Local action plan

District Heerlen Centrum

CE Delft
Committed to the Environment

Interreg North-West Europe
D2Grids
European Regional Development Fund

Local action plan

District Heerlen Centrum

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

This report is prepared in the context of the D2Grids, an Interreg North-West Europe project

Delft, CE Delft, December 2022

Publication code: 22.220182.188

Districts / Policy / Urban / Heating / Cooling / Energy supply / Demand / Storage / Distribution / Costs / Cross-border region

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)

CE Delft
Committed to the Environment

Through its independent research and consultancy work CE Delft is helping build a sustainable world. In the fields of energy, transport and resources our expertise is leading-edge. With our wealth of know-how on technologies, policies and economic issues we support government agencies, NGOs and industries in pursuit of structural change. For almost 45 years now, the skills and enthusiasm of CE Delft's staff have been devoted to achieving this mission.

Content

Summary

This document is the local action plan for the roll-out of 5th generation district heating and cooling networks (5GDHC) in Heerlen Centrum. 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-West 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 for the roll-out of 5GDHC. A local action plan is prepared for the two selected regions. This document is the local action plan for the Heerlen Centrum district in the municipality of Heerlen.

In general, we conclude that scaling up the existing 5GDHC network in Heerlen Centrum 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 Heerlen Centrum district has potential for a roll-out of 5GDHC for several factors:
- A 5GDHC network is already operating in the district. Connecting more buildings to the network is easier than building new infrastructure.
- The neighbourhoods in the Heerlen Centrum district received a high total score in a multi-criteria analysis to assess the suitability for 5GDHC that was prepared for the regional vision.
- The district has high-urban density, and the building stock is generally suitable for district heating and the exchange of heating and cooling.
- Low-temperature heat sources are present and thermal storage (ATES) is not restricted in the area.
- The total cost over 30 years[1] 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. In Heerlen Centrum most of the dwellings are private rental housing or privately owned, there is not a lot of social housing. Involvement in the district heating network is therefore mainly based on individual participation and may be cumbersome from the perspective of the developer.

[1] This is explained in Section 3.6.

There are a lot of old buildings in the district, which means that the streets are also old. It might be more difficult to install new infrastructure in the streets as well as in the buildings.
There are large areas with predominantly buildings with a poor energy performance. This means that high-temperature heating or insulation is needed before 5GDHC can be implemented.
However, there are no renewable high-temperature heat sources available locally.
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 more dutiful and progressive people live in Heerlen Centrum than in the rest of Parkstad. We can conclude from this that the majority of the people in the selected area will be more likely to adopt 5GDHC technology despite the potential higher costs. 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 Netherlands, 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, Heerlen Centrum.

The local action plan is structured in six chapters to provide relevant information for implementing 5GDHC in Heerlen Centrum. 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 Heerlen Centrum 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 the Heerlen Centrum district.

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.

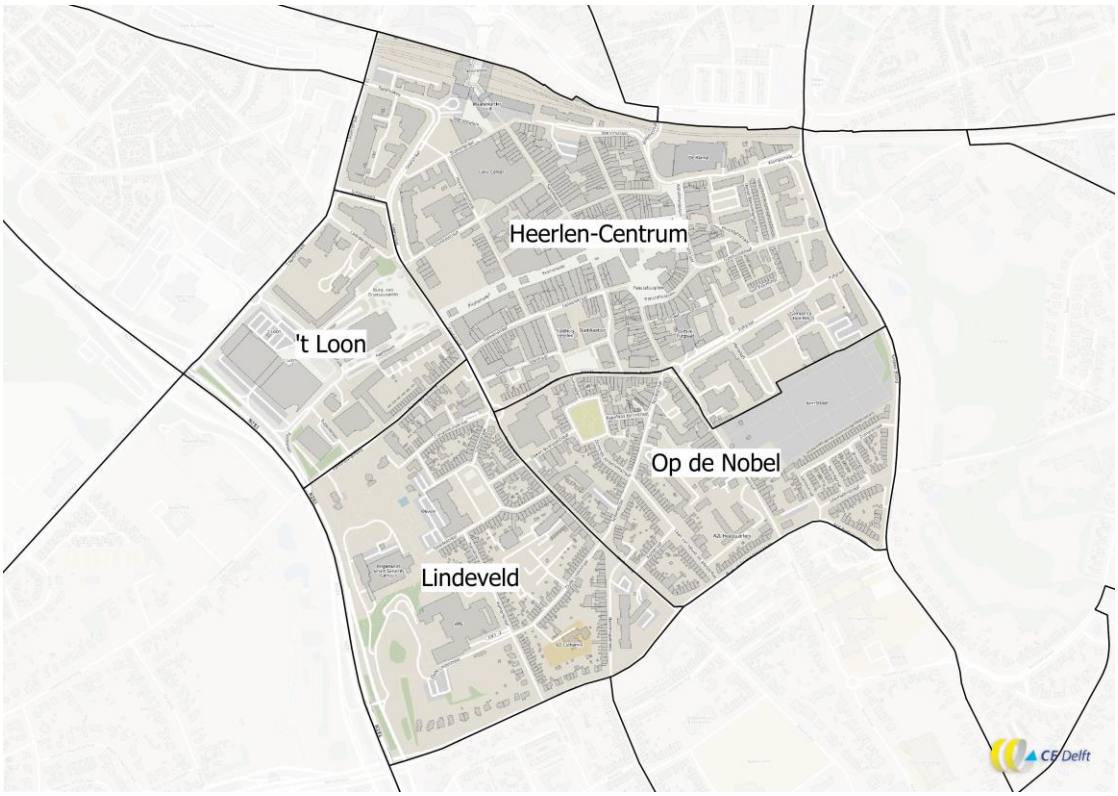
As is the case elsewhere in the Netherlands, most of the buildings in Parkstad Limburg are heated using natural gas-fired boilers. Some buildings are connected to the district heating network of Mijnwater. Mijnwater currently operates a 5GDHC network in Heerlen and Brunssum.

Figure 1 - The two regions for the local action plans. One region is the district Heerlen Centrum, containing 4 neighbourhoods in the municipality Heerlen. The other region consists of 2 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 the Heerlen Centrum district. Figure 2 shows the four neighbourhoods in the Heerlen Centrum district.

Figure 2 - The 4 neighbourhoods in the district called Heerlen Centrum



3.1 Results from multi-criteria analysis for the district Heerlen Centrum

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

- Three of four neighbourhoods score points on room for investment, and the other scores on ratio total costs to insulation costs.
- All neighbourhoods have high-urban density and the Mijnwater backbone already is present in the neighbourhoods.
- There is not a lot of social housing in these neighbourhoods. In order for a successful implementation of 5GDHC, local support is essential. We will say more about this is Chapter 4.
- In all four neighbourhoods heat sources are present, we will go into more detail about this in Section 3.5.

- All four neighbourhoods have high risk for the heat island effect, this is a good opportunity for 5GDHC to provide a better alternative for gas-free heating.
- A large part of infrastructure in ‘t Loon will be replaced before 2024, it is wise to take this into account in the final implementation plan.
- The neighbourhood Op de Nobel does not score on the criterion exchange heating and cooling, this is something to take a closer look at. There might be possibilities for the exchange of heating and cooling that we have not identified in the regional vision. Also exchange with the other neighbourhoods might be a solution.

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

Neighbourhood name	Heerlen Centrum	Lindeveld	't Loon	Op de Nobel
Room for investment	0	0.5	0.5	0.25
Ratio costs/insulation costs	1	0	0	0
District heating in neighbourhood	1	1	1	1
Urban density	1	1	1	1
Social housing	0	0	0	0
Heat source available	0.4	0.6	0.4	0.4
Heat island	1	0.5	1	1
Infrastructure replacement	0	0	-1	0
Exchange heating and cooling	1	1	1	0
Infrastructure costs	1	0.25	1	0.75

3.2 Building stock in the district Heerlen Centrum

In the research for the regional vision, it was established that Heerlen Centrum has 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 Heerlen Centrum.

Mix of residential and non-residential buildings

Heerlen Centrum is a district in the city centre of Heerlen. Because of this there is a great mix of residential buildings and non-residential buildings. Figure 3 shows that total building surface area for non-residential buildings is a bit more than half of the total building surface area in this district.

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

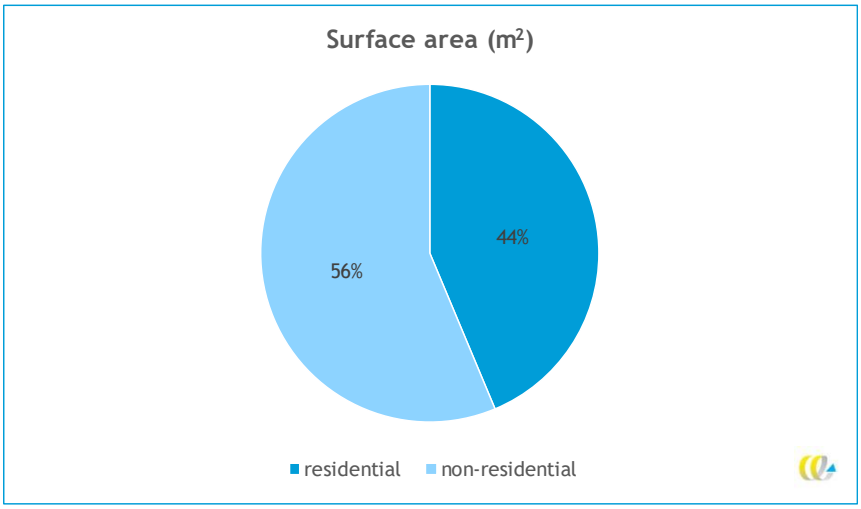


Figure 4 shows the spatial distribution of residential and non-residential buildings. Most of the non-residential buildings are in the neighbourhoods Heerlen Centrum and ‘t Loon (for neighbourhood names see Figure 2). The neighbourhoods Op de Nobel and Lindeveld are more residential neighbourhoods. But in these neighbourhoods, there is still a mix of residential and non-residential buildings.

