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EVALUATION OF THE MARKET TRANSFORMATION POTENTIAL OF 5GDHC

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Data sources:

- Heat Roadmap Europe, 2018, Country Roadmaps Belgium, Germany, France, United Kingdom, Luxemburg and The Netherlands
- Stratego - Quantifying the Heating and Cooling Demand in Europe Work Package 2 Background Report 4
- "The generation battle, 4th versus 5th generation of district heating - Gudmundsson and Thorsen - DHC No 3 '21
- DHC Market Outlook (Euroheat & Power, 2022)
- RES DHC (Euroheat & Power, 2021)
- D2G project, several documents

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Summary

The D2Grids project aims to answer the question what market transformation potential 5th generation district heating and cooling (5GDHC) has in the future.

Because the data needed for the initial method developed for this purpose was not available, an alternative method was developed. This method uses existing studies on the market potential of traditional district heating. This report describes this method which also looks at the similarities and differences between 5GDHC and traditional district heating.

The result of this analysis is that 5GDHC could have a market transformation potential of 15% of the entire heating market by 2050 if district heating were indeed to grow at the rate indicated in the studies studied. This would mean that in 2050 5GDHC systems would cover 40% of all new district heating installed after 2022.

1. Introduction

The D2Grids project aims to answer the question what market transformation potential 5th generation district heating and cooling (5GDHC) has in the future. This concerns the period from the present to 2050. 5GDHC are thereby defined as networks that meet 5 criteria. Initially, an approach based on IPTs was chosen: "Indicator for Potential Transformation". This concept was developed among project partners and each indicator is designed particularly to measure the potential for a 5GDHC market in Europe. The indicators were divided in four main categories, and together will provide an overview of the market transformation potential for 5GDHC. See the report "Work package WPLT, deliverable 4.1, Foundation for the methodology to evaluate the market transformation potential of D2Grids (5GDHC)", September 2022. This looked at 4 types of indicators. Each indicator looked at the geographical level at which the data should be available and the time scale for which the data should be valid.

Table 1 Indicators for Potential Transformation according to D2Grids

Type of indicator	Indicator for Potential Transformation of the market for DHC to 5GDHC	Geographical level	Time scale
Contextual	Supporting legislation and energy-climate policies	• Country	• During D2Grids • 5 years after D2Grids ends • 10 years after D2Grids ends
	Building retrofit planned (%), current and future energy efficiency of buildings	• Country	• 10 years after D2Grids ends
	Current district heating network available (retrofit by 5GDHC)	• Country	• During D2Grids
	Percentage of gas networks	• Country	• During D2Grids • 5 years after D2Grids ends • 10 years after D2Grids ends
Technological	Ratio of cooling and heating demand - balance possibility for a 5GDHC system	• Pilot level • Regional level	• During D2Grids
	Demand for LT heating	• Pilot level	• During D2Grids
	Demand for HT cooling	• Pilot level	• During D2Grids
	Number of LT heat sources available in the region	• Pilot level	• During D2Grids
Economical	Levelised cost of energy for end consumers	• Pilot level	• During D2Grids
	Financial return (for network owners)	• Pilot level	• During D2Grids
	Expected future financial return (optional)	• Pilot level	• 5 years after D2Grids ends • 10 years after D2Grids ends
	Investments trajectory on innovative networks	• Pilot level	• During D2Grids • 5 years after D2Grids ends • 10 years after D2Grids ends
	Public statements to commit to 5GDHC	• Regional level	• During D2Grids • 5 years after D2Grids ends • 10 years after D2Grids ends
	Ratio of investments by source	• Regional level	• During D2Grids • 5 years after D2Grids ends • 10 years after D2Grids ends
Social	Level of social awareness	• Country	• During D2Grids
	5GDHC Added value and comfort	• Country • North-western Europe	• During D2Grids

Unfortunately, the data needed to perform the developed method turned out not to be sufficiently available at the required geographical levels and time scales. For this reason, it was necessary to resort to an alternative method to still be able to make a statement about the market transformation potential for 5GDHC.

2. Alternative method for determining 5G market transformation potential

The alternative method found for determining the market transformation potential of 5GDHC assumes the use of as recent existing studies as possible on the market transformation potential in the future (2040-2050) of more traditional district heating such as 3G and 4G district heating. The underlying justification for this approach is that the deployment of 5G district heating has boundary conditions that are in many cases very similar or even completely similar to those that apply to 3GDH/4G district heating. These are technical, economic, social and contextual boundary conditions. We return to these later in text.

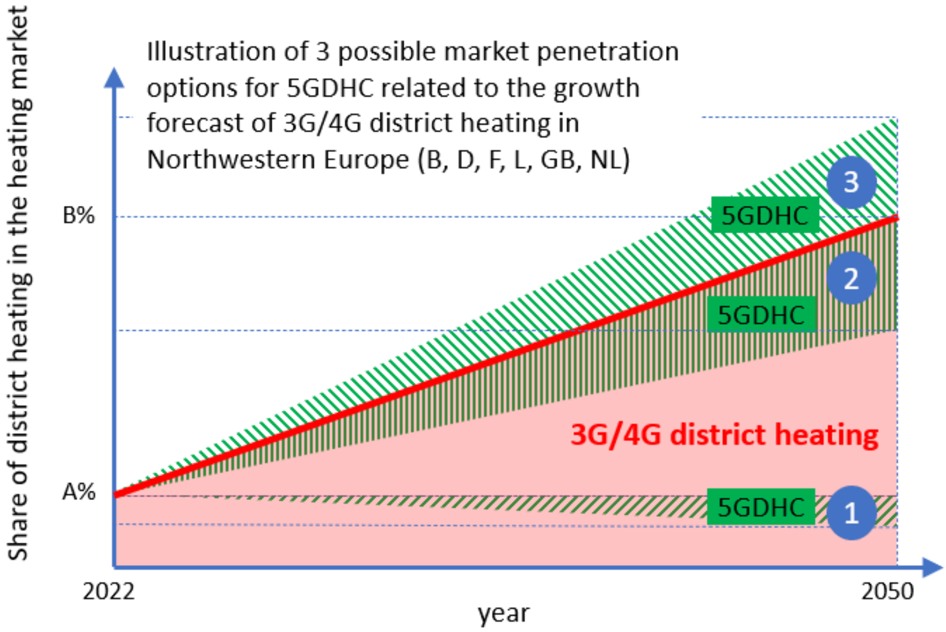
Relative to that potential for 3GDH/4G, 5G has the following market opportunities:

1. Conversion of (parts of) to 5G of 3GDH/4G district heating that are already in place. This usually requires a massive retrofit of all existing customers to suffice with low supply temperatures (30-55°C) throughout the network. Technically this is certainly possible, but it requires strong project management to get all customers to take the necessary measures on the building envelope, ventilation systems and/or emission systems at the same time at the latest[1]. If buyers cannot be enticed to do so voluntarily, strict regulations that set requirements for maximum heat use per unit building area can help.
2. Where a 3G/4G network was envisaged for a new district heating or an extension to an existing 3GDH/4G district heating, a 5G district heating can also be chosen. However, additional conditions must be met to do so:
   a. Retrofit of the customers to be connected so that a low supply temperature (30-55°C) is sufficient (by improving insulation/ventilation)
   b. Link to the existing cold demand to the system
   c. Local heat (and cold) sources and resources (electricity for heat pumps)
   d. Peak shaving of energy resources through smart control and buffering
2. Where a 3GDH/4G does not prove possible (e.g. for economic reasons such as the minimum scale required or because the available heat source has a too low temperature for a 3G/4G network), a 5G network may be possible.

