EUCALC

Explore sustainable European futures

Data and model for the integration of district heating

D2.6

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D2.6

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Short Description
This report summarises the structure, methodology and data used to develop the district heating sub-model for the European Calculator.

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1 Executive Summary

Heating and cooling of buildings currently accounts for 50% [1] of all energy consumption in the EU and 80% of it is covered burning natural gas, therefore any efficiencies of scale in these technologies will have significant impacts on meeting emissions reduction targets/carbon budgets. District Heating is currently used to heat 10% [2] of all European homes and has enormous potential to become even more efficient.

This report describes the data and methodology used for the development of the District Heating (DH) submodule which is part of the building's module of the European Calculator. The reader can find in the data section the sources and procedure followed to define the potentials for DH and its technologies in each European country. The methodology section describes the way the different data is put together to create the submodule, as well as the exchanges with the other modules in the calculator and the buildings module itself.

2 Introduction

District heating as a concept is based on the fact that the heat production and heat demand points are usually in different locations. Hence it is necessary to transfer the heat from the production facility to its consumers. e.g. by means of underground hot water pipes. The goal of district heating is to allow the utilisation of centralized heat production technologies, which generate large amounts of heat and hence require large sets of consumers. A key benefit of this technology is that these centralised systems tend towards higher efficiencies than the decentralised technologies. For example, centralised heat pumps can use lakes or rivers as a heat source. The temperature of the water mass is higher than the outdoors air temperature in winter, so the coefficient of performance (COP) is improved. Furthermore, DH allows the valorisation of other heat sources like the waste heat from industry or the heat produced by CHP technologies.

The heat distributed by DH networks has its origin in heat sources or heat producing technologies. Heat sources supply heat without the need of an energy conversion step. The heat sources contemplated in this submodule are geothermal heat and waste heat from industry. The heat producing technologies convert a form of energy such as a fuel or electricity into heat. The technologies considered in the DH submodule are the following ones:

- Heat from centralised CHP systems (fuels to heat and electricity)
- Centralised solar thermal systems (solar radiation to heat)
- Centralised heat pumps (electricity to heat)
- Centralised boilers (fuels to heat)

Direct electric heating is the only technology not being considered for DH, since its use linked to a DH network does not bring any added value in comparison to decentralised direct electric heating systems installed in households. From this point onwards, the term "technology" will be used to refer to "heat producing technologies".

3 About the European Calculator

The debate on decarbonizing Europe evolved over time from being the concern of individual national governments to encompassing a cross-border heterogeneity of economic sectors, businesses, regional decision makers and individuals. Simulation tools supporting policymaking were mostly shaped by focussed scientific debates and failed to engage with the new diversity of actors willing to drive transformation.

To bridge this gap, we developed the EU Calculator model and its user interface, the Transition Pathways Explorer, where users can define their own pathways using levers. A lever offers the possibility to choose between different options for one question, e.g. the degree of refurbishment in old buildings or the deployment of district heating networks. This tool has identified as potential users mainly European policymakers, businesses, NGOs amongst other societal actors. Its goal is to equip these potential users with the means to create their own low-carbon transformation pathways on the European and member state scale and compare them to other integrated pathways. The results will enable EU policymakers to support the energy, emissions and resources debate on a low carbon transition.

The underlying methodology roots between pure energy simulation and integrated impact assessment, and harmonizes across all sectors to link 1) behaviour, 2) products, 3) material & resources, 4) energy and 5) emissions. It also integrates trade-offs like the impact of eating habits on land-use or buildings renovation on material demand.

