Baseline Replication Assessment Report – Pilot Cities

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1 Introduction

The Baseline Replication Assessment Report aims to map-out and assess the national and local framework conditions for a successful adoption of the THERMOS model.

This document constitutes the final issue of the Baseline Replication Assessment Report and focuses on the four Pilot Cities of the THERMOS project: Granollers, Islington, Jelgava and Warsaw, and the 4 Replication Cities: Alba Iulia, Berlin, Cascais and the Greater London Authority.

Throughout this document the most relevant characteristics and features that should be considered for the adoption of the THERMOS tool are analysed. The analysis covers the following elements in each of the four Pilot Cities studied:

- **Heating and Cooling in the local context**: this section contains an analysis of the local energy system (energy mix, key performance indicators on power and thermal supply and demand), the key energy policy and legislation, the adoption of Renewable Energy Sources (RES) in the city and the existing energy objectives and plans, among others;
- **Stakeholder Identification and Engagement**: the main local and national stakeholders that should be engaged for a successful adoption of the tools developed throughout THERMOS are listed in this section, together with the roles that they can hold towards the THERMOS model replication and the strategies to be followed for their engagement;
- **Towards THERMOS Uptake**: in this section the principal barriers that could prevent the adoption of the THERMOS tool and the solutions to overcome them are examined;
- **THERMOS Case Study**: finally, the document focuses the analysis on a single opportunity in a city district or quarter where the THERMOS tool will initially be applied.

This report is therefore meant to establish a baseline and serve both as a guide and a set of practical examples on the information that should be gathered and the stakeholders that should be engaged for a successful replication and adoption of the THERMOS tool.

2 Granollers

2.1 Introduction

Granollers City Council is the local administration of the Granollers municipality. The city is 14.89km^2 in size and has over 60,000 inhabitants (60,174 inhabitants in 2016) who live in 26,000 family dwellings. It is one of the medium sized cities comprising the second metropolitan crown and is located approximately 30 kilometres from Barcelona, surrounded by an extensive road communications network.

Image: Granollers Mercat EPE

The oldest traces of life found in Granollers date back to 4,000 years ago. The *Porxada*, built in 1587 as a corn exchange place, is the city's most symbolic building, and has been declared as being of national interest.

The city has a continuous urban area with other municipalities that represent all together more than 100,000 inhabitants and attract many citizens of the *Vallès Oriental* region for commercial purposes and services.

From an orographic perspective, Granollers is settled in a valley, a depression limited on the west with the pre-coastal mountain range, the *Montseny* on the north and the coast mountain range on the east. The climatic characteristics of the geographic depressions make the city and its surrounding area vulnerable to air pollution, especially in winter, when the climate

conditions are too stable. Furthermore, the last 20 years have seen an increase in the proportion of dry years, with an average rainfall of 600 l/m per year.

The following links provide a quick overview of the city and its main landscapes:

Granollers images

Short video of the city

2.2 Heating and Cooling in the local context

2.2.1 Local energy system

2.2.1.1 Introduction

Around 47% of the total energy consumption in Granollers in 2012 corresponded to the industrial sector, with 7 industrial parks spanning more than 600 different industrial activities. There is a specific public body, *Granollers Mercat*, which promotes and supports the industrial parks in the city. Industrial consumption went down to 42% in 2014:

Figure 1: Granollers energy consumption by sector (2014)

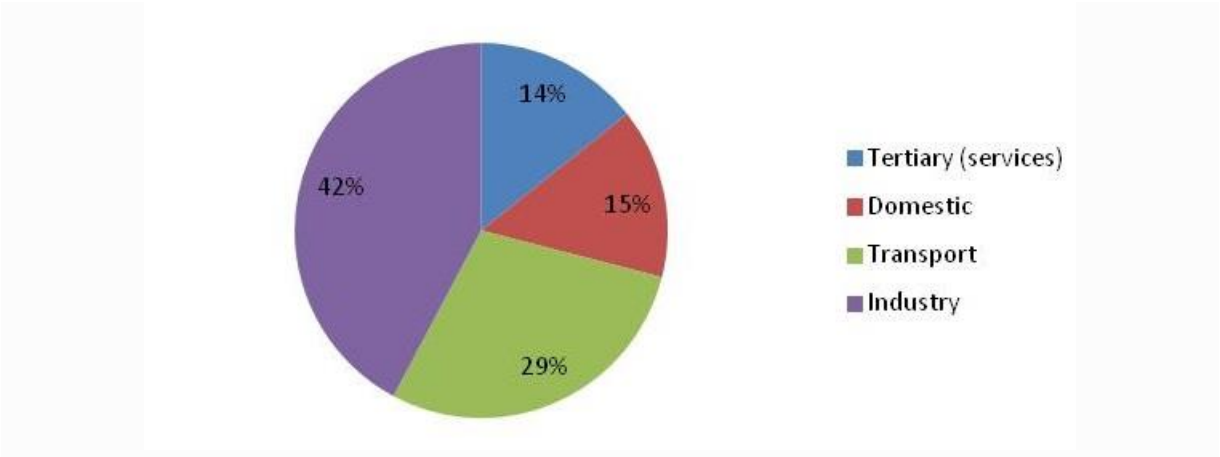
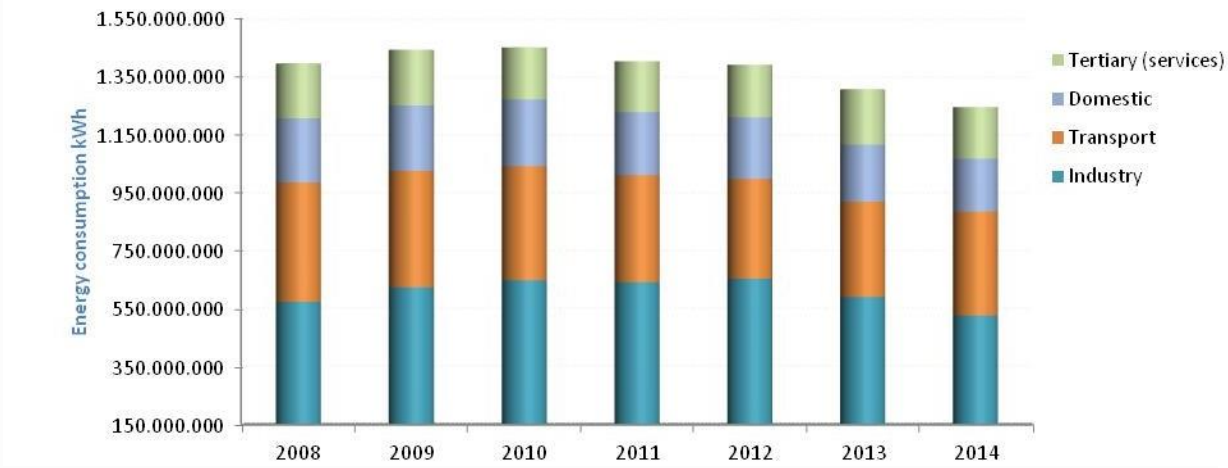


Figure 2: Evolution of the energy consumption in Granollers by sector (2009-2014)



As shown in the figure above, the energy consumption in Granollers has been dropping (kWh per year) in all sectors from 2010

	Variation 2010-2014
Tertiary (services)	-8%
Domestic	-23%
Transport	-12%
Industry	-18%
Total	-16%

The decrease in energy consumption is probably due to the economic crisis that started in 2008, as well as the efficiency measures that the different sectors might have adopted to save money and energy.

The economic activity indicators in the following table show a decrease of 13% in the number of companies between the year 2008 and 2014 which is most likely the cause of the decrease in energy consumption from industry.

Economic activity indicators	2008	2009	2010	2011	2012	2013	2014	2015
Wage earners	24.834	23.206	22.926	21.994	21.139	20.698	21.770	23.654
Wage earners / Active workers	78,41%	74,76%	75,03%	73,02%	71,78%	71,12%	74,39%	80,68%
Self employed and free lance	4.286	4.064	3.949	3.819	3.743	3.717	3.817	3.868
Self employed and free lance/ Wage earners	17,26%	17,51%	17,22%	17,36%	17,71%	17,96%	17,53%	16,35%
Companies	2.658	2.512	2.468	2.437	2.362	2.308	2.322	2.389
Wage earners / Companies	9,3	9,2	9,3	9	8,9	9	9,4	9,9
Technology sectors / Wage earners	36,95%	38,33%	37,73%	36,96%	36,91%	37,96%	37,81%	39,66%
GDP per capita (thousand euros)	n.a.	n.a.	n.a.	35,4	34,9	n.a.	n.a.	n.a.
Income tax per capita (taxable base in euros)	22.012	21.582	21.353	21.216	20.534	20.484	n.a.	n.a.

Domestic sector

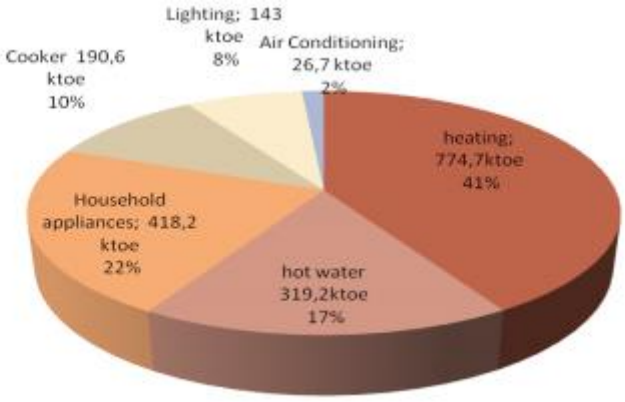
The energy consumption in the domestic sector has been defined from available studies and statistical reports developed at national and regional level.

IDAE (*Instituto para la Diversificación y Ahorro de la Energía*), in the framework of the SECH-SPAHOUSEC project (Development of detailed Statistics on Energy Consumption in Households) led by Eurostat, published a report named 'Analysis of energy consumption in the Spanish residential sector'. This document details the energy consumption demand of different residential sectors, depending on the type of building and the geographical location.

Focusing on the Catalonia region, in the framework of the MARIE project, a detailed benchmarking analysis of residential heat demand has been performed and an annual heating demand ratio (kwh/m^2/year) has been calculated.

The same document includes the breakdown of residential energy consumption by end use in Catalonia:

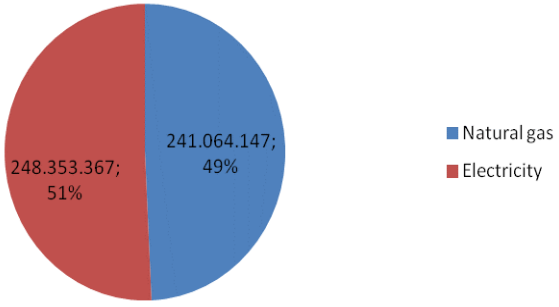
Figure 3: Domestic energy consumption distribution by uses (2007)



Industrial sector

The main energy sources in Granollers are electricity and natural gas. The following figure shows the industrial energy consumption by energy source in 2016:

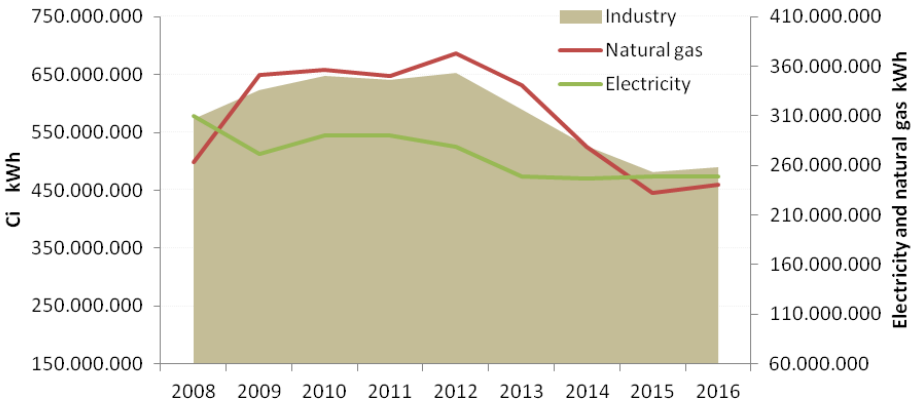
Figure 4: Industrial energy consumption by energy source in 2016



As already mentioned, about 42% of the energy consumption in Granollers (2014) is consumed by the industrial sector, in seven industrial parks with more than 600 different industrial activities. The industrial energy demand is therefore an important issue to work on for the local sustainable development.

With the aim of developing sustainability indicators at the local level and monitoring Local Agenda 21 objectives, the energy consumption of different social sectors has been analysed based on real performance data provided by energy utilities. The following figures show the evolution of the industrial energy consumption in the last 8 years, and the importance of natural gas and electricity as the main energy sources.

Figure 5: Evolution of the energy consumption in the industrial sector (2008-2016)



Because of the nature of industrial activities, it is not possible to define a general industrial heat demand profile: it strongly depends on the sector, and it is necessary to introduce specific profiles for each activity.

The study "Evaluation of suitability of solar thermal systems in the industrial sector", as part of the PER 2011-2020 (Spanish Renewable energy plan), defines a heat demand ratio for each CNAE (national classification of economic activities). However, CNAE's classification categories do not often completely fit real industrial processes, and several industries can fit several categories at the same time.

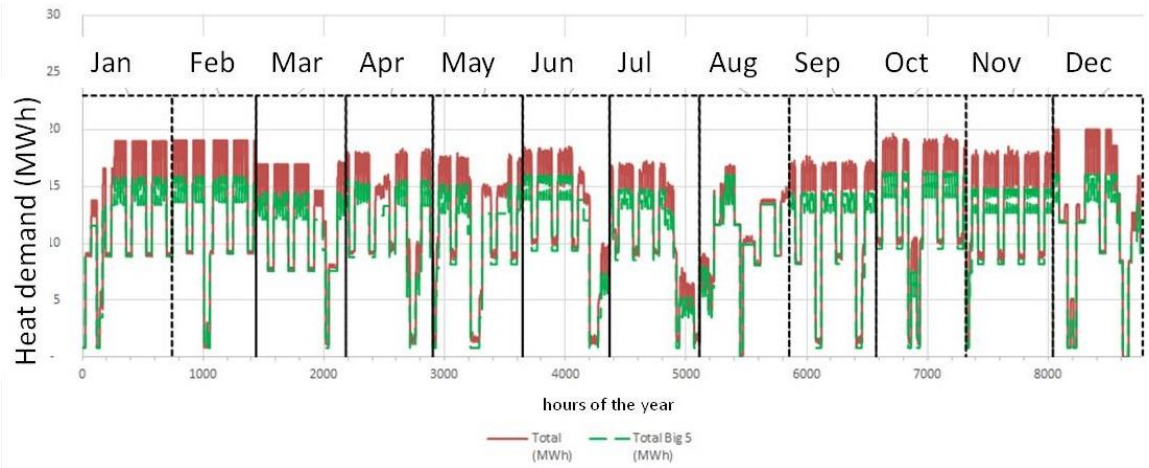
Two main industrial areas have been identified for action: the *Congost* and *Jordi Camp* industrial parks. A range of solutions including solar thermal energy, PV energy, heat exchange between industries, the district heating network, and a cogeneration plant providing steam and hot water is being investigated for both areas.

The calculation of the heat demand of the industrial activities placed in *Congost* and *Jordi Camp* is based on:

- Monitored values: A continuous monitoring of demand has been registered for 9 of the most important industries placed in the selected industrial areas. Only the 12 heat generation systems (steam and hot water boilers) that could be replaced by a heating network have been monitored.
- Surveys and interviews: for some industries, already monitored, additional data has been obtained through specific surveys or interviews.
- Statistical approach: For the rest of activities, the total heat demand has been estimated from the built surface of the industry, the heat demand ratio from IDAE and CNAE's company classification. The yearly value has been then transposed by considering the calendar and the common working time.

The heat demand of the buildings is not being considered because of its reduced size as compared with the heat demand from industrial processes. The following chart reflects the heat demand of the companies with detailed demand profile (monitored or not).

Figure 6: Total heat demand of Congost and Jordi Camp industrial parks



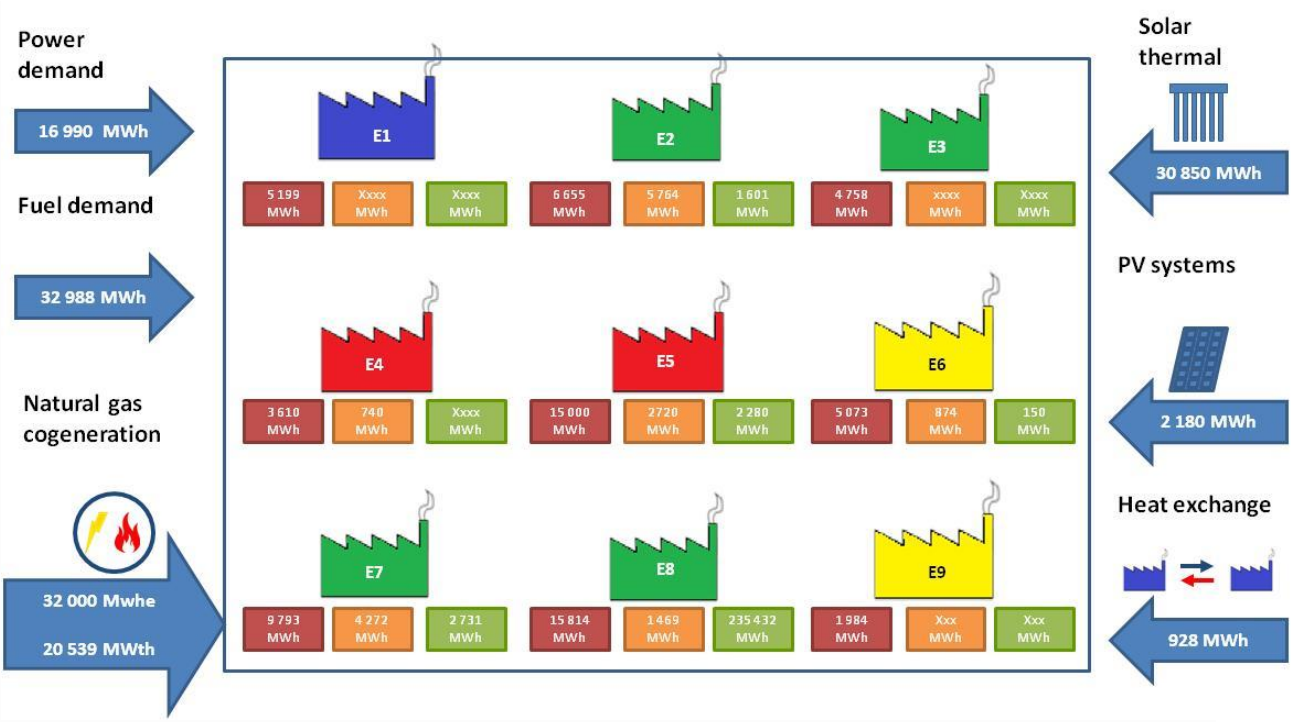
Granollers Mercat started to study the industrial energy demand in 2013 and *IREC* (Energy Research Institute of Catalonia) elaborated the EcoCongost study, which constituted a diagnosis and a definition of alternatives to reduce the energy consumption in the *Congost* and *Jordi Camp* industrial parks.

The EcoCongost project aims to create a singular industrial zone that can improve industries' competitiveness by lowering their energy costs and their environmental impact through the sharing of a high-efficiency cogeneration facility and a district heating network in an area with a concentrated demand for heat. The main objective of the project is to improve the energy use in the industrial area, using renewable sources and surplus heat among different industrial companies and the two biogas production plants available in Granollers (sewage and bio-waste treatment plant).

The study analyses different alternatives in order to reduce the consumption from non-renewable energy sources, as the introduction of solar thermal and PV systems, heat exchange between companies, heat network and centralized energy plant.

