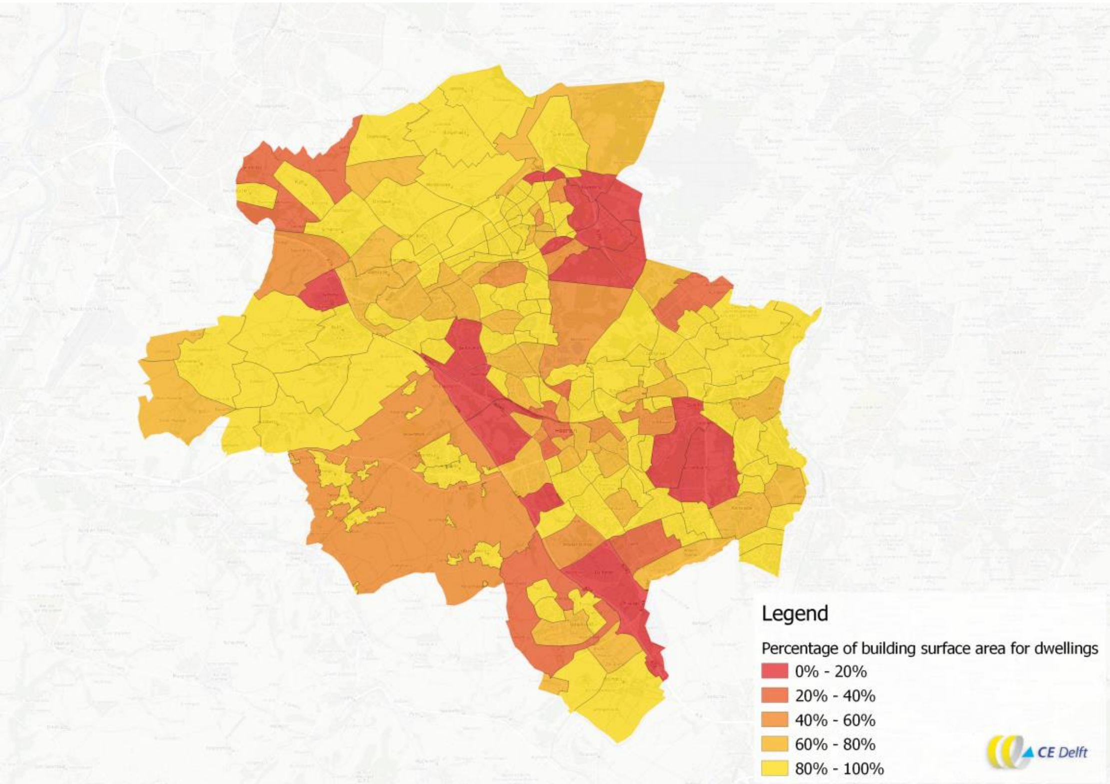
5 Energy sources and storage

Energy sources and storage are an essential part for 5th generation district heating and cooling (5GDHC). This chapter describes the availability of several types of energy sources and storage. As part of the work in D2Grids, a preference scale of energy sources has been developed. The structure of this chapter reflects this ranking, with the highest ranking forms of energy mentioned first.

5.1 Reuse of thermal energy

The reuse of thermal energy by the exchange of heating and cooling demand is already realised in the Mijnwater district heating in Heerlen. In 2020 about 350 dwellings and nine large office building were connected to the Mijnwater district heating (Mijnwater, ongoing-b). Figure 12 shows the percentage of building surface area that are dwellings for each neighbourhood in Parkstad Limburg. The yellow neighbourhoods are neighbourhoods with mostly dwellings in it, the red neighbourhoods are mostly business parks and the orange neighbourhoods are mixed. The reuse of thermal energy by exchange between heating and cooling demands functions best when there is a mix between dwellings and utility buildings. The orange neighbourhoods or the yellow and red neighbourhoods that are adjacent each other are best suited for the reuse of thermal use.

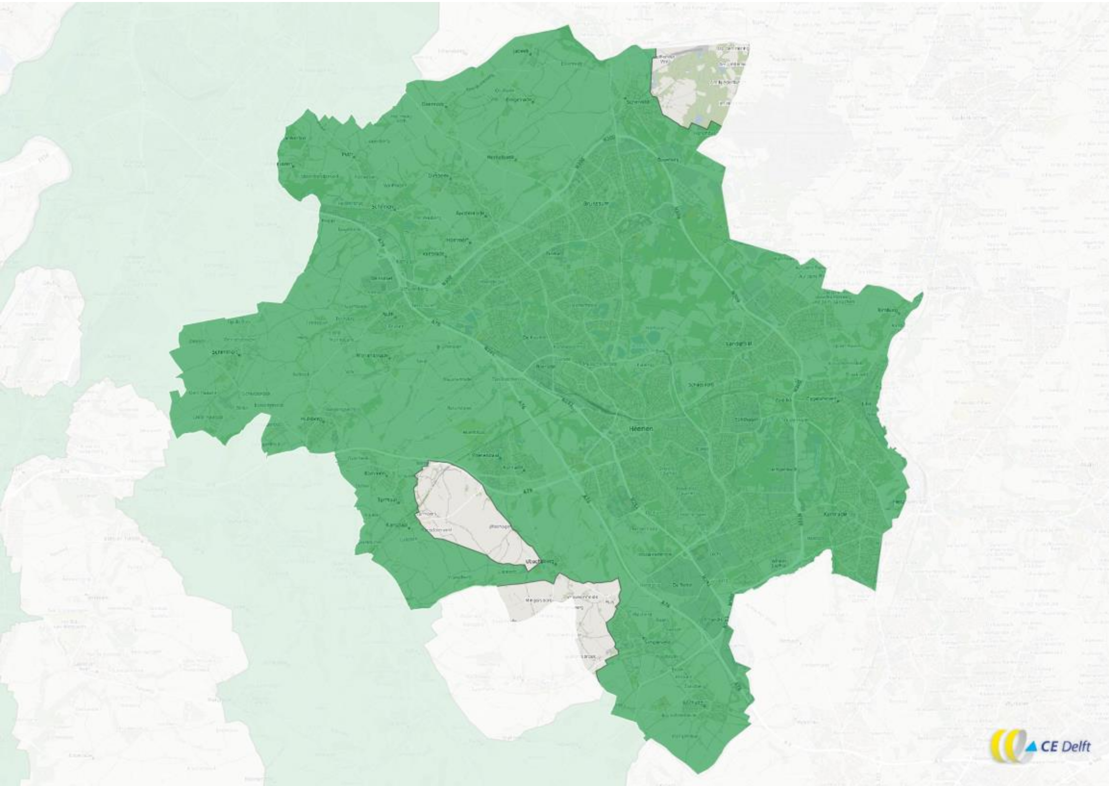
Figure 12 – The percentage of building surface area that are dwellings for each neighbourhood in Parkstad Limburg



Source: Analysis by CE Delft based on (Kadaster, ongoing-a).

The heating and cooling demand of buildings will never be exactly in balance. Because of this, storage is needed such as ATES. In some regions in the Netherlands this are not allowed, for example due to interference with drinking water. Figure 13 shows that these systems are allowed in most of Parkstad Limburg. The regions where this kind of storage is not allowed, are less suitable for exchange of heating and cooling demand.

Figure 13 – The green area shows where ground-coupled heat exchangers are allowed in Parkstad Limburg

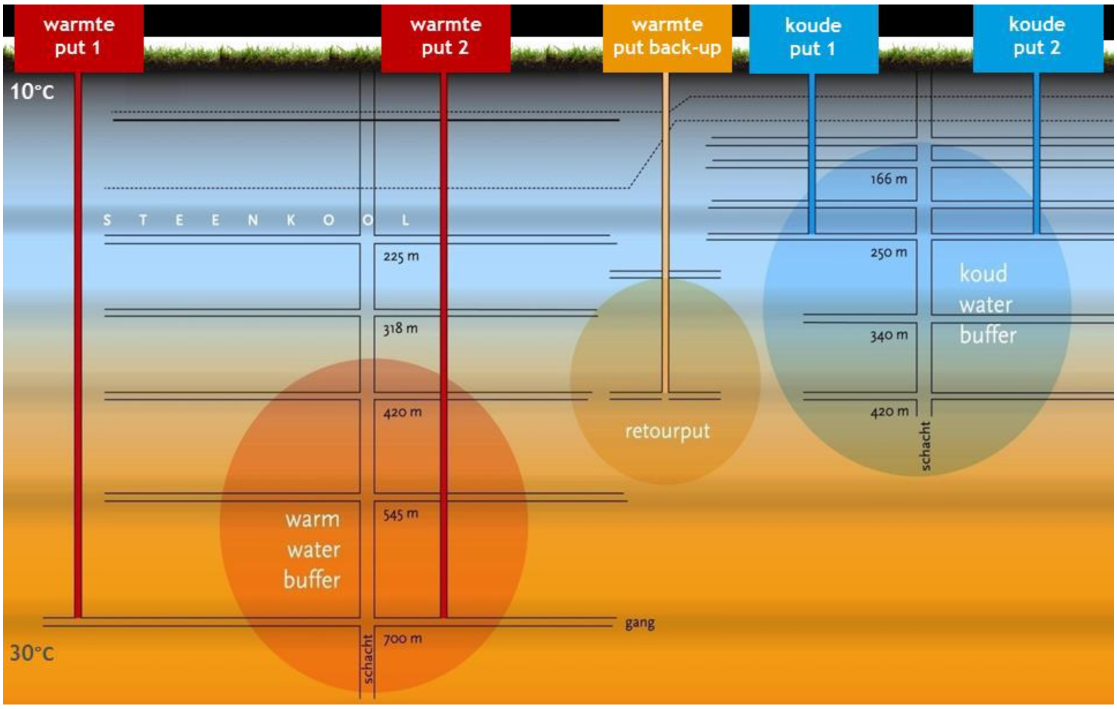


5.2 Ambient thermal sources and higher temperature renewable sources

A flooded mine as thermal storage

The Mijnwater district heating uses a former mine, the Oranje Nassau mine, as a heating and cooling source as well as thermal storage. This is called mine thermal energy storage or MTES. When the mine closed, its corridors filled with water with groundwater that is heated by the earth. The further down the mine, the hotter the water is. Wells were drilled, to subtract heat from the water in the mine. There are two wells at 700 meters below the surface, where the water has a temperature of 28°C and two wells at 250 meters below the surface, where the water has a temperature of 16°C. These wells serve as sources for heating and cooling. A 5th well is drilled to be used as buffer for storage and reuse of thermal energy (CE Delft, 2018). Figure 14 gives a schematic overview of the use of the Oranje Nassau mine for Mijnwater. Innovation has made it possible to use the Mijnwater concept with other storage options (such as ATES) when there is no mine that can be used (Mijnwater, ongoing-b).

