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# PRELIMINARY FEASIBILITY ASSESSMENT FOR ROLLING OUT 5GDHC TECHNOLOGY IN 7 FOLLOWER REGIONS

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# Abbreviations

| | |
|---|---|
| EPB | EnergiePrestatie en Binnenklimaat |
| EPC | energieprestatiecertificaat |
| DH(C) | District heating (and cooling) |
| 5GDHC | $5^{th}$ generation DHC |
| DER | Distributed Energy Resources |
| NECP | National Energy and Climate Plan |
| VITO | Vlaamse Instelling Technologisch Onderzoek |
| VILT | Vlaamse Infocentrum land- en tuinbouw |
| FEBEG | Federatie van de Belgische Elektriciteits- en gasbedrijven |
| VBO | Verbond van Belgische Ondernemingen |
| ODE | Organisatie voor Duurzame Energie |
| VREG | Vlaamse Regulator van de Elektriciteits- en Gasmarkt |
| TWh | TerraWatt Hour |
| CREG | Commission for Electricity and Gas Regulation |
| SME | Small and medium-sized enterprises |
| VEA | Vlaams Energie- en Klimaatagentschap |
| POM | Provinciale Ontwikkelingsmaatschappij |
| KMO | kleine of middelgrote onderneming |
| EU | European Union |
| ETS | Emission Trading System |
| Mton | Million ton |
| CO2-eq/year | Carbondioxide equivalents per year |
| CHP | Combined heat and power |
| SERV | Sociaal-economische Raad van Vlaanderen |
| VLAREM | Vlaams Reglement betreffende de Milieuvergunning |
| VCRO | Flemish Codex Spatial Planning |
| BTES | Borehole Thermal Energy Storage |
| ATES | Aquifer Thermal Energy Storage |
| PJ | Picojoule |
| MW | Mega Watt |
| GWh | Giga Watt hour |
| MWh | Mega Watt hour |
| MWh/a | Mega Watt hour per year |
| KWO | Koude- en warmteopslag |
| R&D | Research & Development |
| GDP | Gross Domestic Product |
| VME | Vereniging mede-eigenaars |

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# 1. Introduction

Activities in the long-term work package aim to sustain and roll out D2Grids outputs to a wide variety of target groups, including policymakers, financial investors, professionals, SMEs and other companies in the DHC industry, as well as to new territories (“follower regions”). Transnational roll-out beyond pilot sites will be facilitated by assessing replication potential of 5GDHC in these follower regions and preparing specific local action plans. This document provides a regional vision development and preliminary feasibility assessment for rolling out 5GDHC technology in one of the 7 follower regions defined for this project, namely: Parkstad Limburg (NL); North-East France; Luxembourg; Flanders (BE); Ruhr-area (DE); Scotland; East Midlands (UK). It aims to define ambitions for low-carbon heating & cooling and to assess the feasibility and potential of 5GDHC's roll-out.

The D2Grids project, has ambitious goals for the future. Five years after the project ends, 2 million $m^2$ of floor area in North-West Europe should be served by 5GDHC, of which 1.5 million $m^2$ by scaling up the D2Grids pilots and 0.5 million $m^2$ by rolling out into the follower regions. The overall capacity of these 5GDHC systems should be 180,000 MWh/a, including 100,000 MWh/a additional renewable energy source capacity. 10 years after the end of D2Grids, the total floor area should be 5 million $m^2$ and the overall capacity 450,000 MWh/a. This document presents a template for regional vision development, which describes ambitions of each of the follower regions on how the region can contribute towards this goal of 0.5 million $m^2$ of floor area after 5 years. To inform this regional vision, a preliminary feasibility assessment is conducted first (see D.LT.1.1).

The goal of the feasibility assessment is to find the potential of deploying 5GDHC in the follower regions within 5 years after the project ends, as well as finding possible longer-term opportunities. This is done by mapping strengths, weaknesses, barriers, and opportunities of 5GDHC for each of the follower regions. The assessment consists of 5 categories: renewable sources; existing infrastructure and planned developments; thermal demand & supply profiles; legal & policy framework; financing options.

# 2. Characterising the region

In this report, the entire follower region of Flanders is being analysed.

**Political environment** - It is important to understand that Flanders is part of Belgium, which has a complex institutional organization. In total, Belgium consists of three regions (Flanders, Wallonia and Brussels-Capital region), three language communities (Flemish Community, French Community, German-speaking Community) and a federal government. Each of them has its own responsibilities and government. The result of this is that, about some topics, there are overlapping responsibilities. For instance, about energy and climate, each region and the federal government has its own responsibilities. Consequently, energy policy in Wallonia and Flanders differs from each other, and there are certain regulations which are not decided by the Flemish Government but by the Federal government. The political climate in Flanders (and Belgium as a whole) is therefore very unstable, which creates a lot of uncertainty about legislation and continuation of legislation.

**Energy usage and climate ambitions** - Flanders is highly relying on gas for its heating purposes. District heating only takes up a very small place in Flanders. Fossil fuels are therefore widely spread in Flanders. While all EU Member States are increasing their levels of renewable energy production and energy efficiency, it should be noted that the Flemish climate policy plan for 2030 is not very ambitious in the sense that it only aims to reduce greenhouse gas emissions by 35% (compared to 2005) while Europe is setting this goal at a reduction level of 50-55%.

**Energy-efficiency of buildings** - The build environment in Flanders shows evidence of older, low energy-performing buildings. Nevertheless, Flanders is a very densely populated region which makes it suitable for collective systems such as DHC grids. As most buildings are not very energy-efficient, heat demand is quite high. This could be a good match with the many sources of high temperature residual heat that can be found in the region, although this is not necessarily a good match for 5GDHC grids.

# 3. Analysis

In what follows, a more detailed analysis of Flanders is given. Specifically, we zoom in on the heating context, on the position of District Heating and on the type of energy sources and storage available in Flanders.

## 3.1. Heating regime

### 3.1.1. Current dominant heating technology or carrier in the region

*Currently dominant heating technology in the region*

Belgium (and therefore Flanders as well) has a history of gas usage. By 1850, each middle-large city in Belgium already possessed its own gas factory. Starting from 1932, a long-distance gas network was developed which was expanded throughout the year. Today, the total network length is about 4,000 km. This network size has in part been reached since the government was pushing access to natural gas for heating. For Flanders, for instance, the energy decree mentioned until the end of 2016 that by 2020 99% of all buildings in urban regions and 95% of all buildings in rural regions should have access to a gas connection. (MINARAAD, 2017) Belgium is not producing natural gas but is quite well located as it takes up a central position in the transport of natural gas through Europe.

However, changes are needed as Belgium's gas network consists of two parts. One part serves high-calorific gas, and one part serves low-calorific gas. The low-caloric gas is exported from the Groningen field in the Netherlands, which will be phased out starting from 2024 (potentially even earlier) (De Cleene, 2018). Currently, Belgium is importing about one third of its gas consumption from the Netherlands. If Belgium wants to continue using gas, it will need to adapt the part of the gas network which is now adapted to the low-caloric gas of the Netherlands. In addition, all domestic appliances and pressure regulators will require check-ups and possible upgrades (Van Horenbeek, 2017). Synergrid, the federation of transmission- and distribution grid operators for energy, started making the transformation from low-caloric to high-caloric gas networks with an indicative planning from 2018-2029 (FEBEG, 2016). The conversion affects about 1.6 million private customers and commercial entities (Gaschanges.be, 2021). The additional investments in the gas network raise the question whether this upgrade is a good investment as some countries are already phasing out gas in line with climate targets. The European Commission calls for a climate-neutral Europe by 2050 (European Commission, 2021). In addition, the transition to other energy-efficient energy technologies could bring along a lower demand for gas, leading to the issue of 'stranded costs' as the costs of the network are fixed and to be depreciated over longer time periods (VBO, 2017).

Apart from gas, oil is also used frequently by Flemish households. In total, about 90% of households in Flanders uses either gas or oil to heat up their houses. (ODE, 2019b)

*District heating in the current heating regime*

Given its gas history, district heating is only taking up a very small proportion of the heat consumption. There is also no national approach towards DHC. This is in part explained by the fact that the Belgian Federal State consists of three regions (the Flemish Region, the Walloon Region, and the Brussels Capital Region) which each have specific competences for their territory. Energy is in part a federal responsibility, but also a regional responsibility. About district heating, more initiatives can therefore be found on a regional level instead of on a national level.

For Flanders, in April 2019, there were a total number of 56 district heating grids. The VREG categorizes them in four categories (VREG, 2020b):

- 6 networks are small networks with less than 100 (mostly residential) consumers;
- 18 networks are larger networks with more than 100 (mostly residential) consumers;
- 25 networks mostly contain small commercial or public buildings (such as hospitals, schools…);
- 7 networks mostly contain industrial consumers.

Especially when looking at the total heat delivered within these networks, it becomes clear that district heating in Flanders mostly serves heat delivery to non-residential consumers (more than 2/3th of the heat in district heating grids). In total, in 2019, 316,5 GWh (VREG, 2020b) heat was delivered to district heating grids in Flanders. Compared to countries like Sweden and Denmark, this is not a lot. Compared to gas, in 2017, the total measured gas demand of Belgian end consumers was about 182 TWh (FPS Economy, 2019).

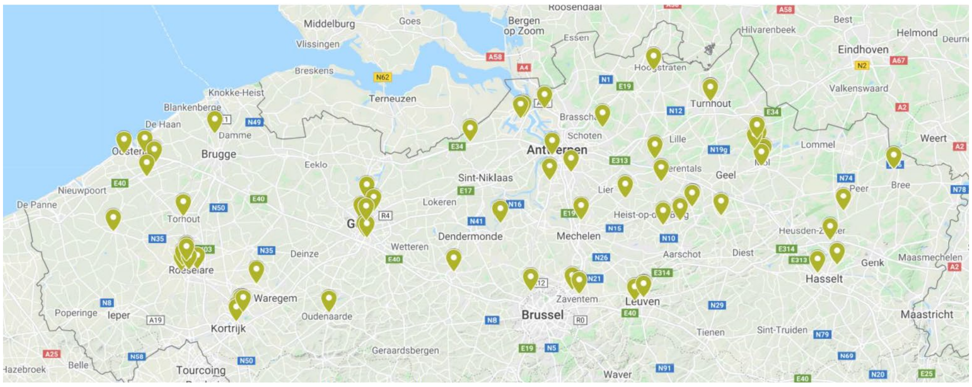

**Figure 1 - VREG map district heating networks Flanders (Webinar warmtenetten 15 juni 2020 (VREG, 2020c))**

## *Main actors in the current heating regime*

**Gas market**

| | |
|---|---|
| **General actors** | |
| VREG | Since December 2001, VREG is the independent authority that regulates and controls the Flemish energy market. They were founded in part to facilitate the liberalization of the Flemish electricity- and gas market. Their tasks, responsibility, working and management are dictated in Chapter I, title III, of the Energy Decree (Energiedecreet). Specifically, for gas (and electricity), VREG sets up technical rules that distribution operators need to follow when operating their grids, they approve grid tariffs and determine the grid tariff methodology, they control the market and grant supply permits to suppliers, they monitor the market, advice policy makers… (VREG, 2021) |
| CREG | The CREG is the federal, independent organization responsible for the regulation of the electricity and gas market in Belgium. The CREG is also responsible for setting social maximum prices. This is not the responsibility of regional regulators (such as the VREG for Flanders). |
| FEBEG | FEBEG is a Belgian employer federation that represents producers of electricity, and importers and suppliers of electricity and gas. With regard to gas, they are therefore only concerned with the import and supply of gas. They represent large industrial companies (33 members) who employ about 7.700 employees. (FEBEG, 2021b) |
| **Input, transport, distribution, supply** | |
| Input stakeholders | Gas is imported in Belgium either through underground or underseas pipelines, or per ship through the gas terminal in Zeebrugge. |
| Fluxys | Fluxys is operating about 4.000 km of high-pressure gas transmission grids in Belgium. It is a fully independent gas infrastructure group with headquarters in Belgium. |
| Distribution System Operators | Fluxys (transmission grid) transports gas to 17 Distribution system operators who operate a total of 70.000 km of low-pressure gas grids. Formerly they were intercommunal companies. The distribution system operators ensure |

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|---|---|
| | consumer connection to the grid, they ensure the gas of the dedicated gas supplier is supplied to the consumer and they are responsible for meter measurements. |
| Gas suppliers | There are 20 gas suppliers who supply gas on the low-pressure gas grid. Suppliers need to have a supply permit to be allowed to supply gas. This permit proves they have sufficient technical and financial means to supply gas. The supplier is responsible for all commercial services and is responsible for invoices. |
| BALANSYS<br>BALANSYS | As from the first of June 2020, the Luxembourg gas transmission system operator (CREOS Luxembourg) and the Belgian TSO Fluxys Belgium worked together to integrate their national markets. BALANSYS as a joint venture manages the commercial balancing of this integrated market. |
| **(sub-)Consumers** | |
| Large industrial end-users | In Belgium, about 200 large industrial end-users are directly connected to the gas transmission grid. In addition, 19 CHPs are connected to the gas transmission grid. Gas supply of industrial consumers connect to the transport network can be interrupted. |
| Power stations | A total of 18 power stations are connected to the gas transmission grid. Power generation from gas has declined mainly due to the closure of CCGT's. However, with the (partly) nuclear exit, it is to be expected that the gas demand by power stations might increase again. |
| Households | About 2,9 million households in Belgium are supplied by the low-pressure gas grid. Together with the SMEs, they are supplied by 20 gas suppliers. Gas consumption in Belgium is quite seasonal due to the large size and importance of the household group in the gas demand. Gas demand for this group is highly temperature dependent as they use it for space and water heating. |
| SMEs | About 100.000 SMEs are supplied through the low-pressure gas grid. |

**District heating**

| | |
|---|---|
| **General actors** | |
| VREG<br>VREG ENERGIE WIJZER | VREG (VREG, 2021) is the independent authority of the Flemish energy market of today and tomorrow. Originally, their mission was to regulate and monitor the Flemish electricity and gas markets, but in the revised Energy Decree of 2019, they also become responsible for specific tasks regarding district heating and cooling grids. Such tasks include informing consumers of DHC grids (prices, conditions), controlling service delivery by heat- and cold suppliers to residential consumers, controlling reliability of DHC grids, arbitrating between consumers and heat/cold suppliers in case of discussions, controlling the implementation of the energy decree, provisioning of studies and statistics to the minister, controlling on the technical regulations, sanctioning in case of not following regulation… |
| VEA<br>VLAAMS ENERGIEAGENTSCHAP | Het Vlaamse Energieagentschap is the Flemish Energy Agency and is responsible for the implementation of a sustainable energy policy. Its role is to stimulate rational and sustainable energy consumption and production. Its focus is mostly on policy preparation, - implementation, awareness creation, reinforcement, policy evaluation… |
| Heat Network Flanders (Warmtenetwerk Vlaanderen)<br>warmtenetwerk Vlaanderen | Originally, Heat Network is a Dutch non-profit foundation. Heat Network Flanders is a department for Flanders of this foundation. The Foundation organizes in the Flemish region active discussions with stakeholders involved in district heating and cooling grids in Flanders. As of 2019, Heat Network Flanders has over 70 members, mostly residual heat generators, grid operators, operators of district heating and cooling grids, knowledge |

| | |
|---|---|
| | centers, consultancy companies, suppliers… The foundation also provides up to date information regarding the current regulation, market development, financial support measurements… They organize study days and an annual conference. (ODE, 2021) |
| **DH operators, financiers, heat producers** | |
| Cooperatives | In Flanders, some cooperatives (Beauvent, Zonnige Kempen, Ecopower…) are investing in and operating DH grids. |
| Energy suppliers | In Gent, Luminus is operating the city district heating grid. One of its electricity plants is linked to the DH grid through which residual heat from the plant is distributed to different buildings in the city. |
| Public grid utility company | Fluvius is the Flemish utility company that builds and operates electricity and gas grids. Fluvius is also operating/building some district heating grids in Flanders (Antwerpen Nieuw Zuid, Mol and Dessel, Turnhout-Niefhout, Roeselare-Hooglede, Kuurne-Harelbeke…) and is looking for other locations in the future. |
| Provinces, cities, municipalities | Many cities and municipalities are stepping up to develop or support DH in their region. Examples are the city of Leuven, Turnhout, Aalst, Antwerp, Gent, Roeselare… On top of that, provinces such as POM West-Vlaanderen are also taking up their responsibility in asking for (for instance) feasibility studies. |
| Waste treatment | ISVAG, IVAGO, IVBO, I.V.M., IVOO, MIROM, IOK, IMOG… are all waste treatment facilities. Many existing district heating grids are linked to waste treatment facilities or are considering district heating. |
| **(sub-)Consumers** | |
| VME | Collective buildings like appartements are obliged to have a VME (Vereniging van mede-eigenaars) or a syndicus who takes up collective tasks for the building. Often, collective buildings have some sort of collective heating installation for all inhabitants. With regard to district heating, in such case it is highly likely that the VME will be the contact point for the district heating operator. |

## *Legal framework and operational context for these actors*

**Gas market Regulation**

In April 1965, the "gas law" (Kruispuntbank Wetgeving, 1965), which regulates the transport of gas products through pipes (Federale overheid, 1965) in Belgium was developed. With the liberalisation of the energy markets, the EU set up some common rules regarding the transport, distribution, supply and storage of gas, the organisation of the gas sector, access to the market, obligations and the development of regulatory organisations who control the market. The European directives were transposed into the Belgian law of the 1th of June 2005 (Economie, KMO, Middenstand en Energie, 2005) and hereby changed the original gas law of the 12th of April 1965.