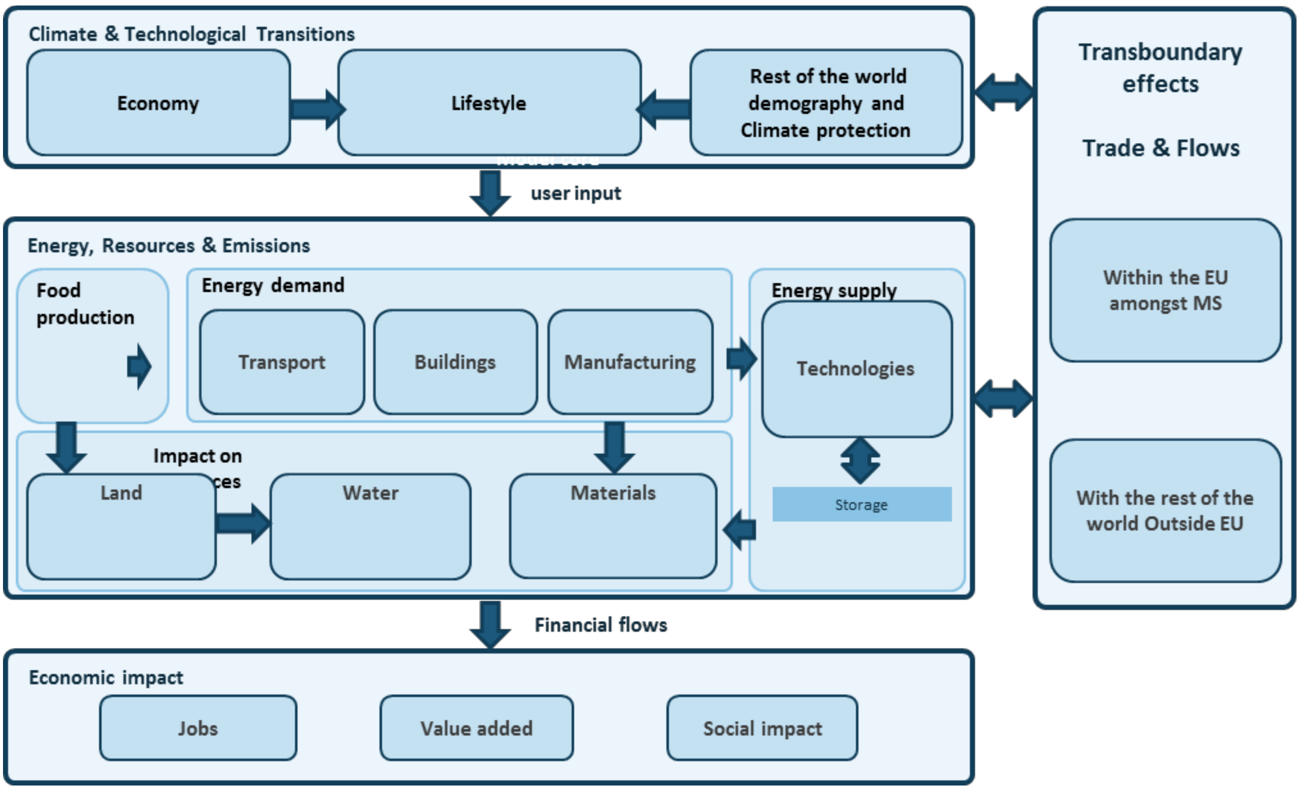

Figure 1 – Modular structure of the EU-Calc model

The European Calculator model consists of several interconnected modules (Figure 1). More information is included in the project's website.

4 Data

This section presents the data used to build the district heating submodule, as well as their sources and the alignment of the data to increase their consistency. Consistency check is here referred to as an expert evaluation and possible adaptation of the available data applying common sense reasoning. This has been e.g. applied to several countries in which the given district heating shares were out of proportion compared to those of other countries from the same geographical region and/or with similar levels of urbanisation. The data of such countries was therefore adapted accordingly (see Bulgaria, Greece, Malta, and Cyprus *Table 3*). The underlying assumptions and data consistency of each country are discussed in detail in the respective tables.

The data section is structured in four main subsections: current district heating status, capacity factors and the geothermal, solar thermal and centralised heat pumps potential. The other heat sources and technologies presented in section 2 do not have dedicated paragraphs because of the following reasons:

- Waste heat from the industry & heat from centralised CHP systems. The amount of available heat for DH is determined by the industry and power modules, respectively.
- Centralised boilers: It exists no limitation for the deployment of centralised boilers.

4.1 Current DH status and development potential

Table 1 contains the data on low temperature (Low T) heating demand, the current coverage of district heating and its potential by country. The current demand on low temperature heat, i.e. used for space heating and hot water in buildings[1], is obtained from source [3] – see Reference in page 22 for details - for each country with some exceptions which are captured below in Table *2*.

The potential for DH for the remaining member states has been obtained from a large list of sources which are listed below in Table *3*.

[1] Opposed to that, high temperature heat is used for industrial processes.

