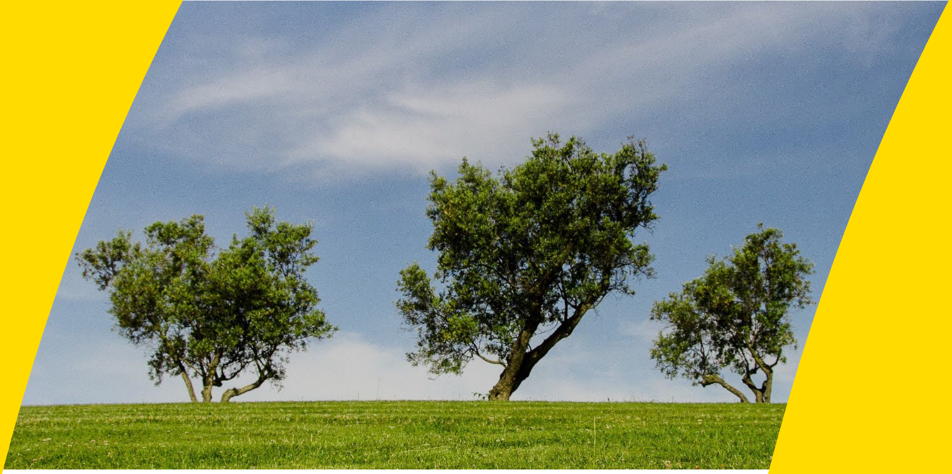

Local action plan

Rolduckerveld and Holz, municipality of Kerkrade

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Local action plan

Rolduckerveld and Holz, municipality of Kerkrade

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Content

Interreg North-West Europe D2Grids

Summary

This document is the local action plan for the roll-out of 5th generation district heating and cooling networks (5GDHC) in Rolduckerveld and Holz in the municipality of Kerkrade. 5GDHC is an innovative, demand-driven form of district heating, operating at low temperatures. This action plan is part of the D2GRIDS project, which aims to increase renewable energy for heating and cooling in Interreg North-Western Europe.

The D2GRIDS project is being implemented in seven regions: Parkstad Limburg (NL), Northeast France (FR), Luxembourg (LU), Flanders (BE), Ruhr-area (DE), Scotland and East Midlands (UK). Mijnwater, a supplier of heating and cooling via a 5GDHC network in Parkstad Limburg, is the lead partner of the D2GRIDS project. Each follower region has prepared a regional vision, describing its ambitions for the roll-out of 5GDHC and identifying the two most promising regions. A local action plan has been prepared for these two selected regions. This document is the local action plan for two neighbourhoods, Rolduckerveld and Holz, in the municipality of Kerkrade.

In general, we conclude that the roll-out of a 5GDHC network in Rolduckerveld and Holz is promising. However, it is important to ensure the participation of residents and building owners in the process. Local support is essential for a successful roll-out of 5GDHC.

Strengths

The neighbourhoods, Rolduckerveld and Holz, have been found to be suitable for the roll-out of 5GDHC for several reasons:

- Rolduckerveld received a high total score in a multi-criteria analysis to assess the suitability for 5GDHC that was prepared for the regional vision.
- A large number of the dwellings in Rolduckerveld is owned by a housing association. This is favourable for implementing district heating, since it is easier to make agreements with a housing association than with a lot of different homeowners.
- Both neighbourhoods have high-urban density and the building stock is suitable for district heating and the exchange of heating and cooling;
- Low- and high-temperature heat sources are present and thermal storage (ATES) is not restricted in the area.
- The total cost over 30 years for alternative heating options offers room for investment in 5GDHC technology. The total cost of heating with gas is highly dependent on energy costs, while 5GDHC technology promises to decrease the dependency on external energy sources and prices.

Weaknesses

There are some challenges that need to be addressed during implementation. Part of the gas infrastructure in Rolduckerveld is scheduled to be renewed in 2024: this may have a negative effect on implementing district heating. In Holz, most of the dwellings are private rental housing or privately owned, there is not a lot of social housing. This poses a risk for participation in the district heating network. In Holz, there are large areas with predominantly buildings with poor energy performance. This means that higher temperature heat or insulation is needed before 5GDHC can be implemented. However, an energy park in

Herzogenrath can potentially provide high-temperature heating. Grid congestion in the province Limburg could cause problems when incorporating large solar panel installations

Local support is essential

A research study into attitudes towards sustainability of residents performed by Motivaction, a market research company in the Netherlands, shows that predominantly structure seekers live in Kerkrade. Also the percentage of progressive people is less than in the rest of Parkstad, especially in Rolduckerveld. We can conclude from this that the majority of people in the selected area will require a careful approach in terms of costs and benefits to adopt the 5GDHC technology. Most importantly, however the plans, the ins and outs of the technology, the implications for sustainability and the financial stability of residents. To increase local support, it is important to involve building owners and residents in the decision-making process.

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); Northeast 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 and other companies in the DHC industry, as well as to new territories ('follower regions'). For the follower region Parkstad Limburg in the Netherlands, CE Delft has put together a regional vision document in which a multi-criteria analysis is performed and two districts are chosen for rolling out the 5GDHC technology. This document is the local action plan for one of these districts, Kerkrade.

The local action plan is structured in six chapters to provide relevant information for implementing 5GDHC in Kerkrade. Following this introduction, in the second chapter titled regional analysis, we provide the background information about the local context by taking over relevant information from the regional analysis. The chapter titled pre-feasibility study is basically a zoom-in into the Kerkrade district. It includes an elaboration on the results from multi-criteria analysis and on the key characteristics of the district like the existing building stock, energy demand, potential sources and current district heating implementations. The chapter is concluded with the costs of implementing alternative heating technologies, which is an indication for the investment opportunities for 5GDHC.
We have devoted the fourth chapter on the social aspect of the local action plan so that the local support and participation can be improved and the relevant regulations are explained for the implementation. Lastly, the fifth chapter discusses the congestion risks in the local electricity network when solar energy is implemented as part of the 5GDHC system.
Finally, a concluding chapter gives the main conclusions on the local action plan as a concise summary of what is discussed in previous chapters.

2 Regional analysis

This chapter is a summary of the regional vision which describes the aspirations of Parkstad Limburg on how the region can contribute to the roll-out 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. This document contains the local action plan for Rolduckerveld and Holz.

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.

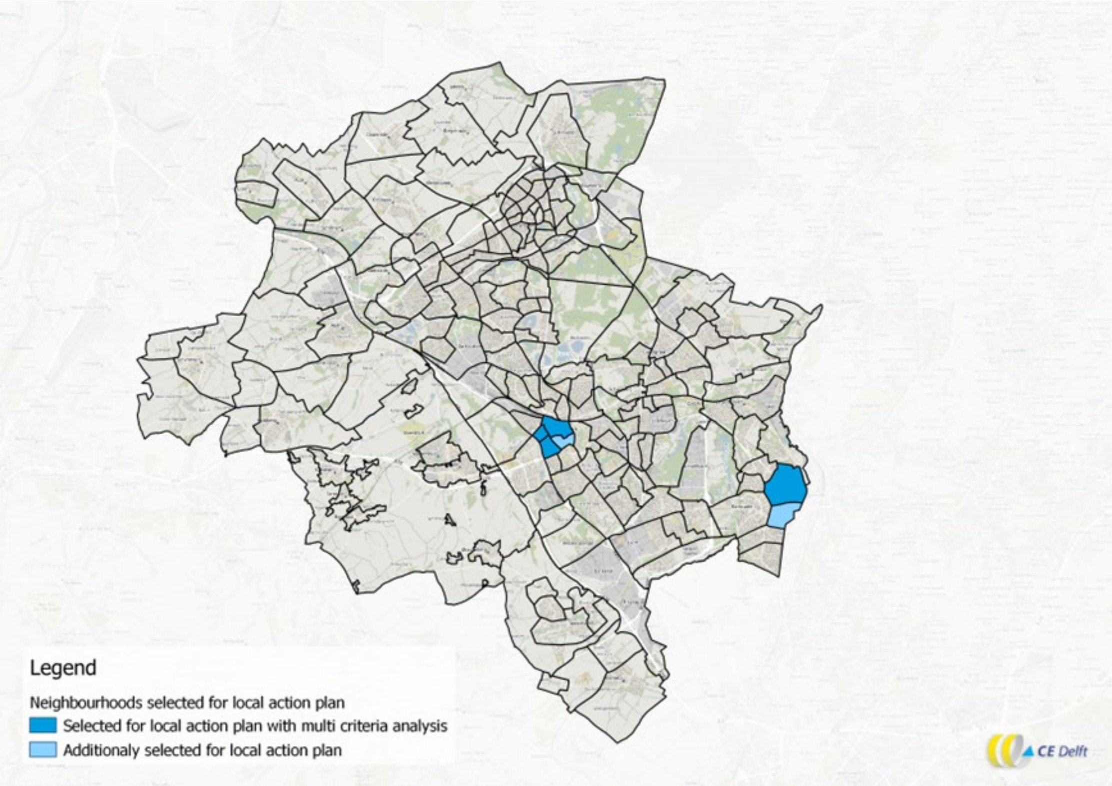
Parkstad Limburg has several potential heating sources. The most promising sources are waste heat, solar thermal energy on repurposed agricultural land and the exchange of heat flows from different types of buildings. Furthermore, ground-coupled heat exchangers are allowed in most of Parkstad Limburg.

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.