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

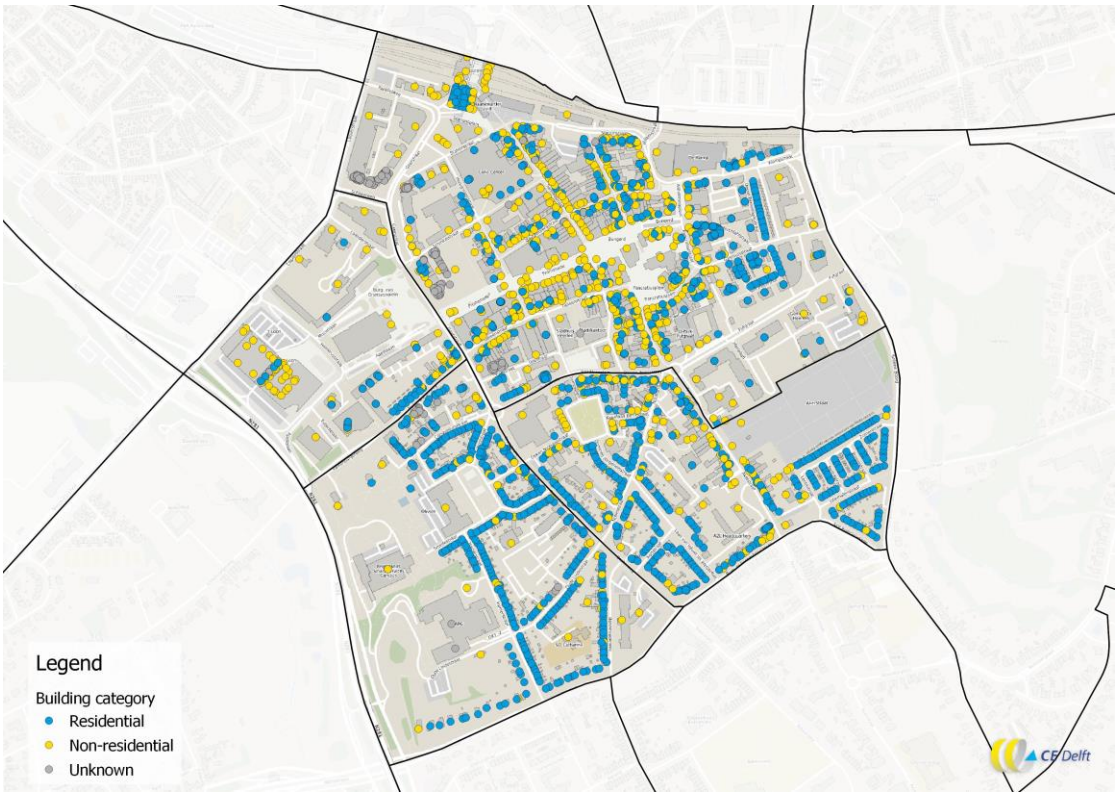


Figure 5 shows the types of dwellings in the Heerlen Centrum district. Most buildings are stacked buildings. There are also some terraced buildings and very few (semi) detached dwellings. This is a typical building stock for a Dutch city centre.

Figure 5 - The types of dwellings in the Heerlen Centrum district

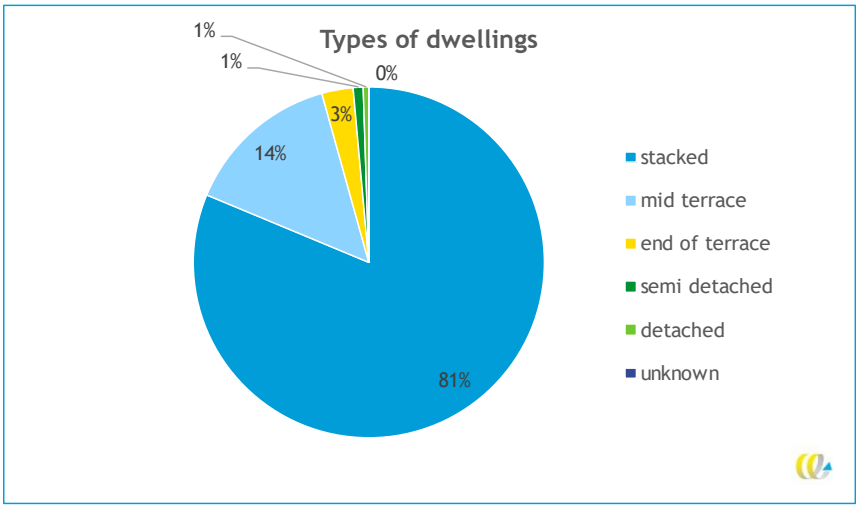


Figure 6 shows the spatial distribution of the dwelling types. Most stacked buildings are in the neighbourhoods called Heerlen Centrum and ‘t Loon. Op de Nobel and Lindeveld contain lots of terraced dwellings. Most (semi) detached dwellings are in Lindeveld.

Figure 6 - Dwelling types in Heerlen Centrum

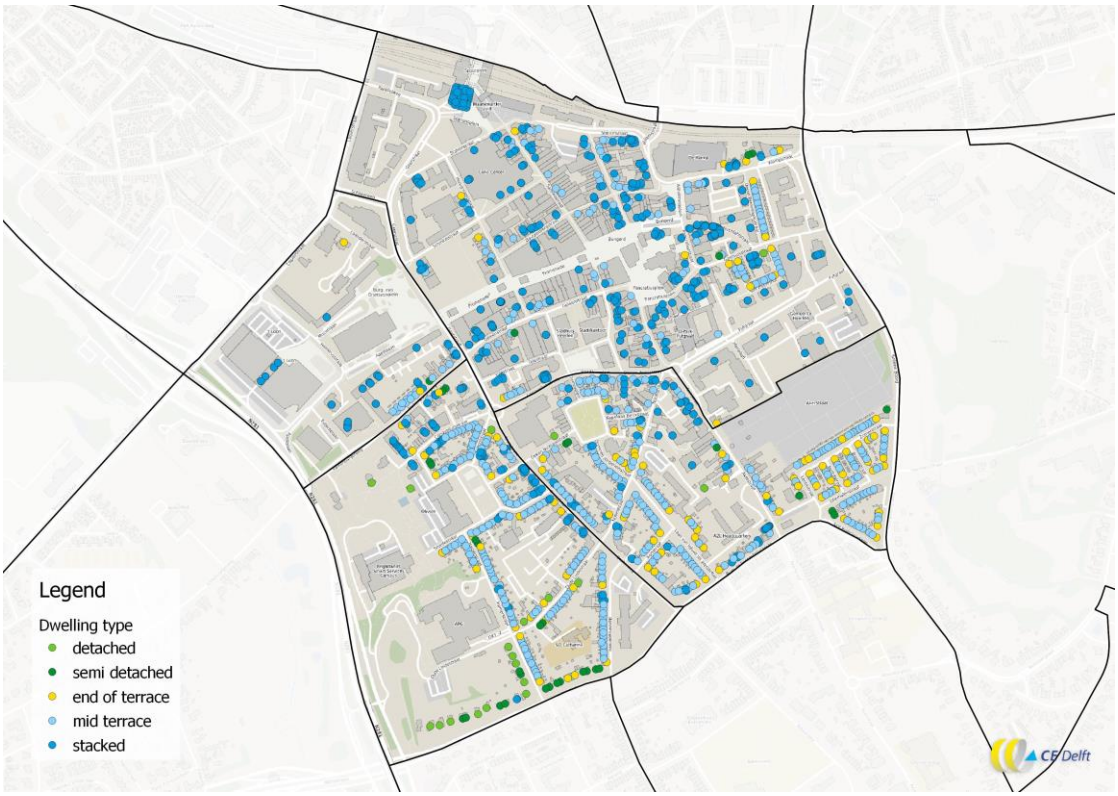


Figure 7 shows the building functions of non-residential buildings. Amongst the non-residential buildings are a large shopping centre, offices, a smart services campus, hotels, a casino and a theatre. Almost a quarter of buildings have a mixed function or the function is unknown.