***Table 1**: Data by country on current low T heat demand, current and potential share of district heating.*

	Current data			Potential
	Low T Heat Demand	Share DH	Supplied heat DH	Share DH
	(TWh/year)	*(%)*	*(TWh/year)*	*(%)*
Austria	71.7	17.2	12.3	28.0
Belgium	94.2	0.8	0.8	50.3
Bulgaria	19.7	25.6	5.0	30.0
Croatia	17.0	15.0	3.0	40.0
Cyprus	2.8	0	0.0	7.6
Czech Republic	70.3	32.0	22.5	40.0
Denmark	51.0	50.3	25.7	69.0
Estonia	10.2	48.8	5.0	72.9
Finland	74.0	48.5	35.9	67.2
France	472.3	5.3	24.9	28.3
Germany	704.2	9.6	67.3	27.2
Greece	40.3	1.4	0.5	7.6
Hungary	70.4	11.3	8.0	28.0
Ireland	33.1	0	0.0	13.5
Italy	299.9	3.2	9.6	7.6
Latvia	14.5	36.7	5.3	72.9
Lithuania	15.1	52.1	7.9	72.9
Luxembourg	6.0	4.3	0.3	22.8
Malta	0.6	0	0.0	7.6
Netherlands	134.9	6.3	8.5	38.7
Poland	185.5	28.4	52.6	56.6
Portugal	28.3	0.4	0.1	17.2
Romania	74.8	19.8	14.8	40.0
Slovakia	30.4	22.4	6.8	54.3
Slovenia	9.3	10.3	1.0	49.2
Spain	194.7	0.5	1.0	19.8
Sweden	90.6	60.4	54.7	71.6
Switzerland	68.0	6.4	4.3	40.0
UK	411.8	0.9	3.8	70.0

Table 2: *Data sources for current low temperature heat demand and DH share*

Country	Low T Heating Demand	Share DH
Switzerland	Obtained from Swiss-Energyscope calculator [4].	
Czech Republic	Sum of residential and tertiary in page 13 of [5].	[3]
Croatia	[6]	[6]
Spain	Sum of residential and tertiary in page 60 of [7].	[8]
Italy	[3]	[9]
Sweden	[3]	[10]
Finland	[3]	[11]

Table 3: *Data sources for the district heating potential*

Country	Source
Austria	[12]
Belgium	Calculated from the potential in the regions of Brussels [13], Wallonie [14] and Flanders [15] averaged by weight by population in each region.
Bulgaria	In [16] a potential of 19.7% is presented, but that is lower than the current value (25.6%), so 40% is assumed. The assumed value corresponds to the potential of Romania (neighbouring country).
Croatia	[6]
Cyprus	In [17] 49% potential share is reported. Nevertheless, this value is considered too high for a south Mediterranean country. Other publications [18] set the value at 0%. Finally, the Italian potential share is used as an approximation.
Czech Republic	[19]
Denmark	Expected DH coverage for 2020 according to [20].
Estonia	Assumed the same as Latvia, due to similar degrees of urbanisation and equivalent climate [21].
Finland	[18]
France	[22]
Germany	Upper District heating cogeneration potential over useful heat requirement for all towns in page 7 of [23].
Greece	Italy presents the lowest reported potential (7.6%). The Greek climate is warmer than the Italian, hence potential should be lower, on the other hand Greece presents a higher percentage of urbanisation [21] in comparison to Italy which brings up the potential. Hence the Greek potential is assumed to be same as Italy.

Hungary	Assumed same as Austria, since they are neighbouring countries with similar urbanisation levels [21].
Ireland	Percentage of national demand in the largest system boundary of 3000 MWh/km in [24].
Italy	[9]
Latvia	[18]
Lithuania	Assumed same as Latvia, due to similar degrees of urbanisation and equivalent climate [21].
Luxembourg	Current DH plus the economic potential for heat from cogeneration from [25].
Malta	With 88% [21] of people living in cities, Malta presents the highest level of urbanisation in the EU, hence DH technologies should be interesting. Nevertheless, its high average temperature in winter (Max. 16°C / min. 9°C) and the short winter season reduces the heating demand which reduces the interest for developing DH networks. So, it is assumed to have the same potential as Italy, since it is the lowest reported potential (7.6%).
Netherlands	[18]
Poland	[26]
Portugal	[27]
Romania	[28]
Slovakia	[29]
Slovenia	Calculated as a proportion with Denmark regarding the share of electricity that is produced by CHP in each country [30].
Spain	[31]
Sweden	[32]
Switzerland	[33]
UK	[34]

4.2 Capacity factors for District Heating technologies

The capacity factor of an energy technology is the ratio between the energy supplied during a certain time interval over the energy that would have supplied if the technology runs at full capacity during the entire time interval.

In the context of DH systems, the parameter is used to link the supplied heat during one year to the installed heating capacity. Hence, it is a key parameter in order to be able to size the DH system and calculate its investment cost.