Figure 14 – A schematic overview of the use of the Oranje Nassau mine for Mijnwater (CE Delft, 2018)

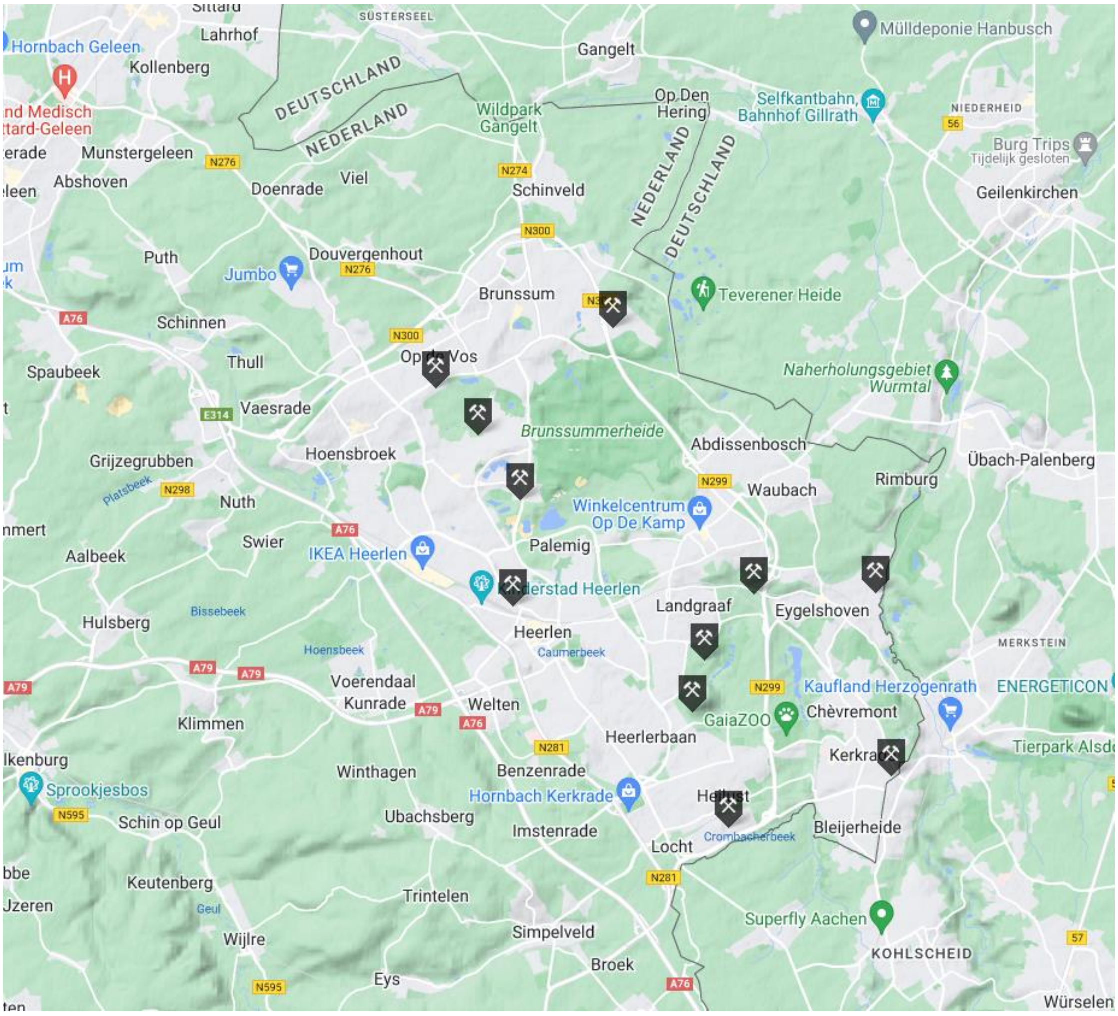


There are eleven former mines in Parkstad Limburg, four in Heerlen, four in Kerkrade, one in Landgraaf, one in Brunssum and one in Hoensbroek (municipality Heerlen). They can be seen in Figure 15. One former mine in Heerlen is already being used as a thermal source and storage. It can be researched whether the other former mines are also suitable for this. As far as we know, besides the Oranje Nassau Mine, there has been no research into the suitability of mines in Limburg to function as thermal source and storage.

A requirement for MTES is large mine water volume (Kallesøe & Vangkilde-Pedersen, 2019). Most of the mines in Limburg are flooded (Projectgroep GS-ZL, 2016). Most of the shafts are filled (for example with concrete) and closed off. The mine corridors are not filled or closed off, however some may have collapsed (PBL, 2021).

In order to determine whether a mine is suitable for MTES, the location of mine corridors should be determined, and it should be researched if there is a location where the drilling of wells is possible.

Figure 15 – The location of eleven former mines in Parkstad Limburg



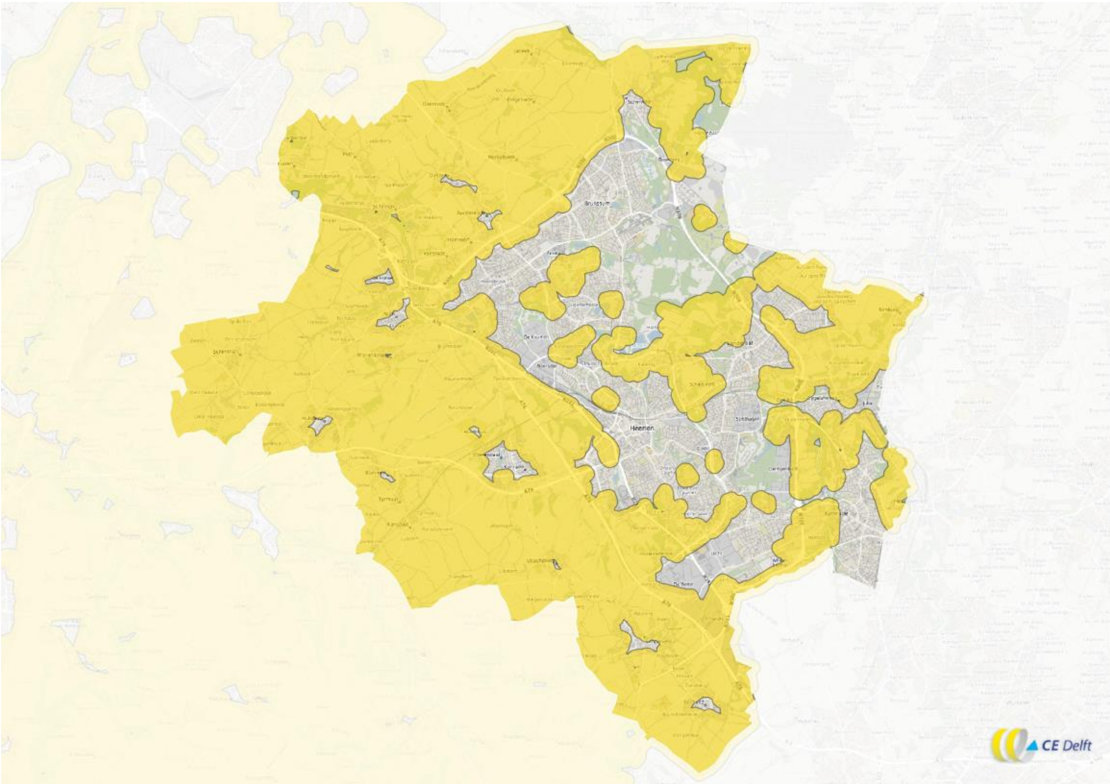
Source: (DeMijnen, 2022).

Interreg North-West Europe D2Grids

Solar thermal energy is possible in Parkstad

There are no large-scale solar thermal installations in Parkstad Limburg. Figure 16 shows the areas (in yellow) that could potentially be suitable for solar thermal energy. An area is appointed to be suitable for solar thermal energy if it currently is used for agriculture and if the surface area is larger than 5,000 m^2 (0.5 ha). We did not take into account the ownership of the land. This map gives an indication where solar thermal energy might be possible. The average potential for solar thermal energy is 0.5 GJ per m2 land (CE Delft, 2020).

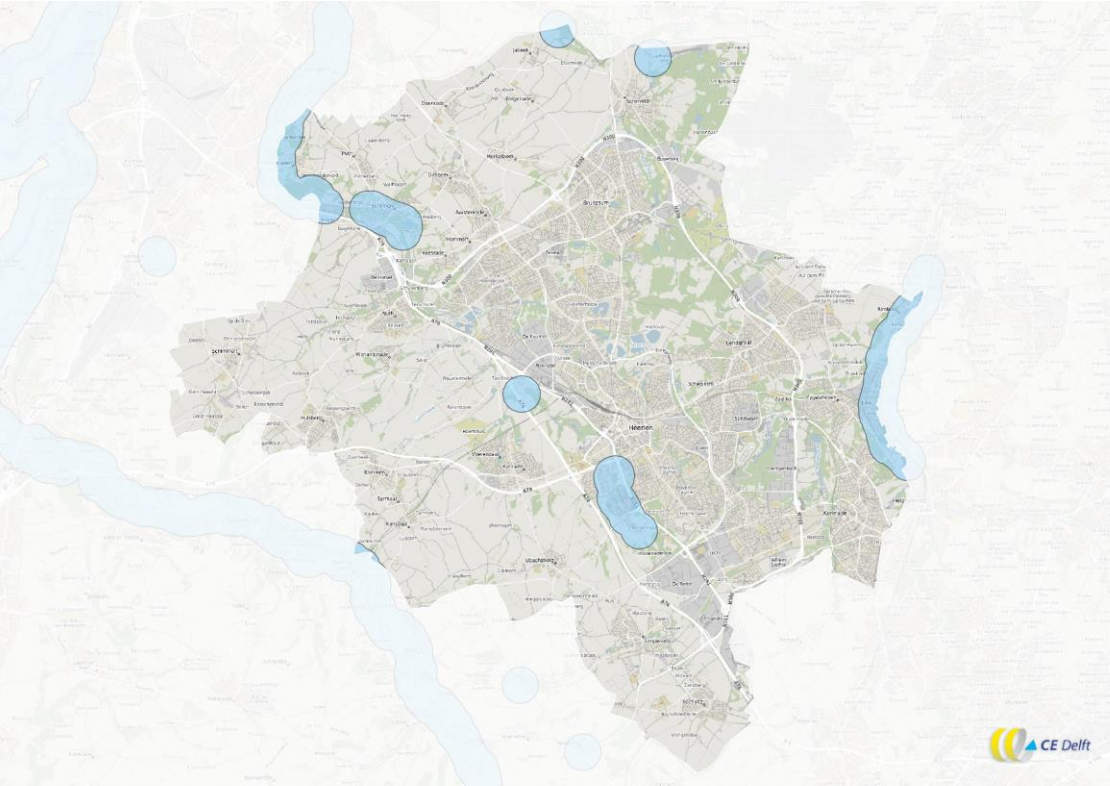
Figure 16 – Potential area's for solar thermal energy. This potential does not take into account the ownership of land



Limited potential for aqua thermal energy

There are a few waters in Parkstad Limburg that could potentially be used for aqua thermal energy from surface water. Figure 17 shows the regions, in blue, where aqua thermal energy could potentially be used. The surface waters with potential are obtained from the Startanalyse[13]. We have assumed that aqua thermal energy could be used within 500 meters from these waters. Currently there are no projects using thermal energy from surface water in Limburg. The average potential for solar thermal energy is 0.5 GJ per m^2 land (CE Delft, 2020).