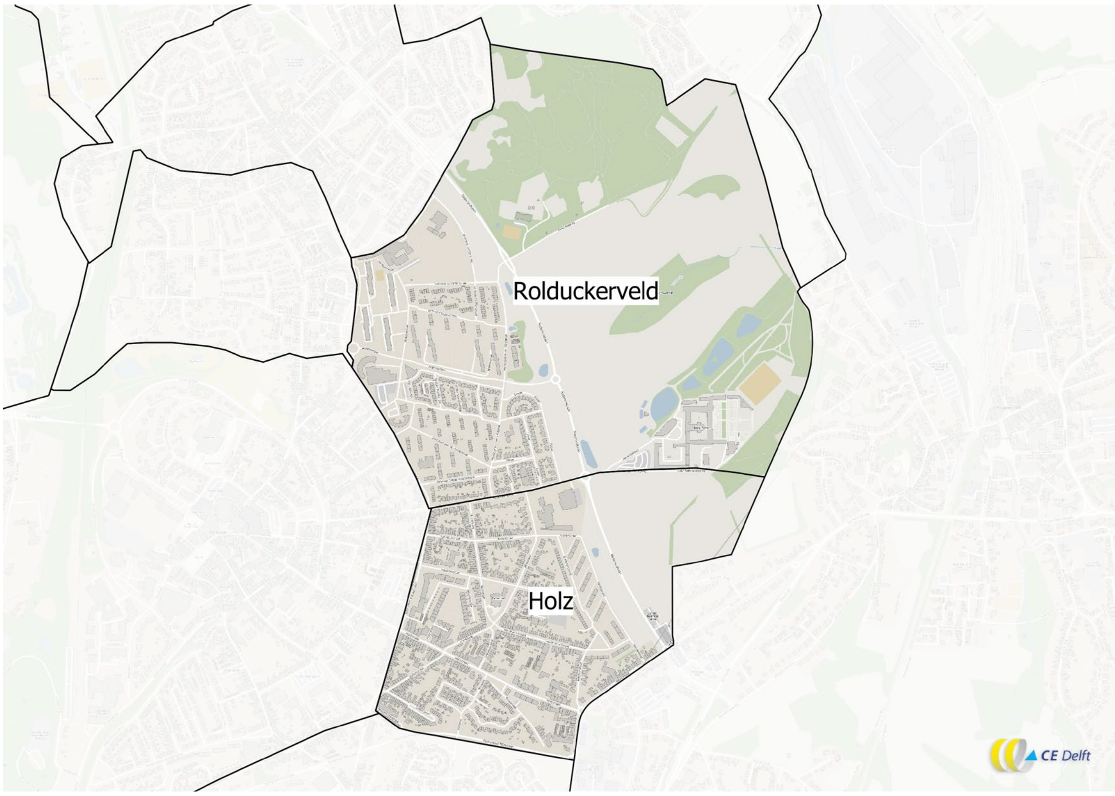
Figure 1 - Two regions that are selected for the local action plans. One region is the district Heerlen Centrum, containing four neighbourhoods in the municipality Heerlen. The other region consists of two neighbourhoods Rolduckerveld and Holz in the municipality Kerkrade



3 Pre-feasibility study

This chapter is a more detailed techno-economical feasibility study for the selected neighbourhoods in Kerkrade, namely Rolduckerveld and Holz. Figure 2 shows both neighbourhoods.

Figure 2 - Two neighbourhoods in Kerkrade selected for this local action plan



3.1 Results from multi-criteria analysis for Rolduckerveld and Holz

For the regional vision we have done a multi-criteria analysis, where every neighbourhood is rated on several criteria. The criteria, a short explanation and the method for scoring is explained in Appendix A. Table 1 shows the score for each criterion for the two neighbourhoods in the district Kerkrade. A few things stand out:

- Both neighbourhoods do not get a score on spending limit, this means that compared to other neighbourhoods the costs for heating are not very high. However the ratio total costs to insulation costs receives good scores in both neighbourhoods, which is favourable for the implementation of 5GDHC. In Section 3.5 we will discuss this further.
- Both neighbourhoods have high-urban density, this also positively influences the costs for district heating infrastructure. The higher the number of connections, the more affordable the costs for end-users.
- More than 60% of the dwellings in the neighbourhood Rolduckerveld are owned by a housing association. This is favourable for implementing district heating, since it is easier to make agreements with a housing association than with a lot of individual

homeowners. In the neighbourhood Holz, the number of social housing is relatively low and more attention for local support is needed. We will go into the latter in Chapter 4.
- There are potential heat sources present in both neighbourhoods, we will go into this in Section 3.4.
- Part of the gas infrastructure in Rolduckerveld is planned to be renewed in 2024. This may have a negative effect on implementing district heating.
- We have identified a high potential for the exchange between heating and cooling in both neighbourhoods.

Table 1 - Score per criterion in the multi-criteria analysis from the regional vision

Neighbourhood name	Rolduckerveld	Holz
Spending limit	0	0
Ratio costs/insulation costs	1	0.5
District heating in neighbourhood	0	0
Urban density	1	1
Social housing	0.5	0
Heat source available	0.6	0.4
Heat Island	0	0.5
Infrastructure replacement	-0.5	0
Exchange heating and cooling	1	0.5
Infrastructure costs	1	1

3.2 Building stock in Rolduckerveld and Holz

In the research for the regional vision, it was established that neighbourhoods Rolduckerveld and Holz have a mixed building stock. Using the data of the BAG (a national dataset with all buildings in the Netherlands) this chapter gives more insight in the building stock in Rolduckerveld and Holz (Kadaster, ongoing).

Mix of residential and non-residential buildings

Rolduckerveld and Holz are two neighbourhoods in the east of the municipality of Kerkrade, on the border with Germany. Rolduckerveld is a residential neighbourhood, whereas Holz is a mixed-use neighbourhood. Figure 3 shows the total building surface area for residential and non-residential buildings. Three quarter of the building area is for residential use.

Figure 3 - The amount of building surface area for residential and non-residential use

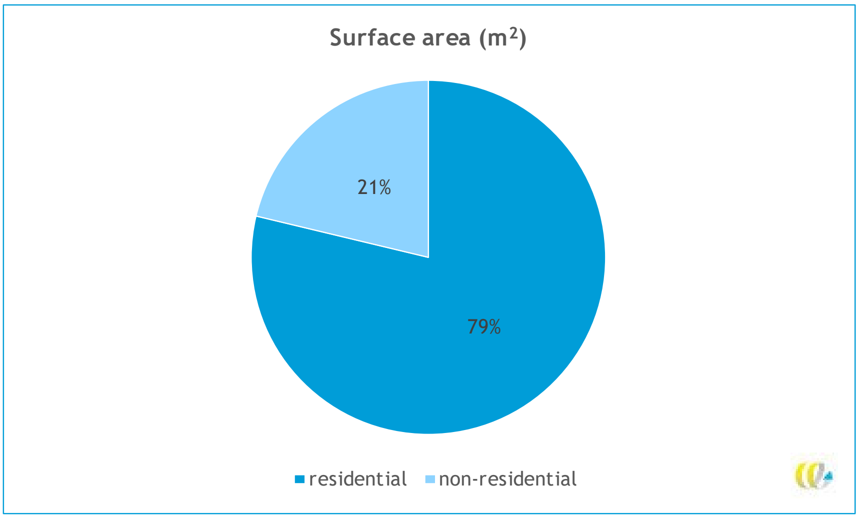


Figure 4 shows the spatial distribution of residential and non-residential buildings. The neighbourhood Holz is a mixed-use neighbourhood. Most of non-residential buildings in Rolduckerveld are garage boxes.

Figure 4 - The spatial distribution of residential and non-residential buildings

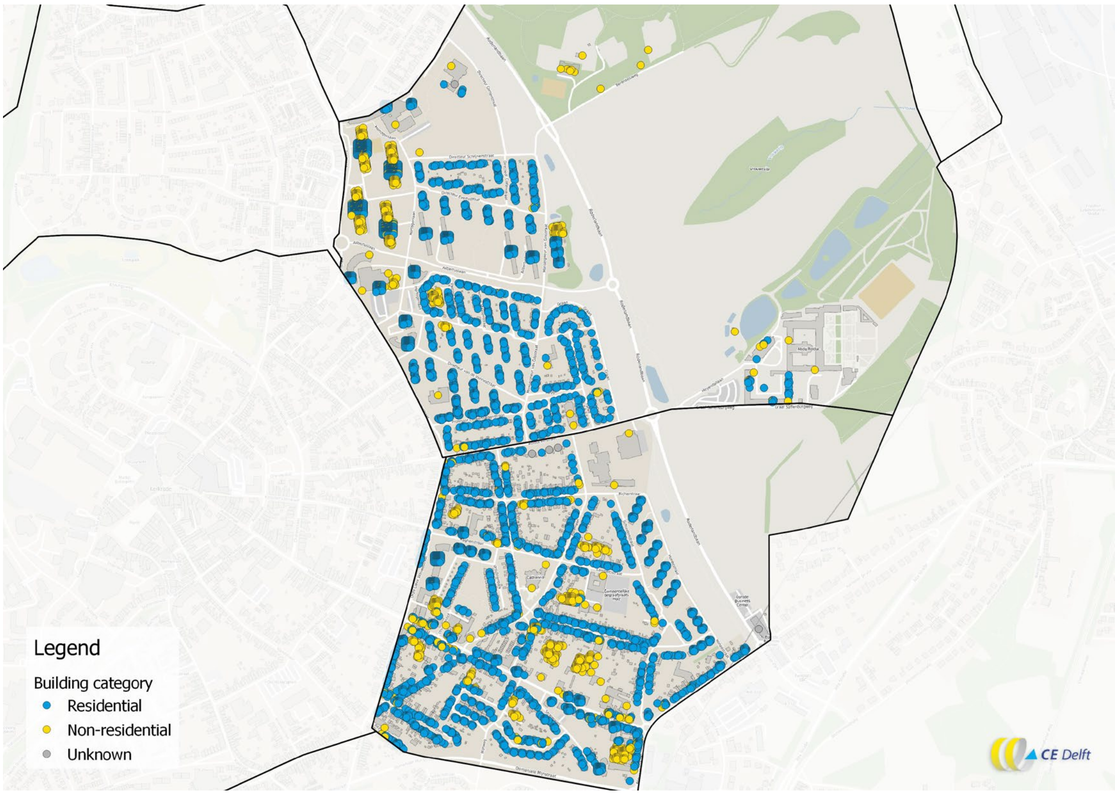


Figure 5 shows the types of dwellings in the two neighbourhoods. Most buildings are stacked buildings (apartments) or terraced dwellings. There are very few (semi) detached dwellings. Neighbourhoods with a higher percentage of stacked and terraced dwellings are suitable for district heating.

Figure 5 - The types of dwellings in the Rolduckerveld and Holz

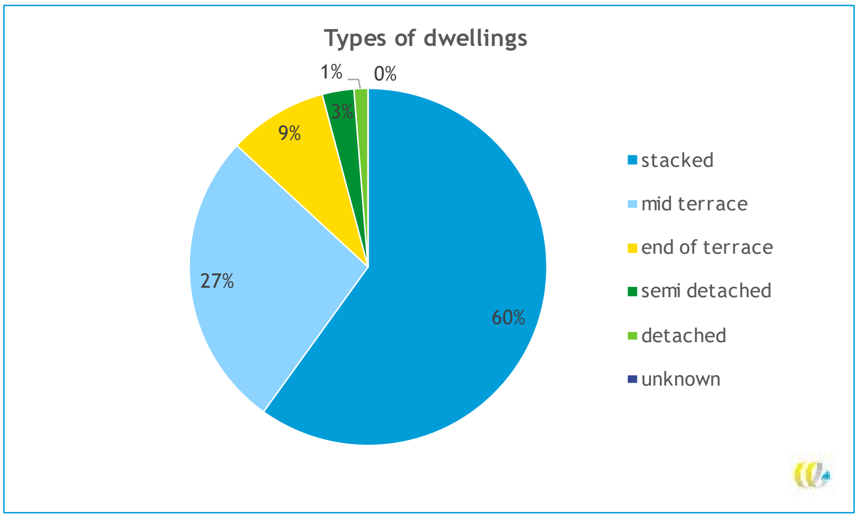


Figure 6 shows the spatial distribution of the dwelling types. On the map, stacked buildings are less visible, since they are often on the same location. In both neighbourhoods there is a mix of stacked and terraced dwellings, while in Holz there are also some (semi) detached dwellings. The existing building stock in Rolduckerveld includes a few semi-detached dwellings.