The capacity factor for each country has been calculated thanks to the reported installed DH capacity and distributed heat in [35]. Nevertheless, that source is not available for the following countries: Belgium, Cyprus, Greece, Ireland, Lithuania, Luxemburg, Malta, Portugal, Slovenia, Spain and UK. For those countries, the authors have chosen to calculate the capacity factors using a linear function connecting the capacity factor to the heating degree days (HDD) [36][2]. 18 data points are used to find the linear regression curve in Figure 1.

The computed capacity factors are available in ***Table 6*** in the "Capacity factor - Others" column. Solar thermal has a different capacity factor since the supplied heat does not only depends on the heating demand, but also on the solar radiation. The capacity factors for solar DH are calculated in section 4.4.

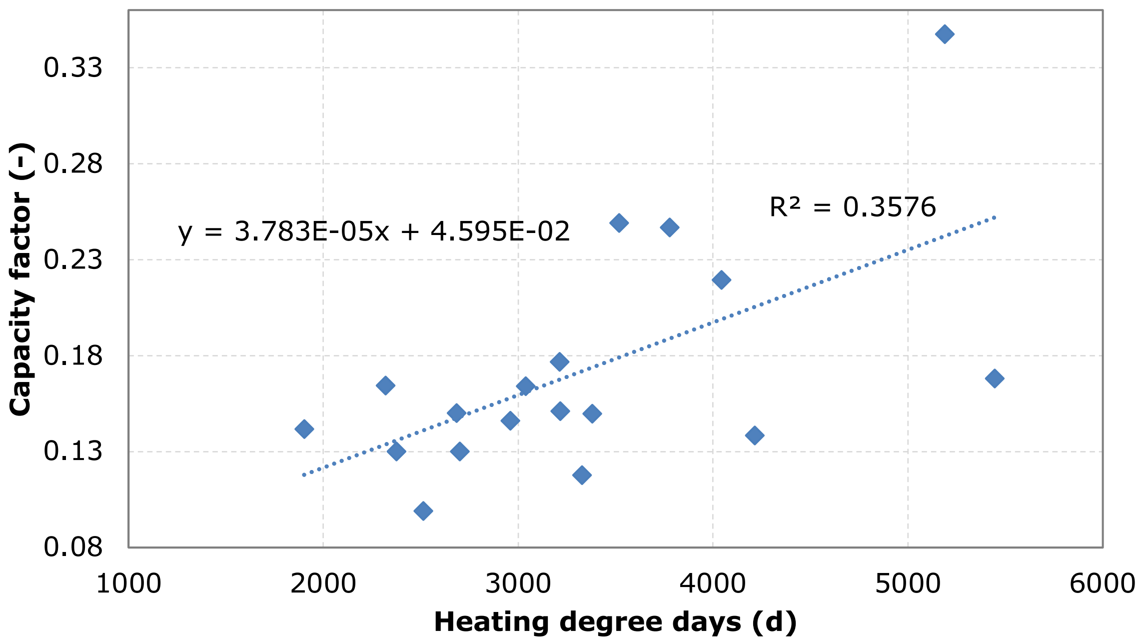

Figure 2 - Capacity factor as a function of the heating degree days from [36]

4.3 Geothermal District Heating potential

Geothermal DH systems distribute heat obtained from geothermal formations, usually meaning below ground. It is important not to confuse a geothermal heat pump used in decentralized heat supply systems with a geothermal heat facility used for district heating. The first geothermal heat pumps - extract heat from the below ground whose temperature is increased through the use of a heat pump. They do not require the existence of a hot geothermal formation below ground, and their underground heat exchanger does not go deeper than 50 meters. In contrast, the heat exchanger of geothermal DH systems reaches far greater depths and uses hot geothermal formations. Table 4 contains the current delivered heat by geothermal DH systems and its potential in each country. Table 5 below

[2] HDD allow to estimate the amount of energy needed to heat a building in a specific location by comparing the ambient temperature to a reference temperature. Several ways for calculating HDD are discussed in the *building module documentation*. The regression presented in Figure 2 is based on an average value (between 2005 and 2017) of the country-specific HDD from the European statistics database [36] in which a threshold temperature of 15°C was assumed in all European countries. For the purpose of this study and the underlying regression, this data was considered sufficient.

contains the sources that have been used to calculate the geothermal DH potential in each country.