The figure below shows the ways in which 5GDHC could fill part of the future market for collective heating systems or even provide an expansion of that market. As we will see later, there are estimates for the future market share of district heating in the overall heat market for the countries that make up North-western Europe (Belgium, Germany, France, Luxembourg, the Netherlands and the UK).

[1] For more information about these measures see:
- Introduction to 5th generation district heating and cooling (5GDHC), August 2022, D2Grids (link: https://www.ou.nl/en/opleiding?sku=NC0610)
- 5th generation district heating and cooling (5GDHC) technology, January 2023, D2Grids (link: https://www.ou.nl/en/opleiding?sku=NC0710)

Figure 1 Illustration of possible market penetration options of 5GDHC related to the growth forecast of 3GDH/4G district heating in North-western Europe (B, D, F, GB, NL) (the figures 1, 2 and 3 refer to the text above). Note: the stated market potentials for 3GDH/4G and 5GDHC are fictitious.



Source: D2Grids 2022.

For all three options for the market penetration of 5GDHC mentioned above, experts need to estimate which conversion factor can apply in relation to the expected growth of 3GDH/4G district heating. Together with substantiated values for the current market share of district heating (A%) and the expected market share (B%), this provides a picture of the market transformation potential for 5GDHC in the 2050 reference year.

3. Differences between 3GDH/4GDH and 5GDHC

3.1. Introduction

If we derive the potential of 5GDHC from the potential of 3G/4G district heating, it is good to have clarity on where these types of district heating differ. Hendrik Lund (Aalborg University, Denmark) has published on this, with others. In the article "Perspectives on fourth and fifth generation district heating " (March 2021), he analyses the differences between 4GDH and 5GDHC. In doing so, he starts by describing the abilities of a 4GDH network (quote Lund et al.):

1. *The ability to supply existing, renovated, and new buildings with low-temperature DH for space heating and domestic hot water.*
2. *The ability to distribute heat in DH networks with low grid losses.*
3. *The ability to recycle heat from low-temperature waste sources and integrate renewable heat sources, such as solar and geothermal heat.*
4. *The ability to be an integrated part of smart energy systems and thereby helping to solve the task of integrating fluctuating renewable energy sources and proving energy conservation into the smart energy system.*
5. *The ability to ensure suitable planning, cost and incentive structures in relation to the operation as well as to strategic investments related to the transformation into future sustainable energy systems.*

Lund et al. then studied a number of publications on projects with district heating at lower temperatures (<50°C) than are common in 4G networks. From these, they derived the following main characteristics of 5GDHC (quote Lund et al.):

a) *take advantage of the synergy of combined heating and cooling in areas of mixed purpose buildings,*
b) *minimise the barrier of utilizing local waste heat sources and minimise upfront investment cost for the utility company, though the required initial investment at the end-users will be higher, and*
c) *enable less restrictive organic growth of the system, as central heat supply is not as critical, since new additional end-users will both add and use heat from the network.*

These key characteristics are largely recognisable when looking at the definition of 5GDHC in the D2Grids project (see also the document 'KPI for 5GDHC' [2]).

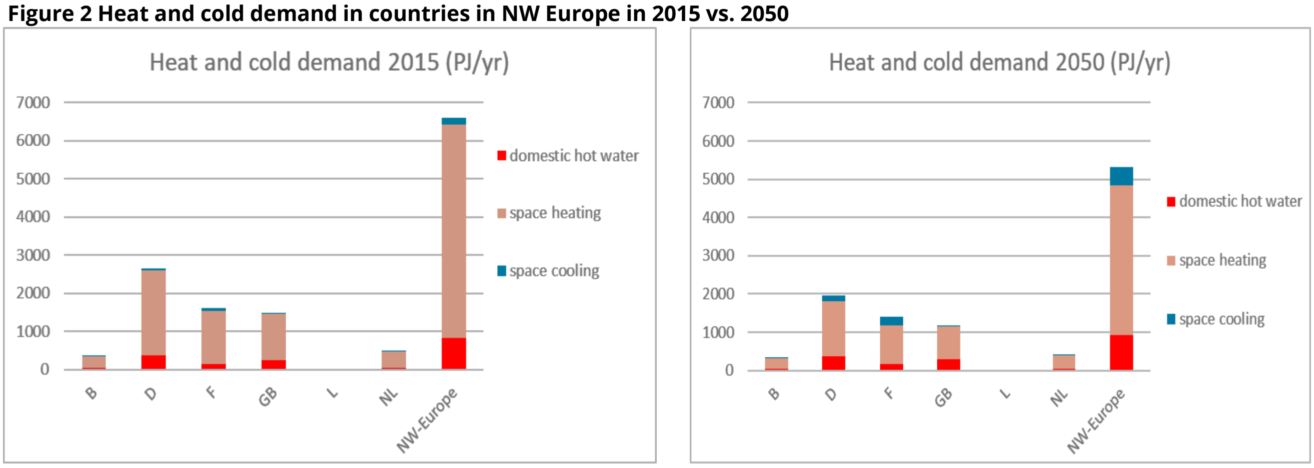
Lund et al. further indicate that 5GDHC will be more appropriate and competitive in areas where heat and cold demand are more in the same order of magnitude (so that heat and cold exchange is profitable) and where no cheap traditional sources of heat and cold are present. Lund et al. also see 5GDHC not so much as a sequential further development of 4GDH but more as a parallel development with 4GDH where 5GDHC is applied under specific conditions. So Lund et al. do not actually expect a major substitution of 4GDH but mainly a complement to it (market expansion for district heating, see option 3 in Figure 1).

3.2. Balance between heating and cooling demand in North-western Europe

A unique selling point for 5G district heating is the ability to supply cold as well. The use of cold is becoming increasingly important in homes and buildings. This is especially true as the climate changes (resulting in warmer summers) and the insulation level of buildings becomes ever higher due to stricter requirements from the European Union. In 5G networks, temperatures are much lower than in traditional district heating and, for example, a heat pump can be used to achieve a limited temperature drop with relatively little electricity to cool a building or home. This can provide an additional earning effect in the business case, making a 5GDHC network perhaps still financially viable in a location where a 4G district heating is no longer feasible.