On top of this law, there is other regulation specifically regarding security and technical obligations of technical installations. Examples are:

- Royal Resolution (Koninklijk Besluit) of 19th of March 2017 regarding the security measures of the development and exploitation of installations for the transport of gas products and other by means of pipes. (ECONOMIE, KMO, MIDDENSTAND EN ENERGIE, 2017)
- Technical codes regarding design and construction, exploitation, risk analysis, management system for security

**District heating Regulation**

In Belgium, there is a division of competences between different regions (the Flemish Region, the Walloon Region and the Brussels Capital Region). As a result, there is no national policy with regard to DHC. Policies towards DHC and (renewable) energy policies are mostly regionalized and until recently, there was not really a clear framework for district heating. Only since 2017, in Flanders, a heat- or cold network is defined in the Energy Decree as a set of interconnected pipes and the associated resources that are necessary for district heating or cooling, with the exclusion of networks on an industrial site (art. 1.1.3., 133/2°). District heating or cooling is defined in the Energy Decree as the distribution of thermal energy in the form of steam, hot water, or cooled liquids from a central production installation via a network that is connected to several buildings or locations, for heating or cooling of spaces or processes (art. 1.1.3., 113/1/1°).

Since April 1, 2019, the energy decree (Energiedecreet) has been amended to regulate the organization of the operation of heat and cold networks in the Flemish Region; and the energy executive order (Energiebesluit) has been adapted to regulate the organization of the operation of heat and cold networks and heat metering in the Flemish Region. This is mainly a response to the 2012/27 / EU directive of the European Commission on energy efficiency. Also, the decree regulating the role of the local advisory committee in the context of the right to minimum supply of electricity, gas and water (replacement decree 19 July 2013, art 3, I: 2 September 2013) and the supply of thermal energy (submitted decree on the 10th of March 2017, art. 2, I: 1 April 2019) adjusted so that it also became applicable for the supply of thermal energy (Flemish Government, 2019c). The same applies to the executive order of the Flemish Government regarding the composition and operation of the local advisory committee regarding the minimum supply of electricity, gas and water and the supply of thermal energy (submitted 1 February 2019, art. 1, implemented 1 April 2019). Note also that the requirements for heat meters are already laid down in the Royal Decree on measuring instruments (April 15, 2016). Finally, the VREG published on the 2nd of June 2020 an advice regarding changes needed due to Art. 9-11bis and appendix VIIbis of the Energy-efficiency directive of 2018/2002 and in the regulatory framework for heating, cooling and hot water supply through heat networks or through central production installations ("collective heating"). In this advice, the VREG is also highlighting potential changes needed in some of the current articles in the energy executive order (Energiebesluit) as they do not always have the desired impact. The advice is also giving suggestions for further, more transparent, and accurate calculations of individual heat consumption and the division of costs of thermal or hot water consumption. (VREG, 2020a)

A more detailed explanation of the most relevant heat regulations for Flanders can be found below:

- **The Energy Decree (Energiedecreet)** of the 8th of May 2009, which contains since March 2017 a framework regarding the organization of the operation of heat and cooling networks in the Flemish region (Title IV/1). (Vlaamse Overheid, 2009) It now explains what a DH or DC grid is, how residential consumers can be protected, what the role of a DH operator is (operation, development, measurements, communication on tariffs), and what the role of the heat supplier is (supply, invoice, social energy measurements, complaints management). It also details the tasks that the VREG receives. That is, the VREG is responsible to inform people about district heating, the buildup knowledge, to keep an overview over all networks and to advice regarding for instance the transposition of the energy efficiency directive. Finally, it also dictates specific technical obligations, among which heat metering. The framework is in implementation since April 2019. (Vlaamse Overheid, 2017)
- **The Energy Executive Order ("Energiebesluit")** of the 19th of November 2010, which was amended on the 1st of February 2019 regarding the regulation of the role of the local advisory commission in the framework of the right on minimum delivery of electricity, gas, and water and the delivery of thermal energy. (Vlaamse Overheid, 2017) The framework is in implementation since April 2019. The Executive Order is setting social energy measures, information obligations for suppliers, and other tasks of the DHC operators (such as reporting obligations).
- The rules regarding central heat meters (Energiesparen.be, 2021b) are mentioned in the **Royal Order of 15th of April 2016** (Federale overheidsdienst economie, K.M.O., middenstand en energie, 2016) regarding measurement instruments. It discusses the minimal requirements of such meters. In December 2016 (Vlaamse Regering, 2016), these new rules were also accepted by the Flemish Government and published in het Belgisch Staatsblad on the 23rd of January 2017.

**<u>Other District Heating Regulations</u>**

A recent study of (Loth, 2020) gave a very detailed overview of all regulations in Flanders that have an influence on district heating implementation. For a more detailed analysis we therefore refer to their study. For this report, we will give a concise overview of regulations that indirectly influence the possibilities to implement 5GDHC.

**Flemish political vision and climate context:**

- **Climate ambitions:** Flanders agreed to reduce its emissions to help reaching the European climate goals. However, Flanders (and Belgium in general) is not ambitious. Flanders' goal is to reduce their emissions of non-ETS (Emission Trading System) sectors by 2050 with 85% compared to 2005 (so not 100% compared to many other countries). In addition, to reach this target, Flanders is not on track as it acknowledges that it should do more efforts to achieve climate targets by 2050. Between 2005 and 2017, non-ETS emissions in Flanders decreased on average with 0,2 Mton CO2-eq/year. Yet, to achieve a reduction of 85% by 2050, an average reduction of minimum 1,1 Mton CO2-eq/year is needed. (Vlaamse Regering, 2019b)
- **Flemish coalition agreement:** The Flemish Government aims to achieve a long-term target by 2050 for housing renovation of (on average) 100 kWh/m². To do so, from 2021 onwards, new oil boilers cannot be installed anymore for new buildings and for serious renovations. Gas connections are for large new parcels or for large apartment buildings only allowed for collective heating via CHPs or in combination with renewable energy systems as main heating source. (Vlaamse Regering, 2019a)
  The Flemish government will prolong support for CHPs for 10 years. The current certificates for heat power savings will only gradually be reduced (with 30% by 2025) in line with evolutions of gas/electricity changes and other support mechanisms.
  Regarding renewable energy production, the Flemish Government has 2 important working points. One is focusing on electricity production, the second is focusing in making heat greener. In this framework, they will work out a heat plan and support local municipalities. They will also provide support for new deep geothermal projects.

**Heat vision**

In 2015, all Belgian regions and the Federal government agreed upon a division of the Belgian climate targets regarding renewable energy by 2020. To achieve the regional objectives, new measurements need to be taken and for heating more ambition was needed. With the new targets, 9.197 GWh green heat needs to be produced by 2020. Yet, with the existing policy measurements, Flanders would only produce 8.765 GWh. Therefore, in June 2017, the Flemish Government approved the **Heat Plan 2020** (Warmteplan 2020 (Vlaamse Regering, 2017b) to determine additional measurement in the short run to achieve the green heat targets.

In the longer run, the National energy- and climate plan 2021-2030 (Federale overheid, 2019), gives a continuous important role to district heating in Flanders. In the period 2017-2020, a yearly growth of 250 GWh/year in DH was planned and the plan is to continue this growth until 2030. This would imply that by 2030, 4000 GWh of heat is delivered by DH grids (compared to 600 GWh in 2017). The heat provided in DH grids consists for approximately 50% out of renewable energy sources in 2020 (in 2017, this was about 37%). Most of this heat is produced through geothermal energy (mostly deep, see further in the discussion on deep geothermal energy), heat pumps, biomass incineration and solar boilers. District heating is seen as a tool to further promote heat distribution of these renewable energy sources. In the following years, the goal is to reevaluate the call green heat, the EPB-regulation and the legislative framework to ensure there are sufficient incentives for green heat.

For 2025, and even 2030, a **new heat plan** is being developed to further increase green heat production. In the Flemish climate plan (Federale overheid, 2019), it is explicitly stated that it will almost always be more cost efficient to obtain impact on climate targets by having more green heat than through green power.

Nevertheless, for a good "heat vision", it is necessary that more concrete "spatial" plans are set up such as local heat plans by cities or municipalities. As can be seen in the next topic on spatial planning, this is currently not the case.

**Spatial vision and/or development**

Currently, no clear spatial vision regarding heating is present in Flanders. Yet, the actions documented below should lead to a more concrete heat vision in the short run.

In November 2016, the Flemish government sets up a "white book" for the **spatial development of Flanders** (Vlaamse Regering, 2017a). The document makes specific reference to district heating. Specifically, it mentions that 1) residual energy demand needs to be filled in by means of energy sources such as CHPs, heat pumps and/or DHC grids, and that the necessary space needs to be foreseen for these technologies; 2) energy exchange needs to be organized spatially by

bringing together functions in buildings, building blocks, areas, industrial sites…; 3) energy infrastructure needs to be bundled where possible, for instance by foreseeing underground pipe- and cable lanes; 4) the Flemish spatial policy is also largely focusing on seaports as these are important for Flanders. These ports have a large potential for residual heat which is acknowledge in the document. In general, to increase energy efficiency, the supply of residual heat through a district heating grid should be encouraged. 5) To increase energy efficiency, it is also important to look at existing areas, whereas currently, heat networks are mostly developed in newly build areas. Specifically, further goals should be to examine in the short run the possibilities for district heating. Concrete actions indicated in the document state that local governments will receive more means to further develop DHC grids, some strategic heat projects (such as energielandschappen 2.0 with the province of East-Flanders, feasibility study for DH in Limburg) and reinforcements of the seaports.
For the government period 2019-2024, **heat zone plans** (warmtezoneringsplannen) are being prepared based on data on energy consumption and -production, based on the availability of new or residual heat sources, based on the possibility to develop DHC grids, and based on the possibility of new decentral (and preferably renewable) heat production… (Federale overheid, 2019) This will help citizens and companies to make proper investment decisions. As indicated by the "stroomgroep", heat zone plans should for instance only encourage heat pumps in regions where no district heating will be developed (Stroomgroep hernieuwbare energie: groene stroom en warmte, 2019).
In line with this, the SERV also indicated in its vision document of 2019 that it is important to properly synchronize different measurements. That is, for instance in zones where district heating is/will be developed, to adapt the level of renovations of buildings to infrastructure plans. (SERV, 2019)

Finally, with regard to spatial planning, there are some instruments that are used to plan, control or restrict new infrastructural investments.

- The **Flemish Codex Spatial Planning (VCRO)**: this Codex regulates the use of the topsoil. It states whether certain functions are compatible with the planning destination. This is governed through the usage of Permit Requirements. Only under certain conditions, such a permit is not allowed. For instance, in case of "usual underground constructions", the installation/infrastructure is exempted from the permits. DHC grids are, however, not perceived as being "usual underground constructions". Similar rules apply to the necessity of having environmental permits for the construction of both above ground and underground structures. (Loth, 2020) The VLAREM environmental permit for instance put specific requirements on the application of geothermal projects. Geothermal projects are also subject to the so-called VLAREL regulations. The **VLAREM-rules** dictate that for certain permit applications, a cost benefit analysis needs to be performed to examine the usage of CHPs or residual heat (via district heating).
- **Regulations of other infrastructure companies** such as Water, Railways, Roads, Bridges… can also pose serious limitations to whether a DHC grid can be installed.
- The **Energy Executive Order** is stating that it is obliged to perform a feasibility study for new larger buildings (>1000 m²) to see whether alternative energy systems are feasible and cost-effective. In this context it is also required to check the connection to a heat network. The study is required for a zone of 500 meters from the designated locations on the Flemish heat map. (Loth, 2020)
- **Soil Decree, Vlarebo, Waste policy, Groundwater decree**: when making use of groundwater or the soil, it is necessary to ensure environmental quality standards are maintained.

**Other regulations impacting District Heating**

- The **EPB sets rules and regulations**, which determine how energy efficient buildings should be, are not favorable for DHC grids. Within the EPB-methodology, specific attention is given to heat delivery, but also to the generation of energy. As such, EPB is having an influence on the type of heating and generation technologies that are used. Specifically, when DHC grids do not make use of renewable energy sources, EPB is punishing the system. Nevertheless, in a lot of cases, DHC grids start with non-renewable energy sources to evolve later to more renewable sources. Furthermore, DHC grids are punished for heat losses that they have through the piping system and for the electricity usage of circulating warm water in the grid.

## *Current organization of heating markets*

**Gas market**

The Belgian gas market is split up in 3 regions (Flanders, Brussels, and Wallonia). Since the liberalisation of the energy market (gas and electricity), transmission, distribution and supply of gas are split up between different actors. These actors and their roles are discussed in the table above. Before the liberalization of the gas market, the entire market was managed by Distrigaz. The European Directive 2003/55/EG of the 26th of June 2003 was transposed into the Belgian law of the first of June 2005 who changed the original gas law of the 12th of April 1965. Originally, the gas sector was fully vertically integrated ("bundled"), implying that production, input, transport, distribution and supply of gas were taken up by one actor. Since January 2007, transport and distribution of gas are disconnected (unbundled) from all other activities in Belgium (in Flanders, this is already the case since June 2003). This led to more competition in the sector. Gas suppliers can buy gas through gas producers directly, or on the gas stock market. (FEBEG, 2021a) As such, only the transport and distribution of gas remain a monopolistic activity where no competition is possible. All other activities are liberalized and open to all (qualified) actors.

**District heating**

Flemish regulation does not require unbundling and one party is allowed to take up multiple roles. In addition, no permits are required to execute the role of heat supplier or operator. It is therefore sufficient if the roles are clearly determined in the contractual agreements of the DH grids in Flanders. As such, everybody can take up these roles if they follow the obligations stipulated by law.