Table 4: *Data on geothermal DH*

	Supplied heat	
	Current (*GWh$_{th}$*)	Potential (*GWh$_{th}$*)
Austria	155	468
Belgium	0	59
Bulgaria	39	117
Croatia	0	122
Cyprus	0	0
Czech Republic	39	176
Denmark	271	0
Estonia	0	0
Finland	0	0
France	1241	5822
Germany	349	7987
Greece	39	585
Hungary	0	964
Ireland	349	4155
Italy	155	3482
Latvia	78	59
Lithuania	0	0
Luxembourg	0	0
Malta	1008	3014
Netherlands	155	2077
Poland	0	263
Portugal	116	936
Romania	39	1053
Slovakia	0	234
Slovenia	0	117
Spain	271	0
Sweden	0	1389
Switzerland	0	0
UK	155	468

Table 5: *Sources for the potential of geothermal DH*

Countries	Source
Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Hungary, Ireland, Italy, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK	[37]
Croatia	[38]
Greece	[39]
Switzerland	[40]
Estonia, Finland, Cyprus, Luxembourg and Malta	Assumed 0 due to the lack of data

4.4 Solar District Heating potential

Solar DH as a technology involves the use of an area covered by solar thermal panels, which transform the received solar irradiation into heat. Solar thermal DH might integrate underground hot water storage systems, which allow to deliver heat during night and in some cases during autumn and winter. During the cold seasons, heat pumps might be used to increase the temperature of the stored heat [41].

The installed capacity in each country was taken from the solar district heating plant database in [42] and is aggregated by country in **Table *6***. The current solar DH production was calculated with the capacity factors for solar DH for each country. Since there is a lack of data in literature regarding the capacity factors for solar DH per country, the capacity factor for Denmark [20] is taken as reference and adjusted to each country taking into consideration the average solar radiation for each country [43] and their average capacity factor for technologies whose capacity to deliver heating services does not depend on the weather, e.g. heat pumps (values available in **Table *6***).

Concerning the potential for solar DH, [44] defines the European potential at 155 TWh, but it does not provide the repartition between countries. On the other hand, [41] estimates the potential equal to 19 TWh. This potential only considers the implementation of solar thermal in already existing. However, since the potential is calculated by country, the data from [41] is used to distribute the 155 TWh among the 29 considered countries.

Table 6: *Data on solar DH*

	Capacity	Supplied		Capacity factor	
	Current	Current	Potential	Solar	Others
	(MW_{th})	*(GWh)*	*(GWh)*	*(-)*	*(-)*
Austria	26.1	30.5	6581	0.15	0.25
Belgium	0	0.0	271	0.11	0.15
Bulgaria	0	0.0	1265	0.14	0.10
Croatia	0	0.0	454	0.14	0.16
Cyprus	0	0.0	31	0.11	0.07
Czech Republic	0	0.0	6581	0.11	0.12
Denmark	947.1	862.2	12676	0.12	0.15
Estonia	0	0.0	1536	0.13	0.14
Finland	1.0	1.0	6493	0.13	0.17
France	8.0	8.6	5411	0.14	0.13
Germany	34.0	32.0	8705	0.12	0.16
Greece	7.1	7.2	445	0.13	0.11
Hungary	0	0.0	8570	0.14	0.13
Ireland	0	0.0	147	0.11	0.15
Italy	2.8	3.2	629	0.15	0.14
Latvia	0	0.0	2841	0.13	0.22
Lithuania	0	0.0	5865	0.13	0.19
Luxembourg	0	0.0	66	0.12	0.16
Malta	0	0.0	30	0.11	0.06
Netherlands	9.5	8.2	724	0.11	0.15
Poland	11.1	10.8	35625	0.12	0.15
Portugal	1.1	1.1	1	0.12	0.09
Romania	0	0.0	10058	0.15	0.15
Slovakia	0	0.0	10464	0.13	0.18
Slovenia	0	0.0	1711	0.14	0.15
Spain	3.0	2.9	40	0.12	0.11
Sweden	17.9	19.6	13933	0.14	0.35
Switzerland	3.5	4.2	784	0.15	0.25
UK	0	0.0	14570	0.11	0.16

4.5 Centralised heat pumps potential

Table *7* contains the current installed capacities for heat pumps supplying heat to district heating networks, obtained from [45,46]. The capacity factors from **Table *6*** (others) are used to compute the delivered heat. The potential is based on the total European potential which is estimated at 520 TWh [47][3] by the Heat Roadmap Europe project, and distributed among the countries proportionally to their heating degree days from Ref. [36] (averaged between 2005 and 2017).