In line with Lund's conclusion, the question is how total heat and cooling demand in North-western Europe might develop up to 2050. For this, we look at a study from 2018, see figure below. This shows the heat and cooling demand of a home or building as a whole, excluding distribution losses in the building itself. This is a good indicator of heat and cold demand.

Figure 2 Heat and cold demand in countries in NW Europe in 2015 vs. 2050



Source: Heat Roadmap Europe, 2018, Country Roadmaps Belgium, Germany, France, United Kingdom, Luxemburg and The Netherlands

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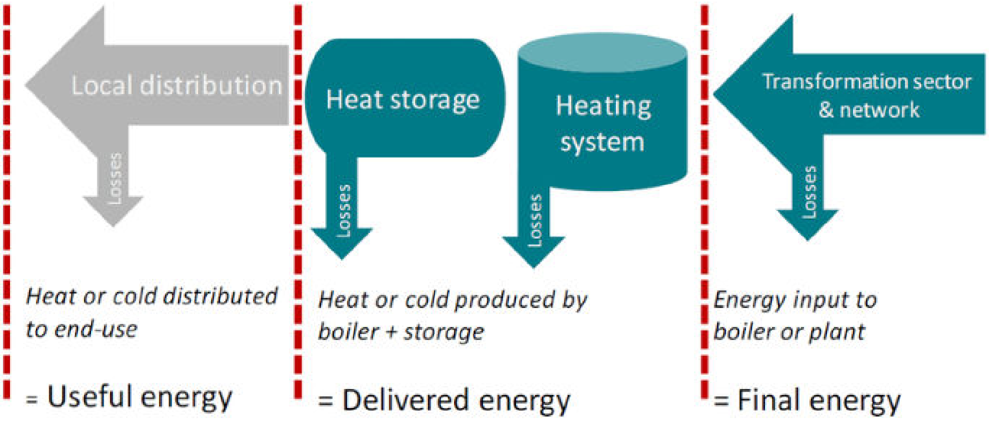
[2] KPI for 5GDHC

Final energy, delivered energy and useful energy

If we look to the heat and cold demand of buildings it is important to have a look at the different kinds of energy: the energy supplied to the building which is converted to useful heat and cold in the building (for example the amount of electricity, natural gas, coal etc.), the energy output of the different conversion equipment (for example boilers, heat pumps, cooling machines but also storage equipment etc.) and the amount of useful heat and cold which flows into the spaces and out of the taps. Aalborg University has researched the development of the 'delivered' heat demand. See figure below for the different kinds of energy.

Definition of final, delivered and useful energy



Source: HRE4 - Heat Roadmap Europe - A low-carbon heating and cooling strategy for Europe (2018)

The 'delivered heat demand' is equal to the amount of thermal energy (heat or cold) which is produced by a central or building integrated heating system and delivered to a building. The 'delivered heat demand' is (almost) independent of the technology with which the heat or cold is produced; only if the local distribution losses can play a role.

In 2050 the total of demand for heat and cold in NW Europe will decrease with about 20%. The absolute cold demand is expected to almost triple from 2015 to 2050 which leads to an increased share of cold supply in the total thermal market for buildings of 9%. The growth of space cooling demand in Belgium, The Netherlands and the UK is expected to grow lower (doubling) but France and Germany dominate this with their size. Delivered heat for space heating in NW Europe decreases with 30% due to saving measures (insulation and ventilation with heat recovery). The demand for domestic hot water in NW Europe might increase with 11% in absolute terms with means that the share increases from 13% in 2015 to 18% in 2050.

The figure above shows that in North-western Europe, cold demand will remain relatively small in relation to heat demand even in the longer term. In countries like Spain and Italy, the situation is obviously quite different. The question is whether this analysis also takes into account that the climate is changing (more cold demand and less heat demand) and that more far-reaching structural renovations of buildings and homes often mean that, due to much better insulation, although heat demand decreases, cold demand may also arise. Given the small share of annual cold demand in the figure above, it does not seem likely that the effects of climate change and renovations will tilt the picture.

If we combine the cold demand map in the Stratego report with the population density in North-western Europe, we also see a considerable difference with the southern part of Europe.

Figure 3 Cold demand vs. population density in Europe

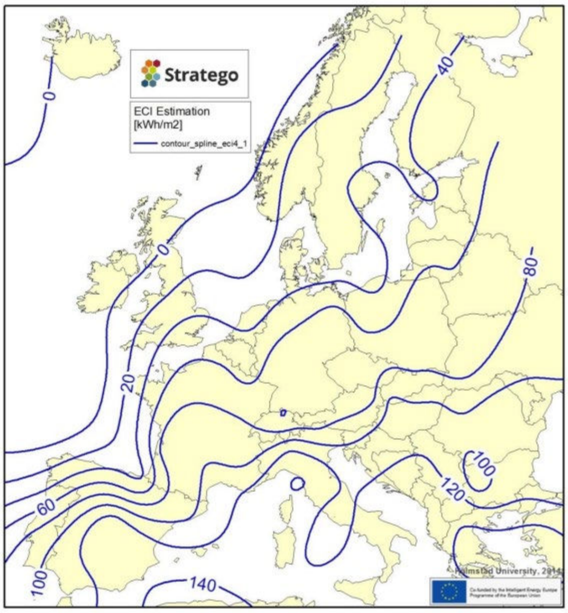
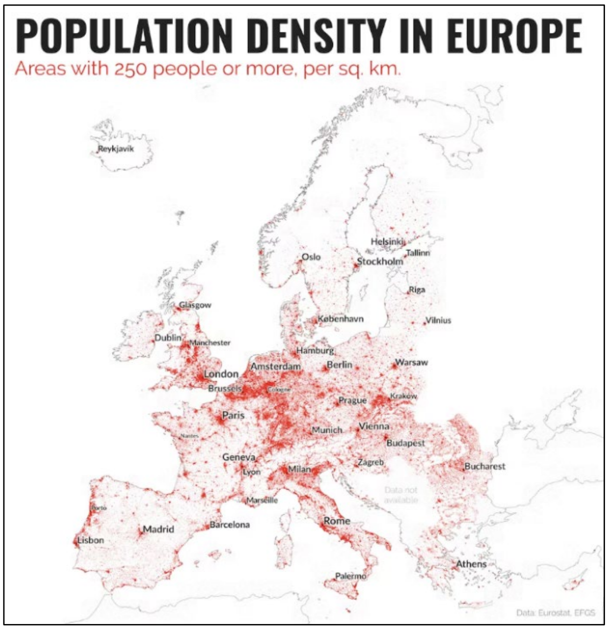


Figure 8. The average specific cooling demands in kWh/m² for service sector buildings for various locations in Europe. The map has been generated by using the red average line in Figure 5 together with estimated ECI for 80 different locations according to (Dalin et al., 2005).