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

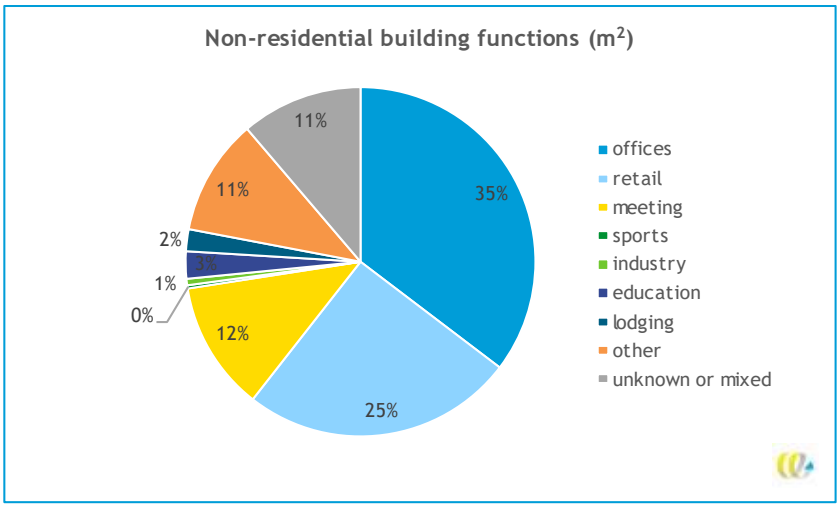
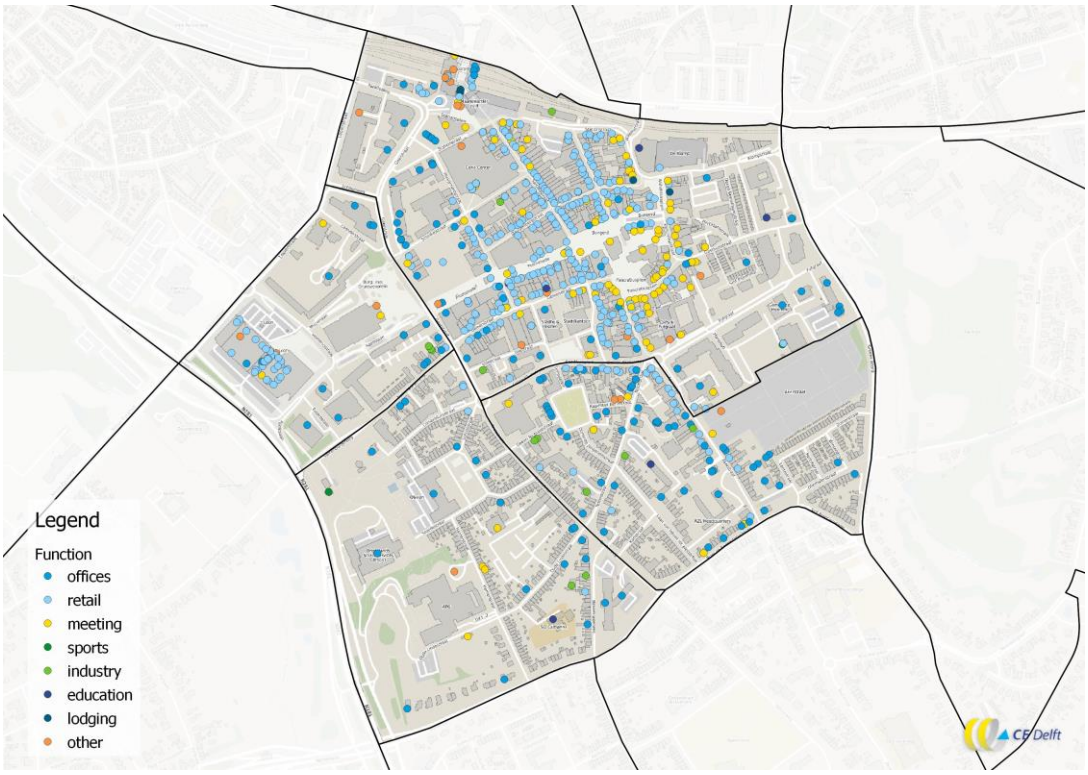


Figure 8 shows the spatial distribution of the non-residential building functions. In the neighbourhood Heerlen Centrum are a lot of non-residential buildings, mostly with retail and meeting functions. The non-residential buildings with meeting function are mostly restaurants and bars, but also a church and a theatre.

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



Building age and energy performance

Figure 9 shows the years buildings were built in the Heerlen Centrum district. Buildings that were built in the same period, often can use the same strategy for insulating the buildings. There are almost no buildings built before 1900. Most of the dwellings are built after 1945 and before 1991. Most of non-residential buildings are built between 1900 and 1945. This period is called the pre-war period. A lot of old buildings indicate that the streets are also old. It might be more difficult to install new infrastructure in the streets as well as in the older buildings.

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

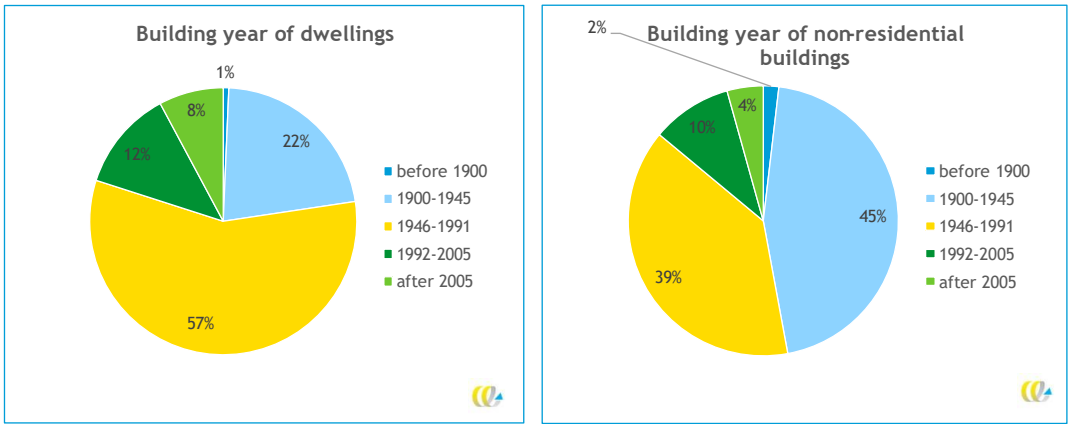
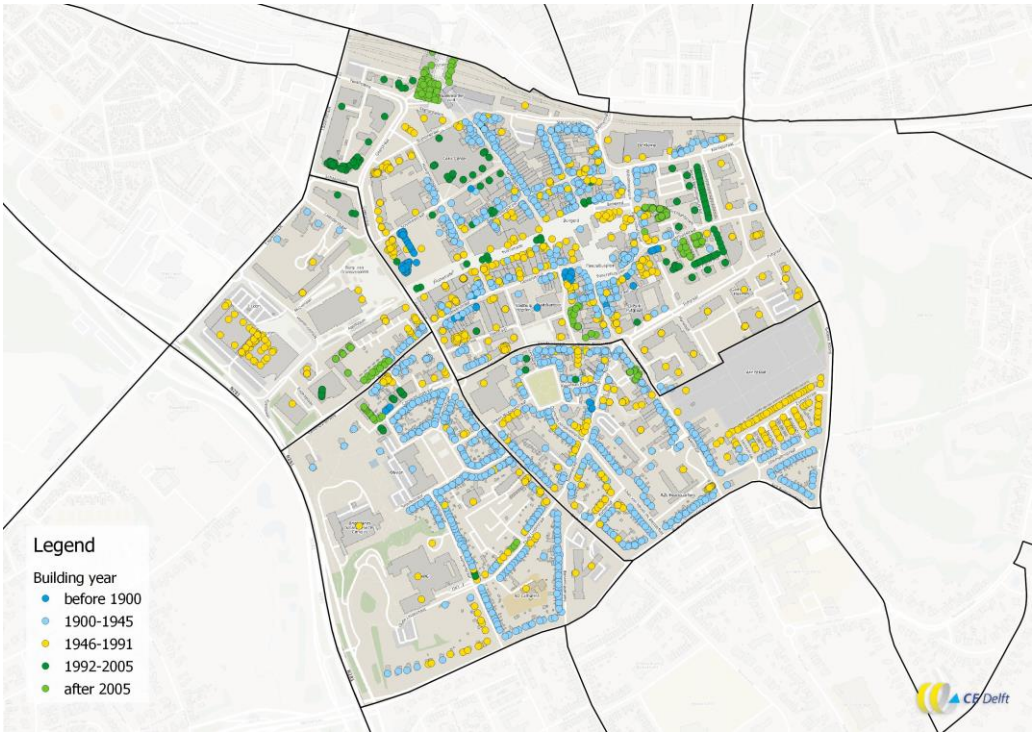


Figure 10 shows the spatial distribution of the construction years of buildings. Buildings that were built in the same period may be clustered for the implementation plans. However, clustering is more challenging in Heerlen Centrum because there is the largest variety in ages of the buildings.

Figure 10 - Spatial distribution of the year's 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 the buildings without a registered energy label we can estimate the label based on building type and building year. In the Heerlen Centrum district 60% of residential buildings and 45% of non-residential buildings have a registered energy label. Figure 11 and Figure 12 show that there is a mix of all energy labels.