The potential for centralised heat pumps depends on the existing heat sources, which can be ambient heat sources (e.g. lakes, rivers and underground) or low temperature waste heat from the industry. In order to be exploitable through centralised heat pumping, the heat source must be close to an urban agglomeration with an existing DH network or with the potential to deploy it.

Table 7: *Data on heat pumps for DH*

	Capacity	**Supply**	
	Current	Current	Potential
	(MW)	*(GWh)*	*(GWh)*
Austria	10.1	15.7	21796
Belgium	0	0.0	16511
Bulgaria	0	0.0	15574
Croatia	0	0.0	14359
Cyprus	0	0.0	4436
Czech Republic	6.4	9.5	20618
Denmark	45	67.9	19985
Estonia	0	0.0	26110
Finland	154.6	268.6	33988
France	5.5	7.5	14726
Germany	0	0.0	18825
Greece	0	0.0	9783
Hungary	0	0.0	16734

[3] The number presented here was extracted from Figure 5 in Ref. [47] estimating the 2050 potential. The source states that the future centralized heat pump share should be between 15% and 50% of the average heating requirement (page 12) in district heating networks. This notion is reasoned with the high efficiency of heat pumps for heat production and their capability for load shifting of renewable electricity production. Applying these figures to the (annual) average heating requirements of 2050 and assuming an adequate capacity factor yields numbers of the same order of magnitude, which justifies the consistency of the adopted number.
A geographic information system (GIS) - based analysis of regionally available heat sources (lakes, rivers, ground, industrial waste) would surely bring a more refined and reliable estimate of the European centralized heat pump potential, however no such study is available, and the lack of data and resources inhibited such analysis.

Ireland	0	0.0	17127
Italy	36.6	51.7	11829
Latvia	0	0.0	25042
Lithuania	15	24.2	23942
Luxembourg	0	0.0	17863
Malta	0	0.0	2980
Netherlands	1.2	1.7	16622
Poland	3.7	5.7	20947
Portugal	0	0.0	7520
Romania	0	0.0	18341
Slovakia	1.8	2.7	19898
Slovenia	0	0.0	17489
Spain	0	0.0	10923
Sweden	1022.3	1888.3	34023
Switzerland	35.4	56.7	23456
UK	0	0.0	18553

5 Methodology

Figure 3 depicts the submodule for DH as well as its interaction with the other modules of the model and its internal data. The interaction with its "parent module" (the Buildings module) are also captured. There are 4 main calculation steps, which are described in the following sections. The title of each one of the section correspond to the output of the section.

A key point on the methodology development is the inputs defined by the DH lever. The DH lever allows the user of the calculator to define the percentage of low T heat supplied by the DH system, as well as the technologies providing the heat to the district heating network.

It is remains to be defined if the levels of the lever will include a qualitative or a quantitative description. A qualitative description would describe the deployment of district heating like "high", "medium" or "low", which would be transformed by the module into percentages of the low T heat to be covered by DH. On the other hand, a quantitative description would directly specify the percentages in the lever description. Same discussion applies to the technologies mix supply heat to the DH networks.

5.1 Heat to be supplied by DH

The results produced by the "Heat Roadmap Europe" [48] project are used to define the evolution of the district heating share in the building sector depending on the position of the lever. The four levels of the lever are defined as follows:

- Level 1 represents the business as usual case. The percentage is assumed to remain constant in time.
- Level 2 has the share of district heating 10% lower than the share reported in "Heat Roadmap Europe".
- Level 3 has the same shares as in "Heat Roadmap Europe".
- Level 4 has the share of district heating 10% higher than the share reported in "Heat Roadmap Europe".

Table 8 contains the evolution of the district heating share at European level. The district heating share evolution is country dependent. The values in Table 8 are weighted averages based on the low temperature heating demand of the countries.

Table 8: *DH shares at European level for the different lever positions*

	DH share [%]		
	2015	2030	2050
Level 1	8.4	8.4	8.4
Level 2	8.4	9.5	13.5
Level 3	8.4	10.6	15.0
Level 4	8.4	11.7	16.5

5.2 Remaining heat to be supplied by DH

In the model the use of waste heat from industry and heat from CHP systems is priorised over any other DH technology. This decision is supported by the fact that the utilisation of this source and technology do not generate any operational cost or emissions, since they are by-products of other activities. Not using the waste heat and the heat from CHP systems would lead to a non-optimal solution from an economic and environmental point of view, since heat would be exuded to the ambient.