- Specifically, for Flanders, this implies that, currently, many stakeholders take up multiple roles at the same time. As such, there is no pure unbundling in Flanders. In most cases operation of the heat grid and supply of heat is done by the same party. This was the case for 49 of the 56 DH networks that we registered by the VREG in April 2019 (see Table 1 in the report of (VREG, 2020b)). This is in part also caused by the fact that district heating grids in Flanders are only of limited size.
- In case a district heating grid is supplying collective residential buildings (apartments), in most cases two heat suppliers exist. The first heat supplier supplies heat to the building and has a contract with the VME. Afterwards, the VME supplies the end-users behind the building meter. Recently, in line with the European Directive on Energy-efficiency, it is regulated by law what the rules are for the division of such heat costs between different end-users in the same building. This is leading to additional obligations for the VME who is seen as a heat supplier. In addition, VREG is indicating that it is in such schemes not clear who is responsible for which part of the network as there is no clear definition of where the DH grid stops. This is important for responsibility regarding maintenance of the grid, but also when it comes to consumers who are not paying their invoices.
- Finally, there are some rare cases where multiple heat network operators and heat suppliers are acting on one network (Bocholt (DH Bocholt – DH Scholen van Morgen Bocholt) and in Roeselare (DH MIROM –DH St.-Idesbald, Subnet Het Laere)). As indicated, juridically, this is allowed, but VREG indicates in it heat network report of 2020 that it is important to question whether (for Flanders) this is an efficient organizational model as it complicates, for instance, transparency in cost division (VREG, 2020b).

On top of this analysis of a possible distinction between distribution and supply, the Interreg HeatNet NEW project notices that within Flanders, depending on the heat source, there is a separation between heat production and distribution. Specifically, in case of industrial waste heat delivery to a residential neighborhood, or in the case of a geothermal source which is connected to a district heating grid, the heat producer is not operating the grid itself. (Interreg North-West Europe HeatNet NWE, 2019)

With regard to third party access, Art. 4/1.1.5. states that the Flemish Government can set obligations with regard to service provision to heat- or cold suppliers who have access to the grid. In this regard, they refer to potential obligations regarding the timing of delivery of measurement data, connection information… Third-party access is therefore allowed, but not facilitated.

Finally, even though the current heat market is freely organized, it should be pointed out that the Flemish Government in its coalition agreement 2019-2024 indicated that it is important to examine how the development and exploitation of district heating can be organized in an efficient way. (Vlaamse Regering, 2019a) Warmtenetwerk Vlaanderen is worried about this statement as it might open doors to allow for a monopoly in the development and exploitation of heat networks in Flanders. Previously, Fluvius, already aimed to convince municipalities to give them the right to exploit heat networks in their municipality. (Warmtenetwerk Vlaanderen, 2020)

### 3.1.2. Developments in heating policy and market contexts

These issues have been addressed in the previous section.

*Current developments in the legal system and market organization*

As there have been recent changes in the legislation with regard to DHC grids, there are currently no concrete plans for further development of the legal system and/or market organization.

*Expected developments in terms of energy transition policy or market transformations to accommodate green energy*

Keeping in mind the European ambitions, it goes without saying that Flanders will move towards a greener region with more attention to renewable energy. However, today, developments in renewable energy are often not facilitated. While “plans” and “climate targets” are present, such plans are often vague and limitedly concrete, which often creates challenges to reach climate targets. Furthermore, some of the plans mentioned, are not always executed (such as the heat ambassador which was proposed (see further)).

## 3.2. Position of district heating

### 3.2.1. Regulation of district heating providers and 5GDHC

As DH in Flanders is very specific and unique from region to region, the legislative framework remains very open. A lot of technical obligations are not regulated in the first district heating framework. The legislative framework is, however, clearly defining market roles and responsibilities. These roles can be taken up and combined by different actors. Everybody can take up these roles if they follow the obligations indicated in the framework. The VREG is responsible for supervising whether the legislation is followed properly, and for controlling whether heat and cold suppliers have an appropriate service delivery.

Specifically, the Energy Decree ("Energiedecreet") is stipulating the role of the DH operator and heat supplier.

- DH operator (operation, development, measurements, communication on tariffs),
- Heat supplier (supply, invoice, social energy measurements, complaints management).

Regarding technical aspects, as discussed earlier, the energy decree is discussing technical aspects of metering.

### 3.2.2. Ownership and operation of district heating systems

As explained earlier, the market for DH is very open in Flanders. DH grids can be owned and operated by any party. In Flanders both private as public parties are playing their role regarding DH grids.

About property rights, there are, however, a couple of regulations to take into account when a DHC-grid is installed on municipal lands. These are in more detail discussed by (Loth, 2020). First of all, there is a distinction based on whether the initiator of the installation of a DHC-grid is a private party or the government is. In case it is a private party, the same rules apply as for the installation of telecom cables. That is, the initiator needs to get easements on the public domain owned by the government. In case the government is the initiator, a concession is required for public works in the utility sector. Such concession can involve various sub-assignments (design, construction, operation…). (Loth, 2020) In case a DHC-grids passes over private property, business agreements must be made with each landowner. Acquiring the rights to go over the different private plots has proven to be very complicated in practise (Loth, 2020).

Specifically, when it comes to specific heat sources, such as geothermal heat, ownership of the heat sources also needs to be examined. Generally, it can be said that in case the geothermal heat is positioned above 400-500 meter, then the owner of the geothermal heat is the owner of the property on the surface. In case that the geothermal heat is situated deeper, than the heat is property of the Flemish Government. (Loth, 2020)

### 3.2.3. Regulation of price setting

Since January 2020, the federal government sets a social heat tariff for vulnerable customers connected to a district heating grid (Dierick, 2019). There is no other heat price regulation in Flanders (nor in Belgium) regarding district heating. Heat suppliers are free to set their own tariffs. Nevertheless, there seems to be a "Dutch" influence in the sense that one often refers to the NMDA-idea. Stakeholders generally tend to compare with tariffs for alternative fuels. Nevertheless, as heat is supplied at different pressures and temperatures, it is harder to compare.

About tariff setting when there is third party access, the energy decree, Title IV/1, Chapter I, section III, Art. 4/1.1.3. states that when "the grid operator does not act as a supplier of thermal energy, he defines the tariffs and conditions through which a third party who wants to deliver thermal energy can get access to the grid". Section IV defines public service obligations that the district heat- or cold grid operators have.

### 3.2.4. Role of building owners and building occupants

*Deciding the heat source of the building*

In case of single-family buildings, the decision for the heat source is most often taken by the building owner. In cases where such single-family buildings are developed during a larger real estate project where a full region is being developed, it might occur that the project developer chooses the heat source. In the latter case, local municipalities might also have their say in case they already developed a vision on heat zones.

In the future, heat zone plans will be developed by the local governments / municipalities and the decisive influence on the heat source choice will not remain solely with the building owner.

In case of multi-family buildings, Flemish buildings are obliged to have a VME (Vereniging mede-eigenaars) who represents all building owners. It is the VME who takes decisions regarding changes in the heating system, although the owners still have voting rights. A minimum majority of owners needs to agree before a decision is taken.

*Investments and energy bill*

As indicated in the section on market organization, the energy bill is paid by the end user. However, it is possible that in case of multi-family buildings, the VME or another third party has a contract with the heat supplier. In that case, the VME pays the heat supplier, and charges the end-consumer afterwards to retrieve the money.

Investments are in the end also paid by the end-user. Nevertheless, pre-financing might be done by the VME, by a project developer, or by a cooperation.

### 3.2.5. Financing and subsidies

*Localized subsidy or grant mechanisms available*

D.T2.1.2 will discuss options for financing in more detail. For Flanders, only the most relevant financing mechanisms are summed up below.

Since December 2013, Flanders has a yearly call for green heat, residual heat and district heating (e.g., call “green heat”). Most of the budget of this call goes to district heating and residual heat projects. For instance, for 2020, the budget for the call was approximately 10 million euros, of which about 70% goes to DHC projects (Energiesparen.be, 2021a).

In the National climate plan, Flanders is highlighting a number of financing tools it aims to continue for the following years:

- About 1,1 billion euro per year are reserved for green energy certificates for renewable energy production
- Cheap or rent-free loans are given for specific target groups (55 million euro/year)
- Distribution system operators are given subsidies for solar boilers (4 million/year), for heat pumps (3 million/year), and for heat pump boilers (1,8 million/year).
- …

In addition, there are other specific subsidies for green heat such as (Agentschap Innoveren & Ondernemen, 2021):

- Heat power certificates (warmtekrachtcertificaten)
- Ecologiepremie+
- Strategische ecologiesteun

## 3.3. Available energy sources and storage

For the development of 5GDHC, it is important that each region gains insights in other (possibly low temperature) heat sources which are available today or in the future. As part of the work in D2Grids, a preference scale of energy sources has been developed (see D.T1.1.4 generic 5G technology model). The structure of this section reflects this ranking, with the highest-ranking forms of energy mentioned first. These sources are in most cases not only relevant for 5GDHC development. When there are many high or medium temperature sources available in a region, the case of 4GDH might be better than for 5GDHC. Currently, we have no way of quantitatively saying what the shares of low-grade sources would be to make a decent 5GDHC business case.

In what follows, we go through the preference scale of D2Grids and examine the existing situation of energy sources, together with possible planned changes to existing sources and planned additions to these sources. Some side notes need to be considered when going through the ranking below. First of all, at the time of writing, D.T1.1.4 has not been finalized, therefore the ranking is conditional. Secondly, it is likely that not for all energy forms in the ranking, data are available on a local or regional level. Finally, the time horizon for this study are projects that are being developed in the period 2022-2025, with a lifespan of approximately 30 years. In case projections of energy sources in the future are available, a distinction will be made between the existing situation and the planned changes to these sources.

Even though the number of heat networks is still small in Flanders, a wide variety of heat sources are already used today. This can be seen on the figure below. Biomass and gas are the most used heat sources in Flanders.

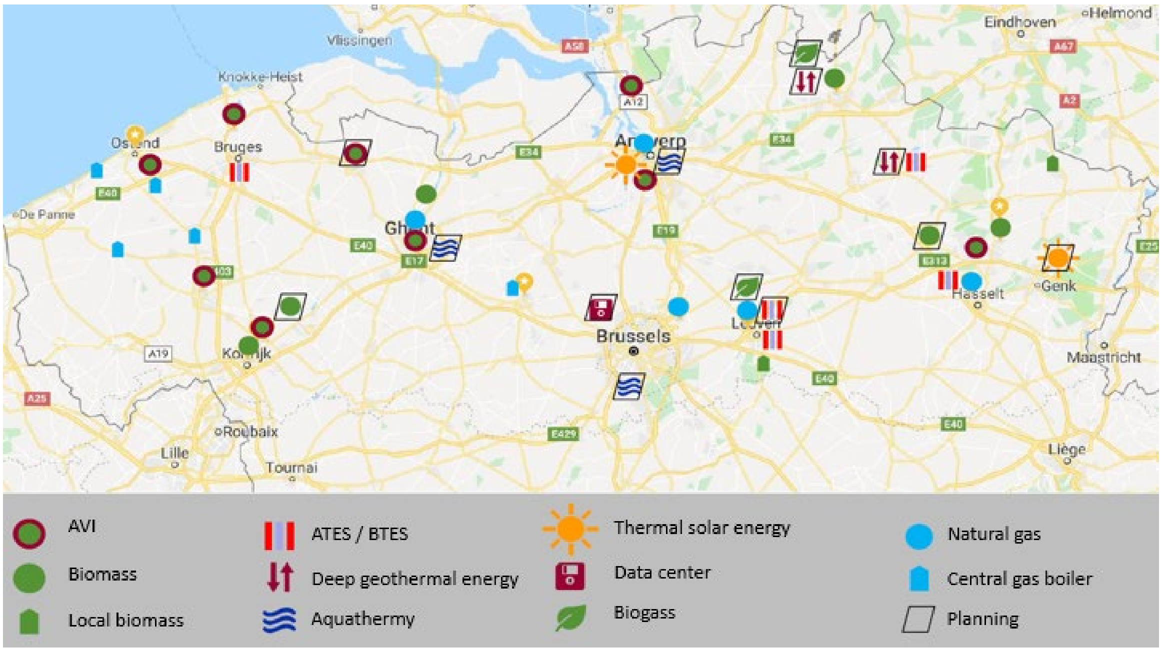



**Figure 2 – Current heat sources used in DH grids in Flanders (presentation Warmtenetwerk Vlaanderen on the launch event of FlexHarvester, 2020)**

### 3.3.1. Reuse of thermal energy, by exchange between heating and cooling demands

The core idea behind 5GDHC is to facilitate energy exchanges between local buildings. For instance, if one building is producing heat for its own consumption, it automatically also creates cold which ideally could be supplied to a nearby building. Ideally, as much local energy should be reused to minimize any possible type of energy losses. Analyzing the potential of these types of energy exchange is, however, not possible on a regional scale. It highly depends upon the project, and detailed buildings consumption and production data, for different time periods, are needed. Its potential highly depends on the design of the network and the type of users involved. Ideally, a good mix of consumers should be present, so that their energy flows and needs are complementary.

Making all building data available to evaluate beforehand such potential, might be a possible action point to take up in the action plan. It is important that all demand and supply profiles can be compared, as this might provide incentives for complementary sectors to join the new site.

### 3.3.2. Ambient thermal sources from soil, water, air, and low temperature solar heat & low grade thermal storage possibilities

Another potential energy source highly suited for 5GDHC grids are lower temperature, renewable heat sources from soil, water, air, and sun.

(Bertermann et al., 2015) analyzed the pan-European very shallow geothermal energy potentials. Very Shallow Geothermal Potential is basically solar heat that is stored in the shallow underground (up to 10-meter depth) (both BTES and ATES). The figure below (Figure 3) illustrates that for Belgium, there are quite some areas with a very high heat conductivity potential. Nevertheless, in some of these areas there are also limitations or restrictions for the implementation of shallow geothermal energy (see stripes in the background). Such limitations are caused, for instance, by protected zones, unsuitable soil types (Histosols, Cryosols, Leptosols, Gleysols, Planosols) or soil slopes >15°C. In Figure 3, heat conductivity is expressed in Watts per meter*Kelvin. Red zones are 'highly suitable' and orange zones are 'very suitable'. Yellow zones, which take up the majority of Belgium, are 'suitable', which is still better than the blue zones with are 'limited suitable' or 'less suitable'. For Belgium it shows that in most regions there are suitable options for shallow geothermal energy.