Figure 17 – The blue area's indicate where aqua thermal energy is a possibility



No geothermal energy in Parkstad

The Warmteatlas, a database with potential for heating sources in the Netherlands, shows that there is no known potential for low-temperature or high-temperature geothermal energy in Parkstad Limburg (RVO, ongoing-d). In 2021 the potential for geothermal energy is researched by TNO within the SCAN research program.

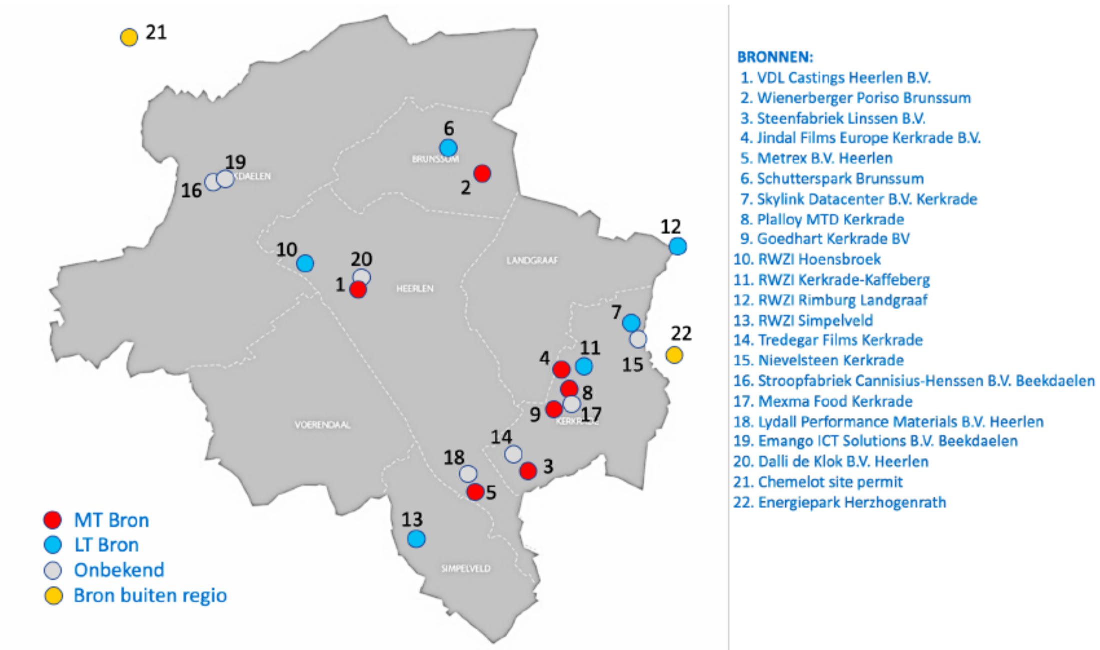
[13] The Startanalyse is an analysis done by the Netherlands Environmental Assessment Agency (PBL). In the analysis they have calculated the national costs for five natural gas-free heating strategies for each neighbourhood in the Netherlands. For three scenarios the Startanalyse indicates the heating strategy with lowest costs for each neighbourhood. For more information see Startanalyse aardgasvrije buurten, versie 2020.

5.3 Higher temperature industrial waste heat

In the Parkstad region there are twenty possible waste heating sources. Figure 18 show these sources and their location. There are two large sources just outside of the Parkstad region: Chemelot (nr. 21) in Sittard-Geleen and Energy Park Herzogenrath, just of the border next to Landgraaf and Kerkrade (nr. 22). The industrial waste heat from Chemelot is already used for district heating outside of Parkstad Limburg (Het Groene Net, Ongoing).

For most of the waste heating sources in Parkstad it is not yet known whether they can really be used as sources in district heating. However some sources are already used in district heating or there are concrete plans to use them. The industrial waste heat from Chemelot is already used for district heating outside of Parkstad Limburg (Het Groene Net, Ongoing). Mijnwater has plans to make a cluster where VLD castings Heerlen B.V. (source nr. 1) can exchange thermal energy with a swimming pool (Mijnwater, ongoing-a).

Figure 18 - Potential waste heating sources in or close to Parkstad Limburg. The red sources are mid temperature sources, the blue sources are low-temperature sources and the yellow sources are sources that are outside Parkstad Limburg



Source: (Gemeente Heerlen, 2021).

5.4 Renewable electricity

In the Dutch Climate Agreement (‘Klimaatakkoord’) it has been agreed to research where and how renewable electricity production can be realised. For this research the Netherlands has been divided over 30 energy regions. For each of these regions a regional energy vision (‘Regionale Energie Strategie’) has been drawn up. Parkstad is part of the vision for Zuid-Limburg. In Table 2 the existing, planned and ambitioned production resulting from this vision is set out. The solar rooftop systems consist of systems of at least 15 kW.

Table 2 - Local renewable electricity production in Parkstad (RES Zuid Limburg, 2021)

Source	Existing (GWh)	Planned (GWh)	Additional ambition (GWh)
Wind	2	0	128
Solar - rooftop	18	27	139
Solar - land	6	26	158
Total	**26**	**53**	**425**

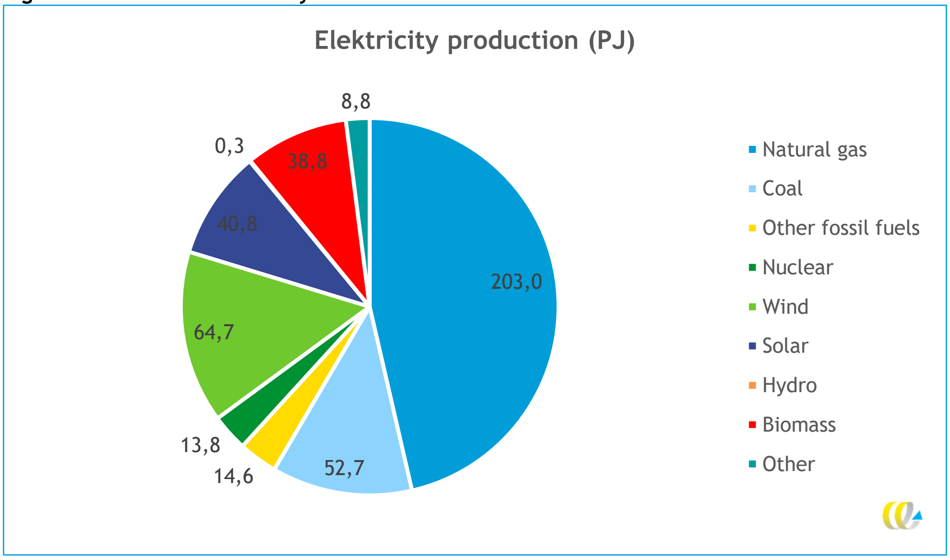
5.5 Electricity use at times of renewable overproduction

Currently there is no known overproduction of electricity from renewable sources in the Parkstad region.

5.6 Electricity mix from the external grid

The national electricity mix for 2021 is shown in Figure 19. Almost half the electricity production is from natural gas. In total 62% of the electricity production is from fossil fuels. A quarter of the electricity production is from wind and solar.

Figure 19 - National electricity mix



Source: (CBS, 2022c).

5.7 High-temperature heating from burning biofuels, biogas, biomass

The Parkstad region has no potential to produce biofuels or biogas. There is potential for biomass. According to Palet 3.0 (Parkstad Limburg et al., 2016) the potential for biomass is 415 TJ.

5.8 High-temperature heating from burning fossil fuels

As Section 2.3 describes, a lot of buildings in the Netherlands are heated using natural gas. In the transition to heating without fossil fuels, natural gas will still play a role until it can be totally replaced by renewable energy sources.

6 SWOT analysis

For the implementation of the 5th generation district heating and cooling (5GDHC) technology, we perform a SWOT analysis.

6.1 Strengths

Experience with 5GDHC (Mijnwater) and District Heating

Regarding the implementation of 5GDHC technology, the most important strength is the experience with the technology itself in Parkstad region. In 2013, the municipality of Heerlen built the first 5GDHC network in Europe using mine water system to store heat and cold. It was initiated as a 4DHC and later by the introduction of a system to exchange heat and cold between customers, it has been turned into a 5GDHC system.

Currently, more than 350 homes (in Heerlerheide and Maankwartier) and nine large office buildings are connected to the network. The company is rolling out its network throughout the city (including the centre pipeline through the heart of Heerlen, including a connection to the new city office) and is a supplier for renovation projects of various housing associations in Heerlen and Brunssum.

Gas phase-out in the Netherlands

As indicated earlier, the national government has set a target to make all dwellings in the Netherlands gas-free by 2050. For this purpose, municipalities have set up heating transition vision documents in which they define the pathways towards a natural gas-free municipality in 2050.

In this framework, available heating sources in the Netherlands have been investigated and inventoried as part of the techno-economic feasibility studies for sustainable heating opportunities at neighbourhood level. This constitutes a good basis for spotting areas where district heating networks are feasible to implement. For 5GDHC technology, this could be an initial step to find out where a heating network can be implemented.

Next to that, in the Netherlands there are currently 64 living labs as part of the Natural Gas-free Neighbourhoods Program (PAW) and through these living labs, practical know-how is built as to how to implement different heating options. Eighteen of these living labs work actively on a heating network and this forms a knowledge basis, not only technical but also organisational knowledge for implementation, for the implementation of 5GDHC networks.

Existing skills and Infrastructure

Thanks to Mijnwater project in the region, there is considerable experts that are actively working on 5GDHC technology. As mentioned above, there are several initiatives in the Netherlands in which the expertise and know-how on district heating networks build up. Therefore, the existing level of knowledge and skills in the Netherlands is an important advantage for rolling out the 5GDHC technology.

The data infrastructure in the Netherlands provides a wide opportunity to investigate the possibilities for the implementation of 5GDHC. The cadastre register includes all relevant data about the building stock. Besides potential energy sources are well registered in databases such as Warmteatlas (RVO, ongoing-d)

Growth of cooling demand

The demand for coolth in the built environment is expected to increase in the Netherlands due to a number of factors:

- average temperature increase due to climate change;
- better insulated buildings;
- heat island effect in the urban environment;
- aging population;
- stricter requirements for comfort in buildings.

6.2 Weaknesses

Bureaucracy

The realisation of a heating network takes several years and it is often a complex process with several stakeholders (DWA, 2020):

- permit applications for the construction and realisation of the heating source;
- apply for grants such as SDE++ for sustainable heating sources;
- communication with residents and other stakeholders;
- consultation and coordination with the grid operator about excavation work to lay the pipes;
- connecting homes and buildings and minimise nuisance as much as possible;
- supervision of the realisation process and work to be performed by the contractor.

Participation

Participation is an important aspect for energy transition in general and also for the implementation of 5GDHC technology. Although a large group of Dutch people is positive about making the gas-free, less than 10% is prepared to take action themselves in the short term. The majority indicate that they prefer to wait for plans from the municipality, the landlord or the VVE (Stichting Warmtenetwerk & DNE Resarch, 2020). This means it will be difficult for stakeholders to start a district heating project because of high risks and uncertainties.

Moreover, the fact that consumer price of the heat from district heating is still coupled to the gas prices makes the connection to a district heating network less interesting for end-users. Although this is going to change in time, the prices will not be totally independent of gas prices in short term.