Source: Stratego - Quantifying the Heating and Cooling Demand in Europe Work Package 2 Background Report 4 p. 17



Source: https://theconversation.com/

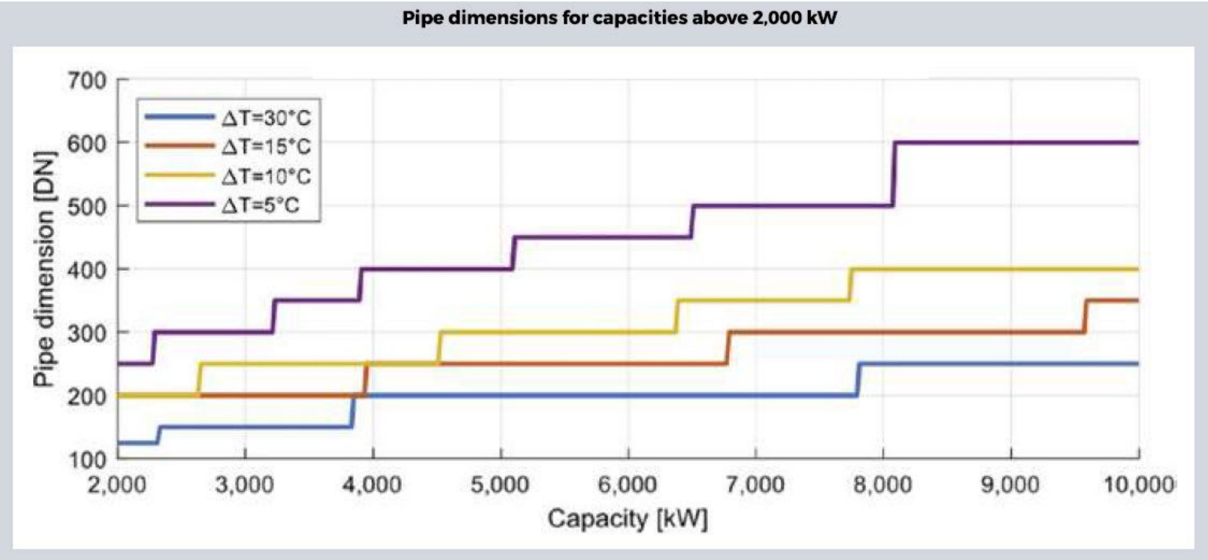
The conclusion thus seems justified that one of the major advantages of 5GDHC over 4GDH, combining heat and cold supply, is certainly present in northwest Europe but has a certain limit due to the imbalance between the total annual heat and cold demand of buildings.

3.3. Transport capacity in 5GDHC vs. 4GDH

One effect that may also co-determine the market opportunities of 5GDHC is the effect of lower temperatures in 5G systems. These also create smaller temperature differences between the supply and return pipes of the district heating. Despite the fact that rational (i.e. lower) heat demand will often be ensured in 5G networks by applying relatively high levels of insulation and improved ventilation, 5G networks will still often have a need to apply thicker and therefore more expensive pipes. See the figure below from the publication "The generation battle, 4th versus 5th generation of district heating - Gudmundsson and Thorsen - DHC No 3 '21[3] . This concerns the larger pipes, to larger customers or for the backbone (>2000 kW).

Figure 4 Pipe dimensions in relation to temperature difference

[3] https://online.flippingbook.com/view/596430928/12/



Source: Gudmundsson and Thorsen - DHC nr 3 '21

Thicker pipes are obviously more expensive than thinner pipes, both in terms of materials and construction costs. Now, pipes operating at lower temperatures may be easier to construct in plastic instead of steel but with the thicker pipes, there are certainly limitations due to the pressures and mechanical strength required.

This raises the question of whether a 5GDHC network should always operate at low or very low temperature for 100% of its total length. There are certainly conceivable configurations in which this is indeed the case (see, for example, the D2Grids pilot in Brunssum), but it is also possible to operate the backbone in particular at (very) low temperature and to use higher temperatures in the sub grids ('clusters') and possibly also four-pipe distribution to be able to supply both heat and cold. Some may not classify this as a 5GDHC system but that is unjustified. After all, heat and cold can then be exchanged in the sub grids at the thermal power plant present there. Thermal energy that cannot be reused directly can be exchanged with a buffer at the sub grid level or with the backbone. Sub grids provided as 4GDH can thus be relatively easily converted or extended to become part of a 5GDHC system. This is expectedly where much of the market transformation potential for 5G lies.

3.4. Density of the heat demand

By starting from studies for 4GDH, there is a basis for the potential of 5GDHC. After all, 5GDHC also needs a certain density for heat demand, just like 3GDH and 4G district heating. This drops off areas with relatively low density such as rural areas. Indeed, in those areas, grid costs will be too high compared to the application of heat pumps in particular at the customer level (without a connecting grid). On heat demand density, we go into a little more detail below. The figure below clearly shows that heat distribution costs rise sharply as heat demand density decreases. With decreasing heat demand density, this leaves less financial scope in the business case for purchasing heat. In areas with somewhat low heat demand density, district heating therefore still have a chance if heat production can be relatively cheap. In 5G systems, source heat does tend to be relatively cheap if heat can be sourced from the ground, from outdoor air, from the return flow of a cold customer, from waste water or from industrial waste heat. On the other hand, heat pumps are usually needed to bridge the temperature difference. Those heat pumps require investment and maintenance costs as well as electricity. Their cost must be added to the cost of source heat. As a result, 5G grids will also definitely have a certain lower limit for heat demand density.

Figure 5 Ability to pay for heat

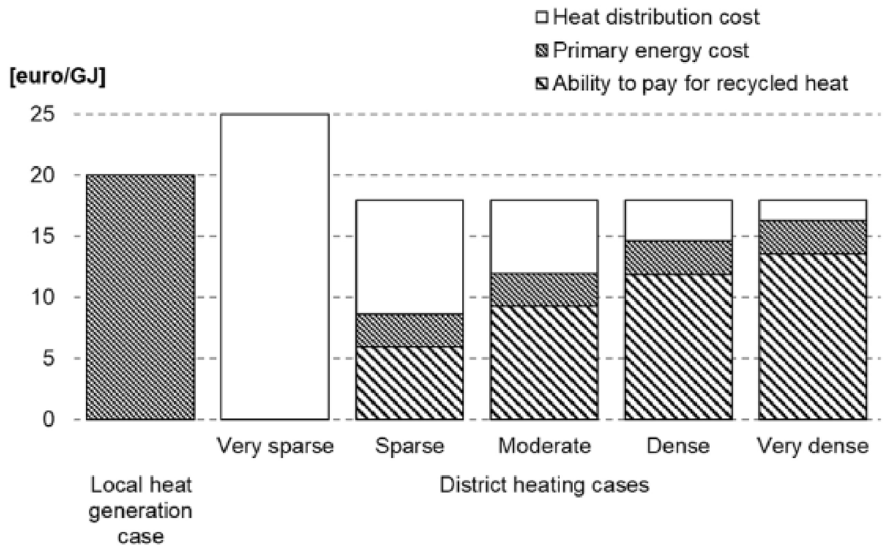


Fig. 1. Example with cost structure comparison between one local heat generation case and five district heating cases with respect to heat distribution costs, primary energy costs (heat generation), and the abilities to pay for recycled heat (excess heat recovery). The five district heating cases consider different concentrations of the heat demands.