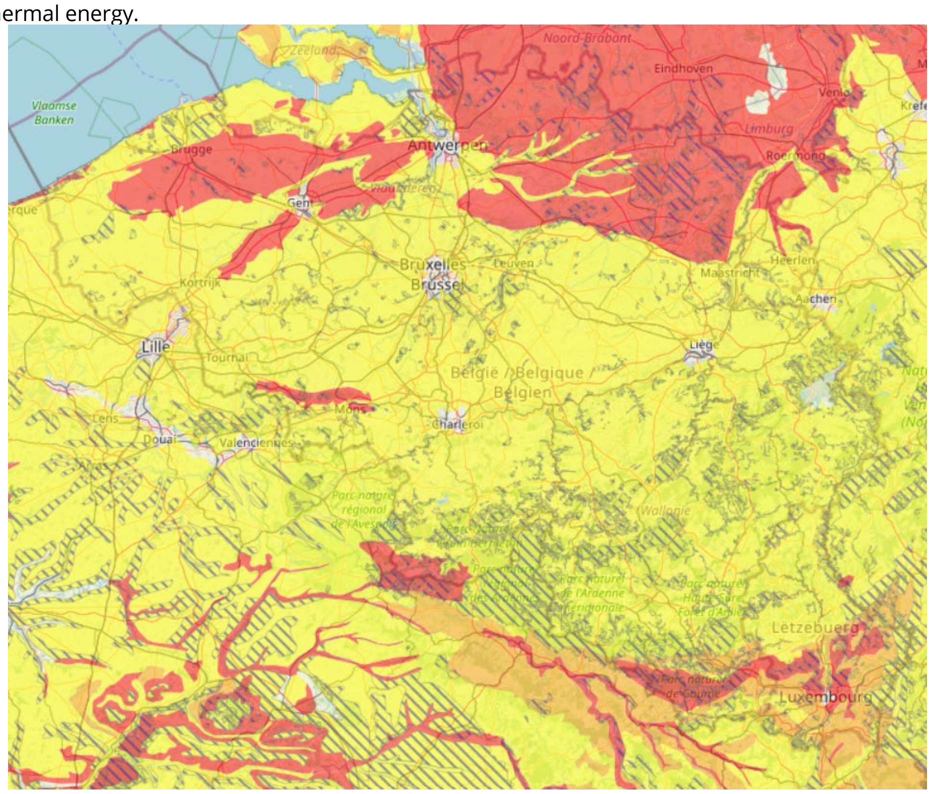



**Figure 3 - Printscreen TermoMap Belgium (Heat conductivity legend: red (>1,2 W/mK), orange (1,1-1,2 W/mK), yellow (1,0-1,1 W/mK), light blue (0,9-1,0 W/mK), dark blue (<0,9 W/mK), stripes in the background: limited usage area).**

When comparing the potential for shallow geothermal energy with its current implementation in Flanders, it appears that there remains a lot of unused potential. In Flanders, only 0.43% of the total gross consumption of heating and cooling in 2018 was delivered through heat pump applications. Of all the green heat, 8% comes from heat pumps (Statistiek Vlaanderen, 2020a). In total, in 2019, there were in the whole of Belgium 337.397 heat pumps. Only 15.804 of these were ground source heat pumps. All the rest were aerothermal heat pumps. For the foreseeable future, it also seems that the growth trend continues in favor of aerothermal heat pumps. Most heat pump installations in Belgium remain air-air heat pumps (94.380 in 2019). In 2019, there were only 2.595 geothermal (ground source) heat pumps. The latter is, however, a significant increase compared to 2018, where there were 1.872 geothermal (ground source) heat pumps. (Eurobserv-er, 2021)

Heat pumps in Belgium are therefore increasing their market share but remain only a very small portion of the heating and cooling production. Solar boilers as well only take up a small proportion of the heat generation. Currently, solar boilers produce about 0,89 PJ in Flanders (on a total of 33,11 PJ green heat). This is less than 3% of the total green heat. (Vlaamse Overheid, Departement Omgeving, 2020)

In Table 1, the expected growth in total green heat can be seen for 2030. Heat pumps will double their efforts. Yet, both solar boilers and heat pumps remain limited in size. By 2030, together, they would generate about 18% of the green heat in Flanders.

**Table 1 - Targets for usage of renewable energy for heating and cooling in Flanders with regard to heat pumps and solar boilers (data from Milieurapport (2020) (Vlaamse Overheid, Departement Omgeving, 2020))**

| PJ | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Goal 2020 | Goal 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heat pump (boilers) | 0,22 | 0,26 | 0,31 | 0,39 | 0,49 | 0,6 | 0,72 | 0,83 | 0,94 | 1,08 | 1,24 | 1,64 | 2,2 | 5,24 |
| Solar boilers | 0,11 | 0,17 | 0,19 | 0,22 | 0,25 | 0,29 | 0,45 | 0,5 | 0,55 | 0,6 | 0,63 | 0,65 | 0,89 | 1,03 |
| Total green heat target | 33,11 | 33,11 | 33,11 | 33,11 | 33,11 | 33,11 | 33,11 | 33,11 | 33,11 | 33,11 | 33,11 | 33,11 | 33,11 | 34,88 |

Furthermore, as discussed by (Loth, 2020), in Flanders there are also options for aquathermia. Aquathermia can be done in open waters or in municipal sewer systems (that is riothermia). In case open water are used for cooling water, a cooling water fee for the usage of river water needs to be paid per m³ of water. In case of riothermia, it depends from one local situation to another to see whether it is possible and allowed.

**Low grade thermal storage possibilities (such as flooded underground infrastructure, and natural and artificial aquifers)**

When looking at geothermal storage applications, as can be seen in Figure 4, a first distinction is made based on the temperature that needs to be reached. Higher temperatures can only be reached in the deeper underground and are part of the discussion in the next section. This section focusses on lower temperature applications.

When it comes to thermal storage systems, making use of shallow geothermal energy (50-150 meter approximately), offering both heating and cooling, the number of applications has been rising throughout the years. Depending on the application and geological characteristics, both BTES (closed system making use of a borehole - BEO) and ATES (open source system, making use of aquifers - KWO) are used. To see whether the soil is appropriate for such applications, it is necessary to have an overview of locations that have suitable ground layers from which water can be pumped up (often limestone and sandy underground).

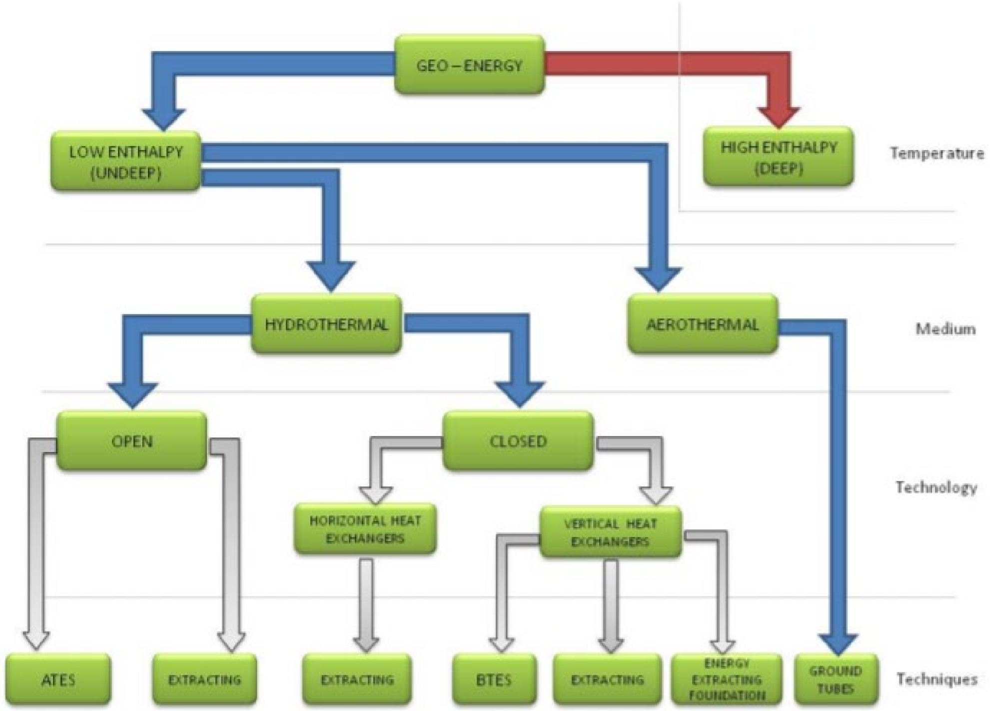



**Figure 4 - Overview of geothermal energy sources (source: VITO beknopte wegwijzer, geothermie in België (De Boever et al., 2012))**

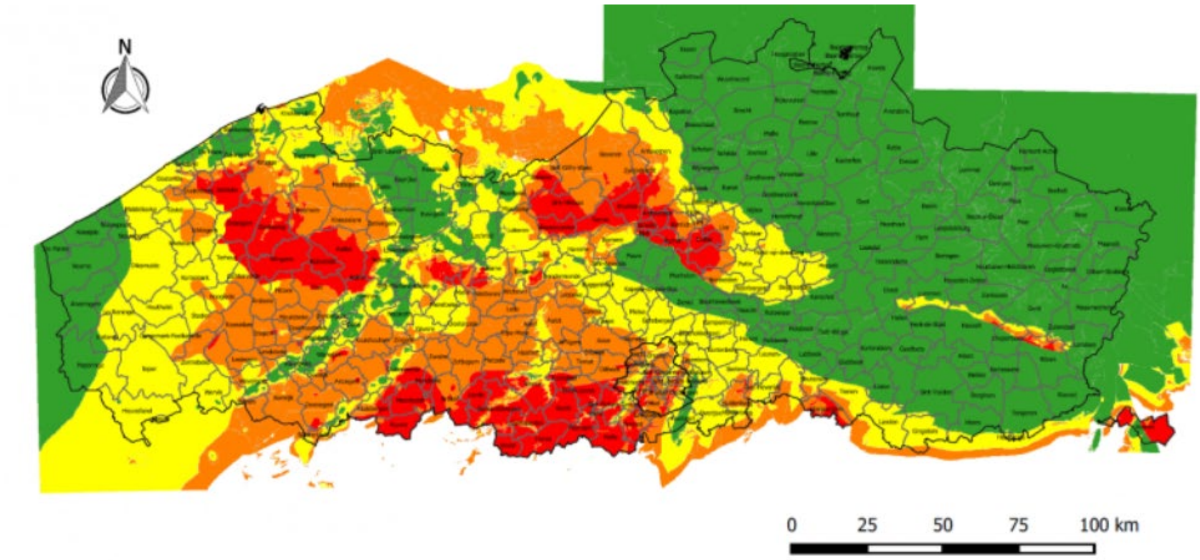



**Figure 5 - Potential for ATES in Flanders (source (LATENT, 2021))**
* red- ATES is not possible (T<50m²/day)
* orange-ATES might be possible (50 m²/day =< T < 125m²/day), a site-specific study is necessary
* yellow-ATES is probably possible (125 m²/day =< T < 250 m²/day)
* green-ATES has a high potential (T>= 250m²/day)

For shallow geothermal systems that make use of open aquifer systems (ATES), it appears that the North-East and the East part of Flanders is suitable (see Figure 5). In other regions, such as the West and the South of Flanders (Gent, Brugge, Oostend), which have a sub-ground that contains more clay, BTES systems which are not dependent on natural aquifers would be an alternative. (De Boever et al., 2012)

The company Terra Energy indicates on her website, that they have over 150 ATES and BTES projects spread out over Belgium. Some of their projects are summarized on their website (TerraEnergy, 2021). ATES and BTES systems allow for both heating and cooling in buildings, and they provide seasonal thermal energy storage. Ground sourced heat pumps are used in winter to extract the heat from the soil.

Finally, Belgium has a mining history, and could therefore also make use of underground flooded mining infrastructure. While most mines were in the Walloon region, in the Kempen in Flanders, in the province of Limburg (Beringen, Zolder, Genk, Maasmechelen) had a number of mines (belgischesteenkoolmijnen.be, 2021). In Genk, in the mines of Winterslag and Waterschei, in the past the thought was raised to use the water from the flooded mines to provide heating to new residential areas in the area. However, until now, such plans have never been pursued (Lemmens, 2018).

### 3.3.3. Higher temperature renewable sources like geothermal, solar heat

Deep geothermal energy in Flanders is still very limited and estimations regarding the potential of deep geothermal energy in Flanders are therefore mostly theoretical. Currently, it is hard to find an interesting business case for deep geothermal projects and Flanders is therefore mostly working with pilot projects to gain further insights in the geothermal potential of the region. Specifically, within Belgium, a large part of Antwerp, Henegouwen and Limburg consists of aquifers in the deeper underground with an appropriate temperature for space heating. In the Belgian underground, temperature increases approximately 30°C per kilometer (starting temperature is approximately 10°C at the surface). As such, to reach a minimum temperature of 25°C, it is necessary to drill at least 500 meters deep.

Vranckx et al. (2015) developed an optimization model for geothermal energy in the EFRO-project GEOTHERMIE2020 and indicated on the map below the maximal potential of thermal energy in the different North-Eastern Flemish regions. The study indicated that these results are with a certainty of 50%.

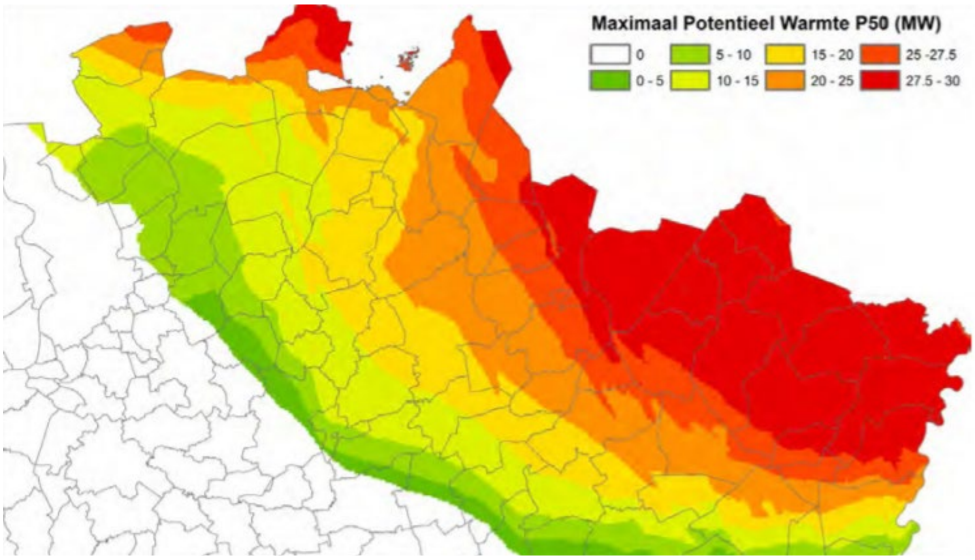



**Figure 6 - Geothermal potential Flanders (expressed in MW capacity and with a 50% certainty) - source Vranckx et al. (2015) (Broothaers et al., 2017)**

In Flanders, there are 2 pilot projects on geothermal energy: the Balmatt-site in Mol, and Janssen Parmaceutica N.V. in Beerse. Nevertheless, the government is assuming that by 2030, there will be about 12 installations with deep drilling between 500 and 3,500 meters, connected to a district heating grid. However, this estimation will be adapted based on the evaluation of two running geothermal projects. (Broothaers et al., 2017)

**Table 2 - projected green heat production per technology in the national energy and climate plan (Federale overheid, 2019)**

| Generation (GWh) | 2020 | 2025 | 2030 |
|---|---|---|---|
| Solar | 193 | 233 | 287 |
| Heat pumps | 610 | 905 | 1,455 |
| **Geothermal energy** | **95** | **345** | **594** |
| Biomass residential households | 3,850 | 2,900 | 1,950 |
| Biomass other | 3,841 | 4,621 | 5,401 |
| **Total** | **8,589** | **9,122** | **9,688** |

With regard to high temperature solar heat, the energy company AZTEQ (AZTEQ, 2018), located in EnergyVille (Thor Park Genk) is installing the first pilot installations for solar mirrors in Ostend, Genk and Antwerp (concentrated Solar Power). Such solar mirrors produce green heat at temperatures up to 400°C. This heat can be used by industrial and large companies. The technology has not been implemented previously in Flanders (nor in Belgium). The Flemish Government offered 819.000 euros in subsidies to the project. In total, the three installations will produce 1.390 MWh additional green heat per year. In Ostend, the heat will be used for the chemical company Proviron (which needs heat at a temperature of 180°C). In Antwerp, the heat is used in a company in the port (ADPO from Kallo). They need heat at a temperature of about 140°C for the storage of liquids. The third installation is used at the science park of Thor Park where the heat is used for experiments (in the laboratories) regarding ORC-installations. Potentially, the heat would also be used for heating the DHC grid that will be installed in the future.

### 3.3.4. Higher temperature industrial waste heat, otherwise rejected in the environment

Regarding industrial waste heat, in 2015, a study was performed by VITO that made waste heat from different industries in Flanders. The study indicated that spread out over Flanders, but mostly in the neighbourhood of the Port of Antwerp, there are numerous suppliers of waste heat. The following maps (Figure 7 and Figure 8) indicate waste heat below and above 120°C (medium and high temperature waste heat).