6.3 Threats

Balance between heating and cooling demand

The main challenge for the implementation of 5GDHC technology, different from a conventional district heating network, is the balance between heating and cooling demand. Especially, in the existing building stock, the fact that the energy demand is mainly for heating and that the cooling demand is minimal is a threat to the functioning of the 5GDHC system.

As an example, the performance of an ATES system is also dependent on the balance between heat and cold demand. In the Netherlands, the performance is guaranteed by regular checks by the province. The permit requires the supplier to submit a report on the performance of the ATES system and the level of soil quality to the province every year. Every five years the supplier is required to submit a more detailed evaluation report. If the results in these reports do not comply with the permit, the province will impose sanctions. These sanctions range from warning letters and fines to even stopping your TES system or revoking the permit.

Initial Investment Costs and Financial Feasibility

The investment costs for the realisation of the district heating networks is already high. This pushes municipalities to take ownership of the district heating projects and cooperate with market parties to realise the projects. For 5GDHC technology, however, investment costs are even higher considering the infrastructure required for cooling and advanced systems for the communication between different users.

6.4 Opportunities

Rolling out existing district heating networks, such as the one of Mijnwater, is the first opportunity that the region has in term of 5GDHC implementation. Especially the new building projects, which have a more balanced heating and cooling demand, are especially interesting for the implementation of 5GDHC networks.

The energy crisis in Europe has been a driving force for the acceleration of gas-free policies and programmes. Due to high energy prices, Netherlands paying the highest price for gas in Europe, and geopolitical risks associated with natural gas, district heating networks become more interesting for policy makers as well as for citizens in the Netherlands.

7 Multi-criteria analysis

The decision on the neighbourhoods where the 5th generation district heating and cooling (5GDHC) technology can be implemented is not straightforward. One needs to take into account many aspects that play a conflicting role in determining where the technology is suitable. It includes financial, technical and social aspects. Therefore, a multi-criteria analysis is the best option to solve this problem with many facets. Criteria for suitable neighbourhoods

In the multi-criteria analysis we rate all the neighbourhoods in Parkstad Limburg to determine the most suitable neighbourhoods for implementing 5GDHC. In the analysis each criterion has a weighing factor; the higher the weight, the more influence the criteria has in the total score for a neighbourhood. The criteria on which the neighbourhoods are rated are listed and explained in this section.

7.1 Criteria for the multi criteria analysis

An overview of all criteria can and their weights can be found in Table 3. Weighing factors are determined by CE Delft taking in consideration input from experts from Mijnwater and the Open University. The criteria that are weighed by two are considered to be more important for determining the most suitable neighbourhoods for 5GDHC.

Table 3 - Overview of criteria, the method for scoring and their weight

Criterion	Explanation	Method of scoring	Weight
Number of dwellings	Minimal number of dwellings necessary for implementing 5GDHC	Less than 50 dwellings are filtered out. Between 50 & 100 dwellings score -1.	2
Room for investment in 5GDHC	High costs for the alternatives provide a room for investments in 5GDHC	Highest 30% score 1. Next 30% score 0.5.	2
Ratio total costs to insulation costs	Higher energy costs give an opportunity for 5GDHC to be more economically viable than alternatives	Highest 30% score 1. Next 30% score 0.5.	1
Exchange heating and cooling	A balance in heating and cooling demand is needed for optimum performance of 5GDHC (mix of functions)	A cooling to heating demand ratio of more than 15% score 1. Two or more buildings with continuous cooling demand score 1.	2
Infrastructure costs	Lower infrastructure costs for district heating makes a neighbourhood more suitable for 5GDHC	20% with lowest infrastructure costs score 1, next 20% score 0.5. 20% with shortest infrastructure per dwelling score 1, next 20% score 0.5.	1
Proximity of existing district heating	Connecting to an existing district heating network is easier than building a new one	Mijnwater backbone in neighbourhood score 1.	1
Urban density	High-urban density favours district heating	Urban density 1 and 2 score 1. Urban density 3 score 0.5.	1
Heating source available	Usually there is more heating than cooling demand in the Netherlands, a heating source can provide this extra demand	A heating source available in neighbourhood score 1.	2
Social housing	Higher percentage of dwellings owned by social housing corporations	> 75% is social housing score 1. > 50% is social housing score 0.5.	1

Criterion	Explanation	Method of scoring	Weight
	provides higher potential to connect a large number of dwellings to 5GDHC		
Infrastructure replacement	If gas infrastructure is replaced before 2024 the neighbourhood is less suitable to start with a gas-free heating option	Neighbourhoods where more than 30% of gas infrastructure will be replaced before 2024 get a score of -1, when this is between 20% and 30% they get a score of -0.5.	1
Heat Island	5GDHC does not increase heat island effect, therefore it is interesting for districts with higher risk of heat island effect	More than 1.4°C score 1. Between 1°C and 1.4°C score 0.5.	1

Number of dwellings

District heating is a collective heating system, multiple buildings are connected to a network that distributes hot water for heating of buildings. Larger-scale implementations are favourable for district heating, in terms of costs as well as performance. This applies even more to 5GDHC. A minimum number of buildings that can exchange heating and cooling is needed to ensure high performance of the system. Because of this, in selecting the most suitable neighbourhoods for 5GDCH, we filter out all neighbourhoods that have few dwellings based on the following rule:

All neighbourhoods with less than 50 dwellings are filtered out completely, neighbourhoods with 50 to 100 dwellings get a score of -1.

Room for investment in 5GDHC

One of the criteria is the room for investment in 5GDHC. This is determined by the costs for alternative heating solutions, where we look at the alternatives for 5GDHC. The higher the costs for the alternatives, the more opportunity for 5GDHC to be an economically more favourable option. In other words, we find out the neighbourhoods where alternative heating options are relatively expensive and therefore provide room for investing in 5GDHC. We look at the total costs for the heating of a dwelling over 30 years and call this the room for investment. This includes the investments for installation and insulation but also the maintenance costs and energy costs for 30 years.

In our analysis, we take three options in consideration for heating dwellings: a gas-fired individual heating system, a gas-free individual system and a gas-free collective system. The gas-free collective system in this study is 5GDHC. The individual systems are the alternatives. For the costs we assume that for heating a dwelling wit a gas-fired individual option, the first fifteen years a conventional gas boiler is used and the next fifteen years a hybrid heat pump is used. The gas will be a mix of natural gas and green gas. The percentage green gas increases linearly from 0% in 2020 to 20% in 2030 and from 20% 2030 to 100% in 2050. For these heating systems insulation is not required, so they are not taken into the costs for this alternative.
The gas-free individual option is an all-electric heat pump. This option takes into account the advised insulation levels which are determined by Dutch specialists based on the Climate Agreement, called the insulation standard (see Section 3.2). For the alternative with gas, energy costs are the most important factor in the costs. For the gas-free alternative, investments in the heating installation and insulation play a larger role.
An overview of the two situations that we calculate costs for can be seen in Table 4.

Table 4 - Overview of reference situations where the costs are calculated for, to determine the room for investment in 5GDHC

Alternative to 5GDHC	Heating system	Insulation
Situation with gas	Condensation boiler for 15 years and hybrid heat pump for 15 years	No extra insulation
Gas-free situation	All-electric heat pump for 30 years	Insulation that is required for low-temperature heating

Using our CEKER model[14], we calculate the total costs over 30 years for two alternative options as explained above. As a result, we find the neighbourhoods with the highest room for investment.

The 30% of neighbourhoods with the highest room for investments get a score of 1. The next 30% get a score of 0.5 and the rest gets zero score.

Ratio total costs to insulation costs

Besides the total costs for alternative heating systems, we also take in consideration what elements the costs are for. Investments in insulation are needed in the gas-free reference, but they may also be necessary for 5GDHC. When most of the costs are needed for insulation, there is less room for investment in 5GDHC. While higher energy costs give an opportunity for 5GDHC to be more economically viable than alternatives. The ratio total costs to insulation gives an indication whether most costs are needed for insulation. A high ratio total costs to insulation is favourable for 5GDHC.

The 30% of neighbourhoods with the highest ratio total costs to insulation get a score of 1. The next 30% get a score of 0.5 and the rest gets zero score.

Potential for exchange between heating and cooling supply and demand

A key component of 5GDHC is the exchange of heating and cooling supply and demand. For each neighbourhood we have estimated a heating and cooling demand based on the type of buildings in that neighbourhood. Therefore, for our multi-criteria analysis, we look at the ratio between the total cooling and heating demand in each neighbourhood.

Neighbourhoods with a cooling to heating demand ratio of more than 15% get a score of 1. The rest gets zero score.

In general the heating demand and cooling demand are not simultaneous, most buildings have a cooling demand in summer and a heating demand in winter. However some buildings, such as datacentres or supermarkets, also have a cooling demand in winter. We have gathered the locations of these buildings with a continuous cooling demand. In neighbourhoods with these buildings, it is more likely to realise a balance between heating and cooling in the network.

Neighbourhoods with two or more buildings with a continuous cooling demand within a radius of 500 meter get a score of 1. The rest gets zero score.

[14] CEKER is a fast and flexible calculation model, developed by CE Delft, that calculates the costs for end users of sustainable heat options. The model works on housing level, neighbourhood level, municipal level and central government level. More information: CEKER Kosten voor Eindgebruikers Rekenmodel (Available only in Dutch).

Infrastructure costs

With our CEGOIA[15] model we can calculate the costs for district heating infrastructure in a neighbourhood. The costs include the investments in the pipelines, heat transfer stations, substations and costs for extra systems to meet peak demand. The costs that we calculate are not the same as for 5GDHC, but they can give an indication of where the infrastructure costs for 5GDHC will be high or low. We assume that neighbourhoods with lower infrastructure costs are more suitable for 5GDHC.

The 20% of neighbourhoods with the lowest infrastructure costs for high-temperature district heating get a score of 1. The next 20% get a score of 0.5 and the rest gets zero score.
The 20% of neighbourhoods with the shortest infrastructure length per dwelling equivalent get a score of 1. The next 20% get a score of 0.5 and the rest gets zero score.

Urban density

District heating generally is more interesting to implement in regions with high urban density. A large share of costs for district heating to the infrastructure and in neighbourhoods with high urban density these costs can be shared by many buildings and owners. Statistics Netherlands (CBS) gives every neighbourhood a score of 1 to 5 on urban density, where 1 is the highest density and 5 the lowest.

Neighbourhoods with urban density 1 or 2 get a score of 1, neighbourhoods with urban density 3 get a score of 0.5. The rest gets zero score.

Availability of heating sources

In the Netherlands, the heating demand in buildings is generally higher than the cooling demand. An external heating source to meet the extra heating demand can be beneficial for the balance in the 5GDHC. Although it is not a requirement, neighbourhoods where heat from an external heating source is available can be more suitable for 5GDHC. Public data from the Warmteatlas (RVO, ongoing-d), a database with potential heating sources in the Netherlands, is used to determine whether a heating source is available. In this case available means that there is a heating source, it is unknown whether the heat is already used, or the whether it is practically possible in that specific case to use the heat in district heating. The heating sources present in Parkstad Limburg are presented in Chapter 5.

Neighbourhoods get a score with a maximum of 1, based on the availability of heating sources in the neighbourhood.