Figure 6 - Dwelling types in Rolduckerveld and Holz

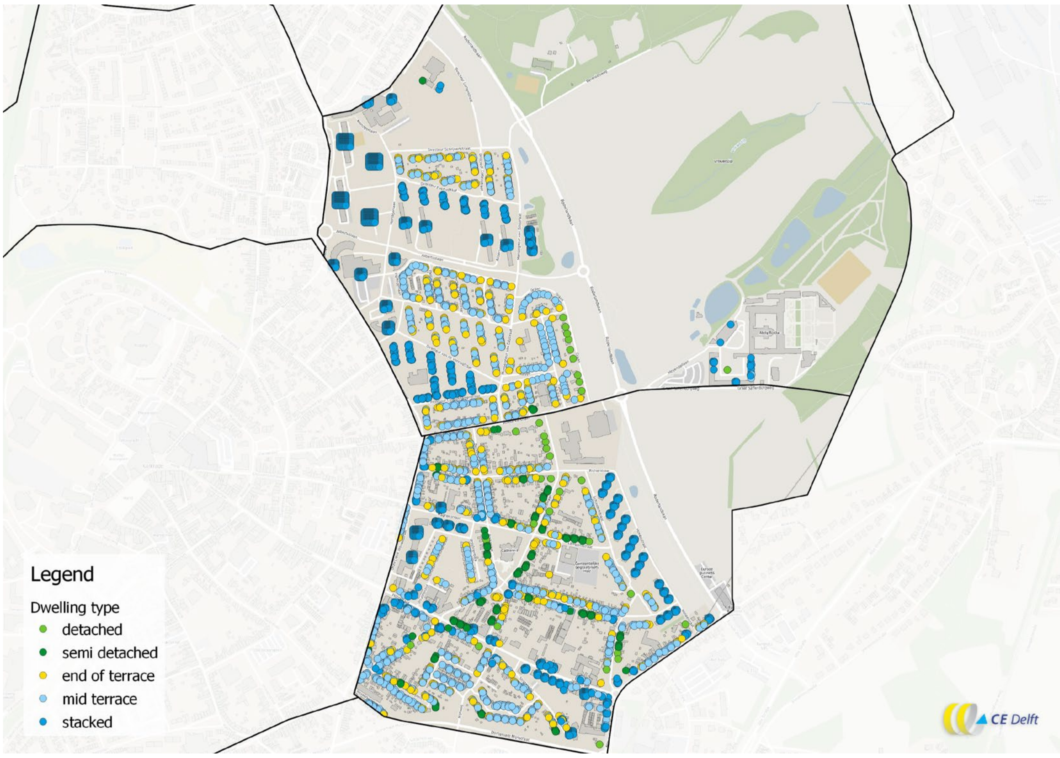


Figure 7 shows the functions of non-residential buildings. Amongst the non-residential buildings are an old abbey repurposed as a hotel, schools, a small shopping centre, a business centre and a church. The buildings that are labelled with function “other” are mostly garage boxes.

Figure 7 - An overview of non-residential building functions in the Heerlen Centrum district

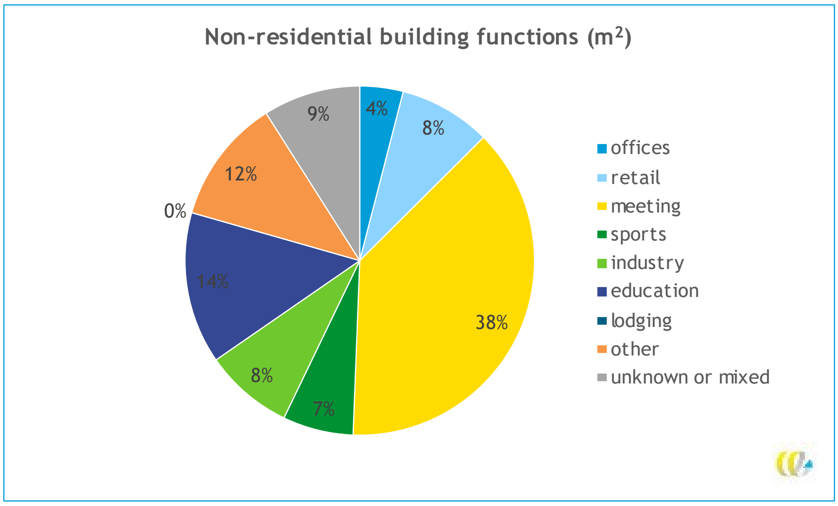
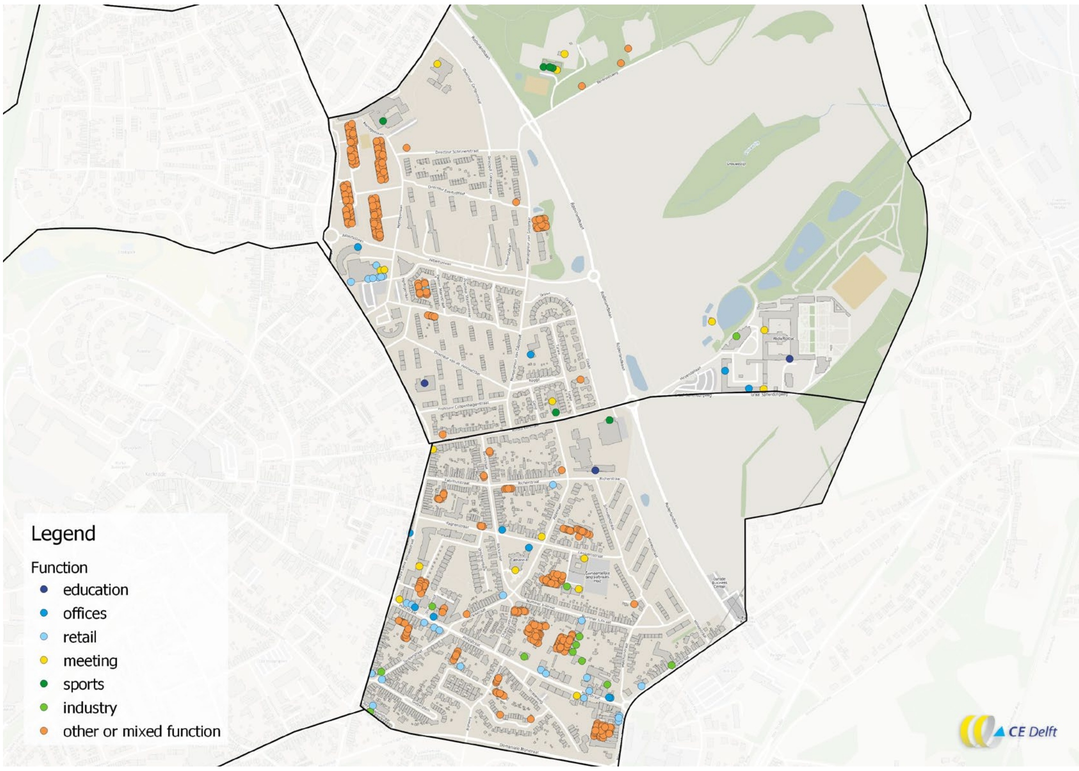


Figure 8 shows the spatial distribution of the non-residential building functions. Most of the orange buildings (with function other) are garage boxes. The buildings labelled as industry function are a gas station and some buildings that are probably used for storage. There is no heavy industry in these two neighbourhoods. In the southeast of Rolduckerveld, there is an old abbey that is repurposed as a hotel.

Figure 8 - The spatial distribution of non-residential building functions in the Heerlen Centrum district



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Building age and energy performance

Figure 9 shows the years of construction of the buildings in Rolduckerveld and Holz. Buildings that are built in the same period are often insulated with the same strategy. Most buildings are built between 1945 and 1991. There are almost no buildings that are built before 1900. About 15% of the buildings is built in the pre-war period (1900-1945). For these dwellings it is more challenging to improve their energy performance by insulating the building skin. Buildings built after 1992 often already have a good energy performance.

Figure 9 - Distribution of the year dwellings (on the left) and non-residential buildings (on the right) are built

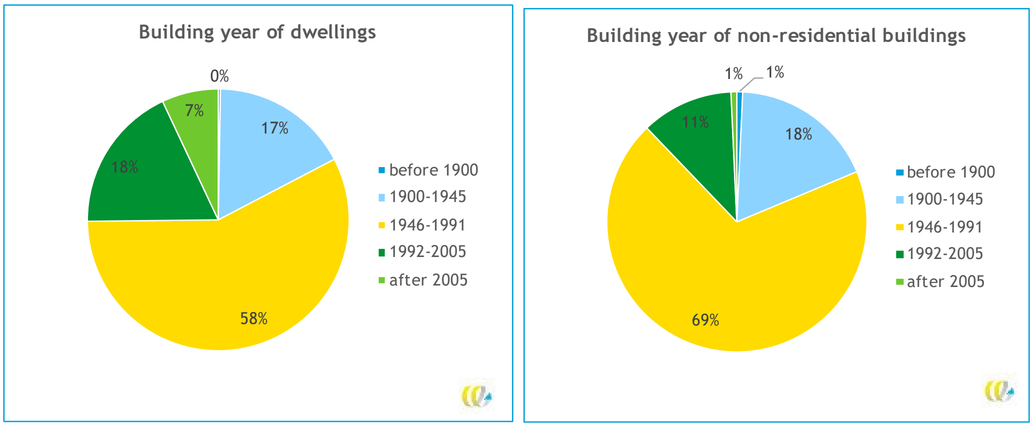
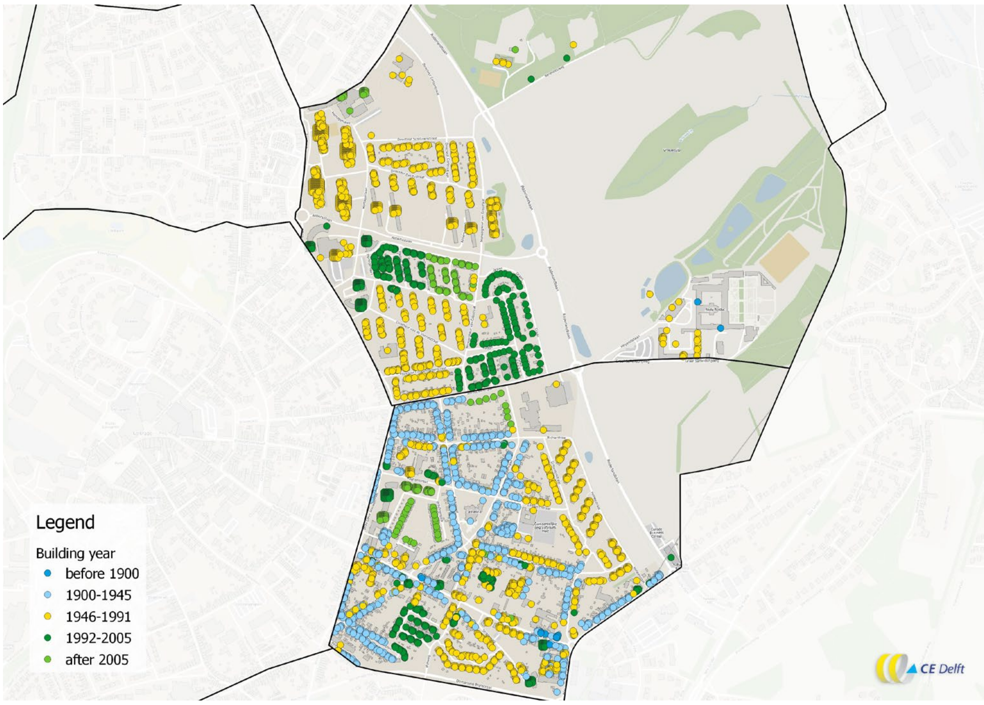


Figure 10 shows the spatial distribution of the construction years of buildings. Buildings that were built in the same period may be clustered for the implementation plans and clear clusters can already be identified as can be seen. In Rolduckerveld most buildings are built between 1946 and 1991, but there are clusters of newer buildings. In Holz, there are clusters of pre-war buildings (1900-1945), buildings from the 1946-1991 period and newer buildings.