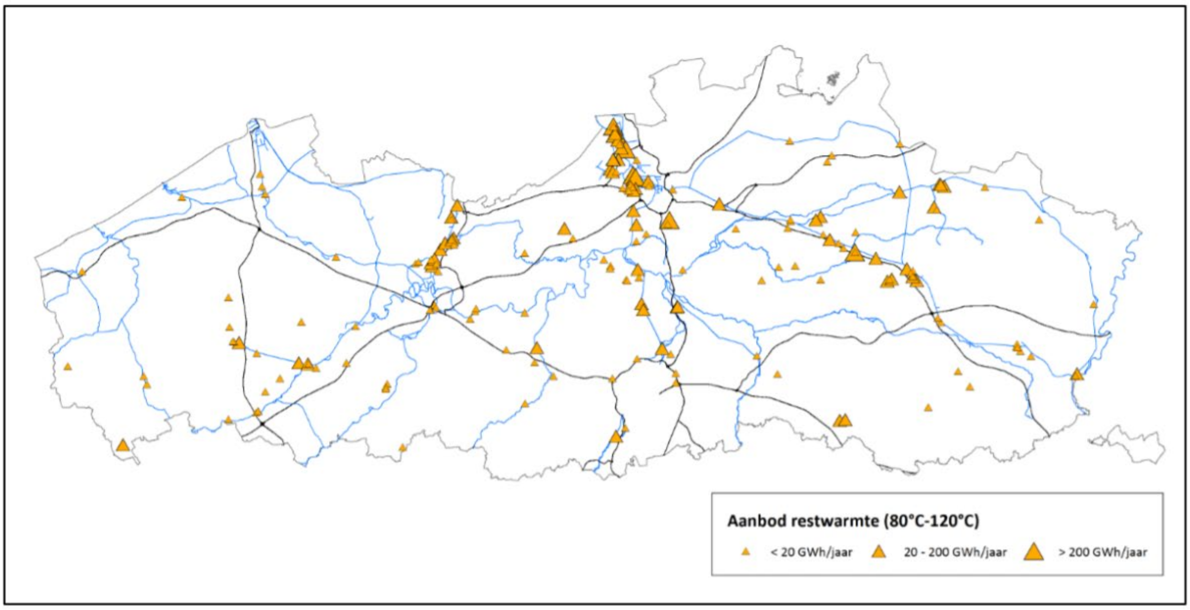



**Figure 7 - Availability of residual heat <120°C from large industry, in 2012 (GWh/year) (source: (Renders et al., 2015))**

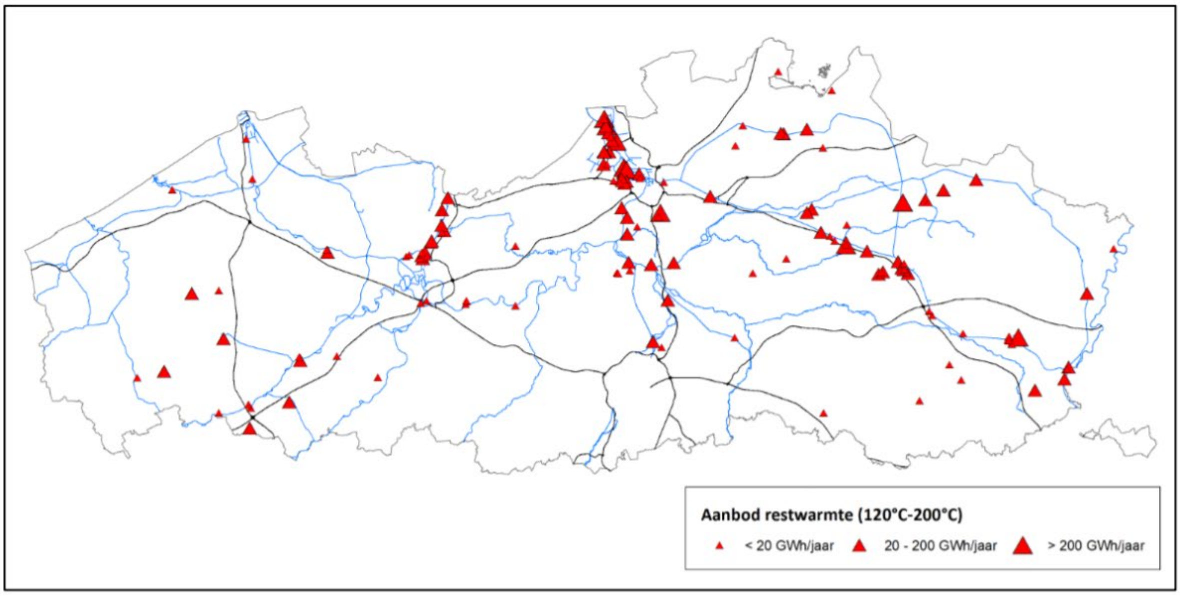



**Figure 8 - Availability of residual heat 120-200°C from large industry, in 2012 (GWh/year) (source: (Renders et al., 2015))**

**Table 3 - Heat demand and residual heat per industrial sub-sector in Flanders in 2012 (source: (Renders et al., 2015))**

| | Heat demand (GWh) | Supply residual heat (<120°C GWh) | Supply residual heat (120-200°C) |
|---|---|---|---|
| **Refinery** | 17300 | 900 | 900 |
| **Iron and steel** | 4300 | 0 | 4300 |
| **Non-ferro** | 1500 | 200 | 800 |
| **Chemistry** | 33600 | 4900 | 4900 |
| **Minerals** | 2100 | 600 | 1400 |
| **Food** | 5600 | 500 | 0 |

The table above shows the results of the industrial sub-sectors in Flanders that offer the most residual heat in Flanders. It should be noted that the amount of residual heat indicated in the table, is not necessarily heat that can be supplied externally, as some of the waste heat will be used through the companies internally. The study also showed that there are large differences between the different supply opportunities of the different companies. Individual potential supply of waste heat can vary from 0 TWh to about 3,5 TWh. In total, about 23 of the 384 companies offer 73% of the total residual heat in the industry in Flanders. (Renders et al., 2015)

For Flanders, the study analyzed which regions were suited for DH grids, based on the assumption that residual heat was transported to the neighboring areas. In that case, the following map was obtained. An important assumption when making this map was that there was government support for sharing waste heat. In case this support is not available, the number of district heating grids with a positive profitability decreases with about 50%.

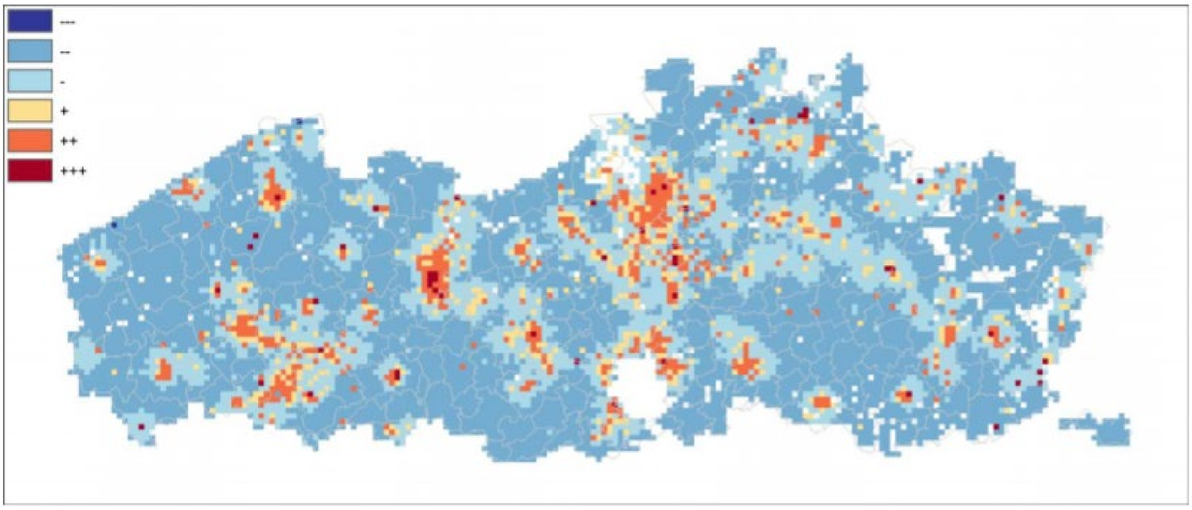



**Figure 9 - Benefits of a DH grid (incl. investment support) if residual heat is transported to nearby cells (source: (Renders et al., 2015)**

Most likely, the map above gives an overview of regions where 5GDHC grids are not suited due to the fact that in these regions higher temperature sources and demands are available. Furthermore, (Loth, 2020) emphasized that for proper planning, a map of higher resolution is necessary. In this regard, the "Pan-European thermal atlas" could be more useful, but, even there it remains necessary to get access to local data on heat sources and demand. Such open source data are, however, not always available.

### 3.3.5. Renewable electricity from local sources like wind, sun

Where possible, 5GDHC aims to make use of local renewable electricity sources to use local electricity to drive heat pumps in the system. As such, it is important to also analyse which regions have a lot of local electricity to place 5GDHC more in their proximity.

For Flanders, however, it seems that 5GDHC should not look at existing installations to determine the position of their grids. First, there is currently not yet a lot of renewable energy in Flanders. From 2005 to 2018, the proportion of renewable energy in the total Flemish gross energy consumption increased from 1,9% to 6,9%. These numbers take into account the usage of renewable energy sources for green electricity, heating, cooling, and transportation (such as biofuels). Looking only at green electricity, in 2018 the gross green electricity production was about 8.525 GWh (which is about 14,2% of the gross Flemish electricity consumption). Nevertheless, it should be pointed out that in Flanders, a large proportion of green electricity is produced through bioenergy. As can be seen on the graph below (Figure 10), over the last decade, there has been a significant increase in renewable energy from solar and wind.

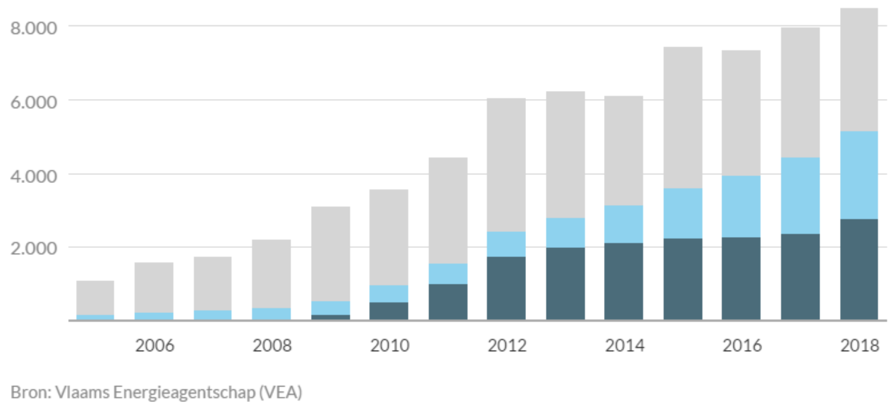



**Figure 10 - Green electricity production (GWh) per renewable energy source for the Flemish Region (source: (Statistiek Vlaanderen, 2020a))**

*Dark blue: solar energy
*Light blue: wind energy
*Grey: bio energy

Secondly, even if a lot of solar energy is available at a specific building, it should be pointed out that in a lot of cases this energy might be dimensioned to the own consumption of the building, and there might not always be a lot of additional energy available.

As such, it is important to look at areas where there is still a lot of potential to install solar installations. In order to look in more detail at solar energy options on a local level, Flanders has a solar map that estimates what the potential of solar energy (both solar panels and/or solar boilers) is on Flemish roofs (2,5 million roofs approximately). The map combines weather data of the KMI, together with building data on surface and orientation of the roof. For each roof in Flanders, it is estimated the potential for solar energy per roof. On this website https://www.energiesparen.be/zonnekaart, the reader can find an elaborate list of all Flemish municipalities, their potential capacity for solar energy, the number of existing solar installations and the capacity that is currently installed. In Table 4, only the top 20 municipalities are ranked (of a total of 308 municipalities). In total, the average Flemish utilization rate of solar installations compared to their potential, is only 4,4%. As such, there is still a lot of unutilized potential in Flanders.

In addition, for 5GDHC it is also interesting to look at the local solar production in center cities (centrumsteden) in Flanders. As indicated on the map with the potential for DH grids, these cities might not be the best place for 5GDH as there is a lot of high temperature heat available. However, also from a perspective of available solar energy, it seems that these cities are not frontrunners with regard to solar energy (see Table 5).

Table 4 - ranking top 20 municipalities with solar installations on building roofs (source: (energiesparen.be, 2021))

| Ranking in Flanders | Municipality | Province | Potential capacity (in MW)* | Corrected installed capacity (in MW)** | Utilization factor (in%)* | Number of installations | Number /1000 inhabitants | capacity/ inhabitant (in W) |
|---|---|---|---|---|---|---|---|---|
| 1 | Dilsen-Stokkem | Limburg | 191,98 | 20,10 | 10,5% | 1557 | 76,66 | 989,47 |
| 2 | Opglabbeek | Limburg | 134,22 | 13,99 | 10,4% | 1118 | 108,35 | 1356,06 |
| 3 | Wijnegem | Antwerpen | 75,13 | 7,73 | 10,3% | 395 | 40,89 | 800,11 |
| 4 | Heusden-Zolder | Limburg | 229,71 | 22,99 | 10,0% | 2445 | 73,74 | 835,23 |
| 5 | Lommel | Limburg | 331,59 | 29,12 | 8,8% | 2861 | 84,16 | 944,93 |
| 6 | Hechtel-Eksel | Limburg | 92,70 | 7,41 | 8,0% | 1226 | 99,87 | 603,53 |
| 7 | Niel | Antwerpen | 45,00 | 3,57 | 7,9% | 378 | 36,93 | 348,49 |
| 8 | Nieuwerkerken | Limburg | 75,03 | 5,92 | 7,9% | 625 | 90,04 | 852,80 |
| 9 | Diepenbeek | Limburg | 142,71 | 10,92 | 7,7% | 1776 | 93,05 | 572,10 |
| 10 | Kinrooi | Limburg | 134,74 | 10,26 | 7,6% | 1278 | 104,10 | 835,76 |
| 11 | Temse | Oost-Vlaanderen | 235,76 | 17,72 | 7,5% | 1611 | 54,58 | 638,75 |
| 12 | Meerhout | Antwerpen | 85,68 | 6,38 | 7,4% | 886 | 86,39 | 622,26 |
| 13 | Lummen | Limburg | 163,74 | 12,17 | 7,4% | 1341 | 91,46 | 830,23 |
| 14 | Boom | Antwerpen | 102,80 | 7,59 | 7,4% | 414 | 23,27 | 426,65 |
| 15 | Geel | Antwerpen | 359,21 | 26,18 | 7,3% | 2983 | 75,40 | 661,77 |
| 16 | As | Limburg | 48,12 | 3,49 | 7,2% | 644 | 78,44 | 424,83 |
| 17 | Neerpelt | Limburg | 119,42 | 8,61 | 7,2% | 1490 | 86,99 | 502,63 |
| 18 | Bekkevoort | Vlaams-Brabant | 76,68 | 5,52 | 7,2% | 469 | 76,46 | 900,66 |
| 19 | Dessel | Antwerpen | 91,68 | 6,54 | 7,1% | 878 | 92,16 | 686,38 |
| 20 | Houthalen-Helchteren | Limburg | 248,65 | 17,66 | 7,1% | 2092 | 68,36 | 577,09 |

*On roof parts where the measure solar radiation is larger than 1000 kWh/m²/j

**Data from the DSOs until 31/03/2018, reduced with the capacity of known ground installations of a minimum of 750 kW

**Table 5 - ranking cities in Flanders with solar installations on building roofs (energiesparen.be, 2021)**

| Ranking in Flanders | Municipality | Province | Potential capacity (in MW)* | Corrected installed capacity (in MW)** | Utilization factor (in%)* | Number of installations | Number /1000 inhabitants | capacity/ inhabitant (in W) |
|---|---|---|---|---|---|---|---|---|
| 35 | Genk | Limburg | 602,18 | 39,26 | 6,5% | 2847 | 43,15 | 595,02 |
| 74 | Hasselt | Limburg | 532,06 | 29,33 | 5,5% | 4099 | 53,15 | 380,33 |
| 88 | Turnhout | Antwerpen | 320,42 | 16,65 | 5,2% | 1489 | 34,26 | 382,95 |
| 109 | Sint-Niklaas | Oost-Vlaanderen | 576,14 | 27,58 | 4,8% | 3423 | 45,02 | 362,82 |
| 112 | Herentals | Antwerpen | 262,46 | 12,39 | 4,7% | 1387 | 49,89 | 445,66 |
| 135 | Aalst | Oost-Vlaanderen | 609,46 | 26,89 | 4,4% | 3865 | 45,55 | 316,87 |
| 160 | Roeselare | West-Vlaanderen | 700,92 | 28,89 | 4,1% | 3704 | 60,07 | 480,68 |
| 174 | Brugge | West-Vlaanderen | 944,40 | 36,84 | 3,9% | 4246 | 35,93 | 311,68 |
| 189 | Kortrijk | West-Vlaanderen | 692,37 | 25,66 | 3,7% | 3666 | 48,40 | 338,87 |
| 195 | Gent | Oost-Vlaanderen | 1.747,62 | 63,65 | 3,6% | 6848 | 26,43 | 245,66 |
| 220 | Mechelen | Antwerpen | 484,58 | 16,49 | 3,4% | 2325 | 27,14 | 192,48 |
| 247 | Oostende | West-Vlaanderen | 427,43 | 13,22 | 3,1% | 2048 | 28,85 | 186,18 |
| 248 | Leuven | Vlaams-Brabant | 504,95 | 15,53 | 3,1% | 2935 | 29,26 | 154,84 |
| 260 | Antwerpen | Antwerpen | 2.290,09 | 66,01 | 2,9% | 5460 | 10,49 | 126,83 |

*On roof parts where the measure solar radiation is larger than 1000 kWh/m²/j

**Data from the DSOs until 31/03/2018, reduced with the capacity of known ground installations of a minimum of 750 kW

Specifically, for wind, the map below show that wind is mostly interesting in the West side of Flanders. As a result, as can be seen in Figure 11, most of the wind turbines can be found in that region.