[15] CEGOIA is an optimisation model with a web-based interactive interface, which is developed by CE Delft. The model finds the cost-optimal heating technology for each neighbourhood in the area of interest, for example a municipality, province or service area. More information: CEGOIA – Heat transition in the built environment.

Proximity of existing district heating

Mijnwater already has a backbone in Heerlen that is used for the current 5GDHC network. Adding more clusters to this backbone can be easier than building new infrastructure.

The neighbourhoods where this backbone goes through get a score of 1.

Social housing corporations

In terms of stakeholder management, connecting dwellings that are owned by a social housing corporation to district heating is usually easier than connecting a large number of privately-owned dwellings. In the case of social housing corporations, a contract with just one party ensures a large number of connections to the network.

Neighbourhoods where 75% or more of the dwellings are owned by a social housing corporation get a score of 1. When between 50 and 75% of dwellings are owned by a corporation the neighbourhood gets a score of 0.5. The rest gets zero score.

Infrastructure replacement planning

Enexis, the owner of energy infrastructure in Parkstad Limburg, has an infrastructure replacement planning. This planning indicates where the gas infrastructure will be replaced before 2024. Since it is not realistic to completely replace the gas infrastructure with 5GDHC before 2024, the neighbourhoods where a large part of gas infrastructure will be replaced are less desired to start with 5GDHC.

Neighbourhoods where more than 30% of gas infrastructure will be replaced before 2024 get a score of -1, when this is between 20% and 30% they get a score of -0.5.

Heat island effect

Heat islands are areas in urban regions that experience higher temperatures than outlying areas. Buildings, roads and other infrastructure absorb and re-emit more heat that natural landscapes, which increases the temperature in urban areas. Installations that emit heat, such as air conditioning or heat pumps that are used for cooling in summer, also contribute to the rise of temperature in cities. In areas with high risk for the heat island effect a system that does not contribute to the heat island effect, such as 5GDHC, can be a better alternative. The heat island effect is indicated with the difference in temperature between the urban areas and the surrounding rural areas.

Neighbourhoods where the heat island effect is more than 1.4 ºC get a score of 1, when the heat island effect is between 1˚C and 1.4 ˚C get a score of 0.5.

7.2 Costs for alternative heating systems

The costs for the alternative heating systems give an indication where alternative heating options are relatively expensive and therefore provide room for investing in 5GDHC. In this section we go further into the costs for alternatives in the neighbourhoods in Parkstad Limburg. As explained in the previous section, two alternatives to 5GDHC are considered (see Table 4). One in which gas is used for heating and dwellings are not further insulated and another where only electricity is used for heating and the dwellings are insulated.

Costs for alternatives

The costs for the gas reference and the gas-free reference are calculated for each neighbourhood that contains dwellings in Parkstad Limburg. Considering all neighbourhoods in the region, the average total costs for heating a dwelling for 30 years is 121 k€ and 123 k€ respectively for the alternative with gas and the gas-free alternative, as shown in Figure 20.

As discussed in the previous section, the total costs of alternative heating systems over 30 years are defined as the room for investment for 5GDHC implementation.

Figure 20 - Average total costs for heating a dwelling for 30 years. The error bars indicate the standard deviation.

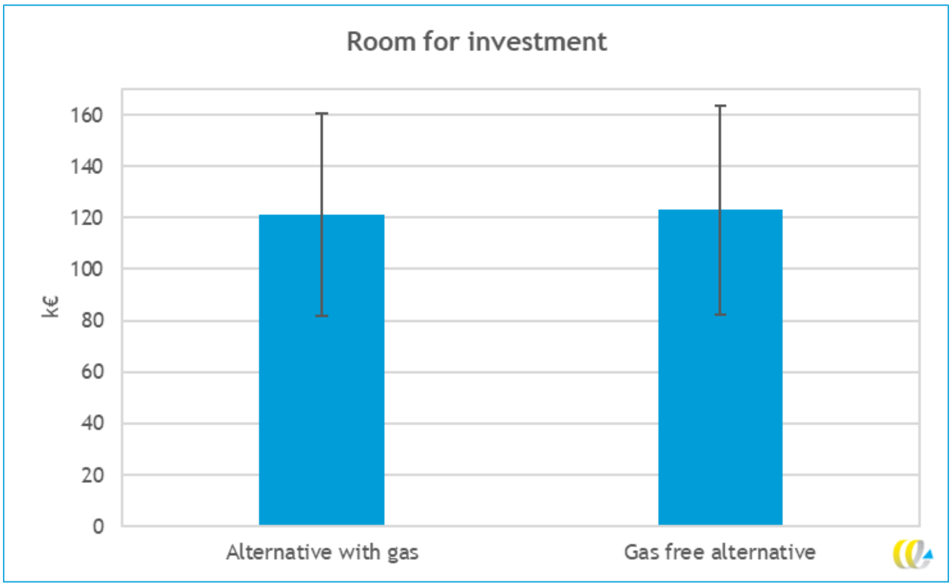
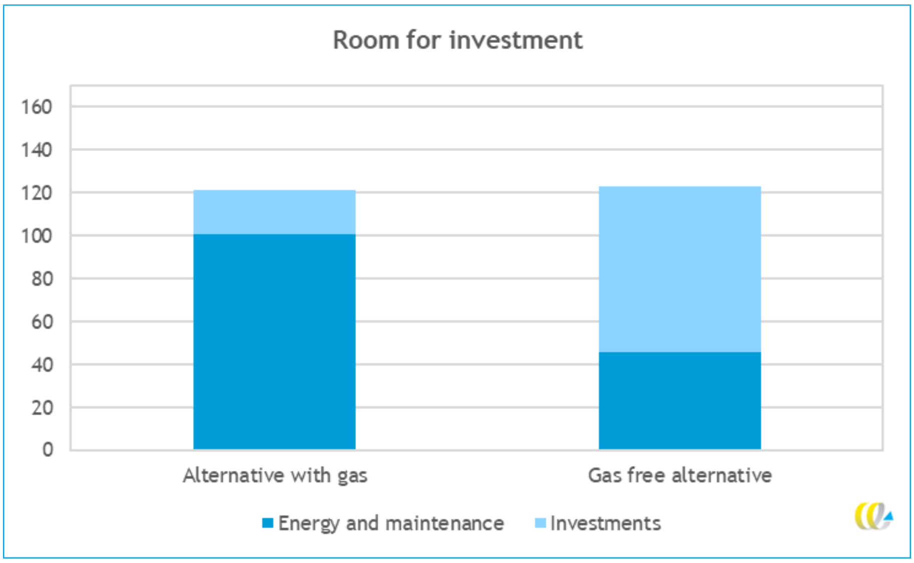


Figure 21 shows the share of operational costs (opex) consisting of energy costs and maintenance and investments (capex) in the heating installation and insulation in the total costs. It shows that the operational costs are the highest in the situation where gas is used, while in the gas-free situation the investments are the main part of the costs. For the alternative with gas, no further insulation of dwellings is needed. Because of this, the investment costs are just for the heating systems, however the energy costs are relatively high. In the gas-free reference the investments are almost four times higher, since a heat pump has higher costs compared to a condensation boiler and a hybrid heat pump. Also the insulation adds to the investment costs. Insulation however, lowers the energy use, and thus lowers energy costs.

Figure 21 - The room for investment split up in operational costs (energy and maintenance) and investment costs (capex)



Differences in costs between neighbourhoods

In the multi-criteria analysis each neighbourhood gets a score based on the total costs over 30 years for alternative heating options. The costs vary from neighbourhood to neighbourhood. Neighbourhoods with large and/or poorly insulated dwellings generally have higher costs per dwelling. Figure 22 shows for various bandwidths of the total costs, the number of neighbourhoods that lies within this range. There are few neighbourhoods with high costs up to around 500 k€ per dwelling. In the figure it can clearly be seen that these neighbourhoods are outliers. Most of the neighbourhoods have costs around 121 k€, i.e. the average cost. Figure 22 shows the costs for the alternative with gas. A similar distribution is seen for the gas-free alternative.

Figure 22 - Spread over neighbourhoods of costs for alternative heating solution in the gas reference. The numbers on the horizontal axis indicate the range for the room for investment.

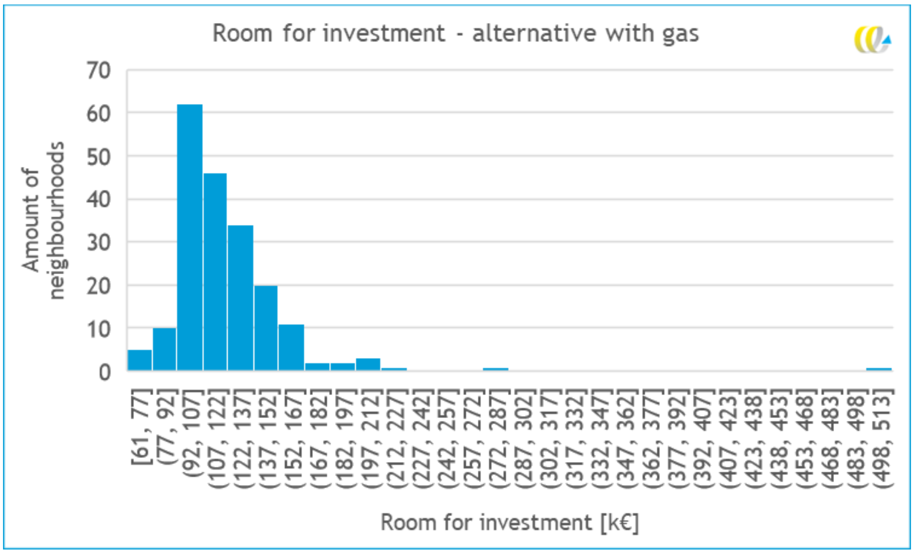
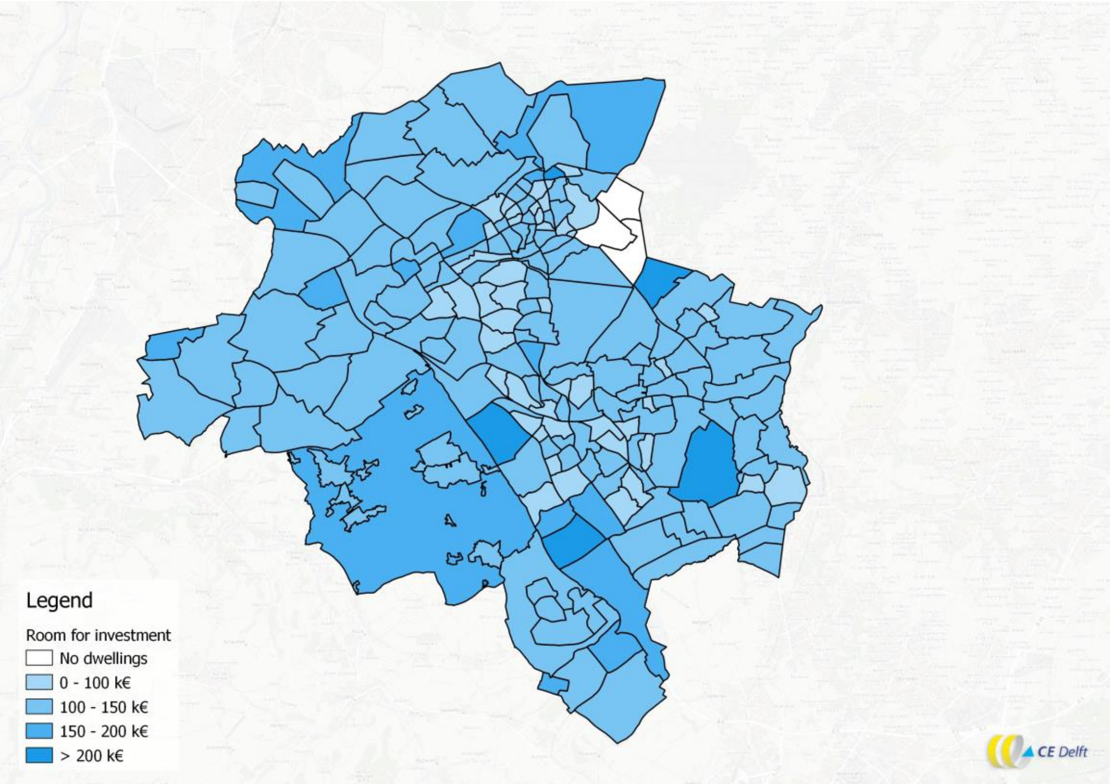


Figure 23 shows the neighbourhoods in Parkstad Limburg with the corresponding room for investment in the reference scenario with heating using gas. Each neighbourhood in the highest room for investment category is not necessarily suitable for 5GDHC. That is why it is important to also look at the other criteria described in Section 7.1.