Figure 10 - Spatial distribution of the years buildings were built in



The energy performance of a building in the Netherlands is indicated with an energy label. A building gets a letter from G to A+++, where G has the worst energy performance and A+++ the best. Not all buildings in the Netherlands have an energy label. For dwellings without a registered energy label, we have estimated the energy label based on dwelling type and building year. In the Kerkrade district 70% of residential buildings and 3%[1] of non-residential buildings have a registered energy label. Figure 11 and Figure 12 show the distribution of all energy labels.

Figure 11 - Distribution of energy labels of dwellings in Rolduckerveld and Holz, registered energy labels (on the left) and estimated and registered energy labels (on the right)

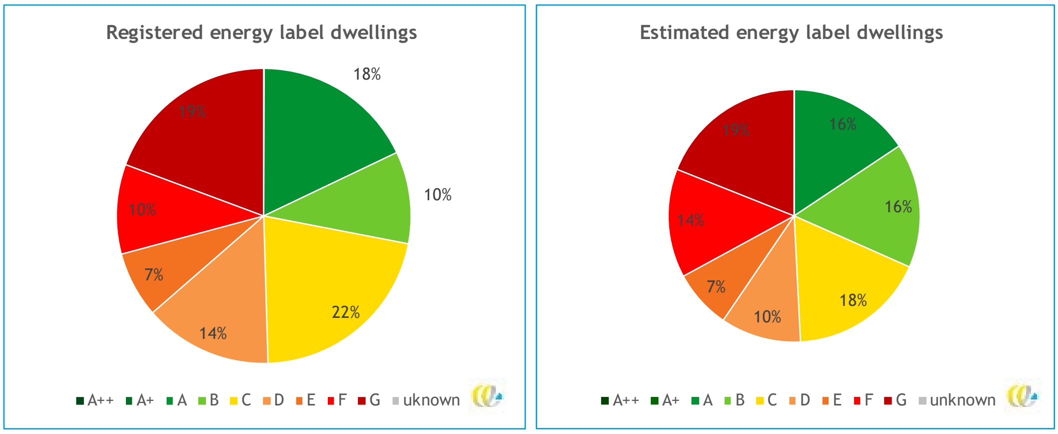


Figure 12 - Distribution of registered energy labels for non-residential buildings in the Rolduckerveld and Holz

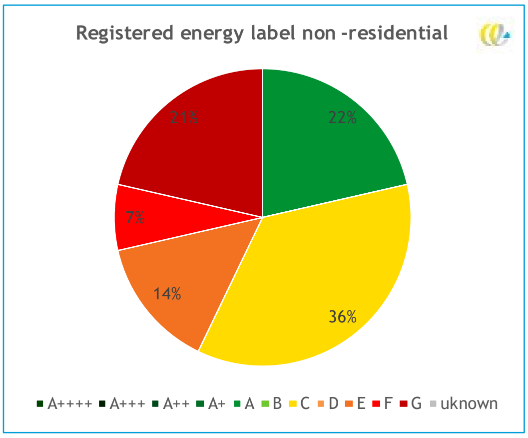
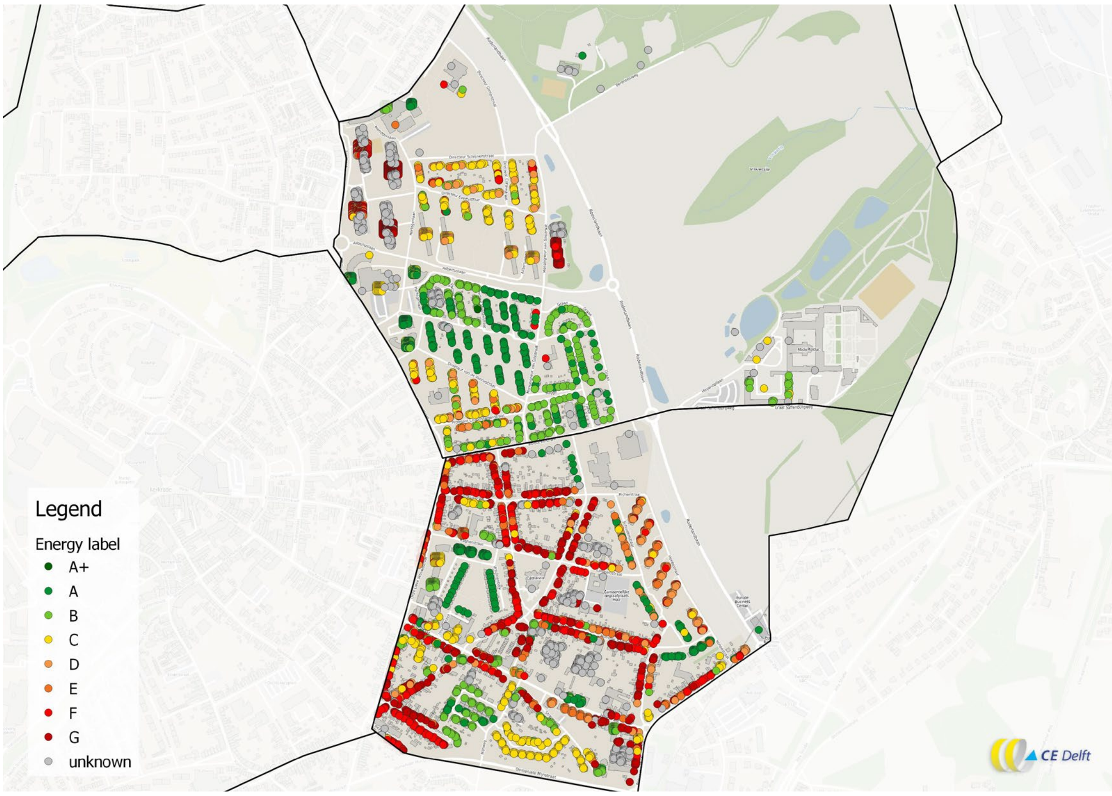


Figure 13 shows the spatial distribution of the registered and estimated energy labels. In Rolduckerveld most buildings have a good energy label, and thus good energy performance. In the northwest there is a cluster of stacked buildings with bad energy labels (mostly E, F and G labels). In Holz there are clusters of buildings with very good energy labels, and clusters with bad energy labels.

[1] Most of the non-residential buildings are garage boxes. Garage boxes are not heated and are not given an energy label. This explains the low percentage of registered labels for non-residential buildings.

Figure 13 - The spatial distribution of energy labels



3.3 District characteristics

Type of road surface

In this section we examine some characteristics of the district to identify specific parts of the district that are suitable or not suitable for district heating. Figure 14 shows the type of road surface in the district. For the roll-out of district heating, removable pavement is preferred. It is easier, and thus cheaper, to put district heating infrastructure in streets where there is removable pavement. Figure 15 shows examples of roads with removable pavement and asphalt roads. In Rolduckerveld and Holz, the main roads are asphalted, but the more local streets have removable pavement. This is favourable for the installation of district heating infrastructure.

Figure 14 - The types of road surface in Rolduckerveld and Holz

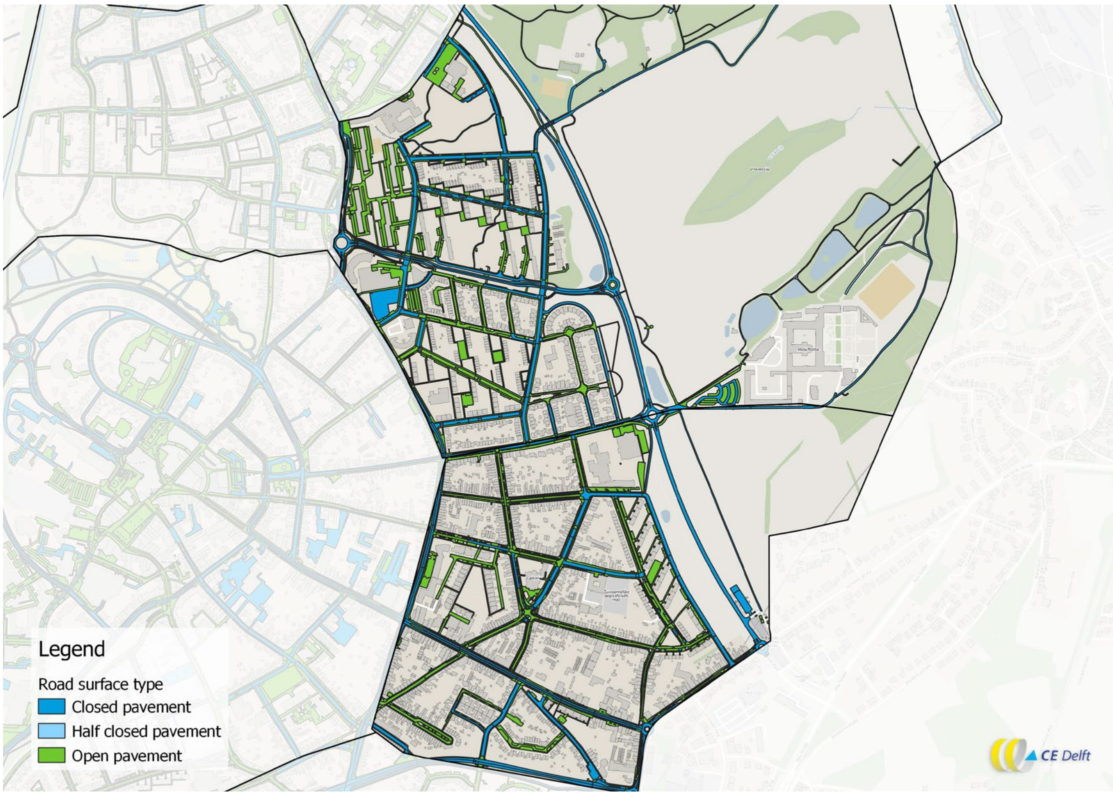


Figure 15 - Two types of road surface: removable pavement (on the left) and asphalt (on the right)

Source: Google Maps (Streetview).