Source: Heat Roadmap Europe: Heat distribution costs, 2019, p. 605

4. Expert view on the market transformation potential for 5GDHC

Looking at Figure 1 and the difference analysis between 3G/4G district heating networks and 5GDHC on the pages above, the question is what proportion of existing or future 3GDH/4GDH networks would be convertible to 5GDHC and how much potential there is for 5GDHC systems that may never be realised as 4GDH. To this end, an expert view was organised within the D2Grids project. From the responses to that expert review (from experts from Mijnwater, VITO, Greenflex and Stroomversnelling), the following estimate can be derived:

Table 2 Expert view D2Grids

Part of market transformation potential (see also Figure 1)		**Expert view (between brackets: all various responses)**	
		2035	**2050**
1	Conversion of heat distribution existing in 2022 to 5GDHC	4% of 3GDH/4GDH grids in 2022 (2,5%, 2,5%, 2,5%, 10%)	10% of 3GDH/4GDH grids in 2022 (5%, 5%, 5-10%, 20%)
2	**Realization of new to build 3G/4G-district heating as 5GDHC**	17,5% of realised 3GDH/4GDH grids, cumulative (12,5%, 20%, 20%, no 4th response)	35% of realised 3GDH/4GDH grids, cumulative (20-25%, 40%, 50%-70%, no 4th response)
3	Realization of 5GHDC-systems which wouldn't be realised since 2022	7,5% of realised 3GDH/4GDH grids (cumulative) (5%, 5%, 7,5%, 10-15%)	20% of realised 3GDH/4GDH-netten (cumulative) (10%, 15%, 20-25%, 30%)

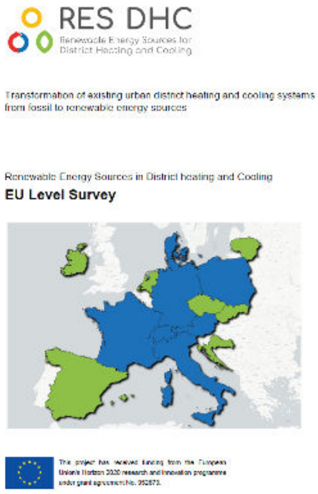
The next step is to find suitable data for the potential of 3G/4G district heating until 2050.

5. Market transformation potential for 3GDH/4GDH to 2050

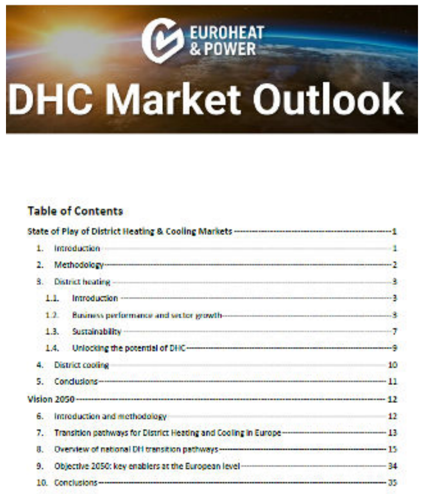
5.1. Introduction

An extensive literature review has shown that only a few studies have examined what share traditional district heating (3GDH/4GDH) could have in the heat supply for the built environment up to 2050. The scope here is the various countries that make up North-western Europe. North-western Europe is defined as the territory formed by Belgium, Germany, France, Luxembourg, the United Kingdom and the Netherlands. Relevant studies in this context appeared to be:

Heat Roadmap Europe 4
(consortium of 14 organizations, 2016-2019)



RES DHC
(Euroheat & Power, 2021)



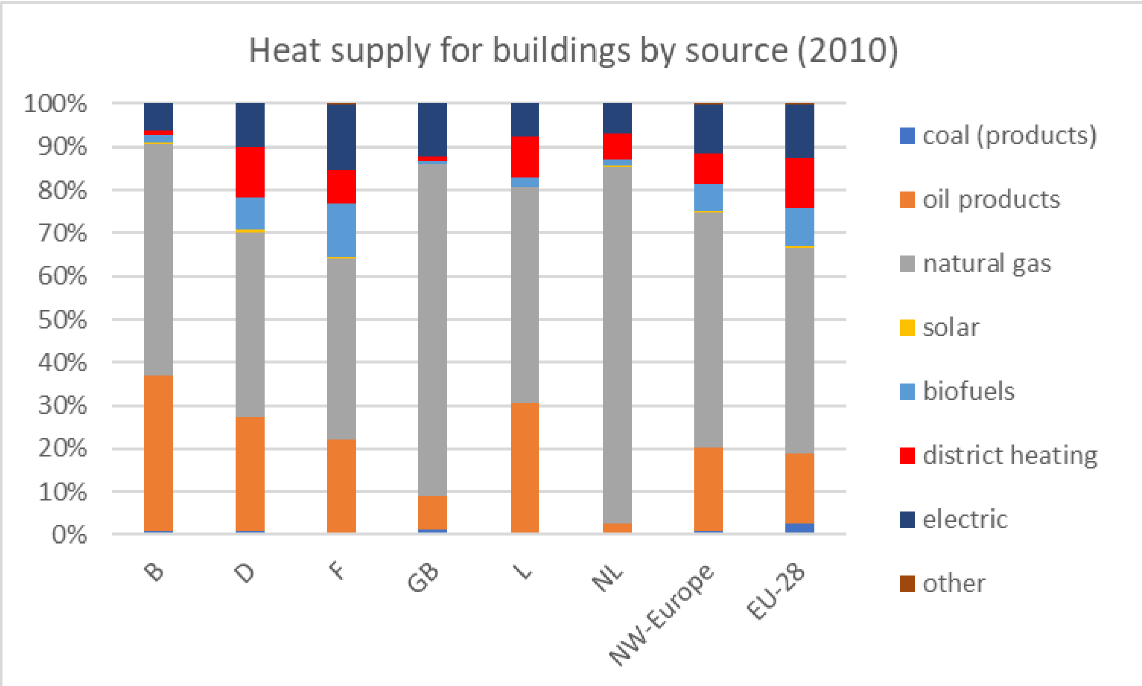
DHC Market Outlook
(Euroheat & Power, 2022)

5.2. Current share of heat distribution in the heating market

Figure 6 below shows how heat was provided in the North-western European countries in 2010. The picture for 2022 will differ slightly from this but in outline this picture will still be the case. Natural gas dominates the heat market in all countries. In Germany and France, however, heating oil, electricity, district heating and biofuels (especially wood) also play a substantial role. According to the Stratego study, district heating had a share of just over 7% in North-western Europe in 2010. In the United Kingdom, coal still plays a very small role.