Figure 23 – Room for investment per dwelling in the reference with gas for the neighbourhoods in Parkstad Limburg



Price scenarios

Investments in district heating infrastructure requires a long-term view. A district heating net that starts operating in 2025, is expected to be in use at least until 2055. The decennia in between also mark the period in which the bulk of the energy transition is expected to occur. The scale of the transition leads to considerable uncertainties. To account for uncertainties in future energy prices and building costs, we have defined three price scenarios:

1. Peak and recovery: after the current peak in energy prices, the prices recover to a level slightly above the price prediction from 2019.
2. Steady state high prices: the current peak results in long-term high energy prices.
3. Recovery with working shortage: this scenario involves fast recovery from the currently high energy prices, however because of a working shortage building costs remain high.

Table 5 shows the energy prices and increase in building costs for each scenario. In the appendix a further explanation of the scenarios can be found. We use the peak and recovery scenario as the base scenario. All results shown before are calculated using the parameters from the peak and recovery scenario.

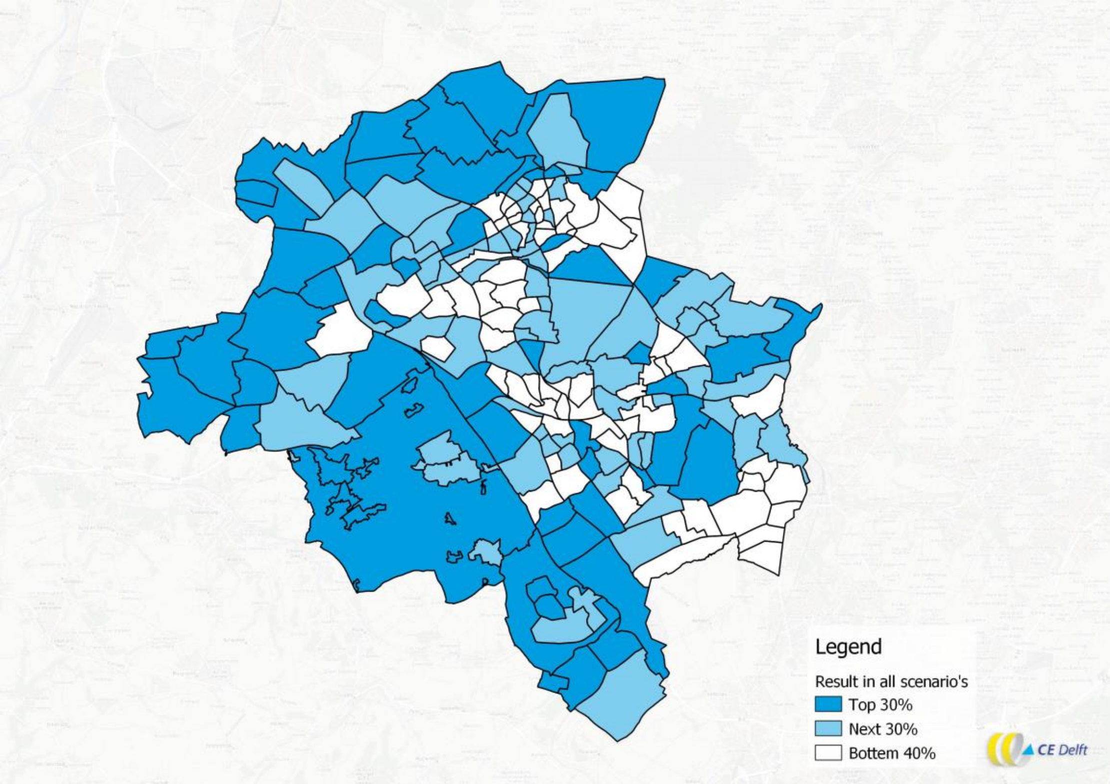
Table 5 - Overview of energy prices and increase in building costs for three scenarios

Scenario	Gas consumer price (€/m³)	Electricity consumer price (€/kWh)	Increase in building costs (%)
Peak and recovery	1.78	0.31	12
Steady state high prices	2.31	0.34	22
Recovery with working shortage	1.25	0.28	17

Higher energy prices mostly impact the alternative with gas, since the main share of the costs is for energy and maintenance. The increase in building costs mainly affects the gas-free alternative, since the main share of the costs are for the installation and insulation. In general both alternatives will have higher costs in the steady state high prices scenario. In the recovery with working shortage, the energy prices are on the lower end, but the increase in building costs is higher than in the base scenario. In this scenario (recovery with working shortage) the costs for the alternative with as is relatively low, while the costs for the gas-free alternative will be of the same order as the costs in the base scenario.

When comparing the room for investment in three scenarios, it can be noted that most of the neighbourhoods that have a high room for investment in the peak and recovery scenario, also have a high room for investment in the other two scenarios. Figure 24 indicates which neighbourhoods have high room for investment in all scenarios. The dark blue neighbourhoods, 63 of the total 201 neighbourhoods in the region, are in the top 30% of the neighbourhoods with highest costs in all scenarios in the reference with gas or the gas-free reference (or both). These neighbourhoods are minimum affected by price, therefore they offer the highest financial room for investments in 5GDHC.

Figure 24 – The dark blue neighbourhoods have a high room for investment in all price scenarios. The light blue neighbourhoods have a bit lower, but still relatively high room for investment in all scenarios. The white neighbourhoods are not in the highest 60% room for investment limits in all scenarios



7.3 Results multi-criteria analysis

All neighbourhoods in Parkstad Limburg are rated on the criteria as described in Table 3. The maximum score possible for a neighbourhood is 12. None of the neighbourhoods receives this maximum score, the highest score is 8. This is achieved by the neighbourhood called Heerlen Centrum, it is the city centre of Heerlen. Figure 25 shows all neighbourhoods with their score in the multi-criteria analysis. Figure 26 shows the top 3 neighbourhoods. They are all located in the centre of Heerlen and close to the current Mijnwater district heating network.

Figure 25 – Neighbourhoods in Parkstad Limburg with their score in the multi-criteria analysis

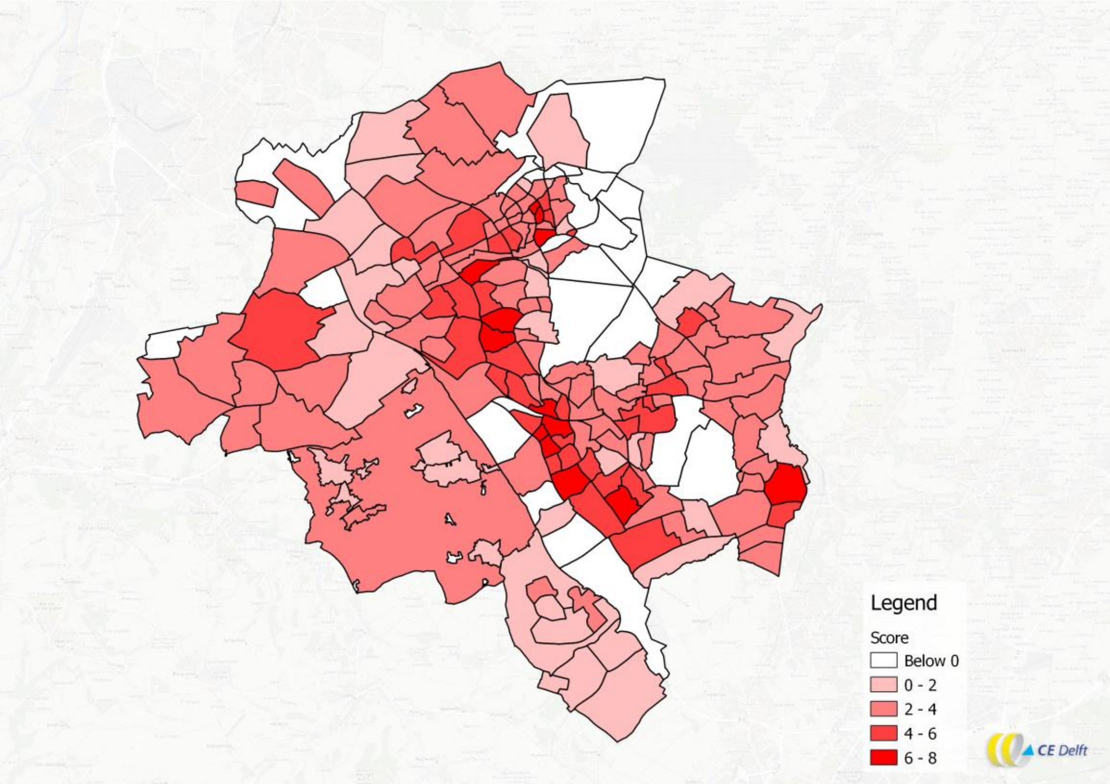
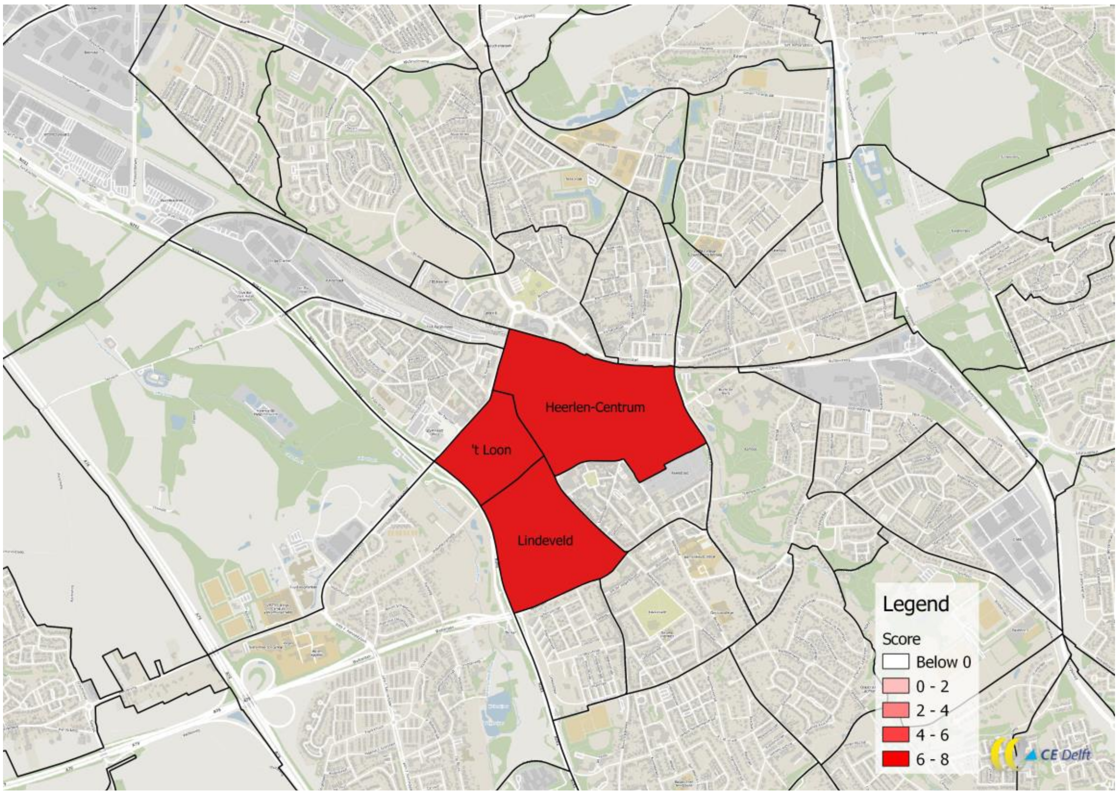