The following figure reflects the potential results derived from the installation of all the proposed solutions:

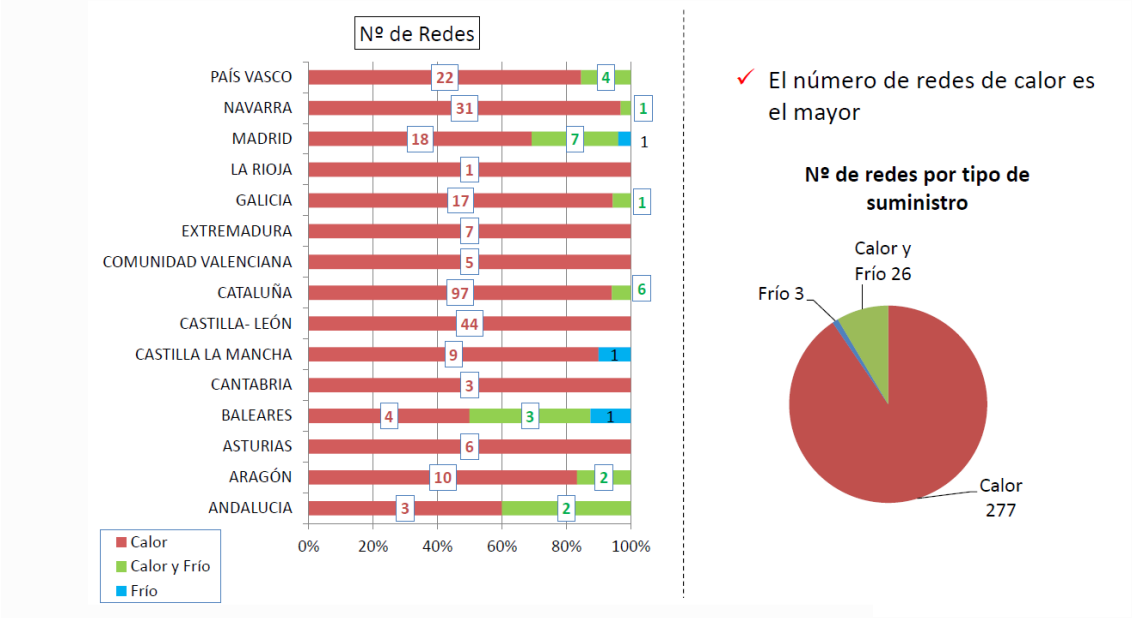
Figure 7: Potential from the installation of the solutions proposed in the EcoCongost project



District heating and cooling

An inventory of district heating and cooling (DHC) networks, compiled by *ADHAC* and *IDEA* in 2016, identifies 306 DHC networks in Spain: 277 provide exclusively heating, 26 of them provide both heating and cooling and 3 networks cover solely cooling needs. Users of DHCs are mostly commercial (69%), although the domestic (23%) and industrial (8%) sectors have presence as well. 28 district heating systems in Spain use only biomass, 14 natural gas, and 2 only electricity. There is still wide room for the development of DHC networks in the way of reaching current figures in northern Europe. Furthermore, at this moment there is not a widespread use of DHC within the industrial sector.

Figure 8: Number and type of existing DHC networks in Spain



Source: ADHAC

Catalonia has three main DHC networks close to Granollers: DISTRICLIMA and ECOENERGIES (DHC) at the north and south of Barcelona, respectively, and TUB Verd in Mataró. But none of those networks has been developed exclusively for the industrial sector. There is another district heating and cooling network nearby, powered by a polygeneration plant and located in the science and technology park of *Cerdanyola del Vallès*, named PARC DE L'ALBA.

ECOENERGIES (DHC) works with hot water (not steam) and *DISTRICLIMA* and *PARC DE L'ALBA* have several economic activities as users, which are mostly from the tertiary sector (services).

As mentioned before, the EcoCongost project is mainly focused on industries and their heat process. It aims to replace the existing heat production systems in industries with a district heating network. Regarding building heating systems used in industrial facilities, a large variety of systems exists. Depending on the type of building (offices and production halls) and the existing heating system, the heating network could be easily connected.

During the last two years Granollers has been working with local industries to analyse the technical, social, legal and economic barriers and the viability of an industrial symbiosis in terms of energy recovery and waste management. From summer 2017 onwards, Granollers and about 20 of the larger local industrial companies will be involved in an energy monitoring campaign. This will enable the city to define the network, the generation plants, and economic figures of the project.

The main objective in the near future is to develop a heating network to cover industrial heat demand in the industrial areas of the city. The network will be heated by biogas (provided by a sewage plant and a wastewater treatment plant), heat recovery from industrial processes and

other renewable energy sources. In a foreseeable long-term future, it will be possible to extend the network to the residential and commercial city centre or other industrial areas.

The biggest challenge is to guarantee the heat distribution in industrial areas by using biogas, heat recovery and other distributed renewable energy systems as the main energy sources. The large number of actors involved in the project increases its sustainability, but also requires a special effort on coordination.

District heating makes it easier to reduce CO_2 emissions thanks to the possibility of implementing local generation using local renewable resources and more energy efficient systems.

At the same time, the case of EcoCongost, focused on the industrial parks, supports the reduction of the energy consumption and/or the energy intensity of the companies located in the industrial areas. This reduction will help increase businesses' competitiveness, which will impact local unemployment and will attract new companies to these industrial areas.

2.2.1.2 Thermal energy supply and demand

Key performance indicator	
Number of generation units and generation capacity	The Register of Electrical Energy Production Facilities under Special Regime is an instrument created for an adequate monitoring of the electricity production in a special regime, both of cogeneration and of renewable energy and waste. Apart from this, there are some available data on renewable generation capacity, which can be found in the table below
Solar thermal energy generation (MWh/ year)	4,300m^2 of solar collectors for low temperature solar heating, 4,000m^2 corresponding to residential buildings and 300m^2 to municipal facilities. 1,056.4 kW of total installed PV capacity in 25 different systems
Heat pump energy generation (MWh/ year)	Available information exists only in two municipal buildings, with a total thermal capacity installed of about 500 kW
Biomass energy generation (MWh/ year)	No local data available
Waste heat potential (MWh/ year)	Not monitored. Two thermal boiler companies have been consulted. The first one has a thermal oil boiler with approximately 300°C flue gas emissions to the atmosphere which consumes 8,000 MWh/year of natural gas. The aim is to recover the waste heat of flue gases until 130°C with an efficient heat exchanger and to obtain 90-95°C hot water.

	The second company has a natural gas-fired thermal oil boiler with 250°C flue gas emissions to the atmosphere. In the scope of the project, this waste heat also will be utilized by flue gas heat exchanger which will decrease the flue gas temperature to 130°C and will supply the hot water network with 90-95°C hot water.
Buildings' energy consumption in the residential sector (MWh/ year)	Not available.
Buildings' energy consumption in the commercial sector (MWh/ year)	Not monitored. Several studies from IDAE define small size commercial business as: 200-600kWh/m^2 Large commercial centres: 300kWh/m^2 The IDAE's document 'Evaluation of solar heating and cooling in Spanish buildings', has defined several ratios of heating, cooling and hot water demand based on building surface and geographic location.
Buildings' energy consumption in the industrial sector (MWh/ year)	All the *Congost* and *Jordi Camp* activities that could be connected to the district heating network consume 145,464.82 MWh/year (in terms of steam or hot water consumption). Thermal energy consumed by direct gas burning or thermal oil boilers is not being considered.

As for generation units, available data is not extensive. A first approach to estimate solar thermal systems installed under the solar ordinance that Granollers approved in 2003 was made in 2010, according to the project presented for the "Urban planning & construction" licenses. However, the review of other systems has not been extensive. The following table summarizes the information available:

Solar thermal systems	4,300m^2 of solar collectors for low temperature solar heating, 4,000m^2 corresponding to residential buildings and 300m^2 to municipal facilities
PV systems	1,056.4 kW of total installed PV capacity in 25 different systems
Geothermal systems	Two municipal buildings with a total thermal capacity installed of about 500 kW
Cogeneration systems	5,936 kW of electrical energy capacity, 1,752 kW of them corresponding to biogas and the majority, 4,184 kW, to natural gas

From 2003 to 2007 there were about 3,000m^2 of solar thermal systems installed in households (dwelling buildings). In 2010 a report reviewing the status of other 62 solar thermal systems (the total area installed then, in residential buildings, was about 4,000m^2), 10 PV installations and one geothermal system (currently, there are two municipal buildings using geothermal systems: *Can Muntanyola*, which installed the system in 2012, and the building of The Centre for Peace, *Can Jonch* 2008) was conducted.

There are 25 PV solar systems with a total electricity generation capacity of 1,056.14 kW. There are two cogeneration plants that use biogas coming from the municipal anaerobic digestion bio-waste plant and the wastewater treatment plan as fuel. The generation capacity registered for both plants is 1,752 kW (1,252 kW and 500 kW, respectively). Furthermore, there are three additional cogeneration plants producing energy from natural gas with a generation capacity of 4,184 kW.

2.2.2 Key Heating and Cooling policy and legislation

There are few key pieces of legislation regarding the thermal energy system in Granollers. This situation relates to the unstable energy policy in Spain, which has led to regulatory risk in recent times. However, despite the lack of specific normative for DHC and of consideration of DHC in urban planning, some background exists in Catalonia: several experiences (103 DHC networks; some of them with renewables) have been already developed and are in operation. The main policies and references to DHC in current legislation are listed below:

- Assessment of national heating and cooling potentials referred to in Article 14 of Directive 2012/27/EC: Promotion of efficiency in heating and cooling
- DHC is mentioned as an efficient technology in building regulations
- Safety of water distribution installations in progress, to be regulated in the coming months
- Solar ordinance (municipal legal regulation approved in 2003) to regulate the incorporation of systems to capture and use solar energy at low temperature for the production of hot water (low temperature) in the buildings of Granollers.
- A modification of the Urban Law is currently in progress. In Barcelona, urban planning laws (*Pla director urbanístic de les àrees residencials estratègiques de l'àmbit del Barcelonès*) are being reviewed to take into account DHC networks.
- On electric distribution: there is a new law in progress which intends to modify some articles of the current Law 24/2013 on the electricity sector in Spain. One of those proposed modifications relates to the recognition of a new network model such as micro-grids, managed by an 'electric aggregator'
- Granollers is one of the signatory cities of the Covenant of Mayors, and has developed a Sustainable Energy Action Plan setting objectives to be reached by 2020
- The Granollers City Council is currently assigned to the Framework Agreement of the Government Plan for the supply of electricity, which will force bidders to

guarantee that a minimum of 30% of the electricity supplied comes from renewable sources or high efficiency cogeneration sources

- The new 'Clean Energy for all Europeans' presented by the European Commission in 2016 included a revised renewable energy Directive that puts more focus on renewable heating and cooling and district heating and cooling networks

2.2.3 Heating and Cooling within urban development and renovation programmes

2.2.3.1 Heating and Cooling Objectives

Sustainable energy policies in the city of Granollers have evolved to form a clear commitment in the last ten years. In 2008, the city was one of the 200 Covenant of Mayors signatory cities in Europe, and approved its SEAP (Sustainable Energy Action Plan) one year later, in 2009, setting the plan to achieve the 20-20-20 European objectives in 2020. Furthermore, Granollers has taken part in several European projects such as Green Partnerships, which aims to support local administrations to overcome existing obstacles and effectively implement a set of measures on the way to energy efficient cities and regions.

The main strategic energy targets in Granollers, to reduce CO_2 emissions, are established in the Sustainable Energy Action Plan (SEAP): the objective to be achieved by 2020 through increased energy efficiency and the development of renewable energy sources is to reduce GHG emissions (tCO_2) by 20%. Furthermore, the mitigation and adaptation strategy integrated into relevant existing plans foresees a 40% reduction in the emission of greenhouse gases by 2030.

The city signed up the Mayors adaptation strategy in 2014 and approved a comprehensive local mitigation and adaptation strategy integrated into relevant existing plans in December 2016. The adaptation strategy pursues the city resilience to the inevitable impacts on climate change in the coming years.

In addition, as mentioned before, Granollers started working in 2015 on an ambitious and innovative project with a few references in Spain, the EcoCongost. The EcoCongost project aims to create a singular industrial zone that can improve industries' competitiveness by lowering their energy costs and their environmental impact through the sharing of a high-efficiency cogeneration facility and a district heating network in a concentrated area of heat demand. The main objective of the project is to improve the energy use in the industrial area, using renewable sources and surplus heat among different industrial companies and the two biogas production plants available in Granollers (sewage and bio-waste treatment plant). EcoCongost will help Granollers advance into the low carbon and resource efficient city that local energy policies aim to reach. The industry sector, mostly located along the river in two main industrial areas (the *Congost* and *Jordi Camp* parks), consumes more than 40% of the energy in the city (in 2012 the industrial consumption reached 47% and in 2014 went down to 42%).

The industrial sector will also play a key role in the energy transition towards lower carbon systems which lead to local reductions in the emission of greenhouse gases. Less energy wastage and lower fossil fuel imports will strengthen local economy. The main targets in the industrial sector are:

- to design and build a thermal energy network, planning it from a long-term point of view and to periodically expand the network according to energy and cost efficiency, present demand and feasible present energy recovery or production and future scenarios (reaching the urban city centre)
- to provide steam and hot water distribution in the industrial area, where a high energy demand exists
- to lower energy costs for economic activities
- to use local energy sources such as biogas from the composting and the waste water treatment plants located in the city, industrial waste heat and solar and/or biomass energy production systems
- to provide local users with stability in their energy bill prices for long-term budget planning
- to reduce the use of fossil energy consumption and GHG emissions from Granollers industries
- to reduce energy dependency at a local level
- to design and build storage for heat recovering
- to open new energy paths for the economic and sustainable energy development of the city, in order to attract new businesses to be settled and avoid industrial relocation in local industrial parks through the sharing of high-efficiency cogeneration and district heating fuelled by renewable local sources in an area of concentrated demand for heat
- to build a brand of Granollers with regards to industrial areas and sustainability and to generate a symbiotic environment to use local resources

Finally, Granollers has different strategic energy targets to reduce CO_2 emissions at European level.

European policies

EcoCongost has incorporated the heating and cooling European policies. The EU policies and measures to achieve the Energy 2020 goals and the Energy 2020 strategy are ambitious and will continue to deliver beyond 2020, helping to reduce emissions by about 40% by 2050.

Renewable objectives

The current 2020 framework sets a EU 20% target for renewable energy consumption which relies on legally binding national targets until 2020. In October 2014, the European Council

agreed the 2030 framework, which sets out a new target of at least 27% for the share of renewable energy consumed in the EU in 2030.

Energy efficiency

The European Union legal framework was constructed around an energy efficiency target of 20% for 2020, which will be reset with a 30% target in mind.

In the roadmap for moving to a competitive low carbon economy 2050 (COM/2011/0112 final) the Commission analysed the implications of EU's commitment to reducing greenhouse gas emissions to 80-95% below 1990 levels by 2050 in the context of necessary reductions by developed countries. The built environment provides low-cost and short-term opportunities to reduce emissions, first and foremost through improvement of the energy performance of buildings. As in the transport sector, shifting energy consumption towards low carbon electricity (including heat pumps and storage heaters) and renewable energy (e.g. solar heating, biogas, biomass), also provided through district heating systems, would help to protect consumers against rising fossil fuel prices and bring significant health benefits.

The Roadmap to Resource Efficient Europe 2050 (COM/2011/0571 final) presents the dual challenge of stimulating the growth needed to provide jobs and well-being to its citizens, and of ensuring that the quality of this growth leads to a sustainable future. To tackle these challenges and turn them into opportunities our economy will require a fundamental transformation within a generation – in energy, industry, agriculture, fisheries and transport systems, and in producer and consumer behaviour.

In the Roadmap for Energy 2050 (COM/2011/0885 final) the Commission explores the challenges posed by delivering the EU's decarbonisation objective while at the same time ensuring security of energy supply and competitiveness. Among the ten structural changes for energy system transformation, there are four directly related to heating and cooling within urban development and renovation programmes:

- Higher capital expenditure and lower fuel costs
- Energy savings throughout the system are crucial
- Renewables rise substantially
- Decentralisation and centralised systems increasingly interact

2.2.3.2 Energy Efficiency Opportunities

There are some existing strategies and plans that provide an adequate framework for the uptake of some of the identified energy efficiency opportunities:

- Improvement of industries' competitiveness by lowering their energy costs and their environmental impact through sharing a high-efficiency cogeneration and a district heating network in a concentrated demand area for heat
- Having two waste treatment facilities in Granollers: the sewage and waste treatment plants, both producers of renewable energy, biogas
- Existing strategies to promote renewable energy sources, like the Catalonian Strategy for the biomass technology
- Action Plan for Energy Efficiency in Industry in Catalonia, working with a specific group of polygons to determine the level of industrial performances that favour energy efficiency
- The installation of a heat network will enable the city to recover industrial waste heat useful for all the industrial park, and not only to neighbour factories as in the direct exchange cases
- The heat network will enable the implementation of political measures to promote energy efficiency in the production processes, considering special tariffs, the temperature exchange, the timing of energy demand, etc

2.2.3.3 Renewable Energy Adoption and Potential

As outlined in previous sections, Granollers has developed some renewable generation facilities over the last few years and has the potential to further extend renewable energy adoption:

Part of the biogas produced in the waste water treatment plant and in the composting plant of domestic organic waste is currently used to produce electricity and heat with cogeneration. There is biogas and heat surplus. The composting plant is also considering the use of industrial organic waste in order to increase the biogas production. This project will materialize circularity concepts given that an industry will provide organic waste to the composting plant and will receive steam through the heat network. The biogas will cover 40% of the industrial heat demand.

As the biogas identified is not enough to cover the expected demand, available biomass from the nearest forestry zones has been identified. The first calculations defined an annual biomass demand of around 25,000Tn/year. The forest owners' associations (*Associació de Propietaris del Montnegre i el Corredor*) are currently defining the maximum yearly extraction potential at 9,000Tn/year. CREAF (Ecology and forestry application research centre) developed studies aimed at defining the biomass potential of different forestry zones around Catalunya.

There are several public buildings which use solar systems to produce hot water (about 300m^2 of solar panels) and two buildings with geothermal heat pumps (one, *Can Jonch*, with a thermal capacity of 206 kW and with a 36,585 kWh annual production, and the other one, *Can Muntanyola* with a higher thermal capacity 224 kW and an estimated annual production of 40.000 kWh).

A study to evaluate the potential of solar energy production in industrial buildings, and the urbanized and non-urbanized areas is currently being conducted by the *Institut Cartogràfic i Geològic de Catalunya (ICGC)*. Their duties are related to the fields of geodesy and cartography, to the spatial data infrastructure of Catalonia and to the activities of promoting and carrying out the actions related to the awareness, survey and information about the soil and subsoil, as regulated by Law 16/2005, of December 27th, on geographic information and the *Institut Cartogràfic de Catalunya*, and by Law 19/2005, of December 27th, on the *Institut Geològic de Catalunya*. The study aims to help the industries placed in Granollers' industrial area install solar thermal systems and inject the waste heat produced into the heat network.

There are two DHC networks currently in project progress in Granollers municipal public buildings. The first network, located in the north of the city, will supply thermal energy to five public facilities: *CEIP Salvador Espriu, EMT, EM Salvador Llobet Cultural Centre and IES Antoni Cumella*. Estimated emissions savings amount to 86.59 CO_2 tons (considering the energy consumption of the future network coverage and 86% of the current natural gas consumption). The network is currently under drafting specifications and executive project for tender by Barcelona Provincial Council (*Diputació de Barcelona*). The second network will be located in the south of the city and will supply thermal energy to seven public facilities: *Roca Umbert (Printing, La Troca, CTUG i Bar) Espai Cangur, CEIP Ferrer i Guardia, CEIP Joan Solans, Pistes Municipals d'atletisme, Pavelló Municipal d'Esports (El Parquet), Pavelló Municipal El Tub*. Emissions savings are estimated at 130.17 tons CO_2 equivalent / year, considering the energy consumption of the future network coverage and 86% of natural gas consumption in 2014. The Barcelona Provincial Council is currently looking for support for drafting the executive project.

2.2.3.4 Transport and infrastructure

The layout of Granollers, which encourages its inhabitants to travel by foot, still leads to significant GHG emissions every day. The rate of motorization in Granollers stands at 637 vehicles/ 1,000 inhabitants, below the regional (698) and Catalan (661) average. In 2014 there were 28,103 registered cars, 1.5% less than in 2006, continuing with the declining trend experienced since 2007.

	%	**Total trips per day**	%	Internal mobility	%	External mobility
Bike +walking	52%	130,784	80%	112,993	16%	17,791
Public transport	12%	29,783	2%	3,099	24%	26,684
Private vehicle	36%	91,107	18%	24,936	60%	66,171
Total trips per day		**251,674**		**141,028**		**110,646**

The sum of residential and visitor mobility made a total of 251,674 daily trips in 2014, which represents an increase of 12% from 2006.