Figure 11 - Distribution of energy labels of dwellings in Heerlen centrum district, registered energy labels (on the left) and estimated and registered energy labels (on the right)

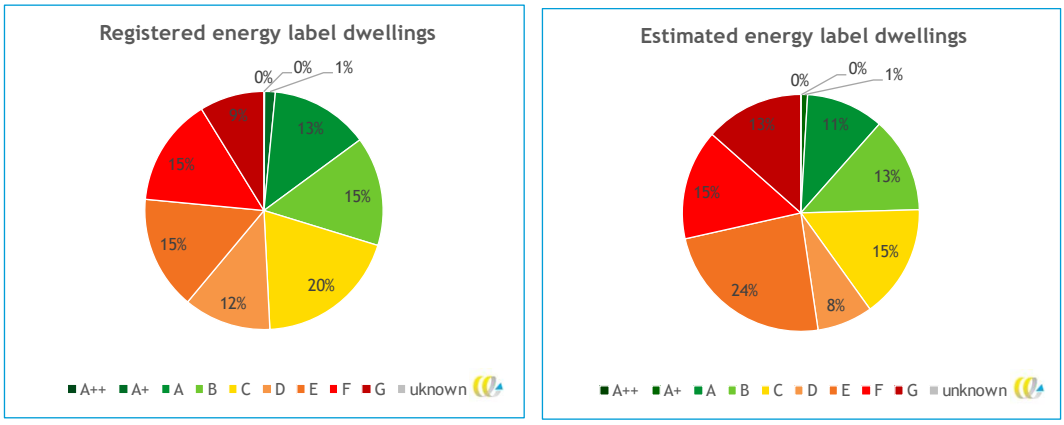


Figure 12 - Distribution of registered energy labels for non-residential buildings in Heerlen Centrum district

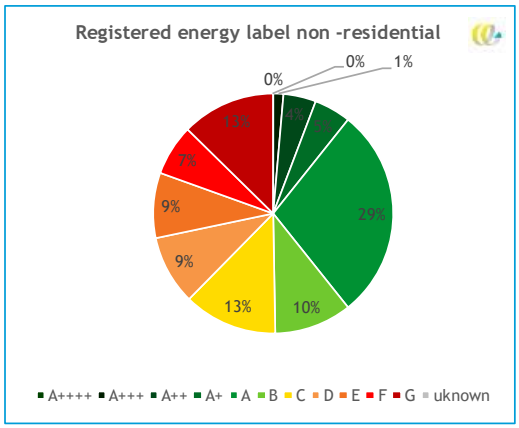
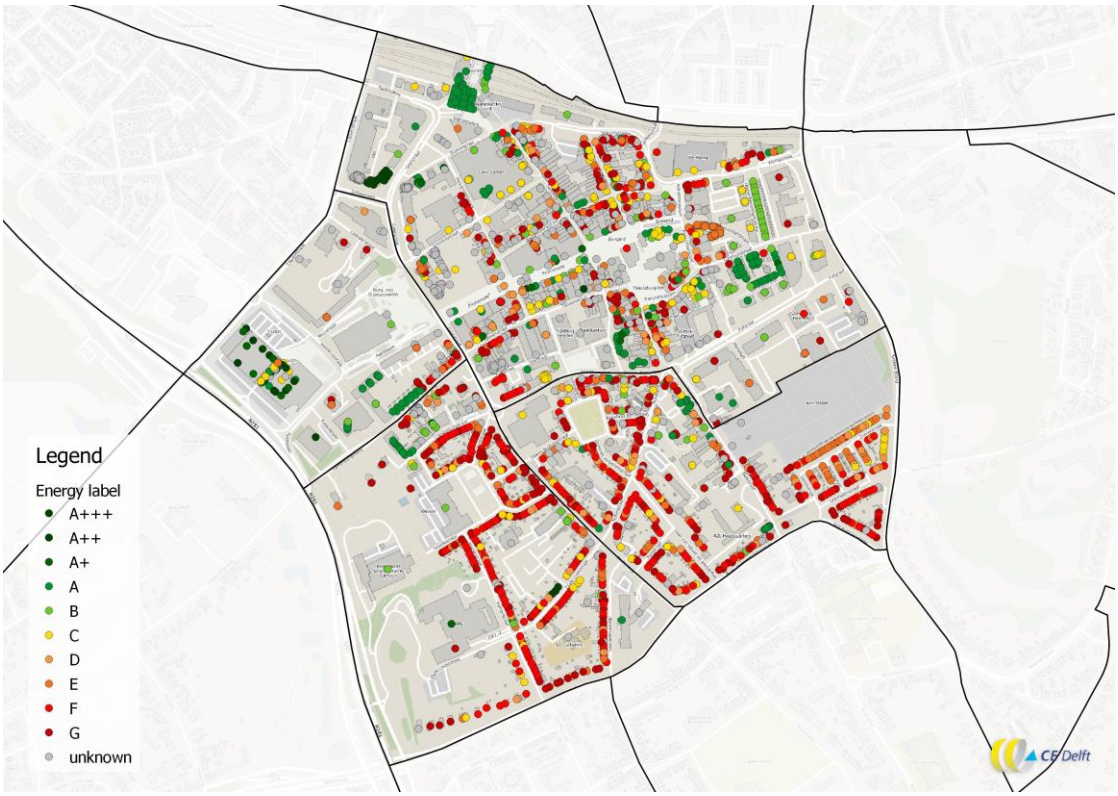


Figure 13 shows the spatial distribution of the registered and estimated energy labels. In Op de Nobel and Lindeveld most buildings have label D, E, F or G. In Heerlen Centrum there is a mix of energy labels. ‘t Loon mostly has buildings with a good energy performance, label B or better, but still there are some buildings with worse labels.

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.
Most of the streets in the neighbourhood Heerlen Centrum have removable pavement. In the southeast of the neighbourhood Op de Nobel the pavement is also removable. The streets in the southwest of Op de Nobel and the streets in Lindeveld are mostly asphalted streets. The sidewalks have removable pavement, but the streets itself are asphalted. In these regions it might be more expensive to put district heating infrastructure.

Figure 14 - The type of road surface in the Heerlen Centrum district

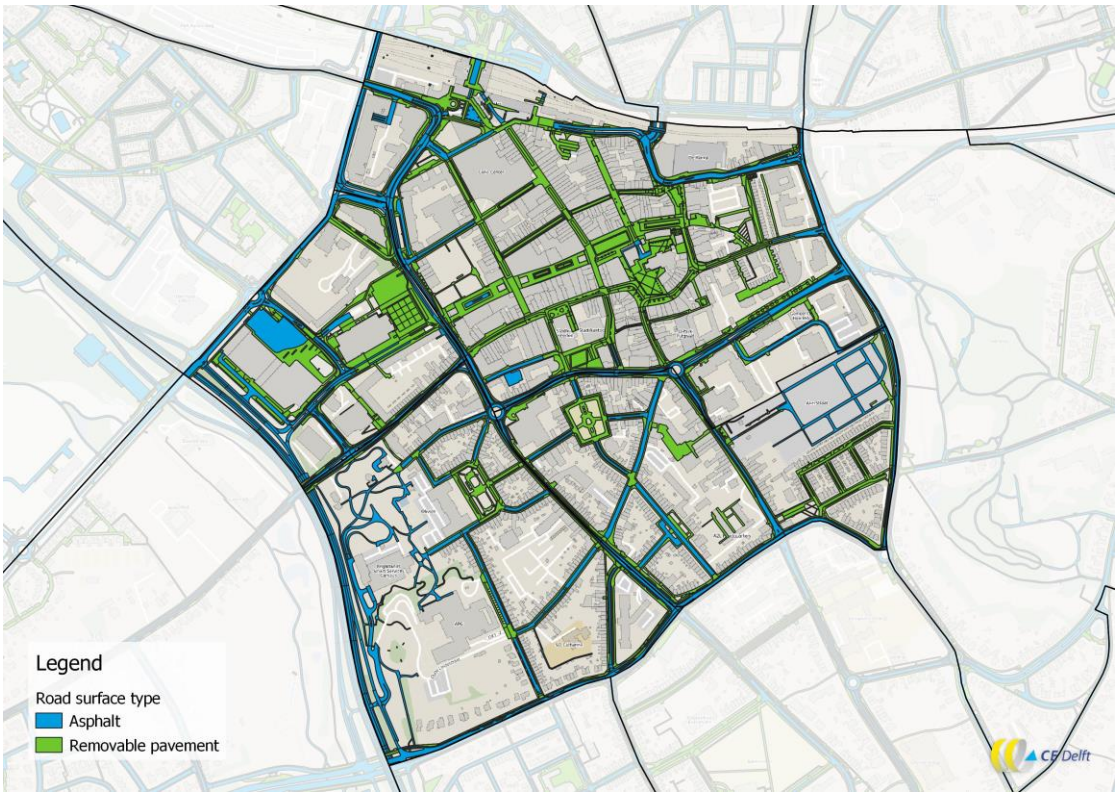


Figure 15 - Two types of road surface: removable pavement (on the left) and asphalt (on the right)

Source: Google maps (streetview).

No gardens in front of houses

It is common in the Netherlands to have a small garden in front of your house. These gardens make it more difficult to connect dwellings to district heating. In the Heerlen Centrum district there are lots of houses 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 - Satellite view of the Hamerstraat in Heerlen, houses without a front garden

Source: (Kadaster, 2020).

3.4 Current Mijnwater district heating

Mijnwater currently already operates a 5GDHC network in Heerlen Centrum. Figure 17 shows that about a third of the dwellings and half of non-residential surface area is already connected to this network. Figure 18 gives a rough indication of the location this network currently operates.