Figure 26 – The top 3 neighbourhoods from the multi-criteria analysis are all in the centre of Heerlen



8 Potential for 5GDHC in Parkstad

8.1 High potential neighbourhoods

The regional vision is an initial exploration of the potential for 5th generation district heating and cooling (5GDHC) in Parkstad Limburg. The regional vision identifies two regions that are promising for the implementation of 5GDHC. The next step is to take a closer look at these two regions and prepare a local action plan.
One of the criteria for the multi-criteria analysis (see Chapter 7) is the proximity to the existing Mijnwater network. It may also be of interest to explore regions further away from the existing Mijnwater network. For the local action plans, we have selected one region in the proximity of the Mijnwater network and one that is not in the proximity of the Mijnwater network.

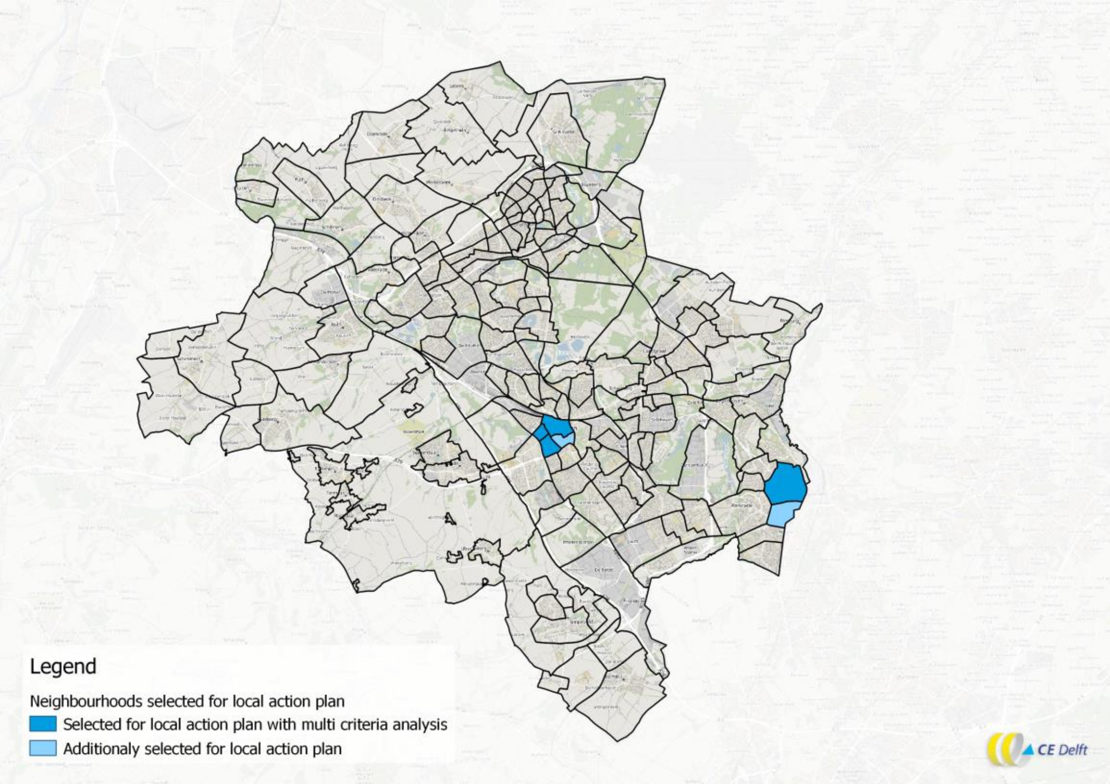
The Heerlen Centrum district

The top three neighbourhoods identified in the multi-criteria analysis are all in the same district ('wijk'): the Heerlen Centrum district. This district consists of four neighbourhoods. It makes sense to select the whole district to examine local action plans.

Neighbourhood not in the proximity of existing Mijnwater district heating

When selecting the region for the second local action plan, a neighbourhood with no existing Mijnwater district heating, we choose the neighbourhood with the highest score in the multi-criteria analysis that is not in Heerlen or Brunssum. This neighbourhood is Rolduckerveld in Kerkrade. This is a neighbourhood with a lot of multi-storey buildings, which makes it suitable for a collective heating option, such as 5GDHC. The neighbourhood just south of Rolduckerveld, called Holz, also scores relatively highly in the multi-criteria analysis. This neighbourhood will be included in the region for the local action plan.

Figure 27 - The two regions selected for the local action plans. One region is the Heerlen Centrum district, consisting of four neighbourhoods in the municipality of Heerlen. The other region consists of two neighbourhoods, Rolduckerveld and Holz, in the municipality of Kerkrade.



8.2 Roadmap

The two regions that we propose for implementation of 5GDHC are the Heerlen Centrum district consisting of four neighbourhoods and two neighbourhoods in Kerkrade. Table 6 gives an overview of the potential for 5GDHC in this area. For the Heerlen Centrum district this excludes the buildings that are currently connected to the heating network (estimated with use of a percentage).

Table 6 - Overview of the potential floor area and energy demand (after insulation) in the selected regions for the local action plan

Region	District Heerlen Centrum	Neighbourhoods Rolduckerveld and Holz
Number of dwellings	2,400	2,600
Number of utility objects	600	550
Total floor area dwellings (ha)	27	30
Total floor area utility (ha)	28	8
Total estimated heat demand (TJ/year)	160	100
Total estimated cold demand (TJ/year)	37	12

9 References

CBS, 2020. *Statline: Particuliere huishoudens naar samenstelling en grootte, 1 januari*, 16 augustus 2021 https://opendata.cbs.nl/statline/#/CBS/nl/dataset/37975/table?dl=42DD6.

CBS, 2021. *Statline: Kerncijfers wijken en buurten 2021*, June 8 2021 https://www.cbs.nl/nl-nl/maatwerk/2021/31/kerncijfers-wijken-en-buurten-2021.

CBS, 2022a. *Kaarten regionale indelingen 2022*, CBS, January 11, 2022 https://www.cbs.nl/nl-nl/achtergrond/2022/02/kaarten-regionale-indelingen-2022.

CBS, 2022b. *Statline : Voorraad woningen; gemiddeld oppervlak; woningtype, bouwjaarklasse, regio : 2020*, CBS, 27 oktober 2022 https://opendata.cbs.nl/statline/#/CBS/nl/dataset/82550NED/table?fromstatweb.

CBS, 2022c. *Statline: Elektriciteit en warmte; productie en inzet naar energiedrager*, CBS, June 17, 2022, http://statline.cbs.nl/StatWeb/publication/?DM=SLNL&PA=80030NED&D1=1&D2=a&D3=0,2-6,11&D4=14&HDR=T,G1&STB=G3,G2&VW=T July 27, 2022.

CBS, 2022d. *Statline: Woningen; hoofdverwarmingsinstallaties,regio*, Octobr 7, 2022 https://opendata.cbs.nl/#/CBS/nl/dataset/84948NED/table.

CE Delft, 2018. *Weg van gas; Kansen voor de nieuwe concepten LageTemperatuurAardwarmte en Mijnwater*, Delft: CE Delft.

CE Delft, 2020. *Verkennend onderzoek zonthermie Zuid-Holland*, Delft: CE Delft.

DeMijnen, 2022. *De Mijnen op de kaart*, https://www.demijnen.nl/mijnen/opdekaart October.

DWA, 2020. *Warmtenetten georganiseerd*, TKI Urban Energy- Topsector Energie, https://www.topsectorenergie.nl/sites/default/files/uploads/Urban%20energy/publicaties/TKI_Warmtenetten%20georganiseerd.pdf 2022.

Gemeente Heerlen, 2021. *Transitievisie Warmte*, Heerlen: Gemeente Heerlen.

Het Groene Net, Ongoing. *Over Het Groene Net*, Het Groene Net B.V., https://www.hetgroenenet.nl/over-het-groene-net August 2022.

Hier opgewekt, 2021. *Lokale Energie Monitor 2020*, Hier opgewekt,, https://www.hieropgewekt.nl/lokale-energie-monitor.

Kadaster, ongoing-a. *Basisregistratie Adressen en Gebouwen (BAG)*, February 2022 https://data.overheid.nl/dataset/basisregistratie-adressen-en-gebouwen--bag- 2022.

Kadaster, ongoing-b. *Basisregistratie Adressen en Gebouwen (BAG) : 2020*, February 2022 https://data.overheid.nl/dataset/basisregistratie-adressen-en-gebouwen--bag- 2022.

Kallesøe, A. J. & Vangkilde-Pedersen, T., 2019. *Underground Thermal Energy Storage (UTES) D1.1.:Underground Thermal Energy Storage (UTES) – state-of-the-art, example cases and lessons learned*: HEATSTORE project report, GEOTHERMICA – ERA NET Cofund Geothermal.

KWINK & Rebel, 2020. *Tussentijdse evaluatie Programma Aardgasvrije Wijken*, Rotterdam: Rebel Energy, Water & Climate.

Mijnwater, ongoing-a. *IJzergieterij VDL Castings*, Mijnwater, https://mijnwater.com/en/projects/ijzergieterij-vdl-castings August 2022.

Mijnwater, ongoing-b. *Minewater now*, Mijnwater, https://mijnwater.com/en/minewater-now.

Mijnwater, ongoing-c. *What is 5GDHC?*, Mijnwater B.V., https://5gdhc.eu/ August 2022.