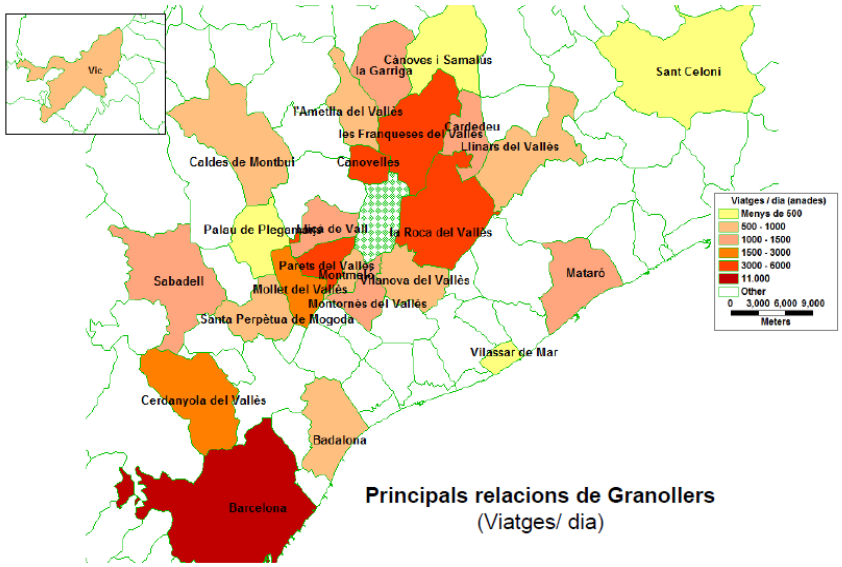
According to the data from the new Granollers Urban Mobility Plan, around 80% of internal travel within the city of Granollers is carried out on foot or bike, 18% in private vehicles and 2% in public transport.

The size of the urban hub of the compact city (3.5 km long by 1 km wide) means that a person without mobility difficulties may do most travel by walking. In fact, this is the most common mode of transport used inside the urban centre of Granollers.

Granollers is highly suitable for the use of bicycles as most of its urban centre is flat and the climate is good. But there is still very little use of them since there is a need to acquire more security both in terms of the itineraries and parking. For this reason, steps are being progressively taken to make the city more bicycle friendly: extension of pedestrian areas; creation of pacified transit 30 kph zones, signposting with safer itineraries, and, in the short-term, safe parking for bicycles, in closed spaces, inside one of the mobility generator centres.

There are 9 bus lines and a bus central station where different companies operate intercity ("*Bus Granollers SL*", "*SA Sagalés*", "*Coaches Barba SL*", "*Sarfa SA*", "*Barcelona Bus SL*"). Furthermore, since 2015 an express bus to Sabadell, Mataró and Barcelona is in place. The presence of major roads such as the AP-7 and C-17 give a daily traffic through the municipality of around 150,000 vehicles, representing a prominent focus of GHG emissions and noise. The AP7 has six lanes and 80,889 vehicles circulate per day (2015), while the C-17 has four lanes and 61,883 vehicles per day (2014). There is a new high capacity infrastructure planned to be used as *Ronda Vallès* is expanding the capacity of road C35. However, the supply of public transport is significant, with three railway stations having suburban and regional services.

Figure 9: Main communications with Granollers



The journeys in private vehicles have decreased by 4.2% for total trips and 31% for domestic travel as compared to 2006.

The last years have seen an increase in the use of public transport for external mobility by the Renfe train and intercity buses, but domestic demand, for internal trips in the city, has decreased from 2006.

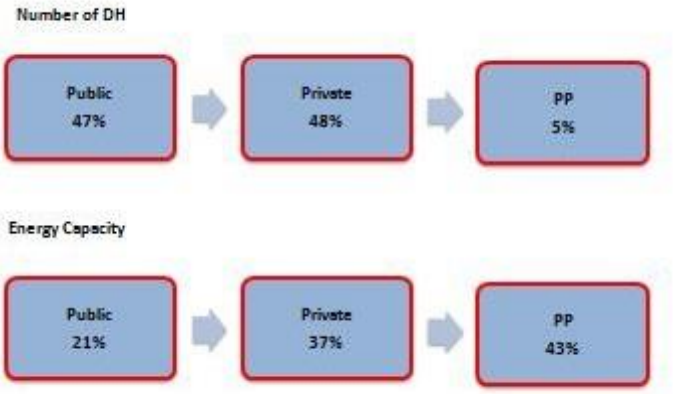
The main mobility flow occurs between Granollers and Barcelona (dark red in the above map) with more than 11,000 one way daily trips. All communications with more than 3,000 trips (bright red in the above figure) are connected by railway with Granollers, except for *Canovelles* (the downtown urban areas of these two cities are continuous, as if they were a unique municipality) and *La Roca del Vallès* (city which has one of its neighbourhoods attached to Granollers, *La Torreta*).

The current mobility plan of the city was approved in 2009 and currently a new Urban Mobility Plan has been elaborated and is planned to be approved by June 2017. It is expected that air pollution episodes can be recurrent and more intense in the future due to climate change. Granollers' concentration of nitrogen oxides and particulate matter in the air will exceed the values set by current legislation. Today, 52% of the population works outside the town of Granollers and 60% of Granollers jobs are occupied by people from outside the municipality.

2.2.4 Financing Opportunities and Instruments

Big heating and cooling networks in Spain are mostly private-public co-financed. This financing mechanisms has been the one used in networks that represent 43% of the energy capacity installed in DHC networks in the country.

Figure 10: Existing DHC networks in Spain by financing mechanism



At local level, municipalities have so far waited for grants that could help co-finance the required investment to build the network. The department of Economic Promotion of the *Diputació* of Barcelona, a public regional authority, has promoted financing schemes for the DH network in Granollers through granting the study of the industrial demand that could be included in the district heating planning. The local authority of Granollers has estimated a maximum yearly amount of 200,000 EUR to be provided once the project is approved (public investment with support of European Funds).

The European Structural and Investment Funds (ERDF, Cohesion Funds) and European funding programs (LIFE, UIA) offer opportunities for local climate and energy actions, such as the development of an efficient district heating network like the industrial one that Granollers aims to build.

District heating networks for municipal buildings are much easier to develop and therefore multiple cases in the country can be identified. For industrial systems, however, the examples are not widely spread. Depending on the Operational Programme of the ESI Funds, there are the Financial Instruments (FIs) to transform EU resources into financial products such as loans, guarantees, equity and other risk-bearing mechanisms. The main objective is to leave the current grant-dependency to allow projects to find a more sustainable and innovative financing mechanism. The national body, the Managing Authority (MA), uses ESIF allocations and place them in FIs through a Fund of Funds or a financial intermediary from which eligible projects can be financed.

Another European Project Development Assistance Facilities (ELENA EIB, ELENA KfW, JASPERS) are also addressed to local authorities will be explored in Granollers for the industrial district heating and cooling network planned.

Other financial instruments to be considered to attract private and public capital into climate financing are the European Fund for Strategic Investments (EFSI), the EIB Municipal Framework Loans, the DEEP GREEN initiative (Debt for Energy Efficiency Projects), Private Finance for Energy Efficiency (PF4EE) instruments or the European Energy Efficiency Fund (EEF).

In Spain, several economic public funds support the renovation and retrofitting of existing buildings (residential and hotel use), including DHC networks, and promote the installation of biomass, geothermal and solar thermal energy systems.

Although there are alternative finance schemes in other countries such as Green Municipal Bonds, Cooperatives, crowd funding, revolving loan funds and/or soft loans, all those finance schemes have not been used in Spain as far as we know. The Energy Performance Contracting (EPC) is one of the few contractual arrangements between an Energy Service Company (ESCO) and a beneficiary about energy efficiency improvements or renewable installations, that has been used as alternative finance scheme.

The European project ENERINVEST aims to develop a web-based platform to provide financing alternatives to different kind of energy projects. The project will provide a tool that will help define what is the best financing method for a specific project.

2.3 Stakeholder identification and engagement

2.3.1 Local Stakeholders

2.3.1.1 Ajuntament de Granollers

Granollers, with a total population of 60,174 inhabitants (2016), is the capital of the '*Comarca del Vallès Oriental*' region and is located 20 km to the north from Barcelona. Granollers, and their neighbour cities, has an important industrial activity thanks to the good location and the good communication and transport alternatives. In that sense, Granollers is the second city of Catalonia in terms of active population working on industrial sector and the fourth of Spain.

Link: http://www.granollers.cat/

2.3.1.2 Institut Català d'Energia

The Catalan Energy Institute is the public regional body responsible for developing the Catalan energy policy and to work for the implementation of those policies. The institute is specially focused on energy efficiency and the development of renewable energy sources.

The institute has two main areas:

Energy management, which is mainly focused on ongoing projects and the application of actual policies, and energy plan, aimed at the development of plans and policies, among others.

2.3.1.3 Oficina Tècnica de Canvi Climàtic i Sostenibilitat - Diputació de Barcelona

The Climate change and sustainability office of the Barcelona province Government (Diputació de Barcelona) offers technical and economic support to local authorities in order to apply sustainability policies and to promote actions in terms of climate change adaptation.

The department is mainly focused on energy management, the accomplishment of the targets on energy and climate set in the Covenant of Mayors, municipal waste management, water management, design and management support of municipal green areas and climate change adaptation.

Link: http://www.diba.cat/en/web/mediambient/canviclimisost

2.3.1.4 Àrea de Territori i Sostenibilitat - Directorate General for Environmental Policy

The Territory and Sustainability department of the Catalan government includes several working areas relating to environmental issues and climate change within the geographic area of Catalonia.

The functions of the department are urbanism policies and planning, soil policies, building and building planning and quality control, building renovation in neighbourhoods and historical city centres, public infrastructures, roads, railroads, ports and airports, transports, environmental quality policies and climate change, water, waste, and the law development.

Link: http://territori.gencat.cat/es/inici/

2.3.1.5 Consorci per a la gestió de residus del Vallès Oriental

The Consortium for Waste Management of the '*Vallès Oriental*' region is composed of the County Council and 39 municipalities in the region. The work of the consortium is mainly aimed at creating, managing and delivering unified services and activities of common interest regarding waste in the region.

The consortium has a basic infrastructure such as a waste dumps regional network, a transfer plant, another plant for anaerobic digestion and composting municipal policies supporting selective collection. The plant is generating organic compost and biogas. This biogas is mainly used in cogeneration motors providing power and thermal energy for heating digesters.

Link: http://www.cresidusvo.info/conres/portada/index.php

2.3.1.6 Institut Català del Sòl

The Catalan Land Management Institute (*Institut Català del Sòl*) is the land management entity of the Catalan Government. The institute has competences in terms of town planning and management of public land or housing.

One of the working areas of the institute is the promotion of new residential or industrial land areas, and social housing promotion. In addition, the institute has been focusing on the renewal and regeneration of urban areas recently.

Link: http://incasol.gencat.cat/ca/

2.3.1.7 Granollers Mercat

Granollers Mercat is the economic promotion department of the Granollers municipality. The activities of the department are mainly focused on supporting local commerce and economic activities located in Granollers and promoting job creation in the city.

One of the areas *Granollers Mercat* is working towards is industrial parks, in terms of their management and specific projects related with innovation, energy efficiency or industrial symbiosis.

Link: http://www.canmuntanyola.cat/

2.3.1.8 ICGC

The Cartographic and Geologic Catalan Institute (*Institut Cartogràfic i Geològic de Catalunya*) is a public body of the Catalan Government, with competences of geodesy, cartography and the spatial data infrastructure of Catalonia, and also the competences of promoting and carrying out the actions related to the awareness, survey and information about the soil and subsoil.

Link: http://www.icgc.cat/en/

2.3.1.9 Estabanell Energia

Estabanell Energia is a local power utility located in Granollers that operates in all the stages of the power sector: generation, distributions and commercialization.

Estabanell Energia manages several micro-hydropower plants located on Ter riverside, from *Osona* and *Ripolles* counties. In these areas, the company also owns and manages the power distribution network.

Finally, the commercial activity of the company is based on selling green energy to the residential, commercial and industrial sectors.

Link: https://www.estabanell.cat/

2.3.2 National stakeholders

2.3.2.1 ADHAC

ADHAC (*Asociación de Empresas de Redes de Calor y Frío)* is the Spanish district heating and cooling association.

ADHAC aims to promote the installation of heating and cooling networks in Spain and to act as a representative of those agents interested in the development of the market. ADHAC carries out studies on the status of DHC in Spain, as the one referred to in previous sections.

Link: http://www.adhac.es/

2.3.2.2 IDAE

IDAE (Institute for the Diversification and Saving of Energy) was established in 1984 as a state-owned business entity that reports to the Ministry of Industry, Energy and Tourism through the State Secretary for Energy. IDAE is the responsible authority within the Ministry for the Renewable Energy Plans (the present one 2011-2020) and for the Energy Saving and Efficiency

Strategy 2011-2020, and is in charge of developing and submitting to the Secretariat General for Energy of the Ministry of Industry, Energy and Tourism the follow-up reports and revisions, and proposals of all the necessary actions and applicable technical solutions during the Plan's temporary limit to achieve its targets.

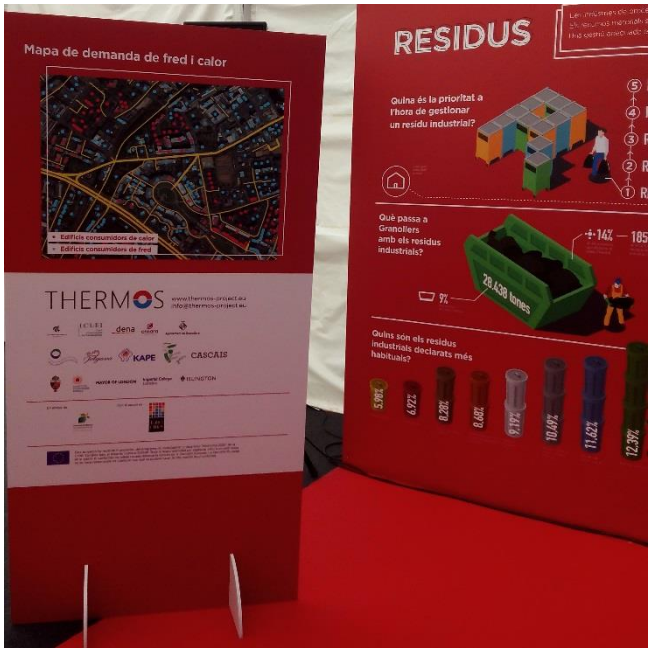
Link: http://www.idae.es/

2.3.3 Existing stakeholder participation processes

This year the local authority stand at the local commercial fair, *Fira de l'Ascensió 2017*, analysed circular economy and industrial symbiosis in the framework of a new project, '*Granollers enters into symbiosis*', that aims to transform industrial areas and to start projects on industrial symbiosis to reduce the use of materials, waste, water and energy.

Wall panels with information on industrial waste origins, quantities, types and current management, and some information on symbiosis in terms of equipments and the EcoCongost energy project were designed.

The local commercial fair was held last May and provided information on THERMOS and its progress, as shown in the images of the stand below. THERMOS could benefit from these local and regional fairs in order to increase the uptake and replication of the tool.



2.3.4 THERMOS Local Liaison Group

The key stakeholders for the replication of the THERMOS model in Granollers comprise actors from the agencies and companies already listed and are included in the Local Liaison Group of Granollers, which is composed of:

1. Environmental councillor - *Ajuntament de Granollers*

2. Head of the economic municipal service - *Ajuntament de Granollers*
3. Head of municipal services and mobility - *Ajuntament de Granollers*
4. Head of the environmental control and licenses of economic activities - *Ajuntament de Granollers*
5. Technological Services Director - *Ajuntament de Granollers*
6. Head of the Territory and municipal Services - *Ajuntament de Granollers*
7. Head of the Catalan energy planning - *Institut Català d'Energia*
8. Head of the support section to the local energetic management. Climate Change and sustainability office - *Diputació de Barcelona.*
9. General manager - *Consorci per a la gestió de residus del Vallès Oriental*
10. GIS representative - *Institut Català del sòl*
11. Projects coordinator - *Institut Català del sòl*
12. General manager - *Granollers Mercat*
13. Head of the unit of local projects - *ICGC*
14. CEO - *Estabanell Energia*

2.3.4.1 Stakeholder roles towards THERMOS model replication

The key stakeholders listed above will hold several roles towards the replication of the THERMOS tool. The following list, which follows the numeration of the previous section, provide an overview of the function that they can hold in supporting the THERMOS model:

1. Political commitment
2. Financial information a feasibility
3. Feasibility and costs estimates
4. Local industrial knowledge
5. Municipal GIS development and data improvement
6. Urban planning knowledge
7. Regional energy planning
8. Replication aspects and dissemination to the rest of cities in the Barcelona province
9. Energy availability from biogas in the short and long-term
10. Integration of the tool regional planning maps
11. Implementation of the tool for regional urban planning development
12. Communication and collaboration with local industries
13. GIS expertise
14. Energy distribution expertise

2.3.5 Stakeholder Engagement strategies

The Local Liaison Group will help gather the required information for the building of the tool and will be used to raise awareness across Spain and facilitate the replication and exploitation of the tool within the country. The specific strategies for engagement will be defined through

the development of the project and will also build on the existing stakeholder participation processes such as the fairs already described.

2.4 Towards THERMOS Uptake

2.4.1 Barriers

The are some existing barriers within the local framework of the energy system that may prevent the uptake of the THERMOS tool.

From a broad perspective, the unstable energy policy in Spain has led to regulatory risks that prevent key market players from taking action in the installation of DHC networks. The lack of specific normative for DHC and of specific consideration of DHC in the urban planning legislation has also been hindering the market deployment. A need to develop local, regional and national legislation supporting thermal optimization can be identified. At a local level, there is a need to develop tax instruments that support DHC networks and the installation of renewable heating and cooling systems as well. The local authority is also facing a dichotomy between the number of users committed to use the network and the imposition of a mandatory use, which would alter users' free choice. In this sense, the lack of price stability is making networks less attractive for consumers and industries.

In addition, there are some local problems that may prevent the uptake of the THERMOS tool by the City Council:

Problems of enough underground space due to existing pipes, which can be categorized in four levels:
-Level 1: immovable pipes, sewer >=600 mm of diameter, high-pressure gas pipeline and pipeline of high voltage electricity.
-Level 2: tubes to be moved with difficulty, water and sewage from 300 to 600 mm in diameter.
-Level 3: medium pressure gas pipe and medium voltage electricity.
-Level 4: other tubes such as electricity, fibre optics.

There is a need to model and estimate costs of:
-Detecting key crossings of networks and different solutions to cross them
-Classification Sections and type of each section.
-Replacement of flooring, according to the service database ITEC (Information Technology Institute).
-New vegetation.
-Assigning streets coefficients depending on the difficulty of pavement replacement costs of existing networks and the width of the streets.

Problems in the management of information include:

-Difficulty in receiving updates of existing infrastructure by suppliers. There is an annual information delivery by suppliers.
-Data sources are usually different, with diverse formats and contents, and required distinct load procedures.

Confidentiality of data

Service companies expressly stress that the data they can provide have internal consultation purposes and should not be published under any circumstances because it is confidential information. There is a need to design a tool that complies with security procedures, with two types of visualization: one for advanced users with restricting privileges consultation and the other open and public.

Different timing and precision of the data

Granollers Mercat has estimated the average daily demand per square meter of the local businesses (with ratios kwh/m^2) with the Statistical classification of economic activities in Spain. Furthermore, the hourly consumption of the high demand industrial factories has been registered.

Little graphic precision of network services

The information provided by companies may contain a significant margin of error. One of the main difficulties found has been the calculation of the free land available (space of the streets) to pass the new network (pipes diameters) depending on existing infrastructure. It has been found difficult to measure the free space of separation between one service and another and the specific location and depth of the network.

Availability of information on energy supply: information at regional level has been recently updated but with a low degree of accuracy.

-Potential geothermal project will be assessed in 2018
-Potential biomass will not be included in ICGC's analysis given the lack of forested areas in the municipality. Granollers is currently searching for information from the association of forest owners of *Montnegre Corredor*, with CREAF and with biomass cluster. Data on availability and potential use of biomass, average prices of biomass in different formats, and the average cost for each of the process (transport, dry, etc.) will be collected from them.
-Potential wind information is not available locally.
-Biogas: information available by the Consortium of waste and the '*Besós Consortium*'

A consortium of waste management companies will provide information on the yearly production of biogas in terms of m^3/hour. Values are being monitored so that variations between summer and winter time can be easily identified.

2.4.2 Proposed solutions

The local administration could consider municipal legal regulations for those new companies that are interested in joining the industrial parks, making it mandatory to install a thermal system from renewable energy sources or to be connected to the district heating. That would partially tackle the lack of specific regulation on DHC.