Figure 17 - The number of dwelling (left) and surface area of non-residential buildings (right) currently connected to the Mijnwater district heating network

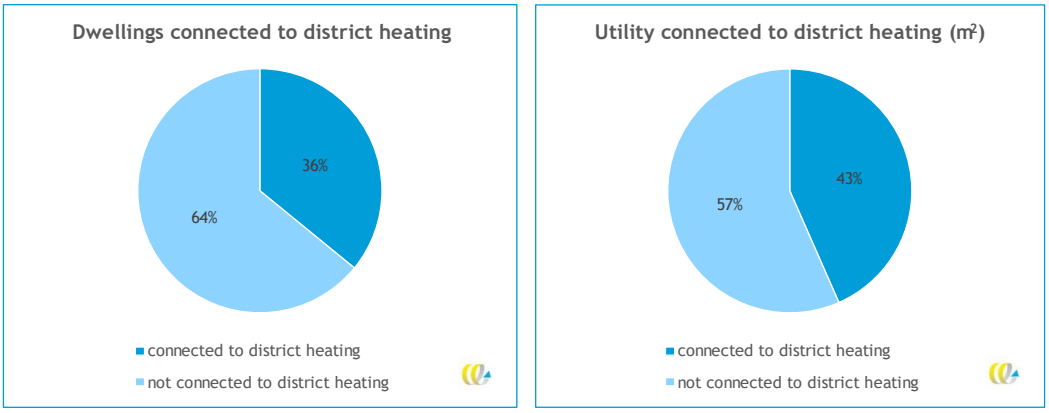
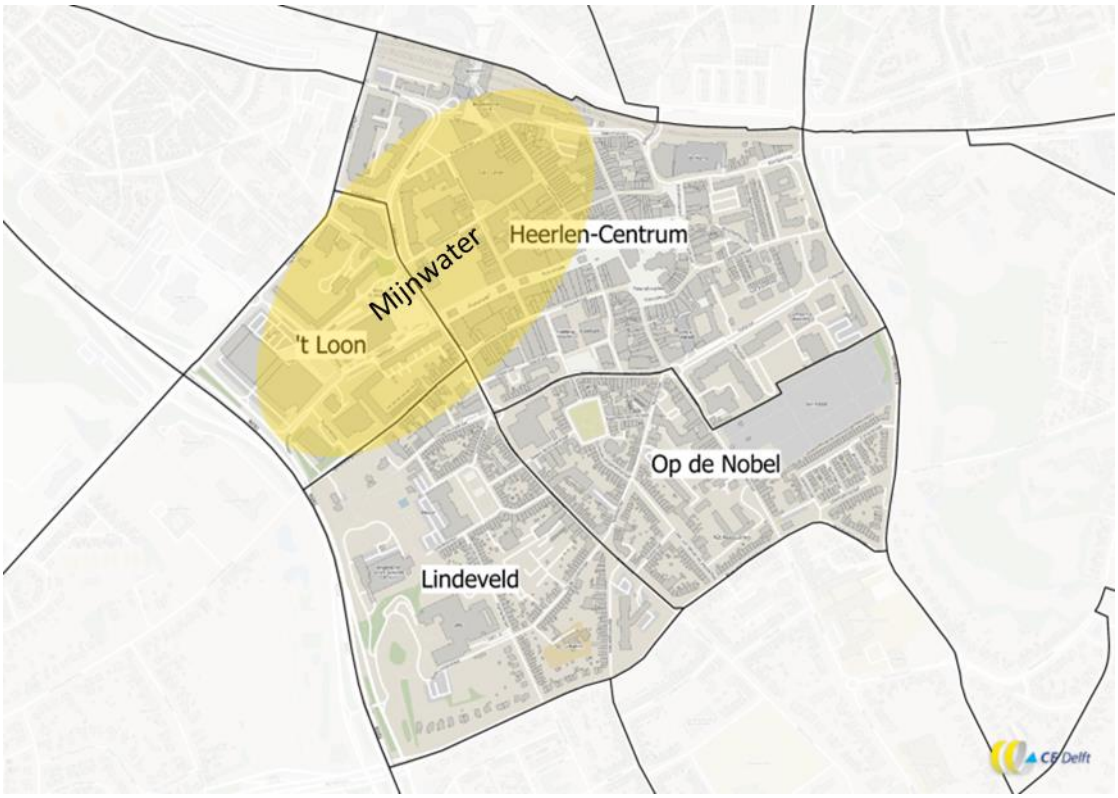


Figure 18 - Rough indication of the region where the Mijnwater district heating network currently operates



3.5 Energy demand and potential sources

This chapter starts with the analysis of the heating and cooling demand in Heerlen Centrum, 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 Heerlen Centrum.

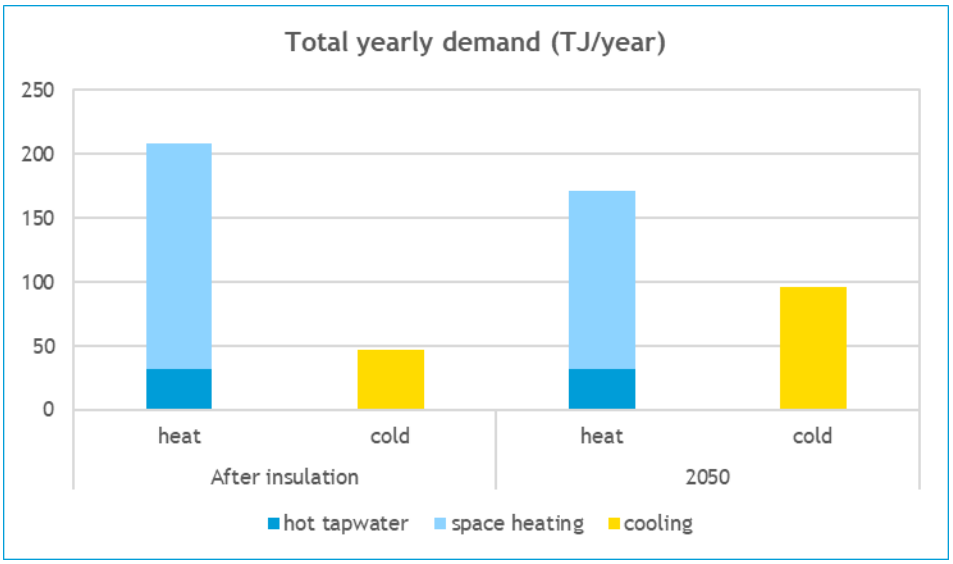
3.5.1 Exchange of thermal energy: heating and cooling demand

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).
The amount of cooling days[3] will be doubled (KNMI, 2017). The effect on the cooling and heating demand is shown in Figure 19.

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

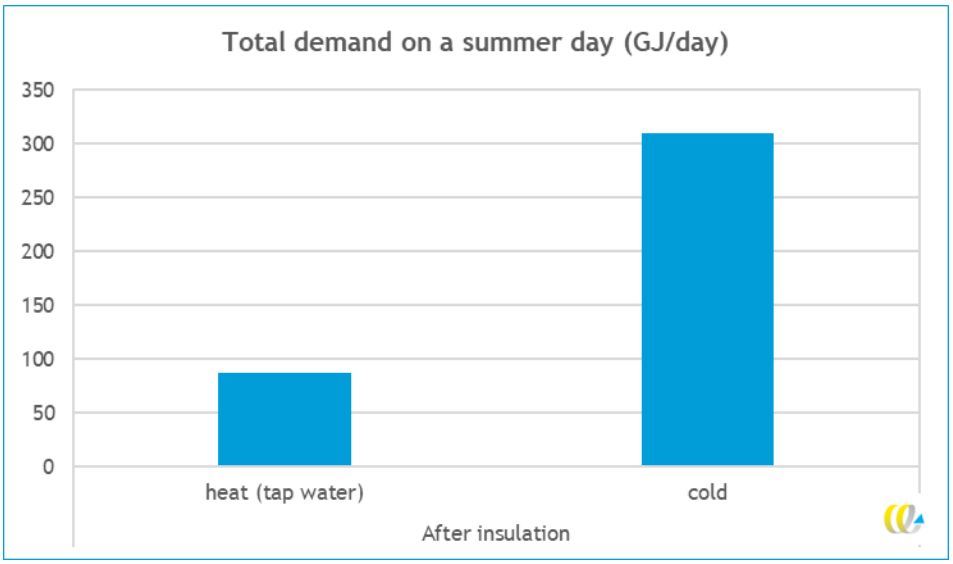
[3] The sum of the difference between the average temperature and 17°C for all days with an average temperature higher than 17°C

Figure 19 - 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. 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 20. With use of thermal storage, the fluctuation in supply and demand can be buffered.

Figure 20 - Total demand for heating and cooling on a summer day after insulation measures and in 2050



3.5.2 Thermal storage

Because the heating and cooling demand of buildings will never be exactly in balance, storage is needed such as ATES. In some regions in the Netherlands these are not allowed, for example due to interference with drinking water. In Heerlen Centrum however, there is not such a restriction on ground-coupled heat exchangers. The current Mijnwater district heating uses a former mine, the Oranje Nassau mine, as thermal storage.

3.5.3 Low-temperature heat sources

South of the neighbourhood Lindeveld, the Welterpark is situated, with a pond. This water could possibly be used for aqua thermal energy from surface water. How much potential there really is should be further researched. Furthermore, there are three supermarkets in the region and north of the train station a datacentre is situated.

3.5.4 High-temperature heat sources

There are no high-temperature heat sources in the region.

3.6 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 four neighbourhoods in Heerlen Centrum[4]. For the regional vision, we have calculated the total costs of alternative heating systems over 30 years and considered that as room for investment for 5GDHC implementation. In 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 considers 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 21 shows the total costs per dwelling over 30 years for heating with gas. Costs vary from approximately € 570K to € 35K per dwelling, depending on the current status and the surface area of the dwelling. A similar variation is observed for the scenario with gas-free heating as shown in Figure 22, which is between almost € 600K and € 40K.[5]

[4] The end-user costs for utility buildings are more complex and have not been analysed in this project.