Remaining heat to be supplied by the mix of DH technologies (geothermal, thermal solar and HPs) is calculated subtracting the 90% of the available waste heat and CHP heat to the heat to be supplied by DH. The 90% factor captures the existence of DH distribution losses.

The losses are considered to be 10% of the generated heat for all the countries, for the present and for the future. This was chosen for simplification. 10% is in the order of magnitude of the losses observed in the Nordic countries today, so it is expected that this will be the standard value for losses in Europe in the future.

However, the DHN losses today vary from system to system and country to country, with some countries having over 20% losses in the DHN.

5.3 Heat to be supplied by each technology

As previously mentioned the lever defines the mix of technologies supplying the heat for the DH networks. The technology mix imposed by the lever applies to the remaining heat to be supplied by DH, i.e. heat to be supplied after having discounted waste heat from industry and heat from CHP. The percentages defined by the lever have to take into consideration the available potential for solar, geothermal and heat pumps based DH systems. Centralised boilers will take the remaining share. Hence the maximum share for each one of the technologies is calculated in the scenario with the largest amount of remaining heat to be supplied by DH, which corresponds to the scenario with the highest demand of low T heat and the lowest amount of waste heat from industry and heat from CHP.

It is important to mention that the calculations described in the paragraph above are carried out at European level. Hence, once the heat to be supplied is distributed among the four technological options (solar, geothermal, HPs and boilers), then it needs to be divided by country. The division is done proportionally to the untapped potential of each option.

The mix of technologies and heat sources for supplying the heat distributed by the DHN is also based on the results presented in "Heat Roadmap Europe" [48]. The four levels of the lever are:

- Level 1 represents the business as usual case. The mixes remain constant in time.
- Level 2 has the same mixes as in the "Heat Roadmap Europe".
- Level 3 is based on the mixes from "Heat Roadmap Europe", but the percentages for coal and oil boilers are brought down to 0% by 2050, and they are replaced by natural gas and biomass boilers.
- Level 4 is based on the mixes from "Heat Roadmap Europe", but the percentages for coal and oil boilers are brought down to 0% by 2050, and they are replaced by centralised heat pumps, geothermal and centralised solar thermal systems.

5.4 Final results

The final results are sent back to the parent "Buildings" module. They include:

- Electricity consumption from centralised HPs
- Fuel consumption from centralised boilers
- Investment cost for all systems, including the DH network
- O&M cost, including the DH network
- Length of the pipes

The data on efficiency and costs of each technology is obtained from the supplementary material in [49], including the investment for the DH network. The installed capacity for each technology is computed from the delivered heat, taking into consideration the capacity factor reported in Table 6.

The output on investment is expressed in terms of annualised investment cost, which is calculated from the total investment cost and the interest rate with the following formula, where C_{invT} is the total investment cost, *i* is the interest rate and *n* is the lifetime of the technology or infrastructure.

$$C_{inv} = C_{invT} \frac{i(1+i)^n}{(1+i)^n - 1}$$

The length of pipes for DH networks is based on a preliminary estimation for the network length (L_{dn}) presented in [50]. The estimation considers the land area (S_z), the number of buildings (n_b) and a topological factor (K). These parameters are unfortunately city-dependent, hence the city of Geneva is chosen as a representative city due to data accessibility (see Table 9 for further information on the parameters). Hence the following equation provides the length of the pipes, which combined with the heat demand density for the city of Geneva, provides the specific pipe length per heat demand: 118.3 m/MWh.

$$L_{dn} = 2(n_b - 1)K\sqrt{\frac{S_z}{n_b}}$$

Table 9: *Data for the city of Geneva [51]*

Data	Unit	Value
Heat demand density	kWh/(year*m^2)	91.25
Area	km^2	35.2
Number of buildings	-	378

6 Uncertainties and limitations

This section presents the uncertainties and limitations of the data and methodology used for the development of the DH submodule.

The main uncertainty originates from the definition of the DH potentials. Unfortunately there is no study at European level that presents the DH potentials for each country. Hence the DH potentials are obtained from a large set of references, almost one reference per country, which are described in Table 3. This approach has a limitation: the definition of the potential is not the same in all references. The potential for DH depends on the heat demand density (kWh/m^2). The potential is calculated by defining a threshold for the heat demand density above which the installation of DH networks starts to be economically attractive (e.g. 10 GWh/km^2 in Austria [12]). Hence the potential is calculated by summing the heating demands (space heating and hot water) of the buildings located in areas with a heat demand density higher than the chosen threshold.