To face the difficulty in the management of data, the THERMOS tool should admit different sources of data and different load estimation procedures based on this information. Since the timing of data is also important for industry - an hourly base should be ideally considered - the definition of the tool must combine general consumption estimates and real data measurements that account for very specific demand profiles.

Confidentiality issues should be addressed by signing an agreement with the collaborating parties, mainly industrial consumers and service suppliers.

As for the little graphic precision of network services, a gradation of difficulty depending on the availability of space (the four levels previously described) and the costs associated with the type of pavement and the type of street or way (e.g. width, pavement) is proposed.

Finally, the lack of availability of information will be tackled through the stakeholders engaged for the Local Liaison Group. In addition, there are long time series of data for municipal buildings with monthly (and even hourly) information on energy consumption. This year the Granollers City Council is working with the platform Sentilo which has the first readings of sensors associated with the consumption of water, electricity and gas and solar thermal installations. Open data related to municipal buildings water and energy consumption is also available.

The last report to monitor Granollers' SEAP (Sustainable Energy Action Plan) shows a change in the consumption of natural gas (use for heating and hot water, therefore used for thermal demand). The report estimated a consumption of 3,471,149 kWh in 2005, which decreased to 2,841,573 kWh in 2015 considering only the existing municipal buildings in the reference year. That indicates a decrease of 18% in heat demand in municipal buildings.

2.4.3 THERMOS exploitation opportunities

The opportunity is to identify optimal thermal systems to be developed in the industrial area taking into account available and estimated data, helping local decision-makers invest in the most efficient systems and plan the optimal (from both an economic and an environmental perspective) phases to develop the network over the years.

In the future, the tool could be used not only in the industrial area but for the rest of the energy city planning, enabling the local authority to analyse alternatives in a more efficient way than today.

2.5 THERMOS Case Study

2.5.1 Objectives

The EcoCongost project aims to implement a heat network in the *Congost* and *Jordi Camp* industrial areas in Granollers. Granollers aims to combine the results from this project with THERMOS and focus the use of the tool in these industrial parks. Different objectives can be identified:

Environmental objectives:

- Reduction of GHG emissions and air pollutants in Granollers municipality
- Promotion of renewable energy generation
- Reduction of the fossil energy consumption and increase in energy efficiency
- Local energy transition
- Contribution to the building of a sustainable city brand

Economic promotion objectives

- Increase the capacity to attract new companies in Granollers industrial areas
- Increase the economic and environmental competitiveness of the companies placed in the industrial areas
- Increase the retention of the companies placed in the industrial area
- Create a collaborative (symbiotic) environment in the use of energy resources
- Promote concepts and benefits of industrial symbiosis and maximize the use of local resources

Social objectives

- Job security within companies already located within the industrial area
- Increase the occupation thanks to the moving in of new companies and to the improvement of the competitiveness of the original ones.
- Direct job creation in the implementation, management and maintenance of the infrastructures related with the project.
- Awareness and training in industrial symbiosis

In order to define the scenarios to be considered in the definition of the DHC network, the following elements have been considered:

- Expected scenario: only the industries monitored will be connected to the DHC network.
- Positive scenario: all the industries monitored and the other biggest companies located in the industrial park (>1M€ in sales) are connected to the DHC network.
- Negative scenario: only the industries monitored are connected to the DHC network, but some of them decrease their production due to financial problems and leave the network.

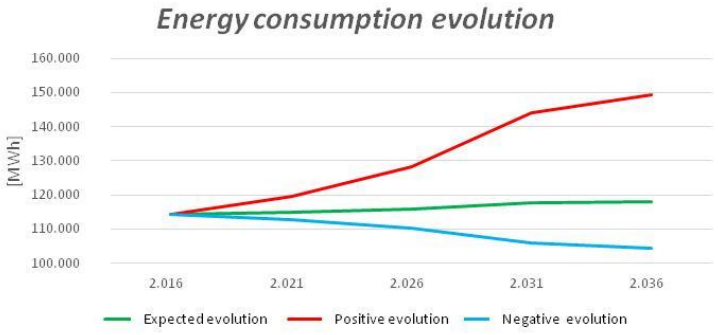
The following tables detail the total heat demand:

Totals (MWh- kW)	114,638.00	36,483.00
Average	17.71	35.41
AvePond	16.89	33.78

Big 5 (MWh- kW)	99,860.00	26,932.00
Average	15.15	30.29
Percentatge	87%	74%
AvePond	14.35	28.71

Finally, the following chart represents the evolution of each of the scenarios defined:

Energy consumption evolution	2016	2021	2026	2031	2036	
Years	0.00	5	10	15	20	
Production increase	0%	15%	40%	85%	100%	
Expected evolution	114,274	114,860	115,835	117,592	118,177	*Mwh*
Positive evolution	114,274	119,538	128,312	144,104	149,368	*Mwh*
Negative evolution	114,274	112,795	110,330	105,893	104,414	*Mwh*



2.5.2 Key stakeholders

- The project is led by the environmental and economic promotion departments of Granollers municipality, and a coordination group with other departments of the municipality holding regular meetings has been established.
- *Consorci per a la gestió dels residus del Vallès Oriental*: Waste management consortium is involved as one of the primary energy providers.
- *Consorci Besós Tordera*: Water consortium responsible of the management of the sewage water treatment plant the second biogas source.
- Industries
- Industrial and sites owners' association
- *Agència de residus de Catalunya*: Waste agency of Catalunya

2.5.3 KPI indicators table

The following chart summarizes a complete list of KPIs, developed in the framework of the CELSIUS Project

Celsius project KPIs

	General KPIs	UM
ENERGETIC	The yearly amount of thermal energy produced/provided by the new system	kWh/year
	Saved primary energy in comparison with baseline situation	kWh/year
	Energy efficiency of the project	%
	Energy recovery from waste/renewable sources	kWh/year
ENVIRONMENTAL	Yearly GHG savings in comparison with the baseline situation	%
	Yearly GHG emissions related to the project	ton CO_2,e/year
	Yearly pollutant emissions related to the project	kg/year
	Yearly reduction of polluting emission in comparison to baseline	
	Carbon footprint	ton C /year
	Ecological footprint	ha
ECONOMIC	IRR of the new investment	%
	Net present value	€
	Yearly depreciation rate per kWh of saved primary energy	€/kWh
	Yearly depreciation rate per ton of saved CO_2e	€/t CO_2e
	Total cost (yearly depreciation rate + OPEX) per kWh of saved primary energy	€/kWh
	Total cost (yearly depreciation + OPEX) per ton of saved CO_2e	€/t CO_2e
SOCIAL	Number of residents/users benefitting of the new project	
	Reduction/increase of complaints due to the implementation of new system in comparison with baseline situation	
	Variation of working hours per year for O&M of the new system in comparison with baseline situation	hours/year
	The internal floor area served by the new system	m^2

2.5.4 Financing status/ opportunities

There are several financing sources supporting the project development so far:

- Catalan Government: The department of Labour finances part of a salary of a technician partially working on the project.
- Barcelona Regional government: *Diputació de Barcelona* has provided finance during the last two year studies to develop some of the aspects of the project.

At the same time, the Council has participated in several project proposals from H2020 and UIA calls in order to finance part of the investment. Unfortunately, only one of those proposals has been accepted so far and without budget for investments.

Other instruments will be studied according to the financing opportunities described in 2.1.4.1 (pg21)

2.5.5 Exploitation of the opportunity

The following barriers can be identified for the development of the case study:

- Legal Barriers: linked to the use of industrial waste for the generation of biogas (use of industrial waste), and to the use of the biogas (transport and commercialization of biogas).

- Technical Barriers: Linked to the distribution of heat (steam) and with the heat network management with multiple points of generation, multiple point of waste heat recovery.
- Economic barriers: Linked to the finance of the project and the municipality role and the system profitability (dependency on industrial activity and its evolution)

3 Islington

3.1 Introduction

Islington is one of the 33 boroughs of Greater London, located in the northern part of inner London. The borough is run by a London Borough Council, the third layer of government below the national UK government and the Greater London Authority. The borough is largely residential, although it has some commercial areas in the south near the border with the City of London. The high density of buildings means that Islington has the least green space in London (see right).

History

Modern Islington was formed by a gradual merger of six separate parishes that were originally in the English county of Middlesex; Charterhouse, Clerkenwell, Glasshouse Yard, Islington, St Luke's and St Sepulchre. The largest of them, Islington, was established around 1005 by the Saxons along the Great North Road, the main road from London to Edinburgh. Clerkenwell became a popular residential area for wealthy Londoners in the 18th century and St Luke's was established in 1733 when the church of St Luke's was built. Charterhouse, Glasshouse Yard and St Sepulchre were very small parishes bordering the city of London.

In 1855 all six parishes came under the jurisdiction of the Metropolitan Board of Works and in 1889 they became part of the newly-established county of London. In 1900 Islington was transformed into a metropolitan borough, whilst the other five parishes were merged to form the metropolitan borough of Finsbury. The two metropolitan boroughs were merged in 1965, creating the modern Islington.

Demographics

At only 15km^2 in size – around six kilometres from north to south and a maximum of 3 km wide, Islington is the second-smallest borough in London and the third-smallest district in the UK. The 1800s saw a population boom as a large amount of housing was built, covering almost the entire parish of Islington – between 1801 and 1901 the population of modern Islington increased from 66,000 to 440,000. It began to decline after 1900, reaching a low of around 160,000 in the 1981 census. Since then the population has begun growing again and is now around 230,000, making it the most densely populated district in the UK and the population density of 15,322 people/km^2 is around double that of Singapore, although lower than that of Paris, Athens or Barcelona.

Climate

Like most of the UK, Islington has a temperate climate with mild summers and cool winters. Average summer highs are around 24ºC with average winter lows around 2ºC, although temperatures can reach as high as 38ºC and as low as –13ºC. As an inner London borough,

Islington benefits from the London urban heat island effect, making it up to 5ºC warmer than the city's outskirts.

3.2 Heating and Cooling in the Local Context

3.2.1 Local energy system

3.2.1.1 Introduction

As common to most London boroughs, there is only a small amount of power generated in Islington from CHP units, solar PV and minimal urban wind turbines (largely constrained to providing energy for the buildings they are located on or in) due to its location in inner London. The borough is instead largely reliant on energy from outside the area, with electricity and gas transmitted to Islington via the national electricity and gas grids and distributed via the local transmission networks.

In 2014 the total energy consumption in Islington was 3,162GWh (see table 1 below). The largest sources of energy were gas (48%), electricity (37%) and petroleum products (15%). However, gas accounted for 73% of domestic consumption (due to heating being largely provided from gas boilers), with electricity almost all of the remaining 23% (table 2). In the commercial and industrial sector (which in Islington is largely commercial as there is very little industry), electricity is the major source of energy at 56%. Road and rail transport are deemed to be 100% from petroleum products, although most of the railway lines in Islington are electrified.

Table 1: *Energy source and usage in Islington (GWh in 2014)*[1]

	Domestic	Commercial & industrial	Road transport	Rail	TOTAL
Gas	895.78	614.09	-	-	**1,509.87**
Electricity	325.58	837.08	-	-	**1,162.66**
Petroleum products	3.22	35.67	446.69	2.16	**487.74**
Manufactured fuels	0.88	0.00	-	-	**0.88**
Coal	0.66	0.05	-	-	**0.70**
TOTAL	**1,226.11**	**1,486.89**	**446.69**	**2.16**	**3,161.85**

Table 2: Energy source and usage in Islington (% in 2014)

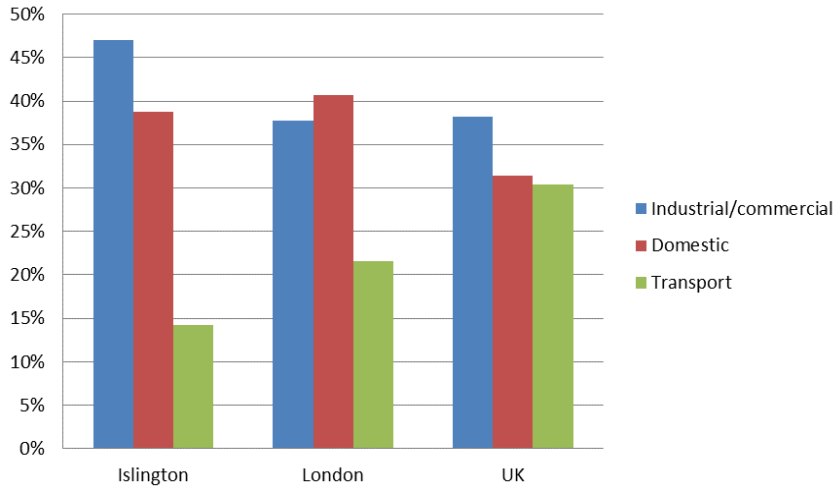
	Domestic	Commercial & industrial	Road transport	Rail	TOTAL
Gas	73%	41%	0%	0%	**48%**
Electricity	27%	56%	0%	0%	**37%**
Petroleum products	0%	2%	100%	100%	**15%**
Manufactured fuels	0%	0%	0%	0%	**0%**

[1] Total final energy consumption at regional and local authority level

Coal	0%	0%	0%	0%	**0%**
TOTAL	**39%**	**47%**	**14%**	**0%**	**-**

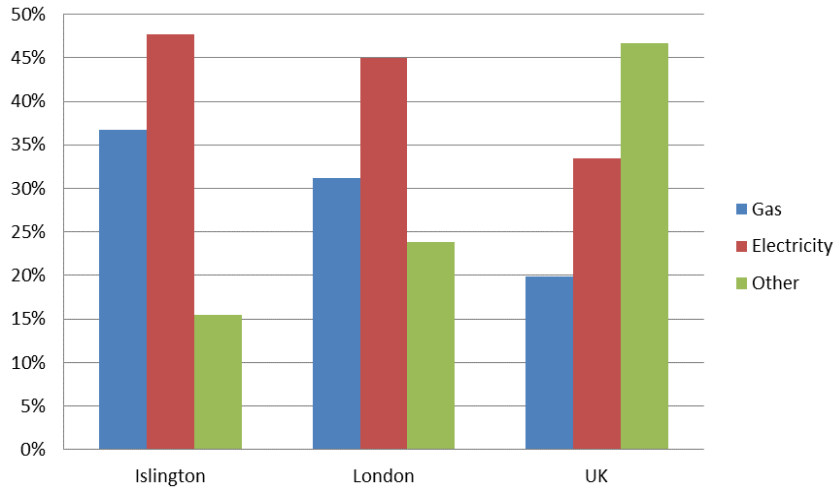
Energy consumption is somewhat different to the rest of London and the UK as a whole (Figure 11), with relatively high levels of industrial and commercial consumption (due to its location bordering the City of London) and low levels of transport-related consumption due to its small size and significant public transport system.

Figure 11: Energy consumption by sector in Islington (2014)



In terms of the source of energy, Islington is also significantly different to the UK average in getting the vast majority of its energy from electricity and gas, whereas the UK as a whole gets over 45% of its energy from other fuels – coal, petroleum products, biomass and manufactured fuels.

Figure 12: Energy consumption by source in Islington (2014)



The significant amount of gas consumption in Islington's domestic sector is due to heating in Islington largely being provided via gas (boilers or CHP), although there is a small amount of

electric and an insignificant amount of biomass heating. Heating via gas is split into three different types; individual boilers, communal systems that serve an entire building and district heat networks, which serve numerous buildings or estates. Individual boilers account for the vast majority of gas heating systems; the council has around 4,000 of its dwellings connected to communal systems and around 800 dwellings connected to its district heating network.

The level of heat demand in Islington is affected by the age of the buildings – over 60% of them were built before 1919[2] – these are largely solid walled houses, many of which have been converted to flats. There is also a very high level of social housing in Islington – at 41% (41,070 of the 101,780 dwellings)[3] it is ranked third out of the 350+ local authorities in England. Home ownership is one of the major dividers in Islington; in 2012 social housing tenants had an average income of around £15,000 and owner-occupiers around £100,000[4]. As a result of the combination of old, inefficient building stock and significant levels of poverty, fuel poverty is a major issue and has become a focus for the council.

Islington Council is the major social landlord in the borough and most of its properties are flats either in the converted townhouses, or more modern estates built from the 1930s onwards. The council operates 48 communal heating systems on its estates, serving over 4,000 dwellings[5]. The council also operates one of the borough's two heat networks, the council-owned Bunhill network, which supplies residential buildings, two leisure centres and a small number of offices, and the Citigen network operated by E.On, which is largely based in the City of London, but serves some buildings in Islington – this network is largely for commercial buildings with a small number of residential properties connected.

Cooling is largely restricted to a minority of commercial and public sector buildings, although demand is expected to be increasing as the amount of commercial floorspace and summer temperatures increase. The Citigen network also provides cooling to the connected buildings.

3.2.1.2 Thermal energy supply and demand

Key performance indicator	
Number and type of energy generation units	No local data available
Solar thermal energy generation (MWh/ year)	No local data available
Heat pump energy generation (MWh/ year)	No local data available
Biomass energy generation (MWh/ year)	No local data available

[2] Housing Strategy 2014–2019
[3] Number of dwellings by tenure and district, England
[4] Two Islingtons: Understanding the Problem
[5] Communal Heating Scrutiny Review

Waste heat potential (MWh/ year)	71,000,000 MWh (whole of London)[6]
Buildings' energy consumption in the residential sector (MWh/ year)	1,226,119 MWh (Islington) 53,206,558 MWh (whole of London)
Buildings' energy consumption in the commercial sector (MWh/ year)	1,486,895 MWh 49,394,526 MWh (whole of London)
Buildings' energy consumption in the industrial sector (MWh/ year)	

3.2.2 Key Heating and Cooling policy and legislation

Heating and cooling legislation is largely delivered through the planning system with national legislation and regional and local planning policy. It should be noted that the UK does not have any legislation or national government policy that requires connection to district heating or cooling networks.

Islington falls under the remit of the London Plan, written and enforced by the Mayor of London and the Greater London Authority. This has several policies that impact on heating and cooling in Islington, including:

- 2.10 Central Activities Zone – Strategic Priorities – aims to 'realise the potential for district energy networks'
- 5.2 Minimising carbon dioxide emissions – requires energy assessments to include proposals to use decentralised energy
- 5.3 Sustainable design and construction – requires major developments to minimise their carbon emissions, including strongly recommending heating and cooling systems

The key policy is 5.5 Decentralised Energy Networks, which sets out a target of 25% of all heat and power to be sourced from heat networks by 2025. It requires the borough councils to develop policies and proposals to develop energy masterplans, establish heating and cooling networks and protecting existing networks.

Policy 5.6 (Decentralised Energy in Development Proposals) requires developments to evaluate the feasibility of CHP systems and consider expanding any potential network beyond site boundaries. It also sets out a hierarchy for energy systems in major development:

1. Connection to existing heating or cooling networks
2. Site-wide CHP network

[6] London's Zero Carbon Energy Resource: Secondary Heat

3. Communal heating and cooling

In Islington these policies have been captured in its Core Strategy, the council's overarching planning document. The Strategy includes policy CS10 on sustainable design, which requires:

- All developments to use low carbon heating and cooling systems and major developments to achieve a 40% reduction in carbon emissions compared to the national building regulations, or 50% where connection to a district heating network is feasible.
- The protection of existing heat networks and support for their expansion
- All developments to contribute to the development of heat networks, including by connection

As part of their planning applications, developers must submit an energy statement. This is reviewed by energy officers who assess whether it complies with the council's energy policies and targets. As part of the planning permission granted, a section 106 agreement is drawn up which includes requirements around connection to or compatibility with heat networks. In cases where developers fail to meet the carbon emission reduction targets, they are required to pay into the council's Carbon Offset Fund, currently at a value of £920 per tonne. The level of payment is included in the section 106 agreement.

Heating and cooling policy is also driven by the Department for Business, Energy and Industrial Strategy (BEIS). Its Heat Network Development Unit (HNDU) was set up to promote the development of district heating in England and supports local authorities through a system of grants for feasibility studies. It has also recently launched the Heat Network Investment Project (HNIP) with £320m of finance available to support the development of networks. The UK's first major policy document on district heating – The Future of Heating – Meeting the Challenge – was only published in 2013.