On a European scale (EU-28) we see almost the same picture as in North-western Europe with a share of natural gas of about 50%, a share of 20% for heating oil, a share of about 10% for district heating and 10% share for other sources.

Figure 6 Residential and service sector building heat market by source



Source: Stratego - Quantifying the Heating and Cooling Demand in Europe Work Package 2 Background Report 4 p. 23

The figure below shows the result of the study Heat Roadmap Europe 4 on the potential of district heating in 14 European countries.

Figure 7 Share of district heating in 14 European countries (Baseline 2015 and feasible share in 2050)

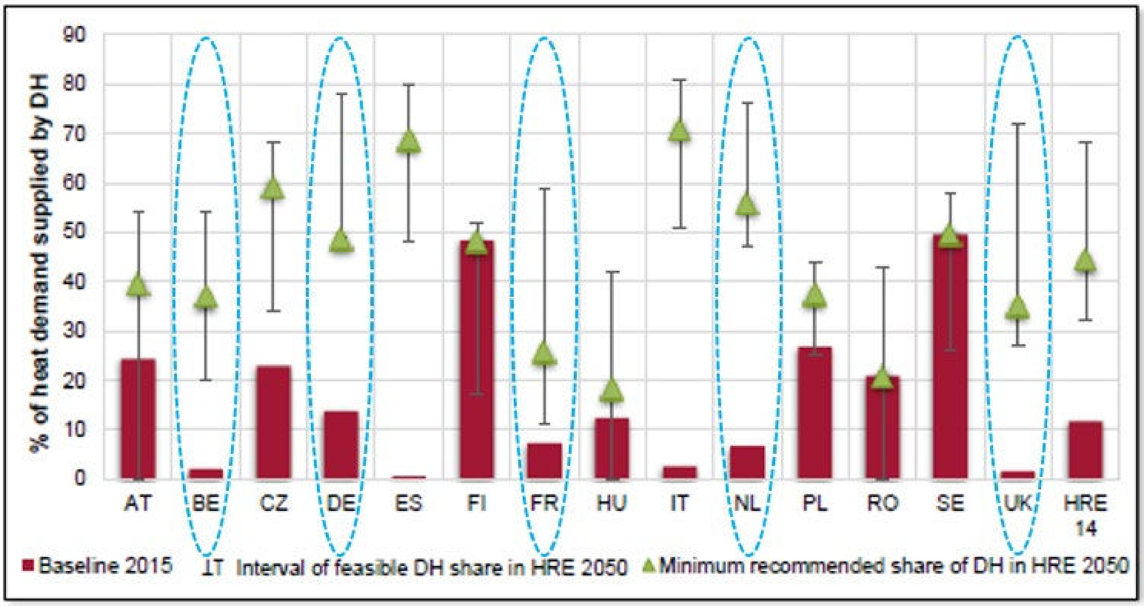


Figure 6. Baseline share of district heating in 2015 and the minimum recommended level of district heating share in HRE4. The range bars represent the amount of district heating that is economically feasible within a 0,5% total annual energy system cost change sensitivity. The recommended minimum levels take into account cost efficient levels and current level of district heating. Going beyond this level can generally increase energy efficiency.

Source: Heat Roadmap Europe 4 (Aalborg University) 2018 p.22

If we look in Figure 7 at the countries that make up North-western Europe (Belgium, Germany, France, the Netherlands and the United Kingdom), the following stands out:

- North-western Europe has a relatively low share for direct heating in 2015 compared to Scandinavian countries;
- The differences North-western Europe are very large with very small current shares for Belgium and the United Kingdom and a much larger share for Germany.

A comparison of Figure 6 and Figure 7 shows that with respect to the baseline for the share of district heating (2010 (Stratego) and 2015 (Heat Roadmap Europe) respectively, these studies are very close to each other with the Heat Roadmap showing slightly higher figures.

<u>Conclusion: the market share of district heating in North-western Europe anno 2022 will be about 10%, an extrapolation of 2010 figures (Stratego) and Heat Roadmap Europe (2015).</u>

5.3. Future share of district heating and district cooling in the heat and cold market

Explorations of the future share of district heating in the heat market are done in particular in the study Heat Roadmap Europe 4 (2018) and the DHC Market Outlook (latest edition: 2022).

For the results Heat Roadmap Europe 4 we look again at Figure 7. In it we see:

- The 'minimum recommended' potential foreseen for North-western Europe is large compared to the 2015 Baseline: minimum 25% (France) to maximum 55% (Netherlands). The differences have mainly to do with the distribution of population density and thus heat demand density in areas with large cities, urban/suburban and rural areas, see the figure in Annex 1 with more details on this;
- Countries that currently have relatively few district heating (Spain, Italy and the Netherlands) can have very large potentials by comparison;
- Countries that already have a high proportion of district heating in 2015 (Finland, Sweden, Poland) have a relatively small growth potential. Here, therefore, some market saturation has already occurred;
- The uncertainty intervals are very large.

If we look at North-western Europe as an area and relate the share district heating to the absolute heat demand as shown in the right part of Figure 2 then the result is in the table below:

Table 3 Shares of district heating in countries in North-western Europe in 2050

Country	Heat demand 2050 on building level (excluding internal distribution losses) (PJ/year)	Low side interval of feasible share in 2050 by HRE	Recommended share for district heating in 2050 by HRE	High side interval of feasible share in 2050 by HRE
B	324	20%	36%	55%
D	1.803	48%	48%	78%
F	1.166	10%	26%	59%
GB	1.144	28%	34%	72%
L*	-	-	-	-
NL	390	48%	55%	76%
NW-Europe	4.827	**32%**	**39%**	**70%**