No gardens in front of houses

It is common in the Netherlands to have a small garden in front of terraced dwellings. These gardens make it more difficult to connect dwellings to district heating.
In Rolduckerveld and Holz there are a lot of terraced dwellings without a front garden, this makes it easier to connect these dwellings to district heating. Figure 16 shows an example of houses without a front garden

Figure 16 – Bockstraat in Holz, terraced dwellings without a front garden

Source: Google Maps (Streetview).

3.4 Energy demand and potential energy sources

This chapter starts with the analysis of the heating and cooling demand, as the balance between heating and cooling demand is an important prerequisite for an efficient 5GDHC system. Following the demand analysis, we describe the availability of several types of energy sources and storage in and around Kerkrade.

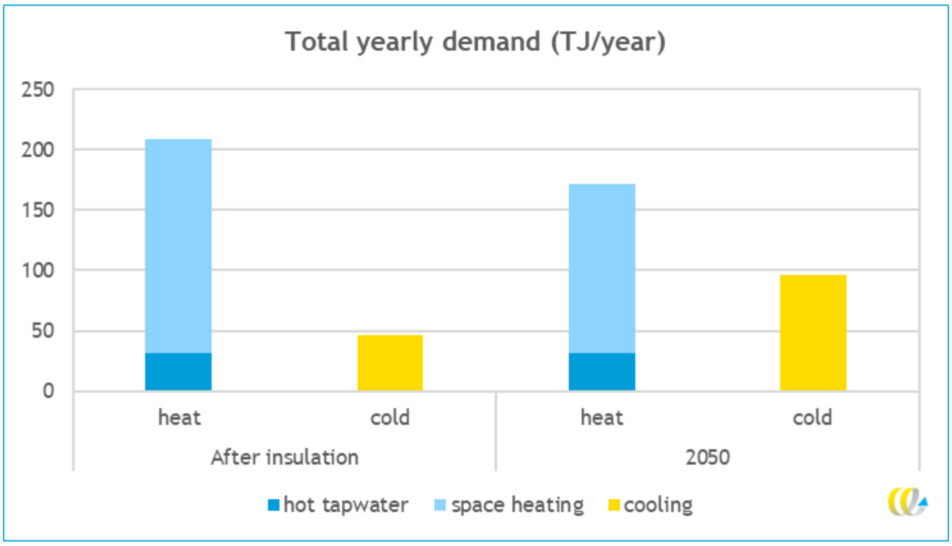
3.4.1 Exchange of thermal energy: heating and cooling demand

We have analysed the total heating and cooling demand of the buildings in the region.
The demands are determined with use of parameters based on the building type, building year and building size. The estimation includes minimal insulation measures necessary for mid-temperature heating.
Due to climate change the yearly demand for space heating is expected to decrease, whereas the demand for cooling is expected to increase. In the warmest scenario according to the 2014 climate scenarios of The Royal Netherlands Meteorological Institute (KNMI), the amount of degree days[2] will decrease with about 20% towards 2050 (KNMI, 2014).

[2] The sum of the difference between the average temperature and 18°C for all days with an average temperature lower than 18°C.

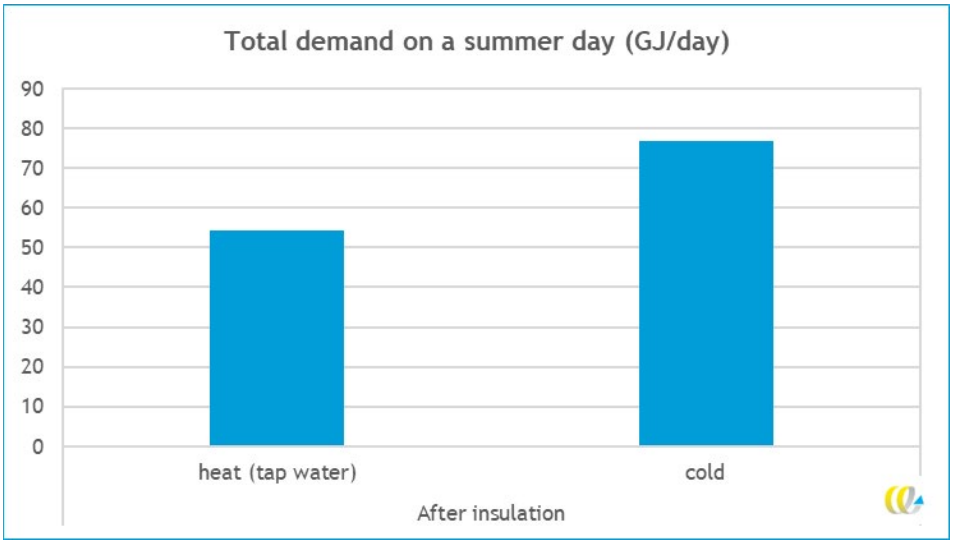
The amount of cooling days[3] will be doubled (KNMI, 2017). The effect on the cooling and heating demand is shown in Figure 17.

Figure 17 - Total yearly demands for heating and cooling after insulation measures and in 2050



The difference between the demand for heat and cold decreases significantly, but the yearly demand for heating remains larger compared to the cooling demand. This imbalance however is seasonal. On a summer day, the demand for cooling will be much larger than the demand for heating. This is illustrated in Figure 18. With use of thermal storage the fluctuation in supply and demand can be buffered.

Figure 18 - Total demand for heating and cooling on a summer day in 2050 after insulation measures



[3] The sum of the difference between the average temperature and 17°C for all days with an average temperature higher than 17°C

3.4.2 Thermal storage

Because the heating and cooling demand of buildings will never be exactly in balance, a thermal energy storage solution is needed such as ATES. In some regions in the Netherlands these are not allowed, for example due to interference with drinking water. In Kerkrade however, there is not such a restriction on ground-coupled heat exchangers.

3.4.3 Low-temperature heat sources

Just over the border in Germany, at a distance of roughly one kilometre from the urban area in Rolduckerveld and Holz, there is a river, “Worm”. This river could possibly be used for aqua thermal energy from surface water. The actual energy storage potential should be further investigated. Furthermore, there are several supermarkets within or close to the neighbourhoods Rolduckerveld and Holz, which potentially have waste heat at low temperatures. In Holz, near the border with Rolduckerveld, a big sport hall (“Sporthal Rolduc”) is situated. This sports hall can also potentially contribute significantly in the exchange of thermal energy.

3.4.4 High-temperature heat sources

Just over the border in Herzogenrath, Germany, an Energy park is planned. This park shall provide the city of Herzogenrath with CO_2-free energy by 2030. Part of the project is a district heating network to the dwellings of Herzogenrath. It could be researched if there is enough capacity to make a connection with a district heating network in Kerkrade.

3.5 End-user costs for alternative heating options

In this section, the costs for the residential end-users, i.e. the dwelling owners and residents, are presented for the two neighbourhoods in the municipality of Kerkrade. For the regional vision, we have calculated the total cost of alternative heating systems over 30 years and considered that as room for investment for 5GDHC implementation. I n this local action plan, we take over the same analysis for Heerlen Centrum.

We have calculated the total costs for two options. The first option is heating a dwelling with a gas-fired individual option; for the first fifteen years a conventional gas boiler is used and the next fifteen years a hybrid heat pump is used. We assume that the gas will be a mix of natural gas and green gas with 0% green gas share in 2020, 20% in 2030 and 100% in 2050. For these heating systems, improvements in insulation are not required, so the costs for insulation are not included in the total costs for this alternative. The second option is an individual option without gas, namely an all-electric heat pump. This option takes into account the costs of advised insulation levels which are determined based on the Climate Agreement, called the insulation standard.

Variation of total costs per dwelling

Figure 19 shows the total costs per dwelling over 30 years for heating with gas, total costs vary from approximately € 60K to € 360K per dwelling depending on the current status and the surface area of the dwelling. A greater variation in total costs is observed for the scenario with gas-free heating as shown in Figure 20, which is between € 55K and € 470K over 30 years.

Figure 19 - Total costs over 30 years per dwelling for heating with gas scenario

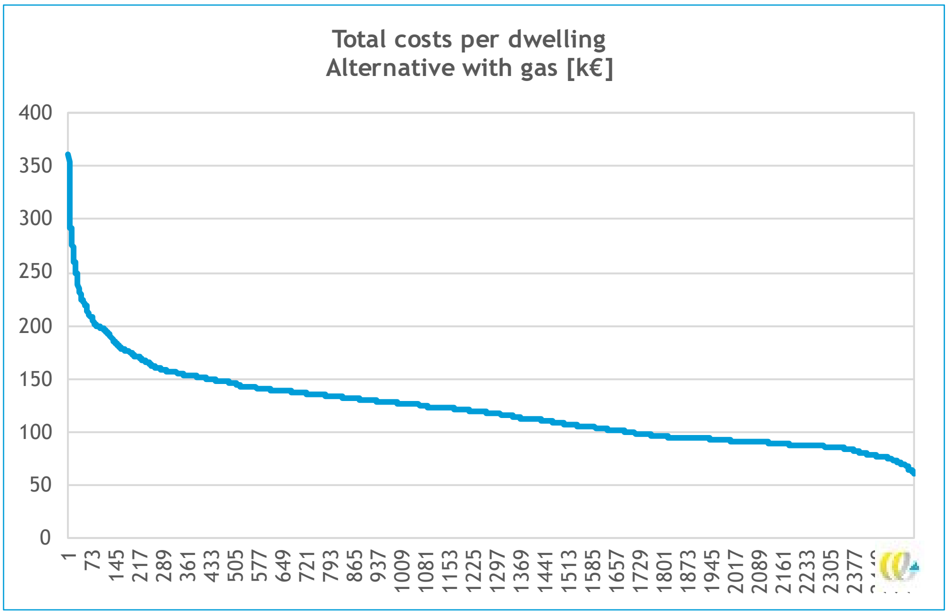
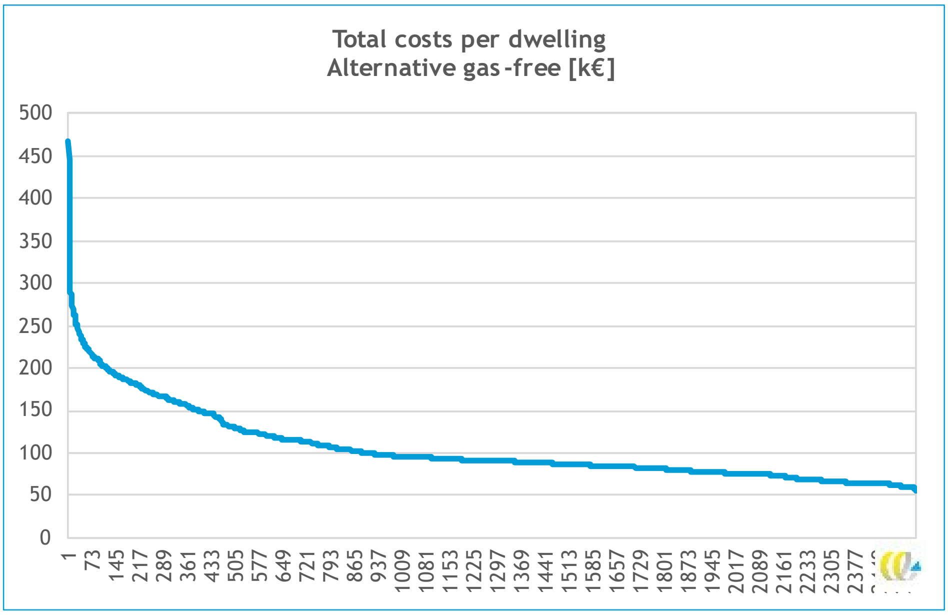


Figure 20 - Total costs over 30 years per dwelling for gas-free heating scenario



Our analysis shows that more than 80% of the dwellings in Kerkrade needs between € 100K and € 150K in the coming 30 years for heating with gas while it is between € 75K and € 125K for gas-free heating. The percentile distributions for both scenarios are shown in Figure 21 and Figure 22. This is an indication for the room for investment to further implement the 5GDHC technology in Kerkrade.