In terms of energy efficiency of buildings, there are several pieces of legislation or planning policy that set out targets, including:

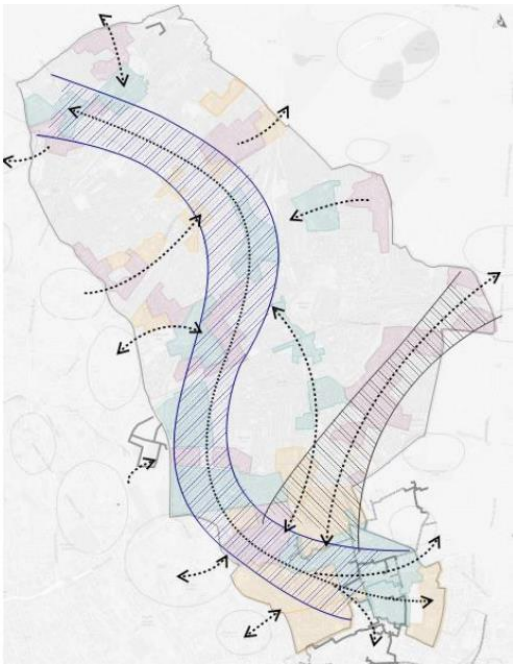
- Building regulations
- The *Energy Efficiency (Private Rented Property) (England and Wales) Regulations 2015*, which requires private landlords to ensure their property has at least an E rating on their Energy Performance Certificate by 2018 if starting a new letting, and from 2023 for any privately-rented property.
- Zero Carbon Homes – initially a central government policy that was due to come into force in 2016 but was later scrapped, this has been adopted by the GLA and requires all developments in London to meet the zero carbon homes standard or pay a carbon offset contribution.

3.2.3 Heating and Cooling within urban development and renovation programmes

3.2.3.1 Heating and Cooling Objectives

In 2014 Islington Council produced a Decentralised Energy Masterplan that set out the vision of how thermal energy systems would develop in the borough. The masterplan identified 11 priority areas for heat network clusters in addition to the existing Bunhill network and its first expansion. Key figures from the masterplan included:

- Total development costs of £77m
- 17km of pipework
- 17MWth of CHP to supply 168GWh/year
- 3% reduction of borough emissions, equivalent to 32,300 tonnes of CO_2 annually



A 'heat corridor' that would link the prospective networks and those from other boroughs was also identified (see right).

3.2.3.2 Energy Efficiency Opportunities

The main method of improving energy efficiency in Islington's housing stock is through insulation and connection to low carbon heating systems; the council has completed cavity wall insulation in almost all of its own stock (only cavities that cannot be filled for technical reasons are left) and is continuing to insulate lofts where possible. However, solid-walled buildings are now the major challenge, with the council owning around 13,700 solid-walled buildings that will require external wall insulation (EWI). The main obstacles to installing this insulation are cost (EWI is at least 20 times more expensive than cavity wall insulation), the lack of funding (changes to the government's energy company obligation ECO fund (which was designed to be used for EWI) have meant it provides almost no funding) and issues with planning (many of the council's solid-walled buildings are converted houses from the 19th and early 20th century and local planners object to any change in their appearance, especially when they are located in conservation areas).

In terms of opportunities, there are several openings to use waste heat in Islington for heat pump-based heat networks. These include:

- Canal basins – the council is currently undertaking a second study into installing a water source heat pump in the Regents Canal basin. This has been shown to be technically viable but the commercial viability is the main challenge.

- Data centres – either as a direct source of heat, or an indirect one (the study on the canal water source heat pump includes the possibility of a cooling loop to the data centre).
- London Underground ventilation – as part of the CELSIUS project, the council is in the process of building an energy centre that will see an air source heat pump installed in a London Underground ventilation shaft to extract the heat from the warm air that is blown out of the tunnels.
- Electricity substations – currently heat from underground electrical substations is being ejected into the atmosphere via radiators on the surface. The council has developed plans to use the heat from one substation to supply its Bunhill network as part of the CELSIUS project, but the substation owner, UKPN, withdrew from the project.

3.2.3.3 Renewable Energy Adoption and Potential

Options for renewable energy in Islington are limited by its geography. As an inner London borough, there is little space available for solar farms, no suitable sites for large wind turbines and no rivers for hydroelectricity. Stringent air quality rules also restrict the use of biomass. The main area of potential is for the installation of rooftop solar PV and solar thermal, and to a lesser extent, roof-mounted urban wind turbines. In March 2017 Islington had at least 1.7MW of solar PV installed (the available figures do not allocate all the installed capacity correctly).[7]

Islington Council has recently installed around 500kW of PV on three roofs – one on a large leisure centre, one on the council's main depot, and one on its largest offices.

3.2.3.4 Transport and infrastructure

Transport in London is largely under the control of Transport for London (TfL), which is overseen by the Greater London Authority. TfL are responsible for all public transport and the city's major roads. Islington therefore has a limited impact on transport planning, largely restricted to the maintenance of minor roads in the borough. However, the council has a role in promoting modal shift, and has installed six electric car charging points around the borough, as well as creating "quiet ways" for cycling, which either involves creating segregated cycle lanes or restricting vehicular traffic to these roads.

3.2.4 Financing Opportunities and Instruments

Heating and cooling systems

Financing heating and cooling systems is the main challenge for Islington Council. The original Bunhill heat network was funded entirely by one-off grants from the Homes & Communities Agency and the GLA. The second phase was part-funded by the EU CELSIUS project, with the council contributing the remaining finance.

[7] Sub-regional Feed-in Tariffs confirmed on the CFR statistics

The council has a small number of internal financing options:

- Council capital – this is council budget set aside for major capital works. As local authorities have been subject to austerity since the financial crash (the funding received from central government (which is the bulk of the council's income) has been halved since 2010), this is no longer a realistic source of significant funding.
- Planning-related funding – this is money raised through the planning system from developers building in the borough:
    - Community Infrastructure Levy (CIL) – this levy is money to contribute towards public infrastructure in the borough, which could include a district heat network.
    - Section 106 (s106) – similar to CIL, but cannot be spent on public infrastructure. However, it can fund, for example, works within a housing estate such as conversion to a communal heating system (which can be connected to a heat network).
    - Carbon Offset Funding – a form of s106 money, this is specifically raised from developers who fail to meet the carbon reduction targets set out in Islington's planning system (a 27% reduction compared to the 2013 building regulations, or a 39% reduction if connection to a heat network is possible). This contribution is valued at £920/tonne. This funding cannot be spent on infrastructure.

There are also some regional and national financing options specific to heat networks:

- Heat Network Investment Project (HNIP): A central government fund set up in 2016 that will provide £320m towards heat networks.
- Heat Network Development Unit (HNDU) funding: A central government fund that provides match funding for heat network development studies.
- Decentralised Energy Enabling Project (DEEP): A GLA fund that provides strategic, technical, commercial/financial and legal support to local authorities developing heat networks. This does not provide capital funding.

Beyond these funding sources, there is also European grant funding, but this is usually limited to demonstrator projects of new technologies rather than being available for a standard new heat network. Private finance is an option, but has not been taken up by the council.

Energy efficiency in buildings

In terms of funding for increased energy efficiency in buildings, there have been several schemes in recent years which have either ended (such as SHESP, which Islington Council used to complete its cavity wall insulation programme) or abandoned (such as the Green Deal, a programme of loans to homeowners to carry out energy efficiency measures – this was abandoned due to low uptake caused by a relatively high interest rate).

The main source for local authorities at present is ECO (Energy Company Obligation). ECO consists of funding that large energy companies are required to set aside to contribute to domestic energy efficiency improvements. The money is obtained from the energy companies, usually through brokers, and is valued on a £ per tonne (of carbon saved) basis. The scheme was originally designed to focus on solid wall insulation (SWI), which meant that the value of a tonne of carbon was relatively high (due to the high cost of SWI), and Islington Council used this to part-fund two SWI projects that insulated around 300 flats. However, reforms to the fund allowed easier works (such as cavity wall insulation) to be funded through it, which in turn significantly devalued the amount available per tonne of carbon saved, making it difficult to fund SWI projects – a third SWI project was postponed when it was discovered that the amount of ECO funding obtainable was less than it would cost to obtain (through certification etc.).

3.3 Stakeholder Identification and Engagement

3.3.1 Local stakeholders

3.3.1.1 Islington Council

Potentially the biggest stakeholder is Islington Council itself. The council owns several large buildings with significant heat loads (such as leisure centres with swimming pools) and 48 housing estates that are already communally heated and would require little retrofit to be connected to a district heating network. This means it has significant levels of baseload that are critical to a new heating network. The council has carried out several feasibility studies for new heat networks, most of which are based around leisure centres and housing estates.

Beyond the 48 communally-heated estates, the council owns over 20,000 other dwellings, many of which are individually heated flats that could be converted to communal heating and connected to district heating networks.

3.3.1.2 Residents

Residents – both in council housing and private housing – are another major stakeholder. Heat networks will need to be attractive to residents, which will primarily come down to cost – will heat from a network be cheaper that their existing heating source? To date the council has achieved a guaranteed 10% saving to all residents connected to the Bunhill network compared with their previous heating bill.

As the Bunhill network is owned by the council, residents effectively have democratic control of the network through the councillors they elect. This helps ensure that the council acts in the best interests of residents when operating the heat network.

3.3.1.3 Businesses

Like residents, businesses are a stakeholder in the network as they are potential connectees and provide the benefit of diversifying the heat load compared with residential properties. Again, the heat network will only be attractive to local businesses if it can provide heat at a price lower than their existing systems, or potentially with more security. The council has several ways of engaging with local businesses, including Town Centre forums and the Islington

Sustainable Energy Partnership, a networking group which helps local businesses improve their energy efficiency.

Businesses are also potential stakeholders as suppliers of waste heat to the network – for example local data centres or electrical substations.

3.3.1.4 Other public sector organisations

Islington Council is not the only operator of large public sector buildings in Islington – there are also hospitals and universities. These provide excellent baseloads for heat networks, as well as diversifying the demand profile, and have been included in the council's feasibility studies for new networks in the borough.

The GLA is another relevant public sector organisation in several ways; it sets regional policy, including the target of 25% of heat and power coming from heat networks by 2025; it provides support to London boroughs on the development of heat networks; and, as the ultimate owner of TfL, it is a partner for the development of projects such as the heat-from-the-tube project that the council is currently undertaking.

3.3.1.5 Developers and building managers

In some cases, Islington's planning system requires new developments to connect to local heat networks, making their developers stakeholders during the construction process. After the development is complete, the organisation that takes over managing the building will become the stakeholder, which in case of residential developments, will not be the same as residents.

3.3.2 National stakeholders

The main national stakeholder is the Department for Business, Energy and Industrial Strategy (BEIS), and in particular its Heat Network Development Unit (HNDU). The HNDU guides national policy on heat networks and is responsible for promoting and supporting their development through funding.

The Association for Decentralised Energy (ADE) is the trade body for district heating providers. It lobbies the government on behalf of its members for policies that support the rollout of district heating in the UK. Islington Council are a Board Member of the ADE.

3.3.3 Existing stakeholder participation processes

Currently there is no formal stakeholder participation process in Islington except for the planning system. Developers must submit an energy strategy, which is reviewed by council officers. There is then a period of negotiation between the developer and the council on the terms of connection, before the connection is made. In order to smooth this process, the council has created two guidance documents for developers and building service designers connecting to the Bunhill network that ensures their systems are compatible with the local heat network:

- Connections Guidance - Part 1 - A guide for developers and building owners

- Connections Guidance - Part 2 - A guide for building services designers connected to Bunhill Heat and Power

Beyond this, stakeholder engagement has been carried out through direct contact with potential connectees such as universities, hospitals etc.

3.3.4 THERMOS Local Liaison Group

The initial members of the London Local Liaison Group (LLG) members have been identified in addition to Islington Council and the GLA and are detailed in the table below. The local authorities are those covering the heat network priority zones for London.

ADE	Trade body for decentralised energy in the UK
BEIS	Government department responsible for heat networks
Brent Council	Local authority in London
Camden Council	Local authority in London
G15	Group of the largest non-council social housing providers in London
Greenwich Council	Local authority in London
Hackney Council	Local authority in London
Haringey Council	Local authority in London
Sutton Council	Local authority in London
Waltham Forest Council	Local authority in London
Westminster Council	Local authority in London

3.3.4.1 Stakeholder roles towards THERMOS model replication

ADE: As the trade body for district heating in the UK, the ADE would be able to advertise its development to members, including other local authorities. It may also be able to help publicise requests for input

BEIS: The government department that has responsibility for heat network development, BEIS would be a potential partner in helping promote and roll out the use of THERMOS

Councils: Other local authorities in London would potentially be users of THERMOS

E.On and SSE: Energy companies like E.On and SSE may seek to become district heating providers (E.On already operates the Citgigen network)

G15: The G15 is a group consisting of the largest non-council social housing providers. Their estates are potential heat network connection opportunities.

3.3.5 Stakeholder Engagement Strategies

Initially the LLG will collate user requirements for the model-building process. Following the model's development, the LLG will be used to help publicise it to local authorities in London and inform national bodies such as the ADE and BEIS so that they are able to raise awareness across the UK. We also plan to present the THERMOS project at a meeting of the London

Environment Coordinators Forum, as well as raising it when hosting events for the CELSIUS project in London.

3.4 Towards THERMOS Uptake

3.4.1 Barriers

In Islington's experience, by far the most significant barrier for local authorities developing heat networks or implementing energy saving measures is finance – i.e. how a new or expanded heat network is funded. If no funding is seen to be available in the foreseeable future, it is unlikely that councils will invest time and effort into developing plans for heat networks, in which case THERMOS would not be used.

If funding is available, the next barrier is lack of expertise within local authorities. However, this is something that THERMOS will help to address. This is why a training programme for local authorities is key to the rollout of the tool.

A UK-wide barrier is the lack of a mechanism by law or in the planning system that requires local authorities to set up heat networks or requires connection to them.

3.4.2 Proposed solutions

The funding availability issue cannot be addressed by the project. However, as noted in section 2.1.1.4, central government has made a significant amount of funding available for heat networks.

The purpose of the THERMOS tool is to address the second gap – i.e. lack of in-house expertise, as it will ensure that local authorities are able to at least partially beginning to develop systems in-house. This will require staff to be trained to use the tool, which is part of the THERMOS project objectives.

If Islington and London can demonstrate the tangible benefits of district heating, it may lead national government to strengthen policies to push the UK towards more district heating; Currently the HNDU and HNIP fund are designed to do this, but they need local authorities to build best practice examples to take it to the next step. THERMOS can play a key role in making that happen, and more quickly.

3.4.3 THERMOS exploitation opportunities

Currently councils across the UK are looking to start developing heat networks in their boroughs or districts and THERMOS is a tool that these councils will be able to use in their development process, reducing their costs and freeing up money for other areas of spending. In the future it may even be possible for community groups to attempt to develop networks if they have sufficient expertise and funding opportunities.

3.5 THERMOS Case Study: Highbury West

3.5.1 Objectives

The main objective is to create a district heat network that would serve the Highbury West ward of Islington. The core scheme would serve a council leisure centre and an estate consisting of four electrically-heated high-rise tower blocks, which would have to be converted to a traditional communal heating system (the existing storage heaters are at the end of their life). The wider objectives include connection to the nearby London Metropolitan University campus.

3.5.2 Key stakeholders

Initially, the key stakeholders would be:

- Islington Council as the owner of the social housing and the nearby Sobell Leisure Centre, which would likely house the energy centre
- Local residents
- GLL, the organisation that operates the leisure centre for the council
- London Metropolitan University

3.5.3 KPI indicators table

Key performance indicator (core scheme)	
Number and type of energy generation units	1
Solar thermal energy generation (MWh/ year)	0
Heat pump energy generation (MWh/ year)	0
Biomass energy generation (MWh/ year)	0
Waste heat potential (MWh/ year)	Unknown
Buildings' energy consumption in the residential sector (MWh/ year)	1,840 (heat)
Buildings' energy consumption in the commercial sector (MWh/ year)	2,390 (heat) 1,385 (electricity)
Buildings' energy consumption in the industrial sector (MWh/ year)	N/A

3.5.4 Financing status/ opportunities

The current financing situation is that the project is unfunded. A bid was made for HNIP funding, with the council using its Carbon Offset Fund to pay for the retrofit of the four high-rise tower blocks. However, the bid was rejected. We are considering amendments to our financial model in order to reapply for HNIP funding as this is realistically the main funding option at present for the council.

3.5.5 Exploitation of the opportunity

3.5.5.1 Barriers

There are no particular barriers in the local energy system; the major barrier at present is insufficient finance for the council to go ahead with the project.

3.5.5.2 Proposed solutions

The lack of finance is a problem specific to the council. Currently we are examining opportunities to apply for funding and considering whether a slightly different business model may be required if we were to reapply to HNIP.

4 Jelgava

4.1 Introduction

Jelgava is a city located in the central part of Latvia, around 41 kilometres southwest of Riga, with about 60,000 inhabitants. It is the largest town in the region of *Zemgale*.

The city is 60.32 km^2 in size, with an elevation of 2.5 to 4.5 meters above the sea level.

The climate is warm in summer and spring, relatively mild in autumn and cold in winter. First frosts are observed in the beginning of October; first snowfalls happen in December and snow melts by the end of March.

The ethnic composition in 2015 was the following: 58.9% Latvians, 26.9% Russians, 5.6% Belarusians, 2.5% Ukrainians, 1.9% Poles, 1.4% Lithuanians, 0.8% Romanians, 2% other.

There is a notable industrial, administrative, educational and culture centre in the city.

As Latvia and Jelgava are situated quite far north, the provision of heat has always been of utmost importance and centralised district heating was introduced in 1960's.

Image: Jelgava city

4.2 Heating and Cooling in the Local Context

4.2.1 Local energy system

4.2.1.1 Introduction

Currently Jelgava has a well-developed district heating system that is located in both banks of the river *Lielupe* and interconnected under the river bank, thus creating one common district heating system for the city that is operated and monitored from a biomass combined heat and power (*Rupniecibas* Bio-CHP) plant. The biomass CHP plant can provide up to 85% of Jelgava district heating load from biomass (at the present situation, from local renewable resource – woodchips). From 2013 onwards, Bio-CHP has replaced the heat production based on natural gas HOBs (heat only boiler houses) and has reduced CO_2 emissions in Jelgava of about 35,000 tons/year.

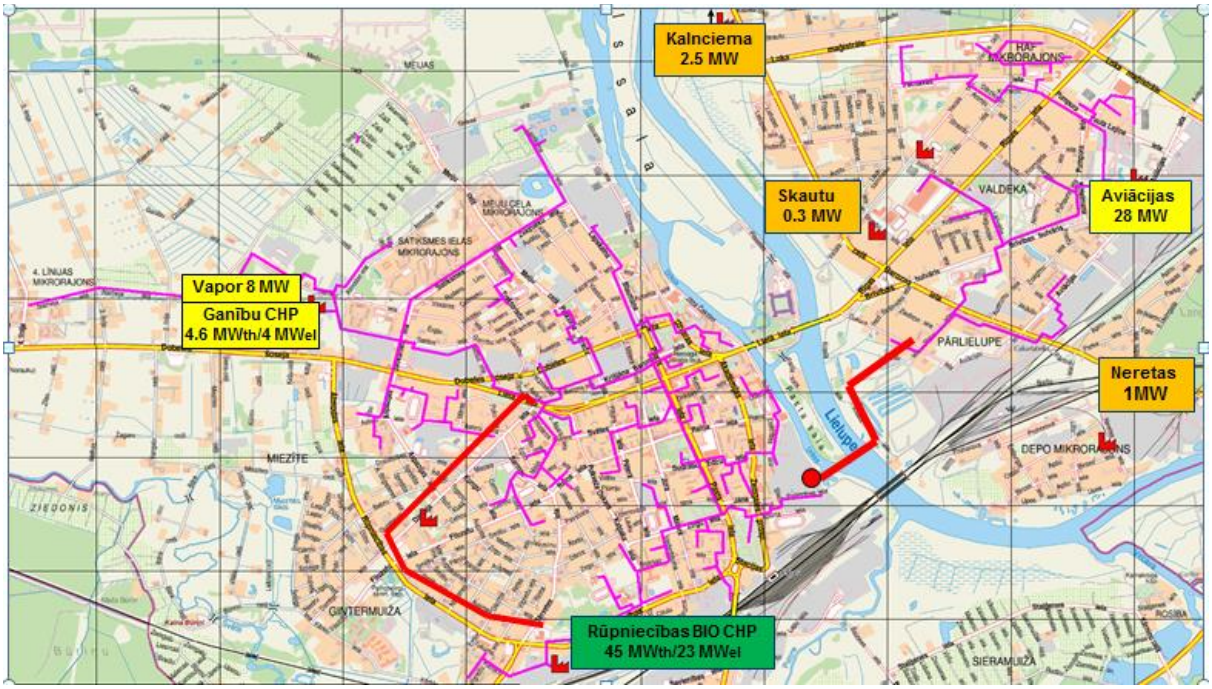
Image: Jelgava city

Jelgava's district heating system is operated by "*Fortum*" since 2008. Currently there are two legal entities: "*Fortum* Jelgava", providing customer service, managing district heating networks and producing heat in natural gas HOBs, and "*Fortum* Latvia", producing heat energy and electricity in CHP mode. Back-up and peak load capacity is provided by natural gas HOBs.