[5] In our calculations, we have spotted two outliers in the dataset: two stacked dwellings with 2,104 and 12,726 m^2 surface areas according to the building register database. For these dwellings, the resulting total costs over 30 years are respectively 1.2 and 5.5 million euros for the alternative gas-free scenario. Since we believe that these are faulty entries in the database, we have taken out the data point from our analysis for both scenarios in order to present a reasonable scale of costs.

Figure 21 - Total costs over 30 years per dwelling for heating with gas scenario

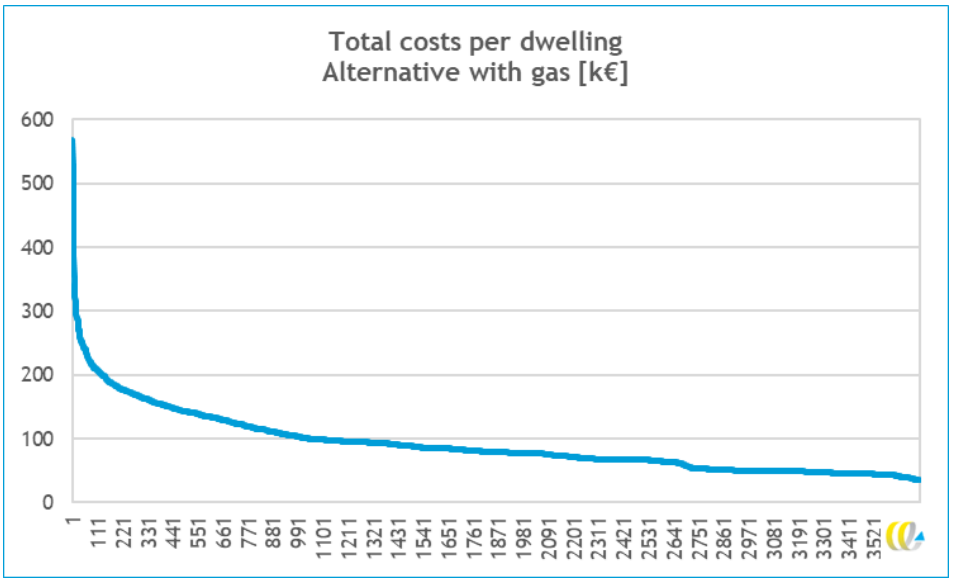
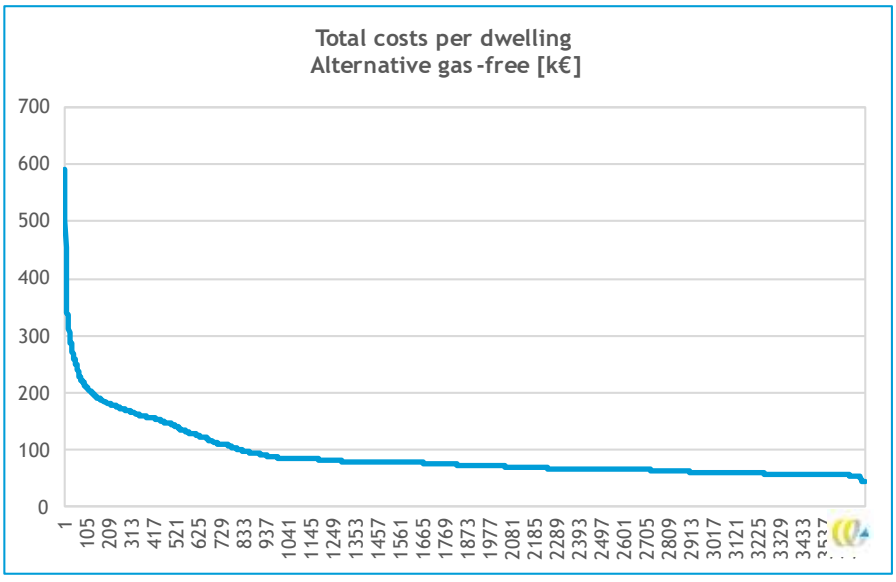


Figure 22 - Total costs over 30 years per dwelling for gas-free heating scenario



Our analysis shows that more than 70% of the dwellings in Heerlen Centrum needs between € 50K and € 100K in the next 30 years for the scenario with gas heating while it is between € 75K and € 125K for the gas-free heating scenario. The percentile distributions for both scenarios are shown in Figure 23 and Figure 24[6]. This is an indication for the room for investment to further implement the 5GDHC technology in Heerlen Centrum.

[6] The dwellings that are already connected to the 5GDHC network of Mijnwater are excluded from our calculations for both scenarios.

Figure 23 - Percentile distribution of total costs over the number of dwellings for heating with gas scenario

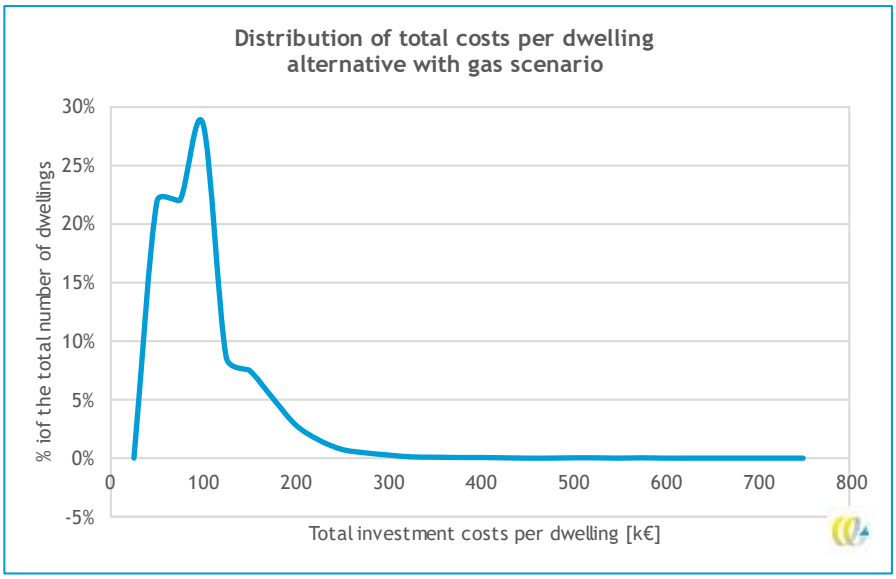
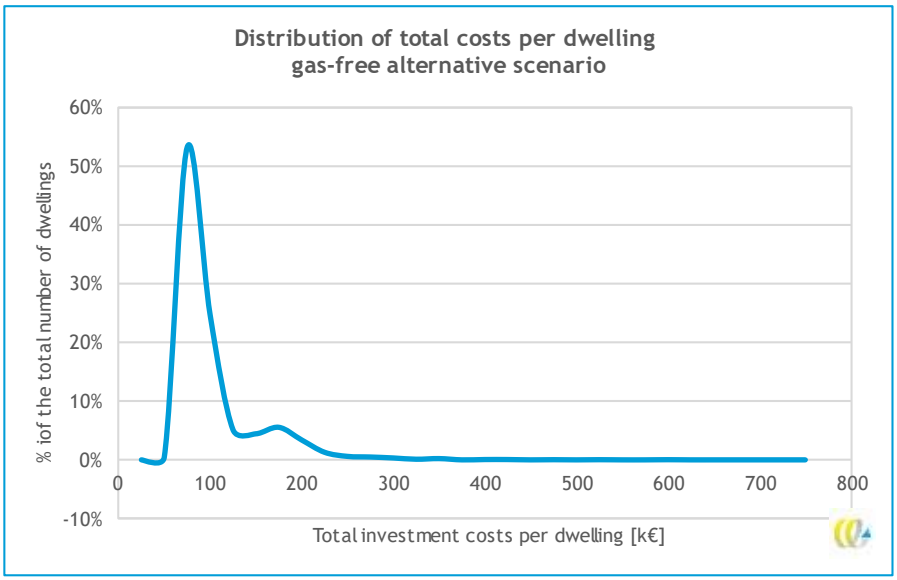


Figure 24 - Percentile distribution of total costs over the number of dwellings for gas-free heating scenario



End-user costs for most common dwellings

Figure 25 shows that the majority of the dwellings in Heerlen Centrum is of stacked type that is built in the period between 1946-1991. This section shows the different costs that add up to the total costs for the most common dwellings.