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Figure 21 - Percentile distribution of total costs over the number of dwellings for heating with gas scenario

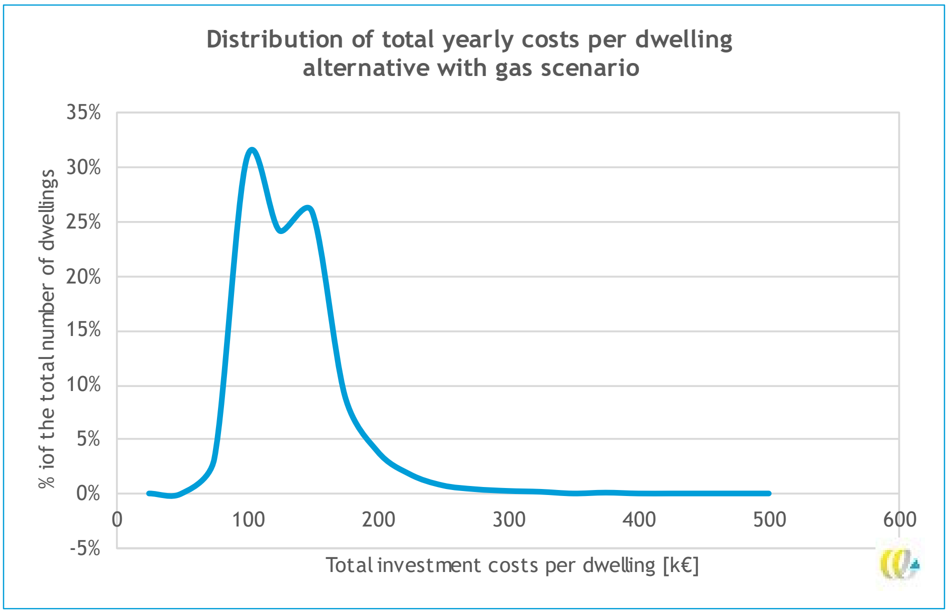
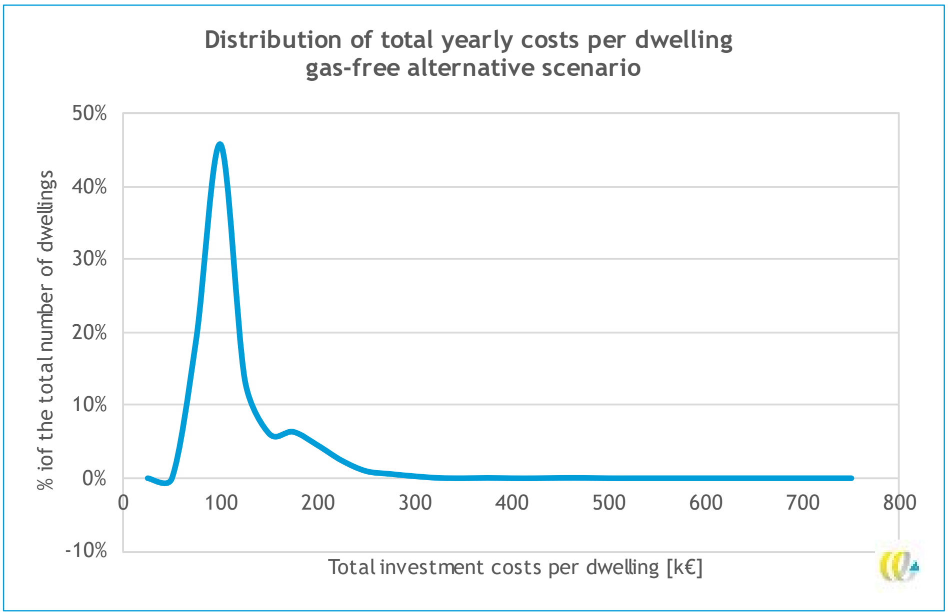


Figure 22 - Percentile distribution of total costs over the number of dwellings for gas-free heating scenario



End-user costs for most common dwellings

Figure 23 shows that the majority of the dwellings in Kerkrade is of stacked type built in the period between 1946-1991. This section shows the breakdown of costs that add up to the total costs for the most common dwellings in Kerkrade.

Figure 23 - Distribution of the number of dwellings over the type and construction year in Kerkrade

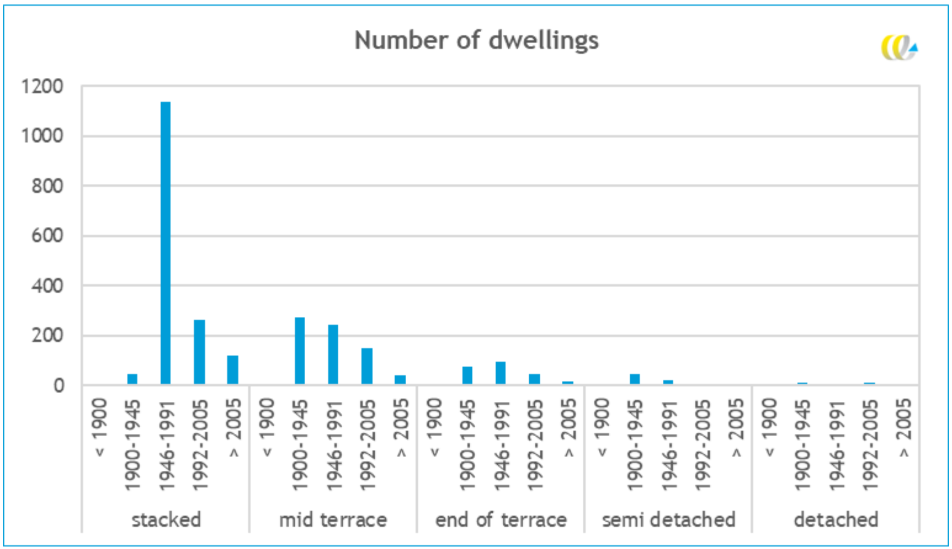
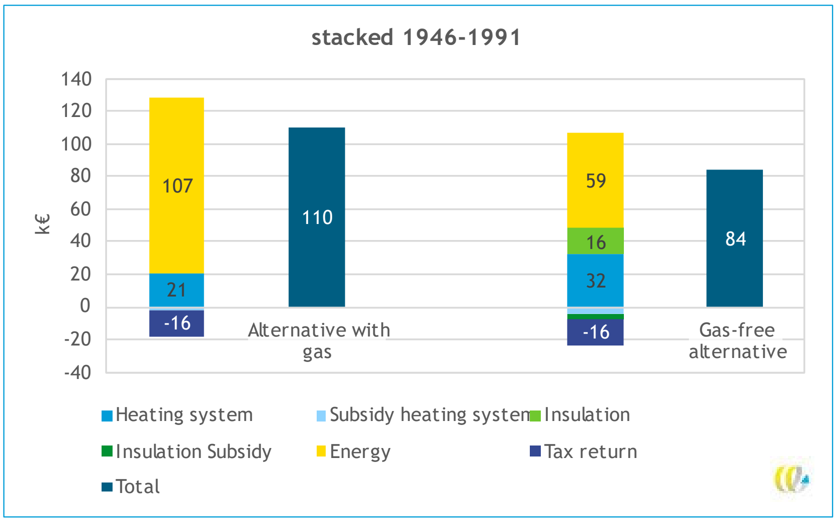


Figure 24 shows the breakdown of the average total costs over 30 years for the two alternative heating scenarios for this specific type of dwelling. For the alternative with gas, energy costs are the most important factor in the total costs. For the gas-free alternative, although the energy cost is the highest cost item over 30 years, investments in the heating installation and insulation play a relatively larger role. Due to lower energy costs, the total costs of gas-free alternative over 30 years is lower than for the alternative with gas.

Figure 24 - Breakdown of the average total costs over 30 years for the alternative heating scenarios of a stacked dwelling built in the period 1946-1991



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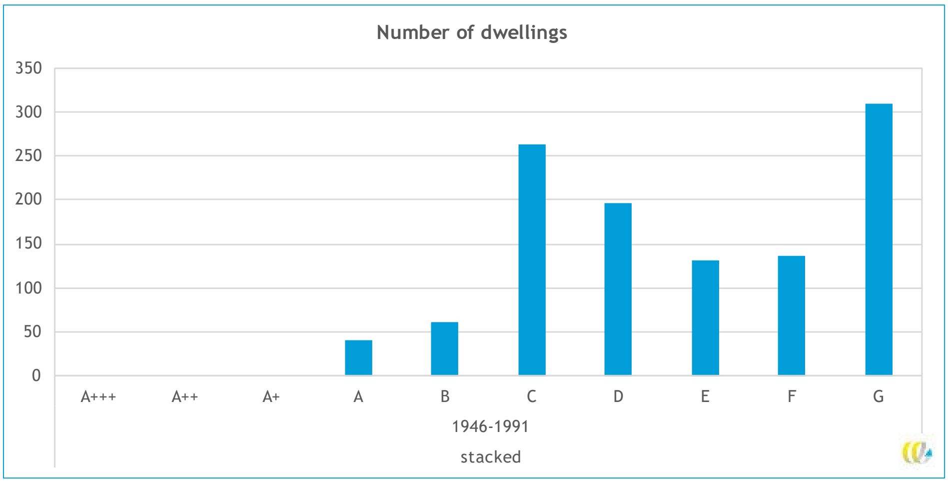
We can conclude that for the most common type of dwellings in Kerkrade, considering 79 m^2 surface area per dwelling in the district, the room for investment for 5GDHC is maximum € 1,400 per m^2 surface area.

For the local action plan, we take a step further in our analysis. Figure 25 shows that the stacked dwellings in Kerkrade have a variety of energy labels, but mostly between C and G label, G label being the most common.