Fortum is a Finnish energy corporation, 51% of the company's shares are owned by the Finnish state.

Fortum in Jelgava (Data of 2017):
•Heat network length - 75km
•Heat sales – up to 200 GWh
•Heat customers – 16,000 households and 400 business customers
•Electricity sales - 150 GWh
•Electricity trade - Nord Pool Spot
•Employees – 78

Figure 13: District heating network and heating sources in Jelgava

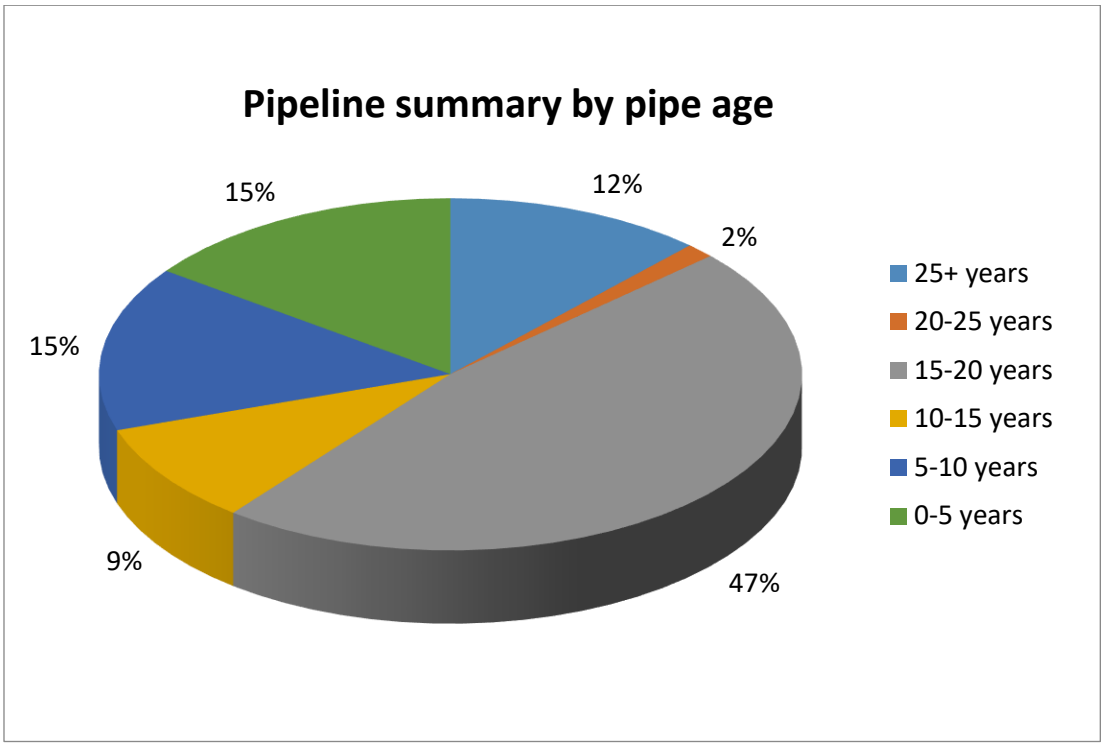


In September 2013, the new biomass CHP plant started its operation in Jelgava. The following are the main technical indicators of the CHP plant:

•District heat capacity – 45 MW_{heat}
•Electricity capacity – 23 MW_e
•Estimated DH produced – 220 GWh (average 2014-2016)
•Electricity – 110 GWh (average 2014-2016)
•Boiler type – bubbling fluidized bed boiler – technology that allows to utilize lower quality wood chips

•Type of wood chips - wood residues and clearings of agricultural lands

Jelgava's district heating system has been rehabilitated and upgraded providing the corporate clients and Jelgava residents with reasonably priced heat energy. The heating tariffs are on average price level when compared to other cities in Latvia.
Heat losses of the DH network are about 16%. Every year part of network is renovated.



Energy consumption

The total electricity consumption in Jelgava in 2013 was around 145 GWh. In the same year, the total heating consumption reached around 230 GWh.

The following charts show the distribution of the electricity and heat production and consumption in Jelgava by energy source and by sector:

Figure 14: Production of local heat in Jelgava by energy source (2013)

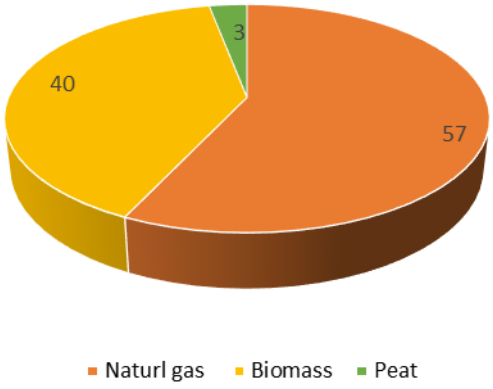


Figure 15: Production of electricity in Jelgava by energy source (2013)

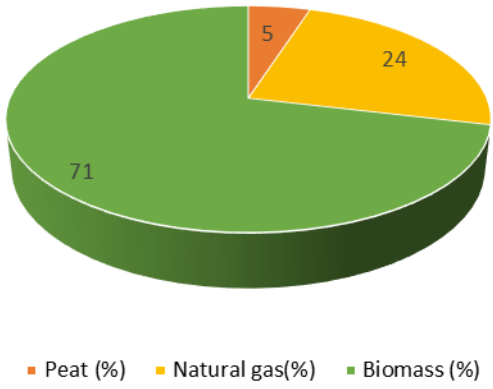


Figure 16: Heat consumption (in %) in Jelgava by sector (2013)

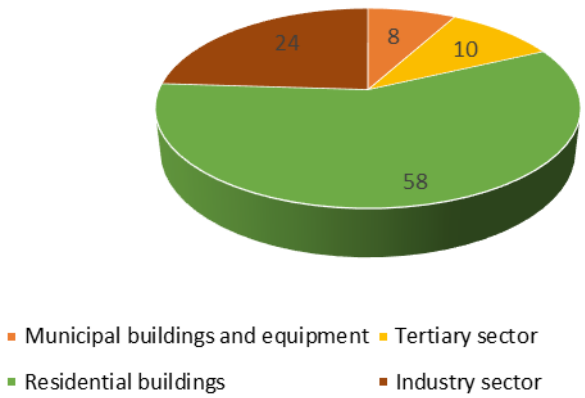


Figure 17: Electricity consumption (in %) in Jelgava by sector (2013)

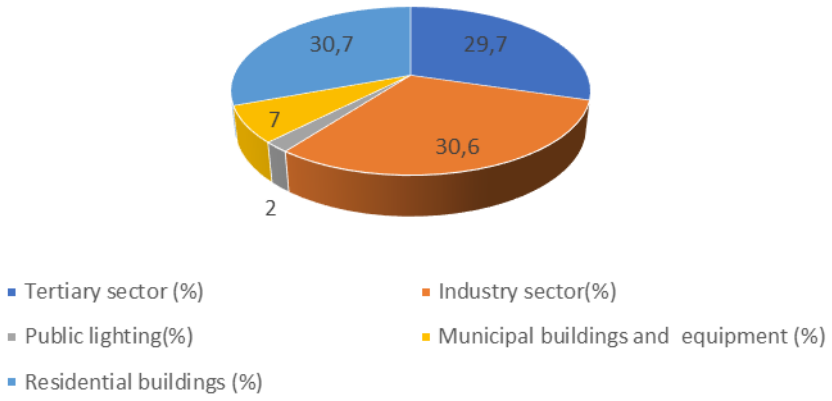


Figure 18: Final energy consumption by sector in Jelgava (2013)

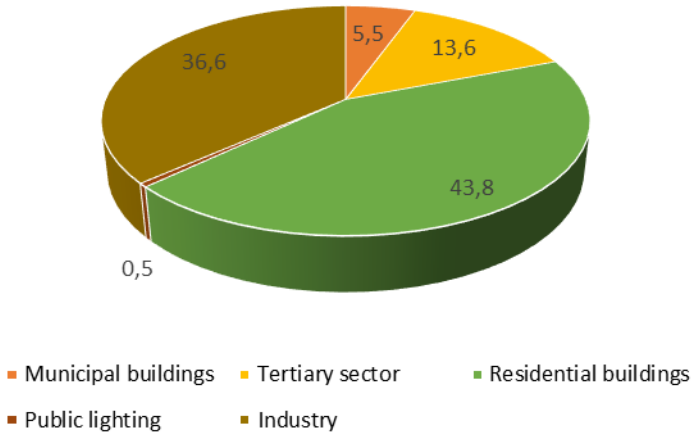
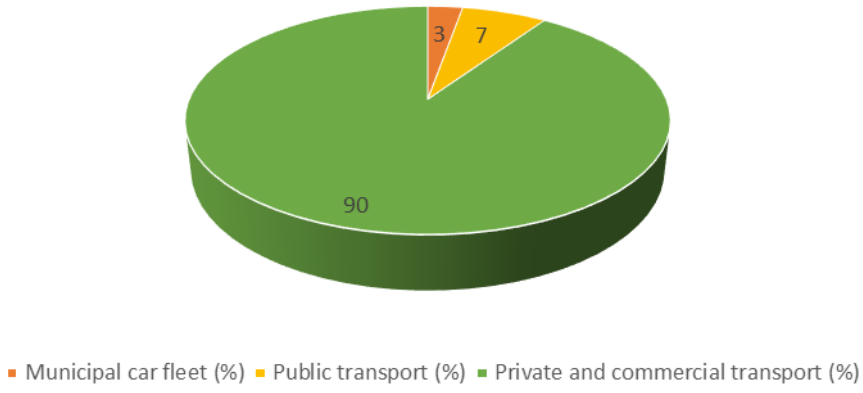


Figure 19: Fuel consumption in the transport sector in Jelgava (2013)



4.2.1.2 Thermal energy supply and demand

The main heat source in Jelgava is Bio-CHP, peak loads are covered by natural gas boilers. The preeminent fuel at the moment is woodchips, which, due to the chosen Bio-CHP technology, can be accepted even at a very low quality and therefore represents a cost-efficient alternative.

There is full back-up capacity for Bio-CHP that is delivered with natural gas HOB. Most of the boilers are in good condition. The main thermal energy users are households in multi-apartment houses. Given the quite far northern position and the cold climate linked to it, the average heat consumption of multi-residential buildings is about 150 – 200kWh/m^2. The renovation process to improve energy efficiency has been ongoing since 2009, with support of national programmes, where part is co-financed by EU funds. In Jelgava 21 multi-residential building have been renovated so far and 4 more are in pipeline to be renovated in the comings years. After the refurbishment, energy savings of 50-60% are usually achieved.

Key performance indicator	DH network	Jelgava city (estimation)
Number and type of energy generation units	Bio-CHP (1), Gas-CHP (1), natural gas HOB (5)	
Solar thermal energy generation (MWh/ year)	0	Very rare, in some private households
Heat pump energy generation (MWh/ year)	0	In some private households
Biomass energy generation (MWh/ year)	150	~190
Buildings' energy consumption in the residential sector (MWh/ year)	130	~140
Buildings' energy consumption in the commercial sector (MWh/ year)	35	~55
Buildings' energy consumption in the industrial sector (MWh/ year)	10	~30

There are very few producers that have waste heat and potential volumes are small and cannot be connected to the network. Bio-CHP in base load at summer time has waste heat and therefore it is critical to increase capacity volumes and use a special base for summer time. Household waste is not commonly used as an energy source in Latvia and the potential in Jelgava has not been investigated.

4.2.2 Key Heating and Cooling policy and legislation

Main normative acts that directly or partly influence the thermal energy system in the city and at national level are:

- Energy Law: sets main principles for power, natural gas and heat energy markets

- Regulations No. 876 "Regulations on Supply and Use of Thermal Energy"
- Law "On Regulators of Utilities" methodology from regulator: establishes the rules for setting tariff, registration criteria, monitoring
- Apartment Law
- Residential Buildings Maintenance Law
- Law "On Rent of Residential Premises"
- Consumer Protection Law
- Personal Data Protection Law
- Competition Law
- Energy Efficiency Law
- Energy Efficiency Law of Buildings

Regarding technical issues:

- Sanitary Protection Zone Law
- Construction Law
- General Construction Regulations
- Regulations of Certain Engineering Buildings
- Law on Procurement by Utilities Companies

4.2.3 Heating and Cooling within urban development and renovation programmes

4.2.3.1 Heating and Cooling Objectives

Since 2009 Jelgava is one of the signatory cities of the Covenant of Mayors. Subsequently the 'Sustainable Energy Action Plan of Jelgava City for the years 2010-2020' was elaborated. The target of the SEAP is to reduce CO_2 emissions at least per 20%, to increase energy efficiency per 20% and to produce 20% of the total energy consumption from renewable energy resources up to 2020 (20/20/20).

The main direction to reach the targets set in the SEAP is to improve the energy efficiency of end users by decreasing their overall energy consumption. In addition, expanding the centralized district heating network would significantly help the city reach the targets: an expanded district heating network would optimize the efficiency of the district heating system, would decrease CO_2 emissions and fossil fuels consumption and would be more cost-effective.

A decrease in the energy consumption due to energy efficiency activities in buildings can however lead to an increase in the cost of energy. Therefore, one of the main priorities for Jelgava is to deliver heat in a stable and safe way being, at the same time, cost-effective and environmentally friendly. The development of the district heating network should follow those premises.

Overall, the city district heating network is in good condition, but there are investments planned to decrease heat losses which are responsibility of Fortum Jelgava.

Regarding the introduction of a centralised cooling system, the situation is being monitored (e.g. for new shopping centres, office buildings or educational institutions). Monitoring activities will help estimate the potential district cooling solution in the city that could be economically feasible and that would lead to significantly lower CO_2 emissions compared to traditional solutions.

4.2.3.2 Energy Efficiency Opportunities

In line with Jelgava's SEAP, the main potentials and measures for energy efficiency are:

1) Improvement of energy efficiency in multi-residential buildings;
2) Improvement of energy efficiency in educational establishment buildings and other municipal buildings;
3) Modernisation of the municipal lighting system;
4) Use of RES for provision of heat and hot water;
5) Provision of energy efficient municipal public transport;

For Fortum, as DH provider, the opportunities comprise:

- Increase in the size of the district heating network by connecting new customers
- Increase in the use of RES to produce heat to DH network.

4.2.3.3 Renewable Energy Adoption and Potential

In September 2013, Jelgava *Fortum* opened the new CHP station fuelled by wood biomass producing electricity and heat. Since then, renewable energy has been used to provide 80% of Jelgava inhabitants and businesses (the customers connected to the district heating network) with green energy.

Customers which are not connected to the district heating network mainly use fuels such as natural gas and wood or pellets. Ground source pumps, coal, electricity heating, diesel are however much less common.

For individual consumers outside the existing DH system, the THERMOS software could help assess potential solutions, such as connecting to the district heating network, electricity network, pellet boilers, solar collectors, ground source pumps or any other technology. THERMOS software could help estimate alternatives considering also CO_2 emissions as a key factor.

4.2.3.4 Transport and infrastructure

The provider of public transport in Jelgava is SIA Jelgava bus park (*'Jelgavas autobusu parks'*). To provide public bus services it operates 35 busses which run with diesel, to which 5% of

biodiesel is added as required by Latvia legislation. Buses are new and comfortable. Jelgava Bus Park is considering the purchase of several electric buses for their fleet in 2017-2018.

The municipality administration, the educational establishments, municipal police and other municipal service providers run their own car fleets, mostly fuelled by petrol and diesel. In 2014 three electrical vehicles were bought for the municipal police, and 1 for the municipal company '*JPPI Pilsetsaimnieciba*', which takes care of the streets, parks and public lighting of the city.

In line with the EU Directive 2014/94/ES of October 2014, on the introduction of the alternative fuel charging stations, it has been decided at national level that by the end of 2020 there will be 60 charging stations for electric vehicles installed on national roads, providing that the distance between such stations is not bigger than 30 km. By 2022, 175 charging stations will be installed on regional roads as long as the distance between them is not greater than 50km.

4.2.4 Financing Opportunities and Instruments

In Jelgava, heating and cooling is provided by the limited company SIA "*Fortum* Jelgava". *Fortum* usually invests their own funds to specific projects of renovation of district heating networks, or construction of a cogeneration station, etc.

The other financial options include:

- Municipal loan from the Latvia State Treasury – this is a usual way in most of the projects for improvement of municipal infrastructure, as the interest rate is usually lower than the one offered by commercial banks.
- Loan from the banks.
- Use of an ESCO company – the ESCO market in Latvia is very new and in the initial phases. For a small country as Latvia, with less than 2 million inhabitants, there are about 7 ESCO companies in the market in 2017. As there is insufficient experience with ESCO type contracts, it is considered that they have heavier terms and conditions and longer periods of time than conventional construction contracts. Therefore, municipalities are reluctant to be the first to try them.
- Now and then some National support programmes (usually using part of financing from EU funds) are announced. In 2017, the Latvian Ministry of Economics has announced a support programme for the reconstruction of heating energy production units to increase energy efficiency and transfer to renewable energy sources; support the improvement of energy efficiency of heat distribution and supply systems, etc.

4.3 Stakeholder Identification and Engagement

4.3.1 Local stakeholders

4.3.1.1 Fortum Jelgava

Fortum Jelgava is the district heating producer and supplier, responsible for maintenance and *development* of DH network and heat supply.

4.3.1.2 Jelgava City Council, Construction department.

The construction department coordinates the construction projects in Jelgava city: issues construction permits, approves the documentation, approves technical designs, issues technical requirements for streets and roads, provides spatial planning of the city etc.

4.3.1.3 Zemgale Regional Energy Agency (ZREA)

ZREA is an energy agency established by Jelgava city council. ZREA is a non-profit body under Latvian Law on Associations (Societies) and Foundations. Members of *Zemgale* Regional Energy Agency represent 4 municipalities, a heating company Fortum, 2 NGO-s, and a house maintenance company (municipal limited company).

The key activity of ZREA is to support improvement of energy efficiency, use of renewable energy resources and green transport in communities of *Zemgale* Region. This includes energy planning, energy data management, advice and consultations to individual residents/ consumers, energy projects and energy events.

In 2010 ZREA prepared Sustainable Energy Action Plan (SEAP) for Jelgava City, the signatory of the Covenant of Mayors. ZREA acts as coordinator, promoter of implementation of the plan, and supporter to the strategic workgroup. ZREA is the authorised representative for Jelgava city in Covenant of Mayors initiative.

4.3.1.4 The Operative Information Centre of the Municipality (POIC)

POIC is the municipality institution responsible for fast exchange of information regarding city infrastructure, for development and safety of city infrastructure.

4.3.2 Regional stakeholders

4.3.2.1 Ozolnieku KSDU

Ozolnieku KSDU is the district heating provider in neighbouring *Ozolnieku* County municipality. KSDUE could possibly use THERMOS tool for planning their district heating networks.

4.3.2.2 SIA 'Auces komunalie pakalpojumi'

'*Auces komunalie pakalpojumi*' is the district heating provider in nearby municipality - *Auce* county. There are three separate district heating systems operated by Ltd. '*Auces komunalie*

pakalpojumi'. They could possibly use THERMOS tool for planning their district heating networks.

4.3.2.3 Ltd 'Jekabpils siltums'

Ltd '*Jekabpils siltums*' the district heating provider in the *Jekabpils* city municipality. It is a municipal limited company that could take advantage of the THERMOS tool for planning their district heating networks.