Figure 25 - Distribution of the number of dwellings over the type and construction year in Heerlen Centrum

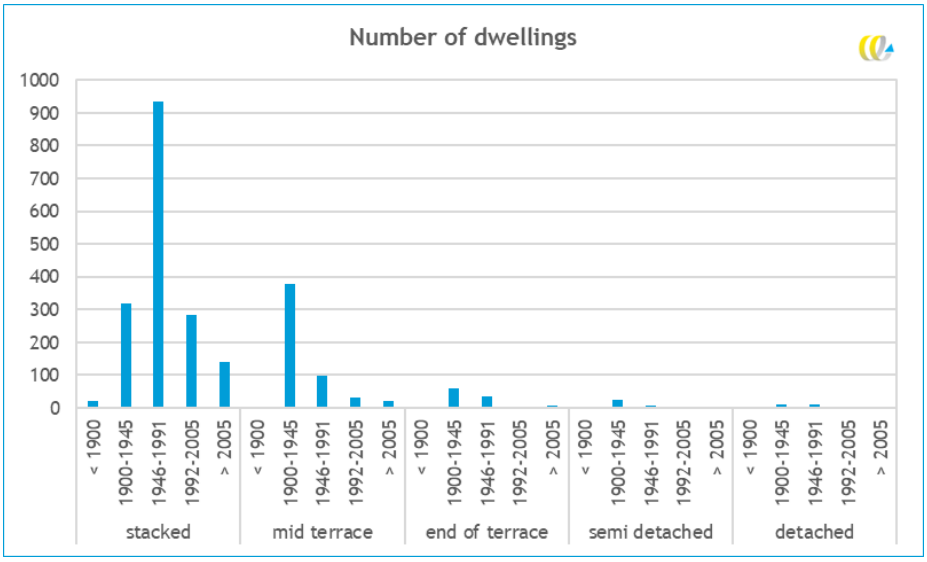
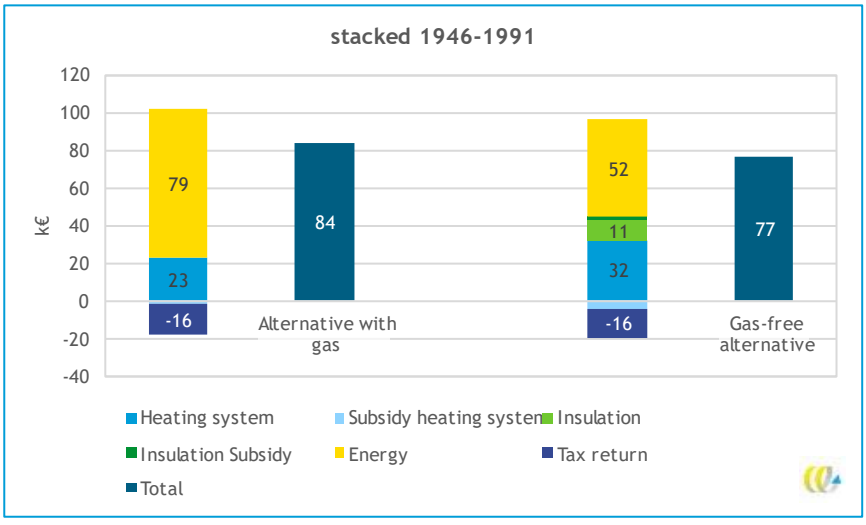


Figure 26 shows the breakdown of the average total costs over 30 years for the two alternative heating scenarios for this specific type of dwelling. For the alternative with gas, energy costs are the most important factor in the total costs. For the gas-free alternative, although the energy cost is the 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.

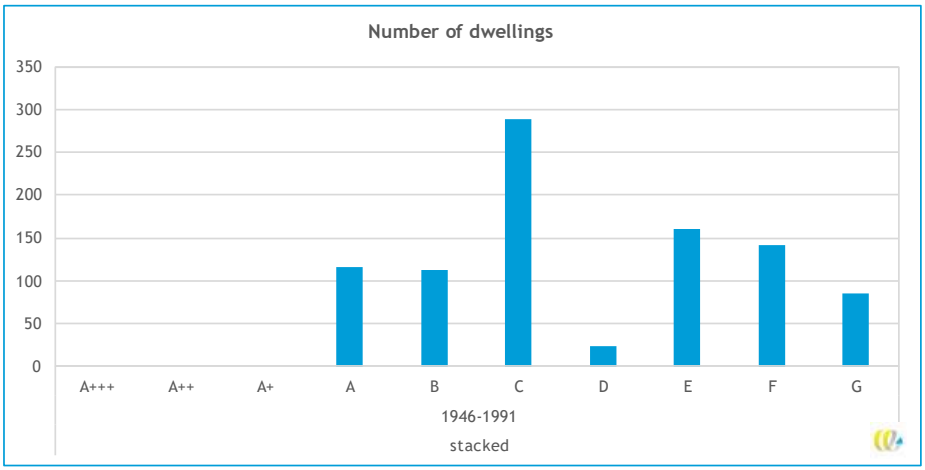
Figure 26 - Breakdown of the average total costs over 30 years for the alternative heating scenarios of a stacked dwelling built in the period 1946-1991



We can conclude that for the most common type of dwellings in Heerlen Centrum, considering 70 m^2 surface area per dwelling in the district, the room for investment for 5GDHC is maximum € 1,200 per m^2 surface area.

For the local action plan, we take a step further in our analysis. Figure 27 shows that the stacked dwellings in Heerlen Centrum have a variety of energy labels, with label C being the most common.

Figure 27 - Distribution of the number of dwellings over energy label and the construction year of the stacked dwellings built in the period 1946-1991 in Heerlen Centrum



A breakdown analysis of costs is shown in Figure 28, but then only for the average stacked dwelling with energy label C built in the period 1946-1991. Figure 29 shows the breakdowns for the same type of dwellings with energy label E. In contrary to the intuition, the average total costs for the gas-free alternative are higher for the dwellings with label C than for the dwellings with E label. This is due to the bigger surface area of the dwellings from 1946-1991 period with C label in Heerlen Centrum, in average 90 m^2, compared to the dwellings from the same period with E label, which is in average 58 m^2.

Figure 28 - Breakdown of total costs for alternative heating scenarios of a stacked dwelling with C energy label, built in the period 1946-1991

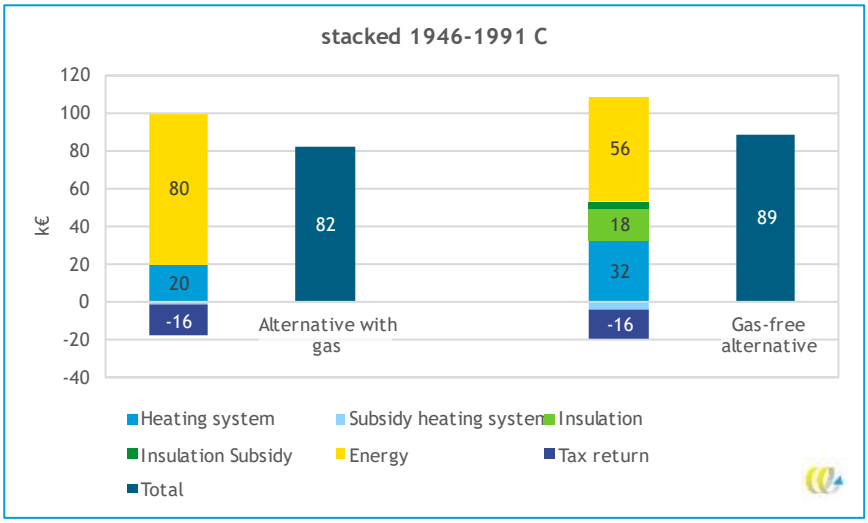
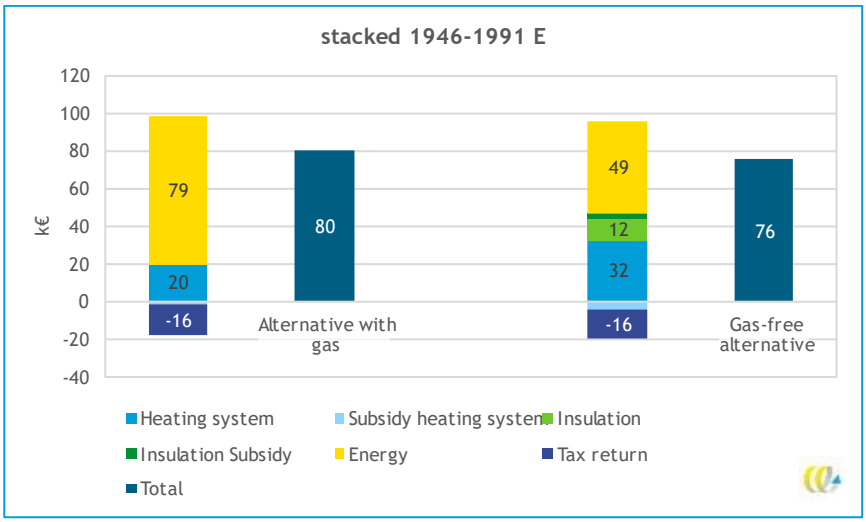


Figure 29 - Breakdown of total costs for alternative heating scenarios of a stacked dwelling with E energy label, built in the period 1946-1991



As a result, the room for investment per square meter is larger in a dwelling with energy label E, in average around € 1,350 per m^2, with respect to a dwelling with energy label C, which is in average approximately € 950 per m^2. In order to make 5GDHC financially attractive and competitive these figures need to be considered.

Another important factor is the energy costs per year, which is in average € 1,850 per year for a dwelling with C 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 types 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 already suitable to 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 wanting 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.