Figure 25 - Distribution of the number of dwellings over energy label and the construction year of the stacked dwellings built in the period 1946-1991 in Kerkrade



A breakdown analysis of costs is shown in Figure 26, but then only for the average stacked dwelling with energy label G built in the period 1946-1991. Figure 27 shows the breakdown for the same type of dwellings with energy label C. As expected, the average total costs for the gas-free alternative is higher for the dwellings with label G than for the dwellings with label C. It is important to note that these figures are dependent on the average size of the dwellings in the studied area.

Figure 26 - Breakdown of total costs for alternative heating scenarios of a stacked dwelling with G energy label, built in the period 1946-1991

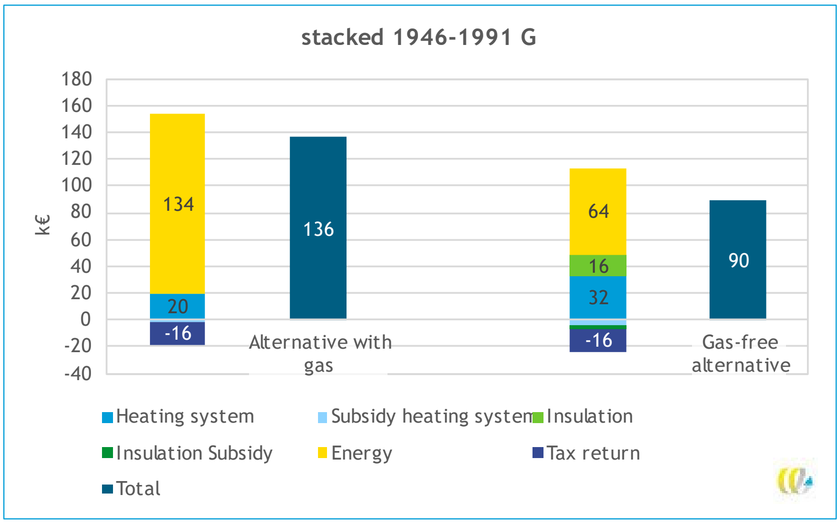
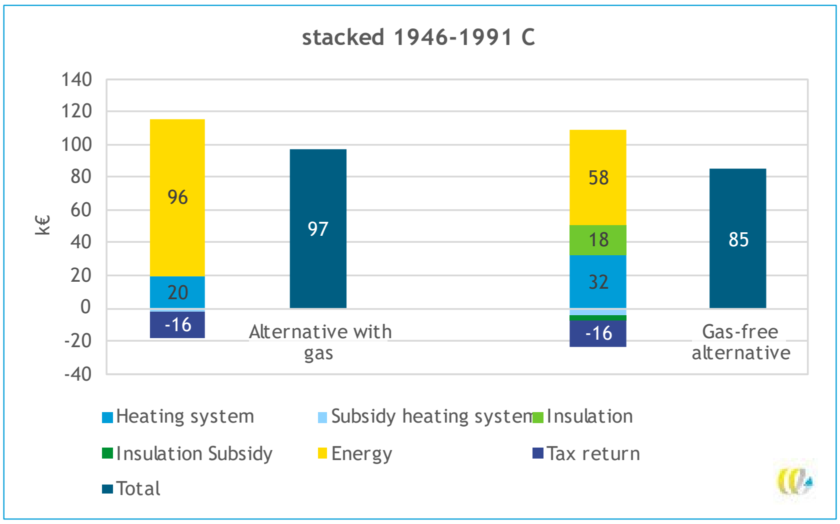


Figure 27 - Breakdown of total costs for alternative heating scenarios of a stacked dwelling with C energy label, built in the period 1946-199



The average room for investment per square meter is around € 1,480 for a dwelling with energy label G in Kerkrade, which has in average 76 m^2 surface area. The same indicator for a dwelling with energy label C is approximately € 1,075 per m^2, which has in average 85 m^2 surface area. In order to make 5GDHC financially attractive and competitive, these figures need to be taken into account.

Another important factor is the energy costs per year, which is in average € 2,140 per year for a dwelling with G label according to the gas-free scenario. In all scenarios, the cost breakdown shows that the energy costs over 30 years is the most dominant factor and considering the increasing trend in energy prices it will keep playing a significant role. Being a promising technology for decreasing the dependency on energy from external sources and making smarter use of locally generated renewable energy, 5GDHC offers a chance to minimise the dependency on energy costs.

For implementing the 5GDHC technology, it is attractive to start with the areas where stacked dwellings with poor energy labels, namely E and lower labels, constitute the majority since these type of dwellings offer the largest room for investment per square meter. However, the costs for implementing 5GDHC in these areas are relatively higher than the areas where dwellings with better energy performance are located. Considering the total costs of alternatives and necessary renovations for connecting to a district heating network, the dwellings with energy label C are possibly “the sweet spot” to start with since they are potentially already suitable connect to 5GDHC network without further insulation in the dwelling. In any case, before starting with the implementation, a more detailed analysis of the costs will be necessary.

4 Action plan: implementation

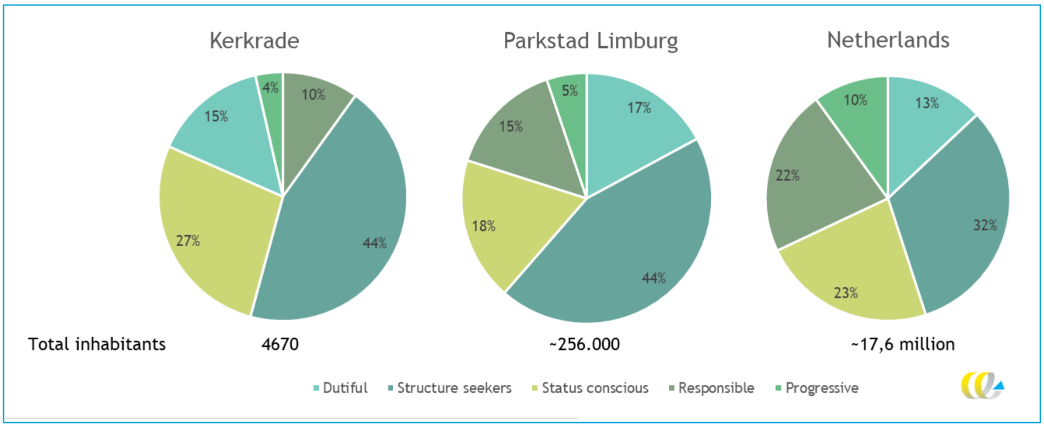
In order to successfully implement a 5GDHC network, local support is essential. Consumers have the right to choose how they want to heat their home. District heating is a collective system, that profits from scale; the more people that want to connect to the 5GDHC network, the more affordable it will be. In this chapter, we describe the attitudes towards sustainability of people living in Heerlen Centrum, actions that can be done fostering local support and how participation of citizens is a part of the new legislation.

4.1 Five shades greener

Five Shades Greener, in Dutch “Vijf Tinten Groener” (Motivaction, 2018), is a research study performed by Motivaction, a market research office in the Netherlands, to show the sustainability-related behaviours of five different consumer groups. Accordingly, the study introduces five groups of Dutch people with their own attitude towards sustainability:
- dutiful (plichtsgetrouwen);
- structure seekers (structuurzoekers);
- responsible (verantwoordelijken);
- status conscious (statusbewusten);
- progressive (ontplooiers).

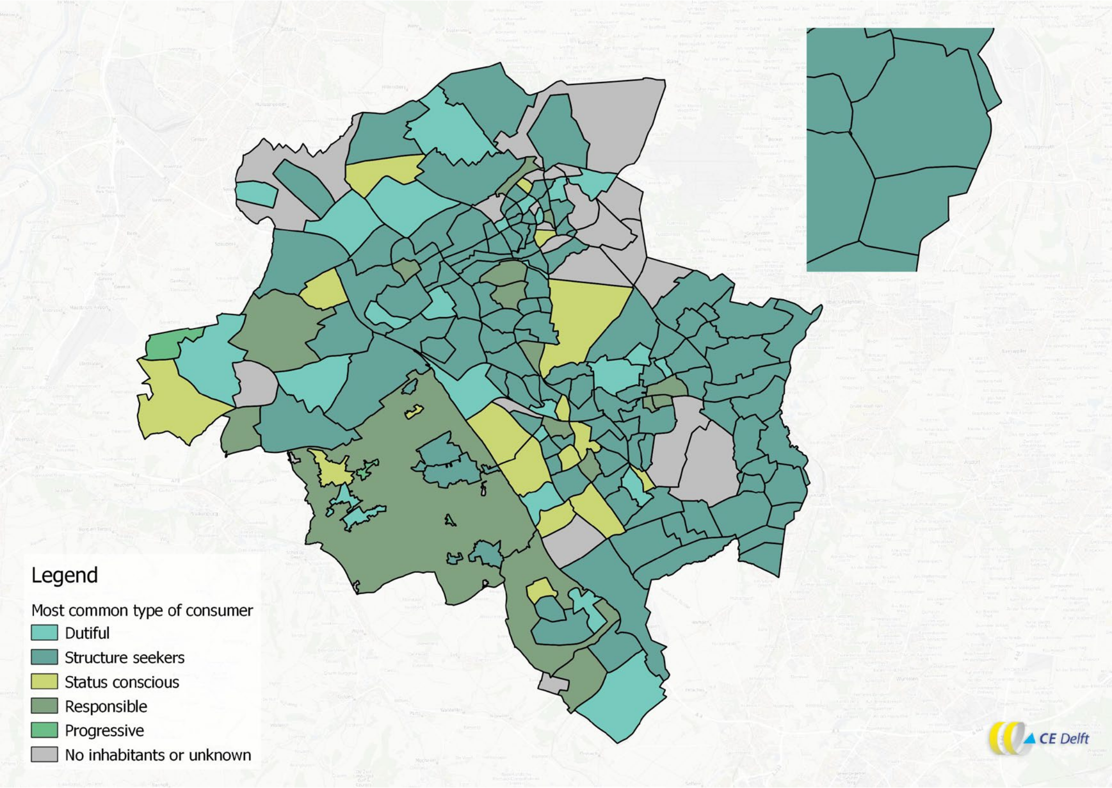
Characteristics of each group with respect to their attitude towards sustainability are presented in Appendix B. Figure 28 shows the percentile distribution of each group in the Netherlands, Parkstad Limburg and the selected area for this local action plan, namely the two neighbourhoods in the municipality of Kerkrade. The majority of the people in all scales are represented by the structure seekers group, which are mostly benefit-oriented people. However, the percentage of structure seekers in Kerkrade is relatively higher compared to those in Parkstad Limburg and the Netherlands.

Figure 28 - Distribution of group of people in Kerkrade (selected area), Parkstad Limburg and the Netherlands



Another important statistic is the relatively lower percentage of progressive people in Kerkrade than the average in the Netherlands. It is comparable to the general profile of people in Parkstad Limburg, but it is markable that the share of progressive people is 0% in the neighbourhood Rolduckerveld. This makes the region more challenging for the implementation of a relatively new technology such as 5GDHC.