4.3.3 National stakeholders

4.3.3.1 Latvian Association of Heat Enterprises

Professional membership organisations that is an active developer and lobby for the heating and cooling industry. Its members are almost all district heating companies, producers or equipment and industry experts. Members from this association would cover a significant part of the users of the THERMOS tool.
Link: www.lsua.lv

4.3.3.2 Ministry of Economics (Department of Renewable Energy and Energy Efficiency)

The Ministry of Economics is the leading state administrative institution in the field of economic policy formation in Latvia. The Ministry plans and manages the provision of measures related to the prevention of energy crises. Another function of the Ministry is to introduce and supervise the programs and projects of EU structural funds and other foreign financial means. The Ministry has developed the Energy Development Guidelines 2016-2020, proposing policy guiding principles, objectives and lines of action in the energy sector over the next five years to the Latvian government.
Link: https://www.em.gov.lv/en/

4.3.3.3 ALTUM

ALTUM's shareholders consist of the Republic of Latvia's Ministry of Finance, the Ministry of Economics and the Ministry of Agriculture. The organisation provides financial aid for measures improving energy efficiency in multi apartment residential buildings, provided to apartment owners of multi apartment buildings. The objective of the programme is to promote energy efficiency improvement, smart energy management and the use of renewable energy resources at apartment buildings. The target audience and beneficiaries are multi-apartment building's apartment owners.
Link: https://www.altum.lv/en/

4.3.3.4 Ministry of Environmental Protection and Regional Development (Climate Change Department)

The Ministry of Environmental Protection and Regional Development of the Republic of Latvia is the responsible for implementing policy in three areas - environment protection, regional development and information and communication technologies. In the area of regional

development, the Ministry implements and evaluates regional policy at state level, provides methodological guidelines and supervises the territorial development planning process, as well as ensures the development and supervision of local governments with the overall goal of achieving a well-balanced and sustainable development of the country. The Ministry is responsible for the climate change mitigation policies and measures to limit and reduce greenhouse gas emissions as reducing carbon dioxide emissions is gaining importance in Latvia in line with the common policy and concerns about climate change in the world and the European Union.
Link: http://www.varam.gov.lv/eng/par_ministriju

4.3.3.5 Latvian Environmental Investment Fund

The Ministry of Environmental Protection and Regional Development of Latvia owns 100% of the Latvian Environmental Investment Fund's shares. The Mission of the Fund is to reduce environmental pollution, promoting the implementation of environmental protection projects, and to increase the capacity of municipalities and commercial organizations in preparing and carrying out qualitative and effective projects from their idea to realization. Our activities are directed to achieving the maximum improvement of environment, investing financial resources in the implementation of environmental infrastructure development projects. From 2010 to 2020 the Fund is providing supervision of the implementation and post-implementation monitoring of projects co-financed by the Climate change financial instrument (Green investment scheme - co-financing approximately 200 EUR million). Since 2015 the Fund manages another financial instrument: Emission allowances auctioning instrument (EKII). The instrument gives support for:

- Improving the energy efficiency of buildings in the public and private sectors;
- Technologies using renewable energy sources (RES) development and implementation
- Implementing integrated solutions to reduce GHG emissions.

Link: http://lvif.gov.lv/?object_id=460

4.3.3.6 The Latvian Association of Local and Regional Governments

The Association is a public organisation compiling local governments of the Republic of Latvia on a voluntary basis. It functions as a representative, advocate and advisor of the local governments in Latvia and Europe and contributes to the development of municipal policies, solve common problems and defend the interests of local governments.
Link: http://www.lps.lv/en

4.3.3.7 Latvian Bioenergy Association

Members are mainly owners of Bio-CHP
Link: www.balteneko.lv

4.3.3.8 Riga Technical University (Faculty of power and electrical engineering) (Course Heatsupply)

The Faculty of Power and Electrical Engineering educates and trains engineering specialists in the fields of power engineering, electrical engineering and environmental science, who are competent in electrical power transmission and distribution systems and their control, electric machines and apparatuses, power electronics and electric drives, industrial automation and computerized control, issues of energy efficiency, as well as environment protection and management.
Link: http://www.eef.rtu.lv/kontakti_fakultate.php

4.3.3.9 Institute of energy systems and environment

The Institute of energy systems and environment deals with energy and climate change policy-making and implementation. In addition, it carries out scientific research in the energy sector.
Link: http://videszinatne.rtu.lv/eng/

4.3.3.10 Latvia University of Agriculture (Applied energy program)

The students of this university acquire knowledge of heat, cold and electricity production, transmission and use of alternative energy and energy economy, power plants and process management. There are opportunities to specialize in energy supply or energy economy.
Link: http://www.llu.lv/en

4.3.3.11 Institute of Physical Energetics

The Institute of Physical Energetics is the leading institute in Latvia in the field of energy research. Its main activities cover a wide scope of energy research issues, such as the modelling and analysis of energy interactions and environmental policy studies, the pricing and tariff policy in the energy sector, the energy efficiency improvement and energy conservation programmes. The integration of the technologies directed towards the rational use of energy to ensure a sustainable development of the Latvian energy sector and the optimisation of the heat energy production and consumption systems in Latvia is given special attention in the research work of the institute.
Link: http://fei-web.lv/en/

4.3.3.12 Riga Energy Agency

One of the main functions of the Riga Energy Agency is to elaborate and update the Development Concept of Riga District Heating System and to cooperate with governmental and municipal institutions, non-governmental organizations and other legal actors as well as physical entities, etc.
Link: http://www.rea.riga.lv/en/

4.3.3.13 Latvian Association of Heat, Gas and Water Engineers

Currently, the association unites 355 engineers which work as engineers or lecturers at universities. The association has elaborated the strategy for the development of the engineering sector and implements it via its members. The association elaborates and corrects the national standards of the relevant areas, sets the criteria for study programmes and provides advice on projects and research studies. The association also provides certification of the physical persons for the works such as the elaboration of technical designs, assembly, issues professional certificates at heat, ventilation, and air conditioning, gas supply, water supply and sewage, as well as in energy audit areas.
Link: http://www.lsgutis.lv/par-mums

4.3.4 Existing stakeholder participation processes

The identified national stakeholders will be involved in liaison group meetings.
The Latvian partners in the THERMOS project will participate in work group meetings which are relevant to the project scope. For example, The Latvian Association of Local and Regional Governments holds monthly meetings for the representatives of the municipalities to introduce and discuss the progresses on the field. This meeting can be used to inform about the THERMOS model. The same applies to the workgroup meetings of the Latvian Association of Heat Enterprises.

4.3.5 THERMOS Local Liaison Group

Jelgava City Council, Construction department
Fortum Jelgava
Zemgale Regional Energy Agency (ZREA)
The Operative Information Centre of the Municipality (POIC)
Ozolnieku KSDU
SIA '*Auces komunalie pakalpojumi*'
Ltd 'Jekabpils siltums'
Latvian Association of Heat Enterprises
Ministry of Economics (Department of Renewable Energy and Energy Efficiency)
The Latvian Association of Local and Regional Governments
Riga Technical University (Faculty of power and electrical engineering) (Course Heat supply)
Institute of energy systems and environment
Institute of Physical Energetics
Riga Energy Agency
Latvian Association of Heat, Gas and Water Engineers

4.3.5.1 Stakeholder roles towards THERMOS model replication

Considering the working field and expertise of the local and national stakeholders identified, they can help in the development process of the THERMOS tool, expressing their visions and/or evaluating the model during its elaborating process.
Local stakeholders will overtake the model and adapt it to the municipality's district heating needs.
National stakeholders (policy makers) will evaluate the tool and give recommendations for its replication in other municipalities.
National stakeholders (educational institutions) could use the tool in the study process. Finally, national stakeholders (associations) could use the tool to evaluate and model cross field cooperation projects for the development of district heating systems.

4.3.6 Stakeholder Engagement Strategies

It is important to engage local and national stakeholders at least in three stages: the initial meetings, in order to raise awareness of the THERMOS tool; at midterm, informing on the progress; and at final stage, demonstrating the ready-made tool and training them in its use.

Thus, the identified local and national stakeholders will be involved in liaison group meetings. In addition, the Latvian partners involved in the project will participate in work group meetings with associations and other relevant stakeholders to the project scope, such as the previously mentioned monthly meetings held by the Latvian Association of Local and Regional Governments or the Association of the District Heating Providers.

4.4 Towards THERMOS Uptake

4.4.1 Barriers

In order to enlarge the existing district heating network, it is key for Jelgava city to develop sustainable heating systems, to fulfil the targets of the Covenant of Mayors and to decrease the costs of heat for end users. The main barrier to stimulate the development of the existing district heating network is that end users already have some heating solutions and often the low purchase power does not allow them to connect to the district heating network or choose alternative solutions that would lead to decreased CO_2 emissions, reduction of fossil fuels consumption and would improve the overall system efficiency. The lack of detailed planning and calculation tools makes the process of network expansion slow as for each potential model of possible network layouts, the investment payback calculation takes a long time. Existing system planning is simple but time consuming, based on human skills (work), without possibilities to make different models and more sophisticated calculations.

4.4.2 Proposed solutions

The municipality can support the reduction of CO_2 emissions and energy efficiency in thermal systems with very limited tools and motivators. The main activities regarding the development (extension) of thermal systems in Jelgava can be done by the heat producer and supplier - *Fortum*. The THERMOS tool could provide faster calculations of modulation of possible network layouts and would decrease timeframes and improve the quality of the decision-making process to focus on areas that would benefit all involved parties.

4.4.3 THERMOS exploitation opportunities

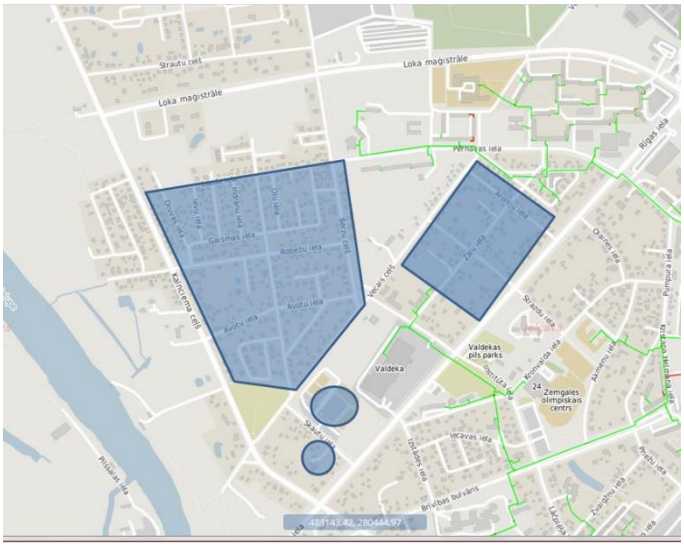
Latvia takes the third place in Europe in terms of percent of population being supplied with the district heating service, after Iceland and Lithuania. Namely, there is a district heating system in all the biggest municipalities (the municipalities are responsible for this service). For instance, in 2013 district heating for sales was produced in 638 boiler houses and in 166 cogeneration stations, which all together produced 7,29 TWh of heat for around 2 million inhabitants and corporative clients in Latvia. There are some DH system planning tools in the market, but they are either expensive or not accessible. The THERMOS tool will be the first open source tool in the area, and as such can be used by many municipal and other district heating providers in the *Zemgale* region and in the rest of Latvia. Therefore, it will be promoted both among the municipalities and heating providers of the *Zemgale* region and in the whole country via the associations.

4.5 THERMOS Case Study

4.5.1 Objectives

There are several areas in Jelgava which are not currently connected to the existing DH network, but that are near to it. Some end users have expressed their willingness to switch to district heating, but their individual connection to the network does not make sense for none of the financing parties. There are no time resources and technical possibilities to make models with possible layouts of the network and minimal capacities and connection points to further develop projects. The THERMOS tool could focus on specific districts of the city and could provide planners with possible alternatives and options of network layouts so that they can decide to connect or disconnect potential end users based on the needed investment, the potential heat consumption, heat losses, payback time and other relevant parameters. This would enable a decision-making process based on qualitative information. In the map below, the marked areas could be potentially interesting for the network expansion and to increase the overall network efficiency, as many of the end users there use fossil fuels at the moment.

Figure 20: Targeted areas for the expansion of the network



4.5.2 Key stakeholders

4.5.2.1 Fortum Jelgava

Fortum Jelgava is the district heating producer and supplier, responsible for the maintenance and development of the DH network and the supply of heat. The company determines the areas where the network will be developed and allocate the necessary funding to implement the planned investment projects. The main challenge is to balance the required investments with end users' consumption, and to make the chosen development areas effective from all perspectives – heat losses, reduction of CO_2 emissions, costs/income balance etc.

4.5.2.2 Jelgava City Council, Construction department

The Construction department coordinates the construction projects in Jelgava and issues all the construction permits and the documentation that has to be arranged. The network has to fully fit spatial planning of the city.

4.5.2.3 End users

End users influence the process the most – it depends on their decisions whether the project will be feasible. End users need help to evaluate the economic and ecological potential, as well as other benefits linked to the change of the energy solution from the existing one to the district heating.

4.5.3 KPI indicators table

Key performance indicator	
Number and type of energy generation units	For each building, own wood or natural gas boiler

Solar thermal energy generation (MWh/ year)	0
Heat pump energy generation (MWh/ year)	0
Biomass energy generation (MWh/ year)	Estimate – 2,580
Buildings' energy consumption in the residential sector (MWh/ year)	Estimate – 4,080
Buildings' energy consumption in the commercial sector (MWh/ year)	1,050
Buildings' energy consumption in the industrial sector (MWh/ year)	0

4.5.4 Financing status/ opportunities

The investment in the district heating network would be made fully by Fortum Jelgava or by sharing costs for connection pipes with customers. There are very limited or even no possibilities to get extra financing from other funds.

4.5.5 Exploitation of the opportunity

4.5.5.1 Barriers

The main barriers are to estimate the minimal amount required from end-users, to start a pro-active process of expansion of the district heating network and to allocate the necessary funding for it. There is lack of tools and time to make the calculations and potential models of different possible scenarios. It therefore leads to slow decision-making processes regarding the network expansion.

4.5.5.2 Proposed solutions

THERMOS could solve the lack of information through the calculation of complex scenarios with different network layout options and with many versions of potential end users connected to the network. In this case study, where there are many small individual end-users, the possibility to model different scenarios is critical to support the next steps of development of the district heating network.

5 Warsaw

5.1 Introduction

Warsaw is the capital and largest city of Poland. The city has a population of 1.7 million inhabitants within city boundaries. Warsaw is located in the central-eastern part of Europe, in the Mazovian Lowland. Warsaw's climate is humid continental with cold, snowy and cloudy winters and warm, sunny and stormy summers. Average temperatures range between −1.8 °C in January and 19.2 °C in July. The average annual temperature is 8.5 °C.

The City of Warsaw provides public services for Warsaw's citizens, including housing, waste collection and management, tax collection, education, libraries, social services, transport, planning, licensing, cemeteries etc.

Warsaw's mixture of architectural styles reflects the turbulent history of the city and the country. During the Second World War, Warsaw was razed to the ground by bombing raids and planned destruction. After liberation, many of the historical buildings were thoroughly reconstructed, but also Soc-realist architecture was introduced in the City. The examples of post-war architecture include the Palace of Culture and Science, a Soc-realist skyscraper located in the city centre, and the monumental Constitution Square. Prefabricated concrete buildings with basic designs, typical of Eastern bloc countries, were erected to rebuild residential buildings.

In recent years, public spaces have attracted significant investment, and thus the city has gained entire new squares, parks and monuments. Warsaw's current urban landscape is one of modern and contemporary architecture.

Lately Warsaw has undergone tremendous changes and development. Every year there are almost 20 thousand flats built. The biggest ecological investment in Europe – '*Czajka*' Wastewater Treatment Plant – was completed and a big programme of revitalisation of the Prague district – located on the right bank of the *Vistula* River – was launched. Apart from these infrastructural changes, a great effort to raise awareness of Varsovians on climate change and to promote ecological behaviour and a conscious approach to ecology has been made. This is extremely important because Warsaw is a unique capital in terms of nature. It borders with one of the largest national parks and a huge half-wild river, the *Vistula*, is flowing through the centre of the city. The right bank of the *Vistula*, in the area of the reserve, has no regulated structure over a distance of almost 4 km, which is quite unusual for a city so large.

5.2 Heating and Cooling in the Local Context

5.2.1 Local energy system

5.2.1.1 Introduction

The energy sector in Warsaw consists of three main subsectors: electricity, heat and gas.

Electricity in Warsaw is supplied from the National Power System, produced in large power plants that are powered with coal and inside the city in combined heat and power plants. In winter, more than 50% of the electricity comes from Warsaw's CHPs, thanks to the large production of heat in this time of the year. In summer about 90% of the electricity is imported from the National Power System.

Gas – used for cooking and in some parts of the city for heating – is 100% delivered from outside of the city.

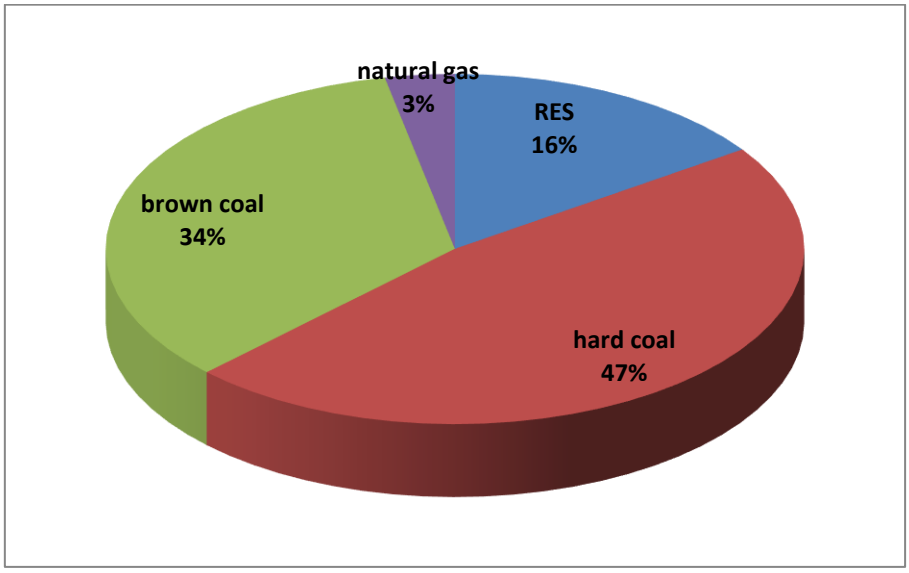
As for the heat system, almost 80% of Warsaw inhabitants uses heat from the district heating network, that is mostly powered by CHPs. The households that are not connected to the district heating network use heat from gas (from the network or individual boilers), heating oil or coal. These are mostly inhabitants of individual houses.

The energy consumption in Warsaw in 2015 was the following:

- District heating: 7,917 GWh
- Gas: 5,195 GWh
- Electricity: 7,447 GWh

The production of electricity and heat is based on coal. The energy mix for electricity used in Warsaw is as follows:

Figure 21: Electricity mix in Warsaw (2015)



In terms of heat production, the basis of the energy system in Warsaw are two large combined heat and power plants (CHP *Siekierki* and CHP *Żerań*), two large heating plants (*Kawęczyn and Wola)* and several smaller sources. 89% of the heat in Warsaw is produced through cogeneration. The two main CHPs operate in cogeneration mode, i.e. they produce electricity and heat simultaneously. In contrast to the typical power plant, the waste heat is not squandered into the air or the river water but used for heating buildings and producing domestic hot water.

As a rule, the volume of electricity production depends on how much of the waste heat can be picked up by the district heating system. Therefore, the electricity that can be produced increases with the number of buildings heated by CHPs. This also results in an improved energy security, because Warsaw is not self-sufficient in energy terms and, as mentioned before, the missing part of the electricity demand is taken from the National Power System.

Power sources in Warsaw	Electric and heat power	
CHP *Siekierki*	[622 MWe]	[1,966 MWt]
CHP *Żerań*	[334 MWe]	[1,435 MWt]
CHP *Ursus*	[6 MWe]	[143 MWt]
CHP *MPO*	[2.2 MWe]	[9 MWt]
CHP *Czajka*	[7.2 MWe]	[6.8 MWt]
HP *Kawęczyn*		[465 MWt]
HP *Wola*		[465 MWt]
HP *Międzylesie*		[70 MWt]
HP *Rembertów*		[29 MWt]

The fuel used in the two largest CHPs is mainly coal (96%), but in *Siekierki* CHP there is a biomass boiler that produces approx. 50 GWh of heat, giving an additional 3.5 % of biomass to heat mix in Warsaw.

District heating

Warsaw has the largest district heating system in the European Union and the third largest in the world, after Saint Petersburg and Kiev. The total length of the double heating pipes is 1,763 km, including 647 km (45%) in pre-insulated technology. District heating supplies 18,600 buildings with 15,000 substations. This represents 78% of the heat demand of the city. Warsaw's district heating (DH) network covers 56% of the city's urban area. The largest diameter heating pipes is 1,200 mm.