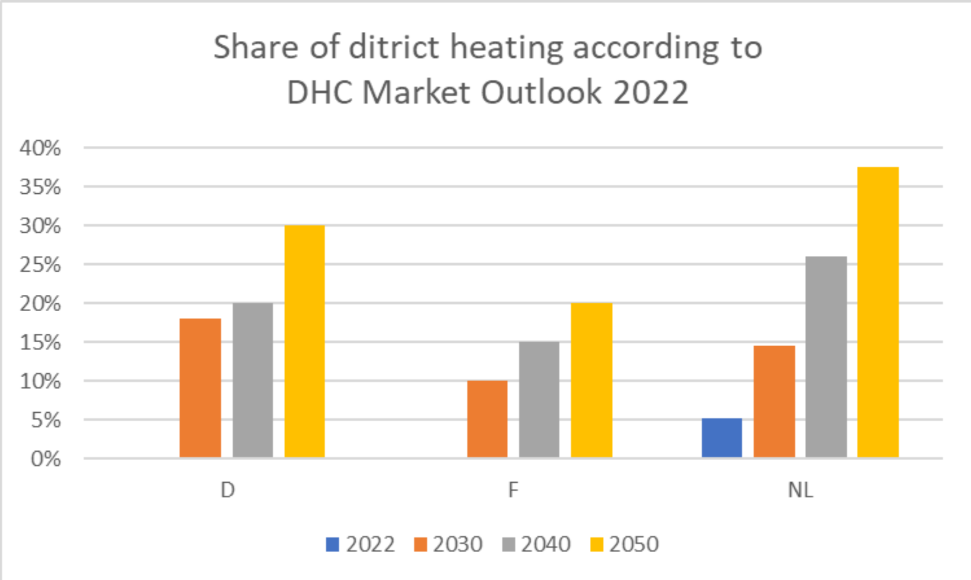
*No data available

Source: Heat Roadmap Europe (HRE), 2018

What is striking in Table 3 is that the uncertainty interval at the top is so wide. This seems somewhat unlikely with such high percentages (over 70% share Germany, United Kingdom and the Netherlands). For this reason, for the desired analysis, we adopt the recommended value: 39% in 2050.

Another prediction of the share of district heating we see in the recent DHC Market Outlook 2022. Figure 8 below shows market shares for two North-western European countries (Germany, France) that are significantly lower than the 'minimum recommended' market shares as indicated in the Heat Roadmap. This may be due to the fact that DHC Market Outlook uses a completely different method to arrive at the figures: the members of industry association Euroheat & Power completed an extensive questionnaire. The answers were supplemented with the latest industry trends, regulations and various challenges and opportunities. Exactly how this was fleshed out cannot be gleaned from the DHC Market Outlook report. Euroheat & Power notes that, due to a lack of data for certain countries, the overview is not complete.

Figure 8 Share of district heating according to DHC Market Outlook 2022



Source: DHC Market Outlook 2022

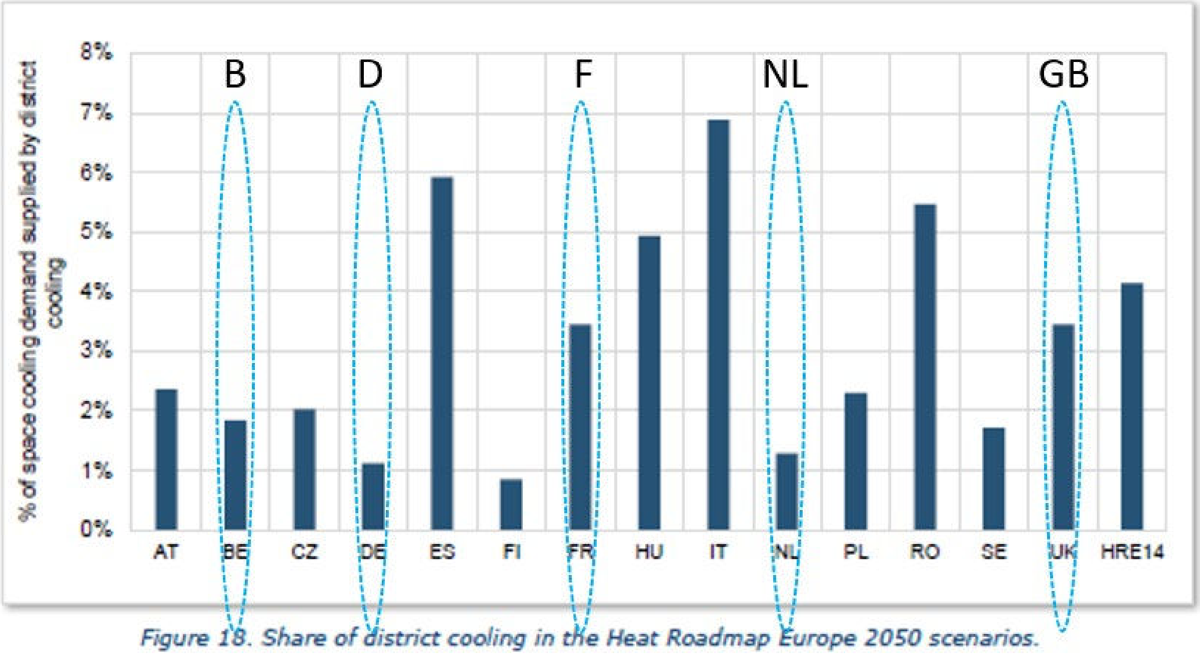
For unclear reasons, the trend seen for Germany differs greatly from the trend for France and the Netherlands for the city between 2030 and 2040. Unfortunately, the DHC Market Outlook also does not appear to provide figures for the countries of Belgium, Luxembourg and the United Kingdom. These are countries with a low share for district heating at the moment.

If we weigh the figures for Germany, France and the Netherlands with the same figures for heat demand as in Table 3 we arrive at a combined share for district heating in 2050 of 27%. This is significantly lower than the result for the 'recommended share' (39%) in Table 3 which comes from the Heat Roadmap Europe 4).

Conclusion: from two different studies on the expected share of district heating in (countries in) North-western Europe, we see a range from 27% to 39%, with the latter figure being easier to derive how this was arrived at.

The Heat Roadmap Europe 4 also looked at the market for district cooling. See Figure 9 below.

Figure 9 Share of district cooling in 2050



Source: Heat Roadmap Europe 4 (Aalborg University) 2018, p. 83

From Figure 9 can be concluded:

- The traditional district cooling market will grow mainly in the southern countries;
- In North-western Europe, Aalborg University foresees a market share of only a few percent. This is in line with the conclusion about the limited development of absolute cooling demand in North-western Europe in section 3.2.

6. Market transformation potential for 5GDHC

In section 2 we discussed an alternative method to determine the market transformation potential of 5GDHC. In Sections 4 and 5 derived the numerical data needed for this purpose. Table 4 (below) shows how the market transformation potential is calculated from this data step-by-step.