Figure 29 - The dominant group of people in all neighbourhoods in Parkstad Limburg and four neighbourhoods in Kerkrade (right above)



As mentioned before, the largest group in the selected Kerkrade area is the structure seekers, representing around 44% of the population in the two neighbourhoods. People in this category feel less responsible for a sustainable society. For example, they prioritise price and convenience over sustainability for their choices. Therefore, this means that this group of people would like to see a better business case rather than the sustainability impact of implementing 5GDHC.

The second largest group of people in Kerkrade is status conscious, well above the average in Parkstad Limburg and the Netherlands. This group is interested in technological innovations and they are entrepreneurial, which are two positive signs for the implementation of the 5GDHC technology. As long as they are well informed about the situation and the benefits for their status and goals, people in this category will commit to the sustainability goals. For implementation plans of 5GDHC in this area, this is a positive sign but still the information about the technology and the individual benefits must be clear.

According to the research, responsible and dutiful people constitute 25% of the total population in the two neighbourhoods. These people will be relatively easy to convince to implement 5GDHC in their neighbourhood as they are already convinced of the urgency of sustainable solutions and collective actions. However, the consequences of the implementation of 5GDHC should be clearly communicated with facts and figures to this group as well.

As a result, we can conclude that the majority of the people in the selected area will require a careful approach in terms of costs and benefits to adopt 5GDHC technology.

4.2 Actions for local support

As said before, for a successful roll-out of 5GDHC local support is a key factor. Here we list some actions that can be done to increase local support:

- Information sessions for inhabitants and other stakeholders. These sessions can provide basis information about alternatives for heating with natural gas or can be more specific about 5GDHC and the potential for 5GDHC in Heerlen Centrum. It is also important to inform people about the consequences the roll-out of 5GDHC has, economically (the energy bill) and practically (what kind of modification to the buildings is needed).
- Collect information from inhabitants. It is important to understand the point of view from inhabitants of the region.
- Identify whether there are local initiatives that serve the same purpose, a collaboration with these initiatives can increase the chance of successful rolling out 5GDHC.
- Include inhabitants and stakeholders in the decision-making process. They are more likely to accept 5GDHC if they also have had the possibility to influence the decisions. It is also important to be clear about where it is not possible to include stakeholders in the decision-making process.
- Combine the construction for 5GDHC with other improvements in the street, neighbourhood or district. For example, add more green to the street after it has been opened for the district heating infrastructure.

4.3 Local action plans in relation to the Environment and Planning Act

It is expected that a new act, the Environment and Planning Act (Omgevingswet), is introduced by July 2023. This act states that the municipal council has to establish an environmental strategy for the entire territory of the municipality, which amongst other things describes the main features of the proposed development of the territory (Ministry of the Interior and Kingdom Relations, 2021). This development partly comes from the regional energy strategies (RES) and the heating transition vision document (TVW).
The environmental strategy is further elaborated in a physical environment plan, which contains agreements and regulations relating to the development of the physical environment (Ministry of the Interior and Kingdom Relations, 2021). These deducted from the plans and agreements in the RES, TVW and local action plan (WUP).
Public participation is a crucial part of the Environment and Planning Act.
The environmental strategy and the physical environment plan should describe how the citizens, companies, civil society organisations and administrative bodies shall be involved (Ministry of the Interior and Kingdom Relations, 2021).

5 Solar energy

This chapter describes the issue of grid congestion that should be taken into account for incorporating solar energy in the roll-out of 5GDHC. It also gives an estimation for the potential of solar energy.

5.1 Congestion

Grid congestion is a problem in the whole province of Limburg (Enexis, lopend).
The transformers and/or cables have no capacity left to transport the electricity generated by an extra solar park or wind farm. Due to the transportation capacity shortage it is currently not possible to add new connections for feeding back into the electricity grid or expand existing connections with a capacity larger than 3 x 80 amp (CE Delft, 2020). Because the grid operator does incorporate autonomous growth in their grid planning, there is not yet a direct capacity shortage for the connection of private individuals and small business. The grid congestion needs to be taken into account when planning to incorporate solar energy in the 5GDHC system in Limburg.

5.2 Potential

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 Energiestrategie") has been drawn up. Parkstad is part of the vision for Zuid-Limburg. In RES Zuid Limburg, (2021) 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. Unfortunately, the plans and ambitions are not geographically specified.

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

Source	Existing (GWh)	Planned (GWh)	Additional ambition (GWh)
Solar - rooftop	18	27	139
Solar - land	6	26	158

The regional program PALET (Parkstad Limburg EnergieTransitie) was set up in 2013.
The goal of the program was to draw up a vision and implementation plan for the energy transition in Parkstad. In PALET 3.0 (Parkstad Limburg et al., 2016) a total of 55 TJ (15 GWh) of solar power produced electricity was planned in the municipality of Heerlen by 2020.

6 Conclusions

The regional analysis has identified two neighbourhoods in the municipality of Kerkrade, Rolduckerveld and Holz, as promising for a roll-out of a 5GDHC network. In this study, we have taken a closer look at the two neighbourhoods and identified opportunities and risks for the scale up of the 5GDHC network.

Opportunities:

- Both neighbourhoods have a high-urban density and a lot of stacked buildings, which makes them very suitable for district heating.
- A large number of the dwellings in Rolduckerveld is owned by a housing association. This is favourable for implementing district heating, since it is easier to make agreements with a housing association than with a lot of different homeowners.
- The total cost for heating with gas is highly dependent on energy costs, while 5GDHC technology promises to decrease the dependency on external energy sources and prices.
- The total cost for alternative heating options offers room for investment in 5GDHC technology.
- There is a mix of residential and non-residential buildings, especially in Holz. This increases opportunities for heating and cooling exchange.
- Roads that need to be broken up to install district heating infrastructure are usually constructed of removable pavement.
- Most houses in the two neighbourhoods do not have front gardens, which makes it easier to connect them to district heating infrastructure.
- There are both low-temperature and high-temperature potential heat sources in the proximity of Rolduckerveld and Holz.
- ATES storage is not restricted in Rolduckerveld and Holz.
- Demand for cooling is expected to increase due to climate change.

Risks:

- Part of the gas infrastructure in Rolduckerveld is scheduled for renewal in 2024. This may have a negative effect on implementing district heating.
- In Holz, most of the dwellings are private rental or privately owned, there is not much social renting. This poses a risk for participation in the district heating network.
- In Holz, there are large areas where the majority of buildings have poor energy performance. Higher temperature heat or insulation is needed before 5GDHC can be implemented. However, an energy park in Herzogenrath can potentially provide high-temperature heating.
- From the consumer groups identified, we can conclude that majority of people in the selected area will require a careful approach in terms of costs and benefits to adopt the 5GDHC technology
- Grid congestion in the province Limburg may cause problems when incorporating large solar panel installations

In general we conclude that, after taking a closer look at Rolduckerveld and Holz, they are still promising for a roll-out of a 5GDHC network. Some risks are present and need to be taken into account in the implementation process. However, there are a lot of opportunities in this region for 5GDHC. During the implementation process it is important to take into account the participation of the residents and building owners. Local support is essential for a successful roll-out of 5GDHC.

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A Criteria in multi-criteria analysis

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 and 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
Heat source available	Usually there is more heating demand than cooling demand in the NL, a heat source can provide this extra demand.	– A heat source available in neighbourhood score 1	2
Social housing	Higher percentage of dwellings owned by social housing corporations provides higher potential to connect a large number of dwellings to 5GDHC	– > 75% is social housing score 1 – > 50% is social housing score 0.5	1
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

B Five Shades Greener: attitudes of five groups of people towards sustainability

Five Shades Greener, in Dutch “Vijf Tinten Groener” (Motivaction, 2018), is a research study performed by Motivaction, a market research office in the Netherlands, to show the sustainability-related behaviours of five different consumer groups. Accordingly, the study introduces five groups of Dutch people with their own attitude towards sustainability:

- dutiful (plichtsgetrouwen);
- structure seekers (structuurzoekers);
- responsible (verantwoordelijken);
- status conscious (statusbewusten);
- progressive (ontplooiers).

Characteristics of each group with respect to their attitude towards sustainability are presented here.

Dutiful

Life purpose: good citizenship, good behaviour in the eyes of the society, the environment and God.

Society: social involved, volunteering, solidarity with minorities and concerned with the environment.

Ambitions: stick to traditional norms and values, family as cornerstone of society, peaceful and harmonious life

Status: relatively less assertiveness, less status sensitive.

Concern: major concerns about poverty and inequality.

Lifestyle and core values: loyal, caring, sense of responsibility, hardworking, social, risk averse, sense of duty, order, regularity and discipline, sober and thrifty, price conscious.

Structure seekers

Core values: enjoy, care, loyalty, security, carefree, familiar, known, proud, following (do what the neighbours do).

Society: desire for authority and rules, desire for recognition and appreciation, little interest in politics.

Ambitions: finding a balance between traditional norms and values and change, status and prestige acquire, have money, material wealth, regular and easy life, happy family life, entertainment.

Concerns: animal welfare, disease control, poverty, unemployment, health and well-being.

Lifestyle: regular living, passive and impulsive (here and now), conformist, consumption and entertainment oriented, locally oriented, not strong aware of the effect of own acting, enjoying and having fun, certainty, confidence, risk averse, materialistic and status sensitive, there want to hear, attach to appearance presentation, luxury, pride, little ambition, little responsibility.

Status conscious

Life purpose: optimistic view of the future, capable of self-influence exercise on life, feeling to be in control, determined to goal to achieve, (materialistic) dreams, private and business ambitions.

Society: interest in technological developments, open to innovation and change, hierarchical, critical, entrepreneurship.

Ambitions: protect and acquire of social status, making a career.

Status: sensitive to showing what they have achieved.

Concerns: own health and that from people in the immediate vicinity.

Lifestyle and core values: exclusive, business-like, rational, exciting, ambitious, goal-oriented, future-oriented, status-sensitive, materialistic, technology-minded, innovation-driven, egocentric.

Responsible

Life purpose: discover, develop, enjoy.

Society: critical idealists, global citizens, social and politically oriented, committed, tolerant.

Ambitions: self-development, social be moved, show solidarity, stand up for the environment, social success.

Status: intrinsically motivated to live sustainably.

Concerns: damage caused by humans to the earth, the bio-industry, technology, materialism.

Lifestyle and core values: adventurous, socially critical, environmentally conscious, living meaningfully and consciously, contributing something to society, autonomously, quality over quantity, active.

Progressors

Life purpose: always experiencing something, self-expression, experimentation
Society: little involved, tolerant, equal opportunities, work is subordinate to private
Ambitions: being free, having fun, gain new experience, be independent
Status: Driven, Intrinsic motivated, enterprising, innovative, looking for fun
Worry: only concern is infestation of one's own freedoms.

Lifestyle and core values: creative, enthusiastic, experience more important than possession, freedom, view of the future, trendsetting, looking for challenges, adventure and personal growth.