On the methodological aspect, it might be considered a limitation the fact of having annual time resolution for the calculations. Working with a higher time resolution (e.g. seasonal, daily or hourly) provides more precision for the calculation of the installed capacity, since the seasonal and the daily variations in the demand and supply can be captured. Nevertheless, this limitation is overcome by using the capacity factors for each country for the calculation of the installed power. Capacity factors allow to make the link between the annual demand or supply and the installed capacity (see section 0 for further information).

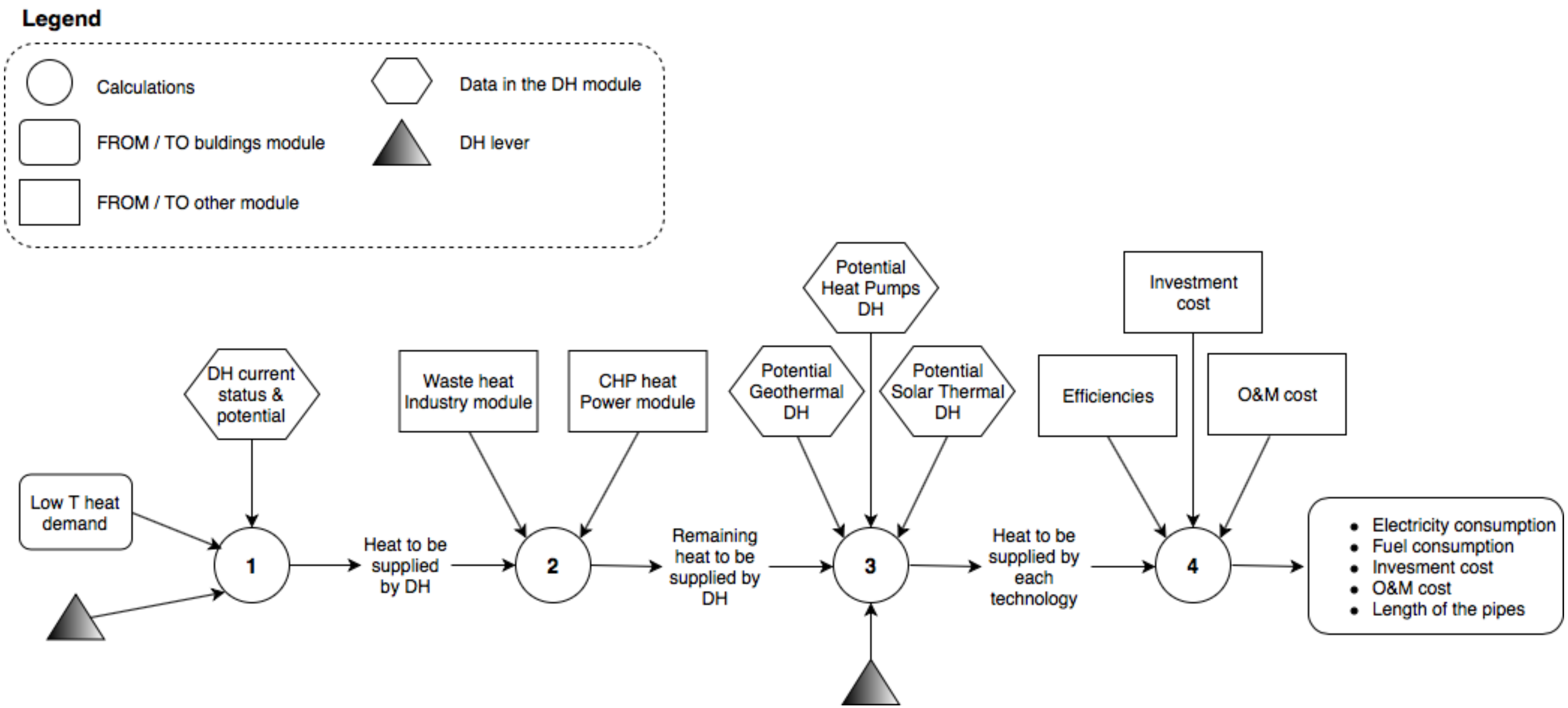

Figure 3 - DH model structure, inputs and outputs.

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7 List of abbreviations

DH – District heating

DHN – District heating network

GHG - Greenhouse gas emissions

HP – Heat pump

CHP – Combined heat and power

COP – Coefficient of performance

8 References

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