The calculation starts with the current market share of district heating in North-Western Europe and the forecast market share for conventional district heating in 2050 (A-C in Table 4). This leads to the absolute potential contribution of district heating in North-western Europe. We then use the expert team's knowledge to infer what share 5GDHC could take over from district heating systems that already exist today (D). Based on the potential of the new amount of conventional district heating to be built, we estimate how much of that could be realised as 5GDHC (E). As a final step, we look at the contribution 5GDHC could have on top of the amount of conventional district heating to be built (F). As a final step, we relate the potential amount of 5GDHC to the total district heating market (H) and the total heating market (I) in North-western Europe.

Table 4 Market transformation potential for 5GDHC

	Aspect	Reference year 2020	2035	2050	Note
A	Heating market in North-western Europe for buildings (residential and service sector) in PJ/yr	6430	5628	4827	2020: see Figure 2, left side 2035: average of 2020 and 2050 2050: see Table 3
B	Share district heating of heating market in %	10%	25%	39%	2020: see section 5.2 2035: average of 2020 and 2050 2050: see section 5.3
C	Share district heating of heating market absolute in PJ/yr	643	1379	1883	Calculation (A times B)
D	1. Conversion of heat distribution existing in 2022 to 5GDHC, in %		4%	10%	expert review in D2Grids-team*
	2. Conversion of heat distribution existing in 2022 to 5GDHC, in PJ/yr		26	64	Calculation (C times D.1)
E	1. Realization of new to build 3G/4G district heating as 5GDHC, as part of new to build district heating since 2022		17,5%	35%	expert review in D2Grids-team*
	2. Realization of new to build 3G/4G district heating as 5GDHC, in PJ/yr		129	434	Calculation ((C minus C (2020)) times E.1)
F	1. Realization of 5GHDC-systems which wouldn't be realised as 3GDH/4GDH as part of the new to build district heating since 2022		7,5%	20%	expert review in D2Grids-team*
	2. Realization of 5GHDC-systems which wouldn't be realised since 2022 as 3GDH/4GDH in PJ/yr		55	248	Calculation ((C minus C (2020)) times F.1)
G	Share of 5GHDC in total market for new to build district heating since 2022, in PJ/yr		210	746	Calculation (D.2 + E.2 + F.2)
H	**Share of 5GHDC in total market for district heating, in %**		**15%**	**40%**	Calculation (division of G by C)
I	**Share of 5GHDC in total future market for building heating, in %**		**4%**	**15%**	Calculation (division of G by A)

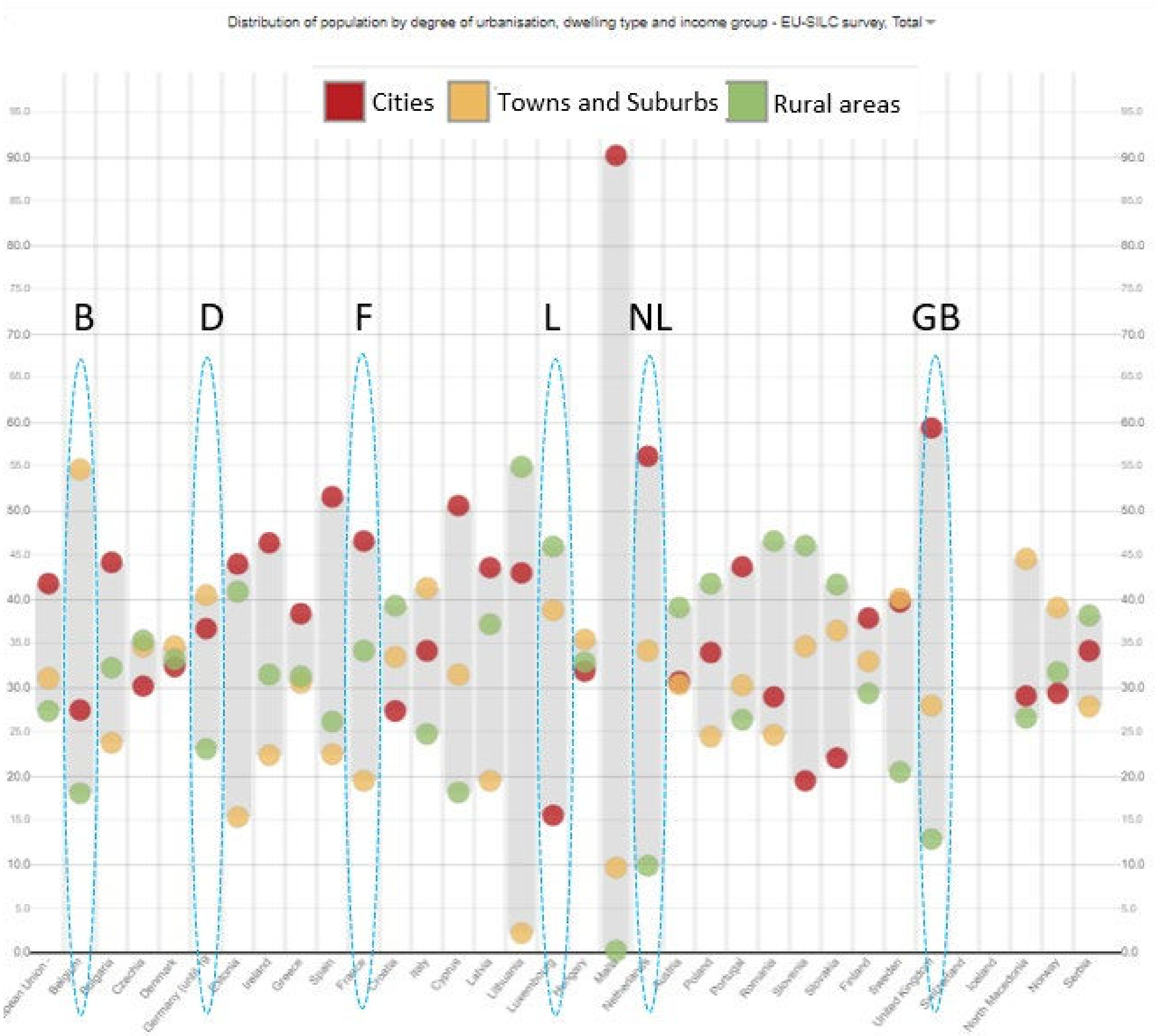
*See section 4 for more details.

The outcome of this analysis is thus that **5GDHC could have a 15% heating market transformation potential by 2050** if the district heating market were indeed to grow at the rate indicated by the studies studied. This would mean that in 2050 5GDHC systems would cover 40% of the total market for district heating.

The effect of 5GDHC obviously extends to the cooling market as well. According to the literature studied and calculations made on this basis, the market for building cooling will grow strongly until 2050 but remains relatively very small in absolute terms in North-western Europe compared to the heat market, despite the noticeable decline in heating demand.

Annex 1

Figure 10 Distribution of population by degree of urbanization



Source: https://ec.europa.eu/eurostat/cache/RCI/#?vis=degurb.gen&lang=en