Ministerie van BZK, 2021. *Kamerbrief van de Minister van Binnenlandse Zaken en Koninkrijksrelaties d..d. 18 maart 2021 over standaard voor woningisolatie*, Den Haag: Tweede Kamer der Staten-Generaal.

Ministerie van BZK & Ministerie EZK, 2018. *Factsheet wijziging gasaansluitplicht per 1 juli 2018,* Den Haag: Rijksdienst voor Ondernemend Nederland (RVO).
Netbeheer Nederland, 2021. *87 procent van de nieuwbouwwoningen in 2020 aardgasvrij opgeleverd*, https://www.netbeheernederland.nl/nieuws/87-procent-van-de-nieuwbouwwoningen-in-2020-aardgasvrij-opgeleverd-1424 1/6/2022.
Parkstad Limburg, Wing & Centre of Expertise NEBER, 2016. *Parkstad Limburg Energietransitie (PALET): PALET 3.0*, Stadsregio Parkstad Limburg, https://parkstad-limburg.nl/wp-content/uploads/2017/06/PUB_uitvoeringsprogramma-PALET-3.0_definitief-webversie.pdf?x34052 2022.
PAW, lopend. *Wat is een transitievisie warmte, inhoudelijke kenmerken*, https://www.aardgasvrijewijken.nl/themas/regieenorganisatie/transitievisie+warmte2/wat+is+een+transitievisie+warmte/inhoudelijke+kenmerken/default.aspx 2022.
PBL, 2021. *Eindadvies basisbedragen SDE++ 2021,* Den Haag: Planbureau voor de Leefomgeving (PBL).
Projectgroep GS-ZL, 2016. *Na-ijlende gevolgen steenkolenwinning Zuid-Limburg,* Witteveen + Bos, ahu AG: Witteveen + Bos, ahu AG.
RES Zuid Limburg, 2021. *RES 1.0 Zuid-Limburg : Samen werken aan een duurzame regio.*
Rijksoverheid, 2019. *Klimaatakkoord,* Den Haag: Rijksoverheid.
Rijksoverheid, 2020. *Compendium voor de leefomgeving (CLO) : Energielabels van woningen, 2010-2019*, 13 augustus 2020 https://www.clo.nl/indicatoren/nl0556-energielabels-woningen 2022.
Rijksoverheid, 2022. *Hybride warmtepomp de nieuwe standaard vanaf 2026*, May 17, 2022 https://www.rijksoverheid.nl/actueel/nieuws/2022/05/17/hybride-warmtepomp-de-nieuwe-standaard-vanaf-2026 August 2022.
RVO, 2021. *MIA andVamil* Rijksdienst voor Ondernemend Nederland, Afdeling MIA\Vamil, https://english.rvo.nl/subsidies-programmes/mia-and-vamil August 2022.
RVO, 2022. *Energy Investment Allowance - EIA*, Rijksdienst voor Ondernemend Nederland (RVO), https://english.rvo.nl/subsidies-programmes/energy-investment-allowance-eia August 2022.
RVO, ongoing-a. *Subsidies & Financiering : ISDE*, Rijksdienst voor Ondernemend Nederland (RVO), https://www.rvo.nl/subsidies-financiering/isde/woningeigenaren/aansluiting-warmtenet 2022.
RVO, ongoing-b. *Subsidies & Financiering : Stimulering Duurzame Energieproductie en Klimaattransitie (SDE++)*, Rijksdienst voor Ondernemend Nederland (RVO), https://www.rvo.nl/subsidies-financiering/sde 2022.
RVO, ongoing-c. *Subsidies & Financiering : Stimuleringsregeling aardgasvrije huurwoningen (SAH)*, Rijksdienst voor Ondernemend Nederland (RVO), https://www.rvo.nl/subsidies-financiering/sah 2022.
RVO, ongoing-d. *Warmteatlas*, https://rvo.b3p.nl/viewer/app/Warmteatlas/v2 Februari/8/2021.
Stichting Warmtenetwerk & DNE Resarch, 2020. *Nationaal Warmtenet Trendrapport 2021*: Dutch New Energy Research,.
TKI Urban Energy, lopend. *Koudenetten (Cold Networks (Dutch only)*, https://www.topsectorenergie.nl/tki-urban-energy/kennisdossiers/factsheets-koudetechnieken/koudenetten#toc--bronnen-verder-lezen September 2022.
VVD, D66, CDA & ChristenUnie, 2021. *Coalitieakkoord 'Omzien naar elkaar, vooruitkijken naar de toekomst',* Den Haag: Rijksoverheid.
W/E Adviseurs, 2018. *Ontwikkeling van koudevraag van woningen,* Utrecht ; Eindhoven: Rijksdienst voor Ondernemend Nederland (RVO).
Warmtenetwerk, 2022 *Mijnwater Heerlen* [Online] https://warmtenetwerk.nl/warmteproject/mijnwater-heerlen/ 2022.

A Price scenarios

District heating requires long-term view

Investments in district heating infrastructure requires a long-term view. A district heating net that starts operating in 2025, is expected to be in use at least until 2055. The decennia in between also mark the period in which the bulk of the energy transition is expected to occur. The scale of the transition leads to considerable uncertainties, among others in terms of future energy prices.

Future energy prices

Future energy prices are of considerable importance for many parties to make investment decisions. That is why different organisations seek to provide insights in future energy prices. We can distinguish two sets of data sources for future energy prices: one for short- and medium-term prices, and one for long-term energy prices. It is important to note that in both cases the energy prices are the *commodity* prices, paid by parties active on the wholesale market. End-consumers pay *consumer* prices, which are for energy comprised of commodity prices, distribution and transportation costs, taxes and levies, standing charges, and a certain markup. This also means that the difference between commodity and consumer prices is partly dependent on current and future policy decisions, such as CO_2 taxation for end-consumers. This memo concerns itself with insights in future commodity prices, leaving developments in other components of consumer prices out of scope.

Short- and medium-term energy prices

Short- and medium-term energy commodity prices are prices for up to the next three to five years. Insights in these energy prices are based on trading in so-called energy futures[16]. The data are accessible through platforms such as www.ICE.com. These short- and medium-term prices are thus expectations of the market itself. The last several months (the third quarter of 2022) the market has responded nervously to the news cycle, which has resulted in high volatility of prices. This volatility impacts both current prices, as well as prices in the medium-term (up to five years).

Long-term energy price forecasts

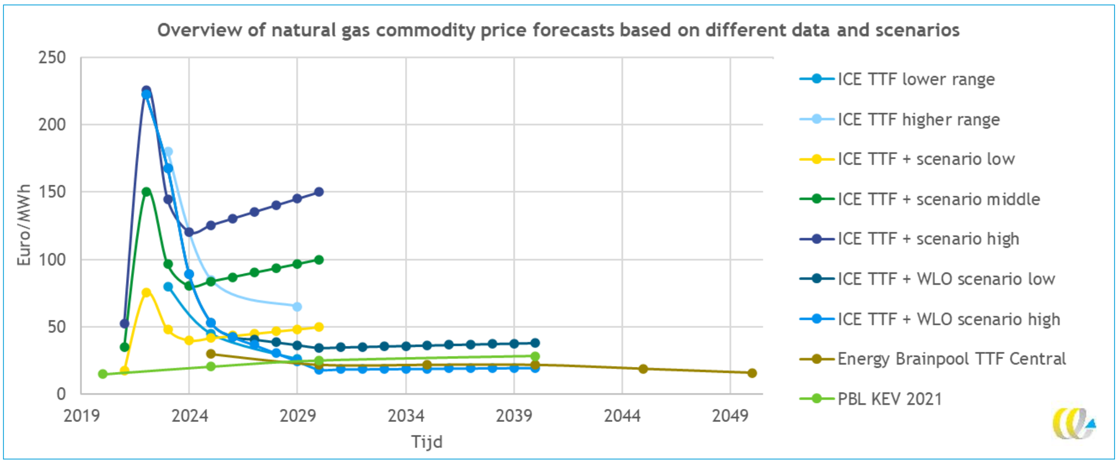
Long-term energy commodity price forecasts are made by research and knowledge institutes and organisations such as the International Energy Agency (IEA) and the Netherlands Environmental Assessment Agency (PBL). These forecasts are based on scenarios describing the future energy system and assumptions of future costs of exploitation of technologies within the system. The IEA World Outlook Scenarios are seen as one of the most important ones. Creating such scenarios and running the corresponding models requires considerable time. That is why such scenarios lag in their assumptions. The latest currently available IEA and PBL scenarios do not take the war in Ukraine, nor the energy crisis into account.

[16] Futures are contracts made by parties at a certain time, for the delivery of energy at a later point in time.

Insights through scenarios

Given the large uncertainties both short-term (volatility of markets) and long-term (difficult of future assumptions), scenarios are a broadly used method to gain insights in possible future outcomes. Figure 28 shows an overview of several scenarios for natural gas commodity prices based on different data sources and assumptions for both short- and medium-term, as well as long-term. In the figure three periods can be distinguished: the sharp short-term peak (around 2023), the highly uncertain medium-term period (2025-2029), and the long-term nearly constant price period (up to 2050). Prices in each period are a product of their underlying data. Short-term data reflect the current market nervosity. Long-term data reflect the pre-existing assumptions in long-term scenarios of institutions such as the IEA, and do not guarantee long-term low prices. The medium-term data are influenced by both short- and long-term data and therefore show the large range of uncertainty. Given the current knowledge, we believe it is this range of uncertainty that should be taken into account in scenarios.

Figure 28 – Overview of different data sources and scenarios for natural gas commodity prices up to 2050



TTF: Title Transfer Facility. WLO: Welvaart en Leefomgeving (Prosperity and Living Environment). PBL: Netherlands Environmental Assessment Agency. KEV: Klimaat- en energieverkenning (Climate and Energy Outlook).

Project scenarios

To account for the large existing uncertainties fuelled both by the current crises and the overall energy transition uncertainties, we advise to take a broad range of commodity prices into account in the scenarios. For natural gas we propose the range between 50 and 150 €/MWh. This corresponds with consumer prices between 1.25 and 2.31 €/m^3.
For electricity we propose the range between 50 and 100 €/MWh. This corresponds with consumer prices between 0.28 and 0.34 €/kWh. Within these ranges we define three scenarios, where we vary the energy prices and the increase in building costs since 2020:

- **peak and recovery**: after the current peak in energy prices, the prices recover to a level slightly above the price prediction from 2019;
- **steady state high prices**: the current peak results in long-term high energy prices;
- **recovery with working shortage**: this scenario involves fast recovery from the currently high energy prices, however because of a working shortage building costs remain high.

Table 7 shows the energy prices and increase in building costs for each scenario.

Table 7 – Overview of energy prices and increase in building costs for three scenarios

Scenario	Gas consumer price (€/m^3)	Electricity consumer price (€/kWh)	Increase in building costs (%)
Peak and recovery	1.78	0.31	12
Steady state high prices	2.31	0.34	22
Recovery with working shortage	1.25	0.28	17

Consumer prices for district heating are currently linked with natural gas prices. However, we expect that link to dissolve in the coming years, either through policy intervention or through technological changes. However, as the energy system is expected to become increasingly more interconnected, electricity and gas (methane and/or hydrogen) prices are expected to continue to be of importance for the competitiveness of district heating systems, and therefore for the investment decisions in district heating.