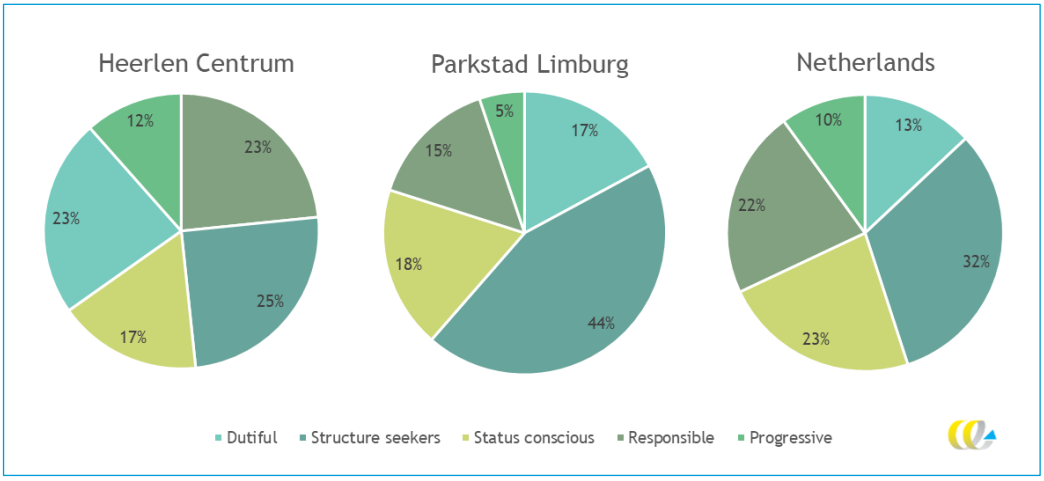
4.1 Five Shades Greener

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);

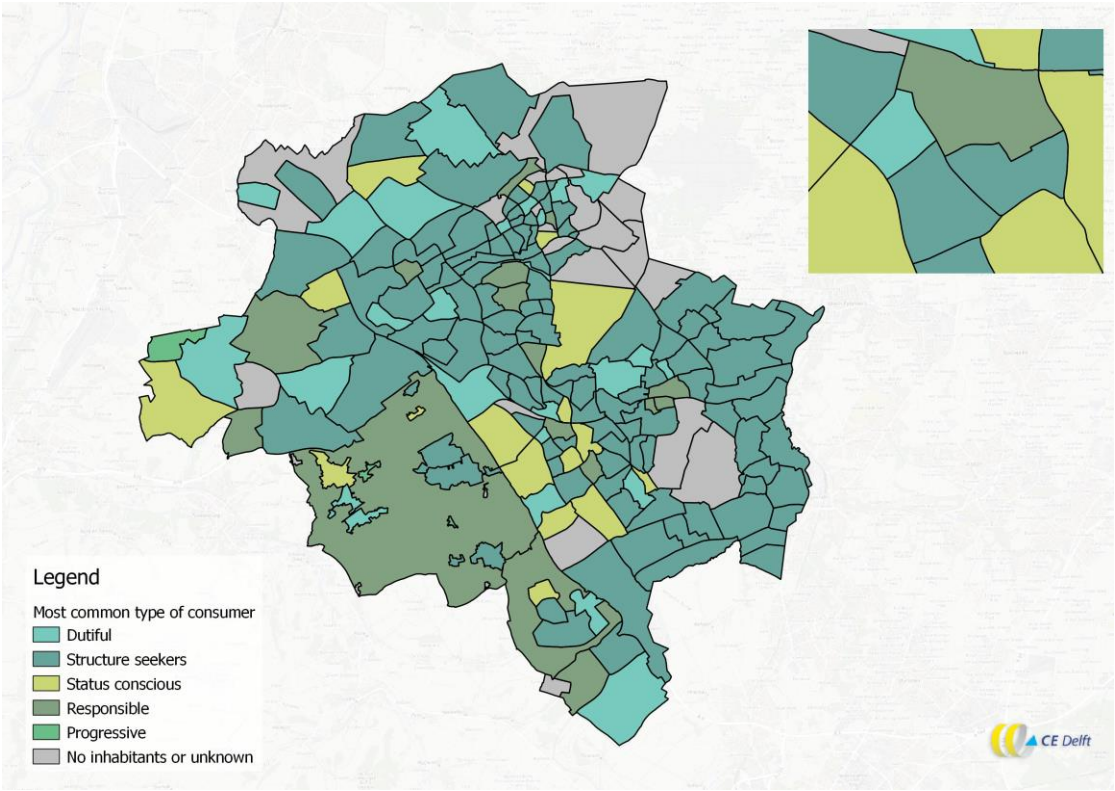
Characteristics of each group with respect to their attitude towards sustainability are presented in Appendix B. Figure 30 shows the percentile distribution of each group in the Netherlands, Parkstad Limburg and the selected area for this local action plan, namely Heerlen Centrum. Most of the people in all scales are represented by the structure seekers group, which are mostly benefit-oriented people. However, the percentage of structure seekers in Heerlen Centrum is much lower compared to Parkstad Limburg.

Figure 30 - Distribution of group of people in Heerlen Centrum (selected area), Parkstad Limburg and the Netherlands



Another positive statistic is the higher percentage of progressive people in the selected area Heerlen Centrum than the average in the Netherlands. When compared to the Parkstad Limburg area, Heerlen Centrum has a two times higher percentage of progressive people in the region. This makes the region more interesting for the implementation of a relatively new technology such as 5GDHC.

Figure 31 - The dominant group of people in all neighbourhoods in Parkstad Limburg and 4 neighbourhoods in Heerlen Centrum (right above)



As mentioned before, the largest group in the selected Heerlen Centrum area is the structure seekers, representing around 25% of the population in the four 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. However, compared to the rest of the Parkstad Limburg area, where the percentage of this group is 44%, the chances are higher that this group may be convinced for supporting the implementation of 5GDHC.

In Heerlen Centrum, ‘t Loon and Lindeveld most of the people are dutiful, well above the national average in the Netherlands, which means that they are already careful about their behaviour such as separating waste, energy saving and responsible consumption. As long as they are well informed about the situation and duties, 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 choices must be clear.

According to the research, responsible people constitute 23% of the total population in the four neighbourhoods. Similar to the group of people that are called dutiful, 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 & figures to this group.

As a result, we can conclude that the majority of the people in the selected area will be more likely to convince to adapt 5GDHC technology despite possible higher costs. However, the most important condition is to clearly communicate the plans, ins and outs of the technology and the impact on the sustainability goals as well as the financial stability of the inhabitants.

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 taken 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 its 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 considered 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 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. The plans and ambitions are not geographically specified. In the centrum of Heerlen however, solar projects will be constricted to rooftops.

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 270 TJ (74 GWh) of solar power produced electricity was planned in the municipality of Heerlen by 2020.

6 Conclusions

The regional analysis identifies the Heerlen Centrum district, containing four neighbourhoods, as promising for scaling up the 5GDHC network. In this study, we have taken a closer look at the district and identified opportunities and risks for scaling up of the 5GDHC network.

Opportunities:
- A 5GDHC network and the main infrastructure (the backbone) is already present in Heerlen Centrum.
- The Heerlen Centrum district has a high-urban density and mostly stacked buildings, which makes it more suitable for district heating.
- 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, which increases the opportunities for heating and cooling exchange.
- Heerlen Centrum has a high risk of a heat island effect. The heat island effect is lower when using 5GDHC compared to using an all-electric option with an outdoor unit.
- Roads that need to be broken up to install district heating infrastructure are usually constructed of removable pavement.
- Houses in Heerlen Centrum generally do not have front gardens, which makes it easier to connect them to district heating infrastructure.
- ATES storage is not restricted in Heerlen Centrum.
- Demand for cooling is expected to increase due to climate change.
- From the consumer groups identified, we can conclude that most people will be more likely to adopt 5GDHC technology despite possible higher costs.

Risks:
- In Heerlen Centrum 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.
- There are a lot of old buildings, which means that the streets are also old. It might be more difficult to install new infrastructure in the streets as well as in the buildings.
- Heerlen Centrum has large areas where the majority of buildings have poor energy performance. Higher temperature heat or insulation is needed before 5GDHC can be implemented.
- There are no high-temperature heat sources.
- 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 the Heerlen Centrum district, it is still promising for scaling up the 5GDHC network. Some risks are present and need to be taken into account in the implementation process. However, there are lots of opportunities in this region for 5GDHC. During the implementation process it is important to take into account the participation of residents and building owners. Local support is essential for a successful roll-out of 5GDHC.

7 References

CE Delft, 2020. *Adjusting environmental prices for human health: method of benefit transfers,* Delft: CE Delft.

Enexis, lopend. *Alle congestiemanagement onderzoeken*, Enexis Netbeheer, https://www.enexis.nl/zakelijk/aansluitingen/congestie-onderzoeken 2022.

Kadaster, 2020 *Luchtfoto/Landelijke Voorziening Beeldmateriaal* [Online] https://www.pdok.nl/introductie/-/article/luchtfoto-landelijke-voorziening-beeldmateriaal.

KNMI, 2014. *KNMI'14: klimaatscenario's voor Nederland*.

KNMI, 2017. *Klimaatbericht: Aantal koeldagen neemt sterk toe*, Koninklijk Nederlands Meteorologisch Instituut (KNMI), 26 juli 2017 https://www.knmi.nl/over-het-knmi/nieuws/aantal-koeldagen-neemt-sterk-toe.

Ministry of the Interior and Kingdom Relations, 2021. *The Environment and Planning Act of the Netherlands,* The Hague: Ministry of the Interior and Kingdom Relations.

Motivaction, 2018. *Vijf Tinten Groener*, Amsterdam: Motivaction.

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.

RES Zuid Limburg, 2021. *RES 1.0 Zuid-Limburg : Samen werken aan een duurzame regio*.

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.