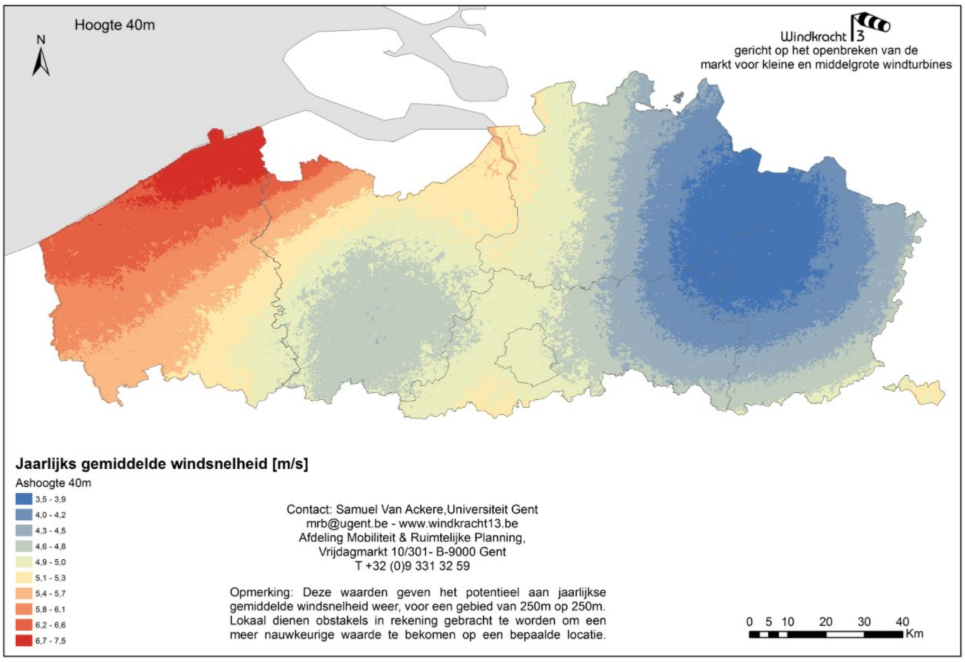



**Figure 11 - Wind map Flanders (source (Van Ackere, 2015))**

In 2015, in Flanders there were 295 large wind turbines, together having a capacity of 690 MW. On the map below, the yellow dots show all wind turbines in 2015 which received a building permit at the time. The green dots are the wind turbines who are already constructed in 2015. End of 2016, the Flemish Government accepted the draft of the wind plan “windkracht 2020” which indicated that by 2020 280 new wind turbines needed to be installed in Flanders. They would aim to focus a lot on the ports of Antwerp, Gent, Ostend and Zeebrugge. In 2019, the total amount of wind energy in Flanders was 1.278 MW (about 543 wind turbines). On the website of ODE, a full list of all large wind turbines in Flanders can be found (ODE, 2019a). In 2020, up on writing of this section, 26 additional wind turbines were installed in Flanders.

Currently, most of the wind turbines can be found in the West side of Flanders (which is in line with the wind map) (see Table 6). Note that Flemish Brabant does not have a lot of wind turbines. This is caused due to restrictions of the nearby airport of for instance Zaventem. (Clerix, 2015b)

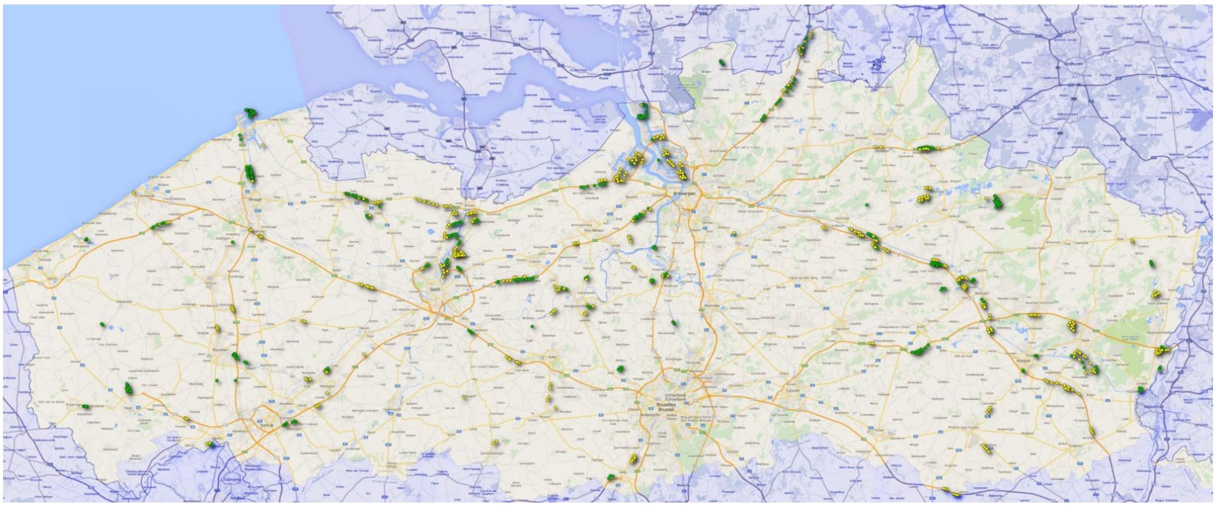


**Figure 12 - Current (green) and future (yellow) wind turbines in Flanders 2015 (source: (Clerix, 2015a))**

Most of the wind turbines in Flanders are build next to high and water ways, followed by wind turbines in industrial areas or in ports. Such wind turbines are therefore more often located in areas that are less suited for 5GDHC. With the windplan, the goal will be to have more small and medium-large wind turbines for, for instance, SMEs and farms. The Flemish government aims to further facilitate regulation in this regard to make sure that procedures are easier. This might be an opportunity for 5GDHC as it gives options to invest in smaller scale wind energy next to the potential 5GDH grid (Clerix, 2015b; ODE, 2020; Team Duurzame Ontwikkeling Vlaamse Overheid, 2021; Tommelein, 2015).

**Table 6 - Additional wind turbine capacity installed over the last year and total capacity installed (MW) (data until October 2020) (source: (energiesparen.be, 2020))**

| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Total capacity |
|---|---|---|---|---|---|---|---|
| Province Oost-Vlaanderen | 82,5 | 28 | 94,25 | 36,82 | 36,9 | 22,85 | **460,92** |
| Province Antwerpen | 32,3 | 39,3 | 86,74 | 31,45 | 6,3 | 16,1 | **351,00** |
| Province Limburg | 62,4 | 20,2 | 26,8 | 14,6 | 8,7 | 19 | **278,10** |
| Province West-Vlaanderen | 19,3 | 15,9 | | 8,05 | 11 | 3,6 | **197,56** |
| Province Vlaams-Brabant | 12 | 13,52 | 7,2 | 10,37 | | | **63,69** |
| **Total** | **208,5** | **116,92** | **214,99** | **101,29** | **62,9** | **61,55** | **1351,27** |

In case a more detailed overview is necessary for the reader, through the following website (https://www.energiesparen.be/energiekaart/cijfers ), it is possible to get an overview of windturbines per municipality. The data are from October 2020 and are updated more frequently. However, this overview as well only focuses on large windturbines.

### 3.3.6. Electricity use at times of renewable overproduction, e.g. when spot price is low

For now, this is only relevant in areas with known overproduction, like the north of the Netherlands (overproduction of PV) and the north of Germany (wind).

### 3.3.7. Electricity mix from the external grid

With regard to the national electricity mix, the TSO (Elia) reported the statistics below. In 2018, some nuclear power plants were out of service, which explains the high dependency on imported electricity during that year. Compared to 2018, however, 2019 saw a significant increase in off-shore (and on-shore) wind energy. As a result, in 2019, Belgium exported more electricity than it imported. In total 1,8 TWh was exported (which is 2,1% of the electricity mix). In the graphs below (Figure 13), it can also be seen that there is an increased usage of gas power plants for electricity.

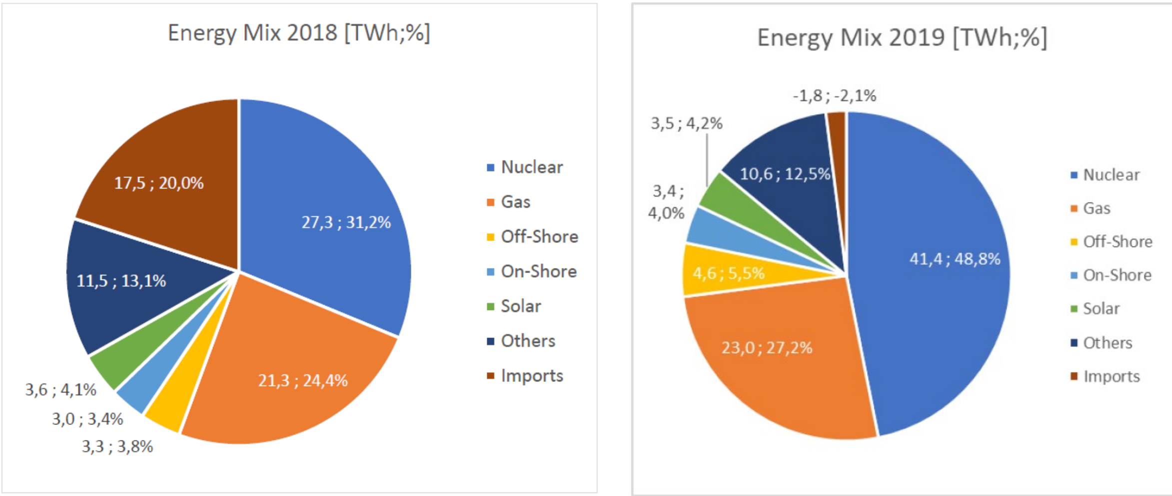



**Figure 13 - Energy Mix Belgium 2018-2019 (Elia, 2020)**

### 3.3.8. High temperature heat from burning biofuels, biogas, biomass

Table 7 gives an overview of all projected green heat production sources in the NECP (National Energy and Climate Plan). In this section, the focus is on biomass which, compared to the other technologies, takes up the largest part of the green heat production in Flanders. With regard to biomass and biogas, a distinction is made between households, and larger installations. Some households heat their houses with wood stoves. Yet, it is assumed that the usage of these energy sources will decrease over time (the target is to decrease their consumption with 50%). Instead, there will be a shift to more central heating installations via (small) district heating grids.

For waste incineration, an important shift is foreseen from green power to green heat through district heating grids. In addition, waste is assumed to reduce by 25% within 2030 due to better waste management. As such, heating capacity needs to have the highest energetic efficiency. It is assumed that larger and more central installations will become more efficient and will further find their way in the Flemish energy landscape (Vlaamse Overheid, Departement Omgeving, 2020).

**Table 7 - projected green heat production per technology in the national energy and climate plan (Federale overheid, 2019)**

| Generation (GWh) | 2020 | 2025 | 2030 |
|---|---|---|---|
| Solar | 193 | 233 | 287 |
| Heat pumps | 610 | 905 | 1,455 |
| Geothermal energy | 95 | 345 | 594 |
| Biomass residential households | 3,850 | 2,900 | 1,950 |
| Biomass other | 3,841 | 4,621 | 5,401 |
| **Total** | **8,589** | **9,122** | **9,688** |

Even though there are quite some biomass installations in Flanders, data about them can only partially be found and focus mostly on their electric potential. As far as we know, there are no public data on the thermal capacity of biomass or biogas installations in Flanders. The 2017 VITO study ‘potentieel biomassa 2030’ (Kreps et al., 2017) gives an overview of biomass and biogas installations in 2017. This study was also used for the projections given in the earlier table.

With respect to biogas, according to VILT (VILT, 2018), biogas is responsible for 10,6% of all green electricity in Flanders, and 12,9% of all green heat.

### 3.3.9. High temperature heat from burning fossil fuels

Residential households in Belgium mostly use fossil fuels for heating their buildings. Data of 2016 showed that natural gas and gas oil were the most commonly used energy sources for households in Flanders.

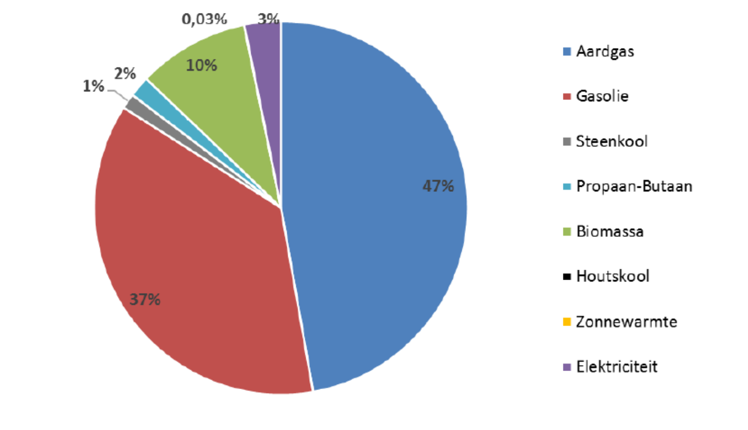



**Figure 14 - Energy consumption for heating of households in 2017 (based on data of 2016 by the Gezinsbudgetenquête) (source: (FOD Economie, K.M.O., Middenstand en Energie, 2019))**

In 2016, 88% of the Flemish households were using natural gas and oil for their heating. This can be derived from the table below

**Table 8 - main heating source households (year 2016) (source: (Stroomversnelling - Werkgroep Hernieuwbare energie, 2017))**

| | Natural gas | Oil | Wood | Electricity | LPG | Charcoal | Heat pump | District heating |
|---|---|---|---|---|---|---|---|---|
| % households | 63,2 | 25,2 | 1,7 | 7,2 | 1,0 | 1,0 | 0,8 | 0,2 |
| Number of households | 1.736.300 | 691.200 | 45.700 | 197.800 | 27.500 | 27.500 | 22.000 | 5.500 |
| Consumption 2016 (TWh) | 25,3 | 17,9 | 4,0 | 2,4 | 0,6 | 0,5 | 0,2 | 0,1 |

# 4. SWOT analysis

Given the information gathered above on the market and on availability of energy resources, an analysis of the strengths, weaknesses, opportunities and threats when implementing 5GDHC in the region can be made. The SWOT analysis will help to interpret the information given earlier and will as such help to understand which locations in Flanders might be better suited for 5GDHC.

## 4.1. Strengths

In what follow, strengths of the Flemish region, that give 5GDHC an advantage over other projects and technologies, are discussed.

### 4.1.1. Flexible regulatory framework with options for different types of systems

In theory, Flanders is not having juridical barriers for DHC grids, of any generation. Different types of business models, organizational structures and collaboration between numerous stakeholders are allowed. This gives opportunities to flexibly test new concepts, ideas and organizational models.

### 4.1.2. (Government) Resources for research and development and interest to adopt state-of-the-art/novel concepts in DH

As 5GDHC still needs to be further developed, it is important that there are sufficient resources for research and development. In this regard, the Flemish region is scoring well compared to other (European regions). In 2018, the Flemish Region spend almost 8 billion euros on R&D, which is about 2,92% of the GDP. Most of the resources go to companies (about 70% of the resources).

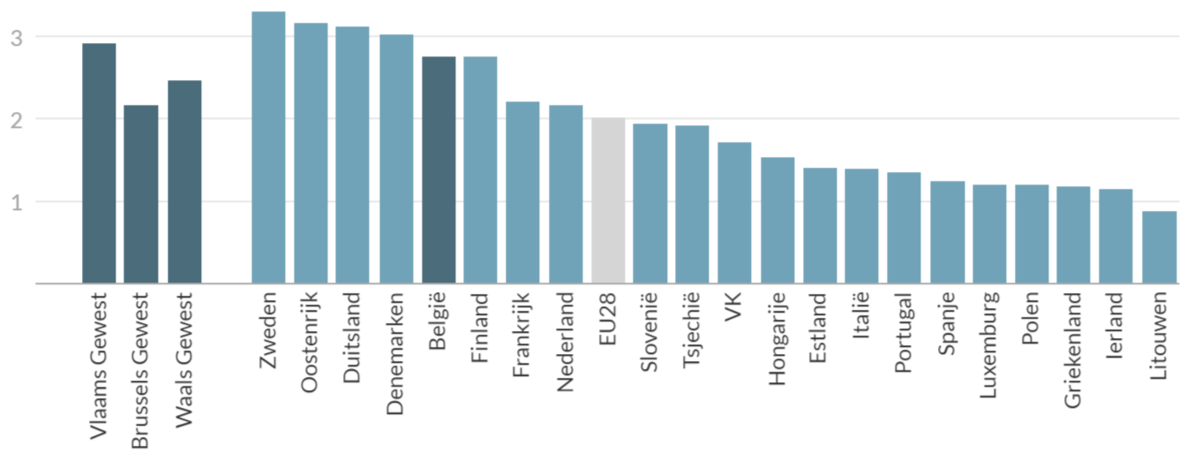



**Figure 15 - R&D resources in % of GDP (data for 2017) (source: (Statistiek Vlaanderen, 2020b))**

Specifically, with regard to R&D, Flanders is home of EnergyVille, a research institute and technology provider on advanced district heating innovation (That is: using low-grade sources for low-grade demand, match supply-demand).

On a somewhat subjective note (this should be tested with some field questionnaires), Flanders seems to have a willingness to adopt state-of-the-art/novel concepts in district heating. This is supported by the expertise of DH engineering companies.

### 4.1.3. Densely populated area

Flanders is a densely populated area. As such, it is better qualified to comply with one of the 5 principles of 5GDHC: "Local sources as a priority". This helps to decrease or even avoid energy losses during transport.

## 4.2. Weaknesses

### 4.2.1. Strong presence of gas (distribution networks)

Flanders has a history of gas usage. Gas distribution networks are rolled-out in most of Flanders. Replacing such networks, which have an existing infrastructure, with an entirely new infrastructure is not easy.

### 4.2.2. DH grids are still rare in Flanders and end-consumers are not familiar with them

Gas is widely spread out in Flanders and is therefore the dominant heating source. Switching to DH grids when existing infrastructure is already in place goes slowly. As a result, people are not yet familiar with DH grids and there is a possible reluctance to change. Stakeholders might also not always be well-informed about the benefits of DH grids. As DH grids are developed over multiple years, it is important that all stakeholders are well-informed so that earlier decisions do not undermine DH grid opportunities.

Furthermore, DH grids have to compete with the existing liberalized gas and electricity markets in Flanders where customers have more freedom in switching between suppliers. In that sense, DH is a real monopolistic market which might scare consumers.

### 4.2.3. Lacks cost efficiency in the short and middle term

In Flanders, innovative energy systems based on renewable energy sources need to compete with traditional fossil fuel systems. The later are heavily under-priced in Flanders as most taxes are charged on electricity instead of on fossil fuels. There are no emission taxes. As a result, business cases for DHC grids in Flanders are low, and given the long-term investment character of DH grids, it takes a long time before a DH developer gains back his investment. This is especially the case for 5GDHC as this requires higher investment costs.

For 5GDHC it is also important that production of renewable energy is incentivized sufficiently. In January 2021, net metering for solar panels in Flanders came to an ending. This will increase electricity costs. Starting from 2022, a capacity tariff for grid tariffs will be introduced.

From an end-user perspective, it also seems that there are only limited subsidies (for instance for connecting to a DH grid).

### 4.2.4. High availability of high temperature residual heat

As became evident from the analysis in section 4.3, Flanders possesses numerous high temperature heat sources. As indicated, a significant amount of such sources is located in the neighbourhood of densely populated areas. While this is definitely a strength for 3GDH grids, it is not entirely clear whether this is beneficial for 5GDHC. Depending on the context, 5GDHC grids can also use high temperature residual heat, but this needs to be examined locally. In any case, higher temperature heat is more beneficial for 3GDH than for lower generations.

### 4.2.5. High demand for high temperatures at residential buildings

Almost 60% of the Flemish houses are older than 50 years old. Most of these houses are not renovated and have a very low energy performance. The average EPC-score in Flanders is about 350 (on a scale to 700).

| | One family building | | Apartment | |
|---|---|---|---|---|
| | # | % | # | % |
| **<1945** | 610.762 | 28,7% | 19.435 | 15,2% |
| **1946-1970** | 565.290 | 26,6% | 34.091 | 26,6% |
| **1971-1991** | 516.447 | 24,3% | 26.824 | 21,0% |
| **1992-2011** | 357.435 | 16,8% | 34.997 | 27,3% |
| **>2011** | 78.838 | 3,7% | 10.206 | 8,0% |
| **Unknown** | 264 | 0,0% | 2.430 | 1,9% |
| **Total** | **2.129.036** | | **127.983** | |

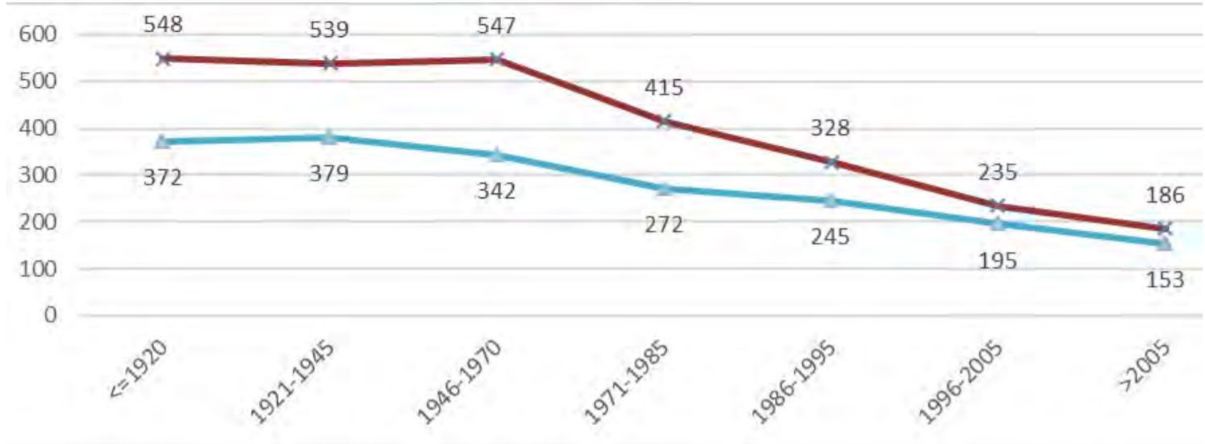



**Figure 16 - EPC correlated by building year in Flanders (red: individual family house, blue: apartment) source: VEA (Vermeiren, 2020)**

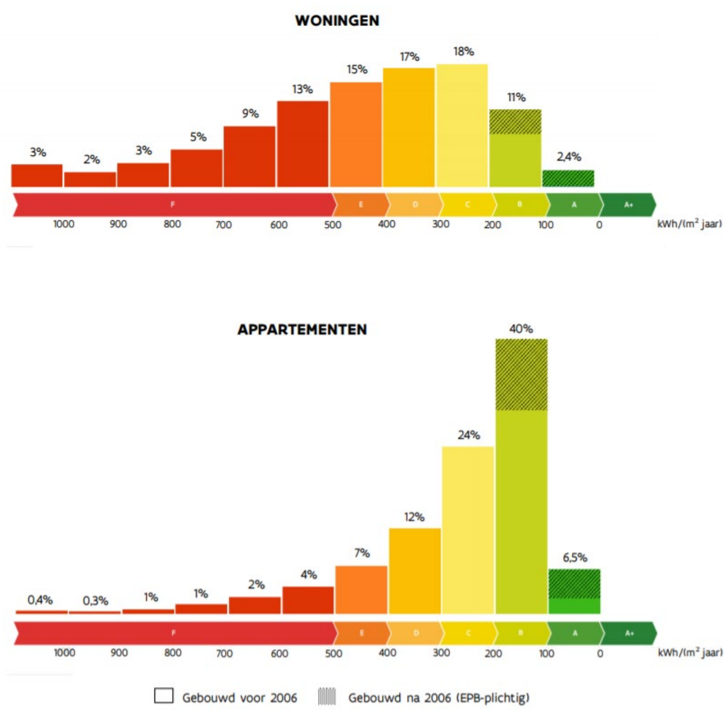



**Figure 17 - EPC value single family buildings ("woningen") and apartments ("appartementen") (source: (Vlaamse Regering, 2020))**

The goal is to decrease the EPC-value for Flanders with 75% by 2050, and thus to achieve a label A (EPC-value of maximally 100). Currently in Flanders, only approximately 3,5% of the houses and apartments reaches this target. In the group of the single-family buildings, about 35% of the buildings as an F label. For apartments, this is less than 9%. It therefore seems that most of the building stock in Flanders is not ready for lower temperature DH grids.

### 4.2.6. Local governments not yet sufficiently enhanced

The Flemish Government recognizes that it is important that local governments (cities, municipalities) are involved in the development of DHC grids. DHC grids are local concepts and public local involvement is important. However, it seems that not all municipalities are well aware of all the different possibilities. The Flemish Government therefore proposed to set up a network of local governments with regional workshops so that they can learn from each other (Vlaamse Regering, 2017b). A guidance book to start the development of DHC grids is also developed. Furthermore, there were ideas to set up the concept of a 'warmtemakelaar' (heat ambassador) that will assist local governments. However, while it is correct that support for local governments is useful and needed, in practise it is not well developed in Flanders. As far as we know, there is only a heat ambassador in Kortrijk. As such, local governments are often not well equipped to help with the roll-out of DHC grids.

### 4.2.7. Lack of open source data

As indicated, to plan DH grids, it is important that there is access to data to match demand and supply. For 5GDHC grids this is even more important as they make use of more local resources. Such local data are often, however, not available in Flanders or they are time-consuming to achieve. This makes planning of such grids more complicated.

### 4.2.8. Lack of focus on cooling options when planning DH-networks

When planning DH grids, stakeholders are easily focusing on the heating part of the grid, and are not necessarily considering the cooling strategy. The same goes for heat plans and heat visions that are set up in Flanders. 5GDHC is considering both heating and cooling, and to reach a full roll-out, it is necessary to value cooling as much as heating.

### 4.2.9. Lack of coordination among various stakeholders and possible partners in DHC

Previous actions taken by other stakeholders (replacement/installation of sewage system, drinking water installation, optical fiber network; roadworks;...) can create options to install immediately other infrastructural improvements in a specific location. However, often, coordination of such district renovations is not taken place and actions are taken separately/individually from other stakeholders. This is especially for 5GDHC grids a weak point, as such grids are highly linked to other systems. 5GDHC grids aim to improve efficiency of the total system and their success therefore also depends on other features of the local environment or related smart grid infrastructures (electricity grid, district heating grid, cooling grids, gas grids, and other infrastructure).

### 4.2.10. Lack of two-sided interaction between heat networks and other energy carriers

These days, heat networks are sometimes already linked to electricity networks to provide ancillary services to the electricity grid. However, a real interaction is still missing as this is mostly a one-sided interaction and often there are still other energy carriers such as (gas/oil...) involved.

### 4.2.11. Lack of huge seasonal storage

As indicated, Flanders has some options for seasonal storage, but the question is whether the existing systems are large enough for 5GDHC. In most cases, 5GDHC grids require a huge seasonal storage due to the unbalance in the heat and cold demand. However, in practise, this might not always be feasible in Flanders. Further examination based on more local data is needed to verify this.

### 4.2.12. Low heat density in rural areas

Although there is a highly populated area in Flanders, in rural parts of Flanders, there is a relatively low heat density in a lot of areas.

## 4.3. Threats

### 4.3.1. No fixed organisational models

The flexible regulatory framework can both be a strength and a weakness of the Flemish region. As there are currently not that many DH grids, stakeholders always have to look from scratch to see how they will organize DH grids. Especially in the case of 5GDHC grids, where there is a possibility that there are even more stakeholders involved, this might complicate doing business together.

Furthermore, as many stakeholders don't have experience with these systems, procedures might take longer than in the case of traditional systems. For instance, in case of public procurement, cities do not always seem to have the knowledge to write out tenders (while they do have to obey public procurement legislation) (Interreg North-West Europe HeatNet NWE, 2019).

### 4.3.2. No clear energy policy vision and incoherence and discontinuity in policy measures

Belgium does not have a clear energy policy. In theory, climate targets are available, but how these should be reached is not worked out in detail. In addition, the measures that will be taken are conservative in the sense that policymakers do not have the courage to shift taxes from electricity to fossil fuels.

Furthermore, there is a lot of uncertainty, as regulation easily changes with different government formations. As a result, there is an incoherence and discontinuity in policy measures to support and incentivize renewable energy technologies (an example is the recent stop in net metering for renewable energy such as PV). Also, there are many different policy levels and regulations with inconsistencies between them.

### 4.3.3. Energy performance regulation does not look at system perspective

Specifically, for heating, EPB-legislation (Energie Prestatie & Binnenklimaat – Energy performance and Indoor climate) is not in favour of DH. DH is punished for its heat losses as EPB mostly looks at technologies from an individual perspective and not from a system perspective. In addition, the use of electricity to circulate warm water in DH is punished. Compared to other generation DHC grids, 5GDHC grids have a benefit in Flanders as they have a higher energy efficiency of heat production and DER (Distributed Energy Resources) due to lower supply and return temperatures. They also have lower heat losses in the distribution grid. Nevertheless, EPB is still punishing system with high electricity usage. And 5GDHC grids still rely on for instance pumps to deliver heat and cold in the system.

### 4.3.4. Gas lock-in and gas network operator monopoly

Gas networks are widely spread out in Flanders. In addition, the gas network operator, Fluvius, would like to gain a monopoly on the development of district heating in Flanders. Most probably, this would not be beneficial for the development of district heating grids in Flanders as Fluvius would compete with its own gas networks against district heating grids.

### 4.3.5. Green heat call in favour of projects with low costs compared to the CO2-emission reduction

Flanders provides subsidies for investments in green heat, residual heat and biomethane. However, such subsidies are less interesting for 5GDHC than for lower generations of DHC grids. Specifically, the green call is ranking projects based on the ratio emission savings versus investment cost. As such, the call is in favor of lower cost projects. Nevertheless, subsidies should be given to innovative projects that are still in a learning phase due to which they have higher costs. 5GDHC grids have higher investment costs and therefore less likely to receive funding.

## 4.4. Opportunities

### 4.4.1. Lack of DH networks

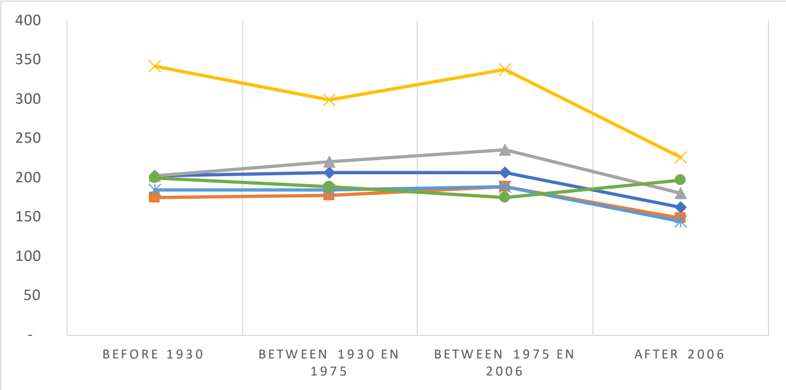
Currently in Flanders, there is only a very limited amount of DH grids. This is actually an opportunity specifically for 5GDHC as it is hard or limitedly feasible to upgrade 3GDH to 5GDHC grids. As a result, in Flanders, one can move directly to 5GDHC grids.

### 4.4.2. Decreasing heating demand (through thermal insulation, passive houses, active houses, etc.)

While a large part of the current heating environment is not yet ready for 5GDHC in Flanders, the goal is in the long run to have better energy performing buildings. As it takes a long time to build out DH grids, there are opportunities to start developing those regions which are more ambitious regarding becoming more energy efficient.

### 4.4.3. Lower heat demand and higher climate ambitions in non-housing buildings

For commercial buildings (offices, schools, hospitals…) Flanders is more ambitious and aims to have an emission free building park by 2050. These buildings currently already have better EPC values than household buildings. The figure below (Figure 17) gives an overview per sector in kWh/m²). It shows that heat demand in these buildings is lower. In addition, commercial buildings also require more cooling than housing buildings. This is an important aspect for 5GDHC.




| | | Before 1930 | Between 1930 en 1975 | Between 1975 en 2006 | After 2006 |
|---|---|---|---|---|---|
| Other social and personal services | EPC number | 202 | 207 | 207 | 163 |
| | #buildings | 3.406 | 3.432 | 2.399 | 597 |
| Health care and social services | EPC number | 175 | 178 | 189 | 149 |
| | #buildings | 1.607 | 2.058 | 1.817 | 454 |
| Shops | EPC number | 202 | 221 | 235 | 180 |
| | #buildings | 6.743 | 6.816 | 4.562 | 1.103 |
| Hotels and restaurants | EPC number | 342 | 299 | 337 | 226 |
| | #buildings | 6.586 | 4.115 | 1.488 | 297 |
| Offices and administration | EPC number | 185 | 185 | 189 | 144 |
| | #buildings | 7.860 | 8.946 | 8.133 | 2.289 |
| Education | EPC number | 200 | 188 | 175 | 197 |
| | #buildings | 714 | 762 | 308 | 68 |
| **Total** | **EPC number** | **230** | **215** | **214** | **161** |
| | **#buildings** | **26.916** | **26.129** | **18.707** | **4.808** |

**Figure 18 - Evolution EPC in non-housing buildings per sector and per building period (figure translated from …) (source: (Vlaamse Regering, 2020))**

### 4.4.4. Import stop of low caloric gas from the Netherlands to Belgium

Normally, the fact that a large part of the gas grid will not be suited anymore to supply gas, should be an opportunity to switch in those areas to alternative, and more renewable heating systems. However, it seems that Belgium is turning an opportunity in a threat by rolling out a plan to replace all low-caloric gas connections with high-caloric gas. This implies replacement at transmission infrastructure, distribution networks and in household appliances. Nevertheless, this report continues to highlight this fact as an opportunity as the project to replace all low-caloric system takes about 10 years. There are therefore still plenty of opportunities to change the plan.

Furthermore, Flanders already decided that gas network operators are not required anymore to provide a gas grid to all houses. Originally, the legislation stated that 95% of all homes in rural areas, and 99% of the houses in urban areas needed to be connected to the gas network.

### 4.4.5. Climate targets

In theory, climate targets should be an opportunity for any type of renewable energy technology. This also counts for Flanders, even though as indicated under weaknesses, Flanders is progressing slowly towards these targets and Flanders is not having a high ambition level regarding climate goals. Nevertheless, to achieve climate targets, Flanders has worked out (or is working out) some plans (such as the heat plan, the wind plan, the solar plan, the spatial vision plans…). These plans could (or should) lead to a better energy policy vision.

### 4.4.6. One third of the Belgian climate target can be filled in with green heat

In Flanders, more than half of the gross final energy consumption consists of heat demand. Green heat has the potential to fill in one third of the climate targets (Vlaamse Regering, 2017b). Regions are aware of this and try to integrate green and residual heat in spatial plans. For instance, in the spatial planning of Flanders (Beleidsplan Ruimte Vlaanderen – BRV), different measures are examined to integrate heat on different levels and to search for synergies. "Het Renovatiepact" is one concrete way in which the Flemish Government further aims to stimulate synergies. It aims to tackle the challenge of integrating green heat in existing buildings.

With regard to the integration of different energy sources (heat, power, gas), the European directive on renewable energy expects that the potential of district heating grids with regard to providing balancing and other system services is examined. Different aspects are being examined:

- Electrification of heat demand through the integration of electrical heat pumps in DH grids and buildings for temperatures below 90°C. This will allow to switch between green power and green heat.
- Making CHPs more flexible by foreseeing thermal energy storage and technical components that allow production to easily start or stop.
- Focussing more on hybrid DH grids, which are grids that make use of different energy sources.
- Combining more DH grids with heat storage.
- Making electricity demand more flexible by making use of industrial cooling (data centres, cold storage…), electrical cooling in office buildings in combination with thermal storage…

### 4.4.7. Thor Park (Genk) is a living lab with possibilities to create a 4-5GDHC

As will be indicated in the roadmap, Thor Park Genk is an SME site which is readily available and interested in a 5GDHC grid. Thor Park is the home of EnergyVille, which is conducting significant research in low temperature DHC grids. This could further boost knowledge and expertise on DHC grids in Flanders.

### 4.4.8. High potential of low temperature heat in cities

Cities contain many sources of low temperature residual heat. This can come from datacentres, sewage water (plants), metro stations, tunnels, office buildings… It should be examined to which extent these can be integrated in a low temperature DHC grid.

### 4.4.9. Natural seasonal storage

It could be an opportunity to use seasonal storage like ATES, BTES and old mines. ATES is possible in the Campina region (Part of province of Antwerp and Limburg), BTES is almost everywhere possible in Flanders. Nevertheless, as indicated previously, it should also be examined whether the size of such systems is sufficient as it seems that opinions differ in this regard.

### 4.4.10. Cascading

As there is a lot of high temperature residual heat in Flanders, it could be interesting to use that heat in 3-4 GDH grids that need to supply higher temperature demand. The heat in the return pipes could then be used as an input for 5GDHC grid.

# 5. Regional vision

The regional vision addresses which barriers need to be addressed first and which opportunities should be taken when rolling out 5GDHC in the region. The vision includes a roadmap describing how much thermal demand (in MWh and/or floor area) could be fulfilled between the end of D2Grids and 2030, including likely locations where implementation can start.

## 5.1. High potential areas and potential pilot sites

The above analysis of Flanders shows that it is hard to clearly identify concrete potential pilot sites for Flanders for 5GDHC. Instead, a more general appointment of Flanders is given below based on the insights of the previous analysis.

One of the most important key aspects of 5GDHC is the reuse of thermal energy. As indicated, such reuse is only possible when a good mix of end-users, who are complementary to each other with regard to their consumption and production profiles, is present. However, for Flanders, it is hard to find public data on production and consumption profiles of different buildings. As such, it is hard to determine which regions are ideal with respect to plausible energy exchanges. This is an analysis that can only be done when a specific site has been selected, and after consultation of the different buildings.

With regard to energy generation and availability, within Flanders, it seems that there are quite some regions with high-temperature energy sources. Such sources are often situated in densely populated areas such as cities. With regard to energy demand, it seems that many Flemish buildings are badly insulated and therefore require high temperature heat sources. As such, regions with a supply of residual high temperature heat, in combination with high heat demand, are more likely to be suited for lower generation DH grids.

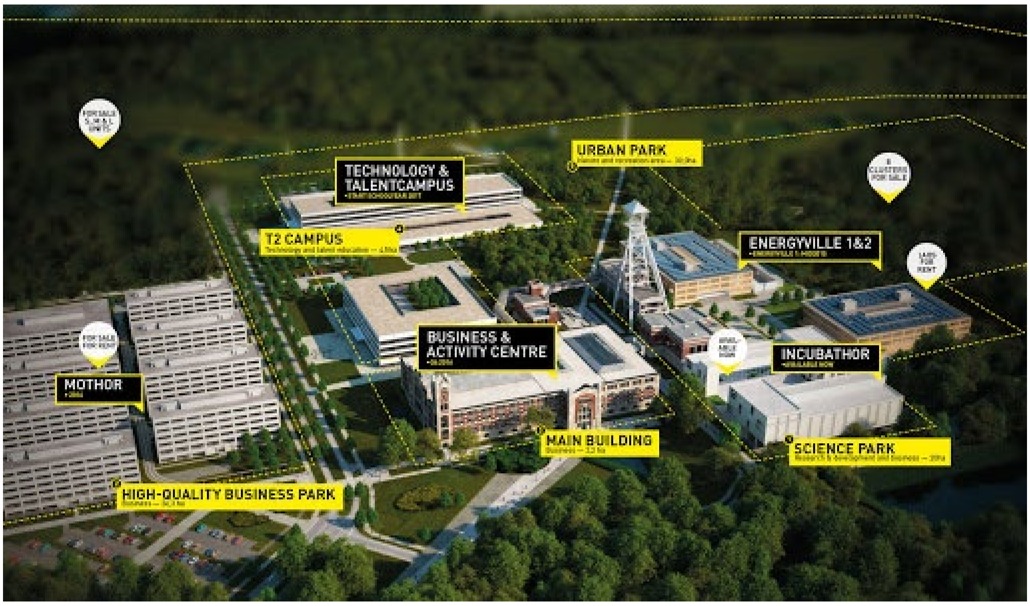
Interesting locations for 5GDHC grids in Flanders are therefore slightly more rural or suburban regions, which are further away from residual (high-temperature) heat sources. In these regions, 5GDHC grid developers need to look for low-temperature heat demanding buildings. Specifically, the previous analysis indicated that more commercial buildings have higher climate ambitions in the short run, and are often better insulated. As such, commercial sites, and/or modern highly insulated new-build residential housing areas, are more likely to be suited for 5GDHC grids in Flanders.

When looking at energy sources available in the above described regions, it seems that mining regions such as Genk, could be interesting, especially with regard to utilizing thermal energy from the flooded mines. However, it is important that some vision is created in this regard as for instance in Thor Park (Genk), a concentrated Solar Power installation is being build and this high temperature heat would potentially be used for the DHC grid that one aims to implement there.

## 5.2. Roadmap

The roadmap systematically shows the steps to take to implement 5GDHC in the follower region, based on the analysis made for this deliverable.

For 2022 the roadmap assumes Thor Park (Genk) is the first pilot site to roll-out 5GDHC in Flanders. Thor Park houses the restored mine building, the IncubaThor office building, the T2 Campus training centre and the buildings of EnergyVille, the collaboration between KU Leuven, VITO, imec and UHasselt for research into sustainable energy solutions. In 2020, Thor Park became the first regulatory sandbox in Flanders and it is allowed to exchange energy between different buildings on the site. It works on three key pillars. First of all, its aim is to better integrate and exchange (renewable) energy locally. Secondly, the researchers want to experiment with an innovative thermal network to optimally integrate renewable sources. For example, the consumption of the heat pumps can be adjusted to peaks in solar and wind energy to simultaneously produce, store and then efficiently deploy heat and cold where necessary. Thirdly, the park aims to implement innovate DH (direct current) networks and connections.




Currently, Thor Park has 5 buildings, of which 4 are planned to be part of the 5GDHC. The buildings that will be part of the grid are summarized below.

**Table 9 - Thor Park 2022**

| Building | m² | Function | Total heating demand (MWh) | Total cooling demand (MWh) | Side note |
|---|---|---|---|---|---|
| Incubathor | +/- 5.400 m² | Mostly offices | 279 | 150 | |
| Thor Central | +/- 11.000 m² | Different functions | 300 | 240 | Currently an additional +/- 11.000 m² is not used |
| EnergyVille 1 | +/- 10.000 m² | Labs and offices | 300 | 300 | |
| EnergyVille 2 | +/- 5.000 m² | Labs and offices | 225 | 225 | Total building is larger than EnergyVille 1, but is not completely in use yet. |
| Total | **31.400 m²** | | **1.104** | **915** | |

For 2032, we assume that the existing Thor Park is expanded with 8 additional buildings. When assuming that those buildings are similar to the building of EnergyVille1, the results below are obtained.

Table 10 - Assumed Thor Park 2032

| Building | m² | Function | Total heating demand (MWh) | Total cooling demand (MWh) | Side note |
|---|---|---|---|---|---|
| Thor park 2022 | +/- 42.400 m² | Offices, labs, varia | 1.479 | 1.230 | EnergyVille2 and Thor Central completely in use |
| 8 additional lots | +/- 80.000 m² | Offices, labs, varia | 2.400 | 2.400 | 8 additional lots with similar characteristics as EnergyVille 1 |
| Total | 122.400 m² | | 3.879 | 3.630 | |

Assuming a linear growth, we assume that Thor Park in 2027 will have 4 additional lots filled in. This would result in the following characteristics for Thor Park.

Table 11 - Assumed Thor Park 2027

| Building | m² | Function | Total heating demand (MWh) | Total cooling demand (MWh) | Side note |
|---|---|---|---|---|---|
| Thor park 2022 | +/- 42.400 m² | Offices, labs, varia | 1.479 | 1.230 | EnergyVille2 and Thor Central completely in use |
| 4 additional lots | +/- 40.000 m² | Offices, labs, varia | 1.200 | 1.200 | 4 additional lots with similar characteristics as EnergyVille 1 |
| Total | 82.400 m² | | 2.679 | 2.430 | |

It is reasonable to assume that by 2032 there will be a second pilot site. However, currently, no concrete site is envisioned yet.

| | | 2022 | 2027 | 2032 |
|---|---|---|---|---|
| PROPOSED 5GDHC ROLL-OUT | Floor area [m²] | 31.400 m² | 82.400 m² | 122.400 m² |
| | Energy [MWh/a] | 6,43 MWh/a | 6,20 MWh/a | 6,13 MWh/a |

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