The district heating network was owned by the City until 2011, but was then sold to the private company 'Veolia Energia Warszawa'. This means that the City of Warsaw has no direct influence on the directions of development and modernization of the district heating network. It doesn't mean, however, that Veolia has no obligation in this area. According to investor's contractual obligations it is Veolia's obligation to invest EUR 250 million in 7 years from 2011 – 80% of this amount is meant to be invested in the district heating network, according to the list of guaranteed investments. Another positive side of the privatization and the selling of shares to a company of global range is the possibility to use their experience and introduce new technologies in the City that allow the district heating network to be more efficient, modern and eco-friendly.

The plans for the development of the DH network in the following years will be focused on connecting social buildings in the Prague District (more in 5.2.3.1) to the network, on expanding the network in the areas of City development and on modernizing the existing network.

5.2.1.2 Thermal energy supply and demand

Key performance indicator	
Number and type of energy generation units	See section 5.2.1.1

Solar thermal energy generation (MWh/ year)	157,998
Heat pump energy generation (MWh/ year)	2,143
Biomass energy generation (MWh/ year)	No data
Waste heat potential (MWh/ year)	No data
Buildings' energy consumption in the residential sector (MWh/ year)	12,548,616
Buildings' energy consumption in the commercial sector (MWh/ year)	3,876,568
Buildings' energy consumption in the industrial sector (MWh/ year)	2,778,039

5.2.2 Key Heating and Cooling policy and legislation

According to the Local self-government Act, Warsaw, as the municipality, is responsible for the supply of electricity, heat and gas. Article 18 of the Energy Law states that the commune's own tasks include planning and organizing the supply of heat, electricity and gas fuels within the municipality.

The energy planning at local level is two-step and two-pronged. The Mayor of Warsaw, as an executive body, is obliged to prepare a document named "Assumptions for the plan of supply with heat, electricity and gas fuels for the City of Warsaw", which is an inventory of all energy systems and forecasted energy demand. On the other hand, energy companies prepare their own development plans. If the assumptions are not consistent with the development plans of enterprises, the Mayor of Warsaw prepares plans for the supply of heat, electricity and gas for the individual areas for which energy companies do not provide the supply.

These assumptions constitute a legal tool for shaping the energy economy and energy planning in the city. The assumptions are the numerical description of the functioning of the energy system. The core principles are the values of the current and projected demand for heat, electricity and gas fuels in the city and the assessment of its fulfilment.

The assumptions are prepared for the area of the municipality for at least the following 15 years and updated at least once every three years.

Other City documents that shape energy planning in Warsaw are:

- Energy Policy of The City of Warsaw until 2020 adopted by the City Council in 2006. In terms of the heat subsector this policy assumes:

- Providing safe conditions of heat supply
- Motivating large heat recipients and system operators to energy saving
- Stimulating development and modernization of district heating networks
- Supporting thermal retrofitting of building and promoting use of RES for heating

- Sustainable Energy Action Plan (SEAP) for The City of Warsaw in the perspective of 2020 adopted by the City Council in 2011.
The main goals of SEAP are:

- 20% reduction of CO_2 emissions in 2020 compared to 2007
- 20% reduction of energy consumption in 2020 compared to 2007
- Introduction of RES in energy mix in Warsaw

Activities planned for implementation to ensure the fulfillment of these goals are:

- Thermal retrofitting of public, private and residential buildings
- Modernization of heat sources and distribution networks
- Reduction in electricity and heat consumption due to, among others, utilization of new technologies
- Use of RES for generation of electricity and heat

- Low-carbon Economy Action Plan adopted by the City Council in 2015
It acquires SEAP targets in terms of CO_2 reduction and reduction of energy consumption and adds the goal of improvement of air quality in the City.
The Low-carbon Economy Action Plan has a list of investments to be implemented by the City of Warsaw and other stakeholders of the city, like 'Veolia Energia Warszawa' – operator of Warsaw district heating network.

Examples of these investments in terms of district heating network are:

- Connection of social buildings to the district heating network in the framework of the Revitalization Programme
- Modernization and development of Warsaw's district heating network
- Replacement of group, exchanger-based heating substations with individual heating substations and modernization of heat distribution network

5.2.3 Heating and Cooling within urban development and renovation programmes

5.2.3.1 Heating and Cooling Objectives

Most of the heat needs of Warsaw's inhabitants are covered by the district heating network. However, there are some parts of the City where the DH network is not developed, especially in areas with individual residential houses and on the right bank of *Vistula* river, in the Prague district, where there is a significant amount of social buildings. These areas are often heated by individual sources using coal or even illegal wastes for heating, which leads to a deterioration of the air quality.

One of the main priorities for the City of Warsaw is counteracting the formation of air pollution. This implies a strong commitment to ensure the development of the district heating network and the connection of new buildings to it.

A programme named 'District heating for social buildings' has been launched in recent years. The programme is connected to the already mentioned Revitalization Programme and is focused on 3 districts: Prague-North, Prague-South and *Targówek*. From 2010 to 2016 there were 131 buildings connected to the district heating network and the plans for next years (2017-2020) expect 229 social buildings to be connected to the network.

In addition, to encourage citizens to replace their inefficient and air polluting heat sources by the connection to the district heating network or to a gas source, the City of Warsaw is offering subsidies from the beginning of 2017. In terms of DHN, the subsidies amount to 2,500 Euros for natural persons and 5,000 Euros for housing associations, legal persons or entrepreneurs.

The development of the district heating network is, as mentioned before, dependent on the company running it.

Finally, Warsaw introduced a significant project in the period 2012-2017 named "Replacement of group, exchanger-based heating substations with individual heating substations and modernization of heat distribution network in Warsaw Capital City's high-density multi-family housing areas where permissible air pollution levels are exceeded" - marketing synonym - "Individual substations for Warsaw". The main objective of this project is to increase energy efficiency and reduce emissions and air pollution in Warsaw. A heating substation is a device or plant used for changing the type or parameters of a heating medium delivered from a connection point, and for controlling the quantity of heat delivered to end-user lines. Initially, this project involved the replacement of 100 group substations with 765 individual substations. In 2015 it has been expanded, resulting in 111 group substations liquidated and 810 individual substations built.

The outcomes of the project will be:

- reduction of CO_2 emissions, by 20,305 Mg/year
- reduction of emissions of particulate matter PM10 by 2,613 kg/year, SO_2 by 76,193 kg/year, NOx by 38,197 kg/year, which corresponds to the overall reduction of heat consumption and losses at 201,038 GJ annually

5.2.3.2 Energy Efficiency Opportunities

The improvement of energy efficiency is one of the main goals of the City. Activities to achieve this goal may be undertaken in many sectors of the city operation. One of the most important sectors in terms of the possibilities for energy efficiency improvement are buildings. This sector is crucial because the provisions of the Directive on energy performance of buildings states that after 31 December 2018, new buildings occupied and owned by public authorities shall be nearly zero-energy buildings and points to the leading role of the public sector in

implementing policies and actions that stimulate the transformation of buildings to the level of nearly zero-energy.

Because of that, the improvement of energy efficiency in buildings will be one of the most important goals of the currently emerging 'Warsaw Housing Standard', which will be a set of guidelines for constructing new buildings or estates and modernizing the existing ones. This standard will be applied to the buildings built and owned by the City, mostly social, but can also be used by property developers.

In terms of energy efficiency of the district heating network, the main opportunity in recent years was the privatization of the district heating company. As already mentioned, the current owner of the DHN is an international company with many years of experience. That leads to the possibility to utilize the knowledge, best practices, experiences and ideas of the projects implemented by this company in other countries.

One of the projects that will have a positive impact on the energy efficiency of Warsaw's district heating network is 'Intelligent heating network' (IHN). The main goal of IHN is to support all processes related to the efficient operation of the network. The existing district heating network will be equipped with measuring equipment, means of data transmission and decision support applications for optimizing the control of the network operation under both normal and emergency operating conditions. The predicted benefits of the project are:

- 123 TJ/year - Savings in transmission heat losses
- Greater heat supply security, faster fault detection
- Avoidance of CO_2 emissions by 14,500 tones/year

5.2.3.3 Renewable Energy Adoption and Potential

Renewables are a valuable energy source in the city. One of the main goals of Warsaw is to increase the share of RES in the energy mix. In terms of RES used for heat production, it is important for Warsaw to promote this kind of energy source in the areas where the development of the district heating network is subject to technical difficulties or economically unjustified. To encourage Warsaw inhabitants to invest in RES, subsidies for RES introduction are operating in the city from 2012. Between 2012 and 2016 almost 1 million Euro was conceded as a subsidy for more than 300 projects (PV, solar panels, heat pumps). In the first quarter of 2017, 110 proposals for solar panels and heat pumps have been registered:

Type of installation	2014		2015		2016	
	Number of installations	Grants awarded [EUR}	Number of installations	Grants awarded [EUR]	Number of installations	Grants awarded [EUR]
Solar panels	45	83 528	37	60 640	32	48 781
PV	1	724	43	118 895	89	247 298
Heat pumps	9	48 855	29	129 460	18	79 948

Summary	55	133 107	109	308 995	139	376 027

As mentioned before, the majority of the heat produced in the CHPs plants is produced from coal, but in the *Siekierki* CHP plant there is a biomass boiler operating which produced 50 GWh of energy in 2015.

5.2.3.4 Transport and infrastructure

Public transport plays a key role in global mobility system of Warsaw. Public transport consists of buses, trams, two metro lines and the Urban Rapid Rail. The biggest share in the use of public transport system is for buses – 573 million passengers in 2015, trams – 272 million passengers in 2015 and metro – 224 million passengers in 2015.

Several activities have been undertaken for improving energy efficiency in the transport sector. All the new trams that are bought by the City of Warsaw have braking energy recovery systems. As for buses, Warsaw is in the process of purchasing a bus fleet that will reduce emissions of pollutants and will utilize modern technologies. Now in Warsaw there are 4 hybrid 18-metre Solaris buses in operation since 2011, 35 gas buses that joined the Warsaw fleet in 2015 and 10 e-buses purchased in 2014. 10 additional e-buses will be available in Warsaw in the following months. The operation of electric buses brings significant savings in operating costs, besides environmental benefits.

For that reason, Warsaw is planning a big project on electric buses. It will be a major step forward towards the transformation of Warsaw's urban transportation, lessening its dependency on fossil fuels. The project aims to set 130 buses (1/10 of vehicle stock of Warsaw MZA municipal bus operator) in operation, together with modern associated infrastructure, including the construction of aerial chargers at the end of selected bus lines and the adaptation of bus depots. In the long run, the project shall assist the Poland-wide trend towards electric mobility, limiting risks related to CO_2 emissions generated by fossil fuels consumed in the transportation sector worldwide. The project will also massively reduce the amount of pollutants such as NO_x and SO_2, which are generated by Diesel buses, apart from the reduction of noise produced by standard vehicles.

5.2.4 Financing Opportunities and Instruments

In general, it is possible to obtain funding for heating and cooling development investments and investments in heat savings in buildings through thermal retrofitting. The main institution offering subsidies is the National Fund for Environmental Protection and Water Management. Currently in the Infrastructure and environment Programme there are the following possibilities for funding:

- **Supporting energy efficiency in buildings (private and public)** – investments in deep thermal retrofitting of buildings
- **Effective distribution of heat and cooling** - reconstruction of existing district heating and cooling networks to reduce transmission and distribution losses;

construction of connections to existing buildings and installation of individual nodes resulting in the liquidation of group nodes; construction of new sections of the heating network together with connections and heating nodes, in order to eliminate existing local sources of heat, fired with solid fuel and connection of buildings to the district heating network aimed at the liquidation of individual and collective low emission sources

The white certificate scheme is another significant instrument for funding infrastructure projects. In the context of district heating and cooling systems, it should be recalled the Announcement of the Ministry of Energy, dated 12 December 2016, that included a detailed registry of ventures that help increase energy efficiency and a list of activities to increase energy efficiency related with district heating, such as:

- replacement or modernisation of individual and group district heat substations with higher energy efficiency equipment and technology (e.g. insulation, drives, armature, exchangers),
- modernisation of system supplied by group heat substations by converting those systems into individual systems,
- installation or modernisation automation systems and monitoring of the performance of the work of heat substations and heating networks,
- replacement or modernisation of local cooling and air condition systems,
- use of cogeneration systems in local heat sources,
- modernisation of local heat sources (boiler plants, neighbourhood heat plants),
- modernisation of drainage for steam-based installations

There is also the possibility of subsidizing the connection to district heating network from the budget of the City of Warsaw. Details of these subsidies can be found in section 5.2.3.1.

5.3 Stakeholder Identification and Engagement

5.3.1 Local stakeholders

5.3.1.1 Veolia Energia Warszawa

'Veolia Energia Warszawa S. A.', a part of the Veolia Group, is a private company that owns the district heating network in Warsaw. Veolia manages the network and delivers heat to 18,000 buildings. It operates in Warsaw since 2012 (between 2012 and 2014 as *Dalkia Warszawa*), when the privatization of the SPEC company was performed. Now Veolia holds 85% of the shares with the remaining 15% belonging to company employees.

Veolia is bound with the City with contractual obligations of:

- Investing EUR 250 m in the next 7 years following the privatization of the network – 80% of this amount invested in district heating network, according to the list of guaranteed investments
- not selling shares in at least 10 years
- assuring that the company offices will stay in Warsaw, which means that tax will be paid in the city
- following the rules of cooperation in terms of energy safety policy and Energy Law

Veolia creates and implements energy efficient solutions in Warsaw, in line with Veolia's sustainable development policy. It is actively involved in the life of the city, working for the protection of the environment by implementing a number of pro-ecological investments and cooperating in the education of children and youth.

5.3.1.2 PGNiG TERMIKA

PGNiG Termika, a state-owned company, is the biggest producer of electricity and heat through cogeneration in Poland. The production of electricity and heat within the City borders is undertaken in two CHPs – *Siekierki* and *Żerań* and HPs *Kawęczyn* and *Wola*.

The main goal of *PGNiG Termika* is ensuring the security of heat and electricity supplies in the City and its respect for the environment. This is visible in the continuous development of installations that ensure less air pollution and an improved energy efficiency.

5.3.1.3 City of Warsaw Departments

Warsaw City Hall consists of 37 departments, of which some should be THERMOS stakeholders. Some examples would be the Architecture and Spatial Planning Department, responsible for the creation of spatial planning policy for the city, the Mobility Policy Department, responsible for the coordination of the activities in the scope of functioning of public transport in Warsaw and the Centre for Public Communication, responsible for society participation and dialogue.

5.3.1.4 Warsaw University of Technology

The Warsaw University of Technology is one of the leading institutes of technology in Poland and one of the largest in Central Europe. It employs 2,453 teaching faculty, with 357 professors (including 145 titular professors). The number of students as of 2011 amounted to 36,156, mostly full-time. There are 19 faculties (divisions) covering almost all fields of science and technology, from which some could be THERMOS stakeholders: Faculty of Geodesy and Cartography, Division of Power Engineering, Division of Thermodynamics or Division of Rational Use of Energy.

5.3.1.5 The Association of Municipalities Polish Network 'Energie Cités'

The Association of Municipalities Polish Network '*Energie Cités*' (PNEC) is a non-governmental organization which supports sustainable energy planning and implementation on the local level. Since 1994 PNEC promotes energy efficiency and the use of renewable energy sources, implements projects supporting the sustainable energy development of Polish municipalities

and organizes conferences, seminars, workshops and study tours devoted to energy-related issues.

5.3.1.6 Polish District Heating Chamber of Commerce (IGCP)

The organization gathers companies whose business activities are related with district heating, mainly owners and managers of municipal assets used for generation, processing, storage, transmission of heat and trade heat. The primary objective of the chamber is the initiation and collaboration in upgrades and the complex development of heating in accordance with changing needs.

5.3.1.7 Municipal Waste Company (The Urban Solid Waste Treatment Station)

The Municipal Waste Company is a public company with an integrated waste management system that owns the first incinerator in Poland.

5.3.1.8 Municipal Road Authority

The Municipal Road Authority is a budget entity with the main focus of maintaining the existing status of the district, state and Voivodship roads, with expiation highways and express dual carriageways. Within the sphere of competence of the Municipal Road Authority is 800 km or roads, sidewalks and bike paths, 108 thousand luminaires, 487 bridge gullies or the Road Traffic Management System.

5.3.1.9 Municipal Bus Operator (MZA)

The purpose of the company's operation is to provide bus public transport within the capital city of Warsaw. MZA operates more than 1300 buses. It is 74% of Warsaw bus fleet. Remaining 26% belongs to private bus companies.

5.3.2 National stakeholders

The main stakeholders for the replication of the THERMOS application could be other cities in Poland that have a district heating network. It could be especially interesting for the cities that have their own municipal district heating network operator to assess the possibility of expanding the network and the benefits or challenges related to it.

5.3.3 Existing stakeholder participation processes

The City of Warsaw is focused on ecological education of the citizens. Because of that, many events are organized to raise awareness on ecology, climate, energy efficiency. Two of the main events where THERMOS could be exploited are:

- Warsaw Energy Day – organized every year within the European Energy Week. It is an event where new solutions regarding energy efficiency, RES, e-mobility are presented.
- Picnic with Climate - organized every year within the platform "Partnership for Climate", whose members are embassies, companies and NGO's that are committed to act against climate change.

5.3.4 THERMOS Local Liaison Group

1. Veolia Poland
   http://www.veolia.pl/
2. *PGNIG Termika*
   http://www.termika.pgnig.pl/
3. Warsaw University of Technology
   - http://www.gik.pw.edu.pl/ - Faculty of Geodesy and Cartography
   - http://www.itc.pw.edu.pl/ - Division of Thermodynamics, Division of Rational Use of Energy
4. The Institute of Heat Engineering - Division of Power Engineering,
   http://www.itc.pw.edu.pl/
5. Public Transport Authority
   https://zdm.waw.pl/
6. The Association of Municipalities Polish Network '*Energie Cités*'
   http://www.pnec.org.pl/pl/
7. The Institute of Heat Engineering - Division of Thermodynamics
   http://www.itc.pw.edu.pl/
8. The Institute of Heat Engineering - Division of Rational Use of Energy
   http://www.itc.pw.edu.pl/
9. Municipal Waste Company (The Urban Solid Waste Treatment Station)
   http://www.mpo.com.pl/
10. Polish –District Heating Chamber-of Commerce (IGCP)
    http://www.igcp.org.pl/igcp
11. Municipal Road Authority (ZDM)
    https://zdm.waw.pl/
12. Municipal Bus Operator (MZA)
    http://mza.waw.pl

5.3.4.1 Stakeholder roles towards THERMOS model replication

5.3.4.1.1 Veolia Energia Warszawa

Heat supplier in the City of Warsaw – cooperation with the City in terms of development of the district heating network

5.3.4.1.2 PGNiG TERMIKA

Electricity and heat producer – cooperation in terms of the development of district heating network – providing sufficient amount of heat for the City.

5.3.4.1.3 Warsaw University of Technology

Support in testing Thermos tool, access to methodology of gathering energy and special data, assessing the quality and reliability of results.

5.3.4.1.4 The Association of Municipalities Polish Network 'Energie Cités'

Support in promoting tool, sharing experience and knowledge about specific needs.

5.3.4.1.5 Polish District Heating Chamber of Commerce (IGCP)

Support in promoting tool, sharing experience and knowledge about specific needs.

5.3.4.1.6 Municipal Waste Company (The Urban Solid Waste Treatment Station)

Potential prospective heat supplier.

5.3.4.1.7 Municipal Road Authority

Sharing experience and knowledge about activity of institution regarding the development of the district heating system.

5.3.4.1.8 Municipal Bus Operator

Introduction of e-buses in the city.

5.3.5 Stakeholder Engagement Strategies

The assessment of possibilities for engagement is difficult. The possibility to engage the Polish District Heating Chamber of Commerce is high due to the strong relation of the institution with the subject of project. The engagement of other stakeholders depends on the level of relation with the subject and the potential benefits of involvement and is therefore difficult to foresee.

5.4 Towards THERMOS Uptake

5.4.1 Barriers

In general, district heating is quite popular in Polish cities. It was developed in the communist era but in many cases there is a need of modernizing and developing the network identified. The main barriers for it are:

- Costs of district heating network modernization and development
- Connection of individual houses or new estates build in the suburbs of cities not being cost effective
- Lack of subsidies for the development of larger installations using RES

5.4.2 Proposed solutions

The economic and environmental outcomes of the THERMOS tool will allow to focus the development of the district heating network on the most favourable areas, not only in economic terms but also taking into account indicators on air quality and GHG emissions reduction.

5.4.3 THERMOS exploitation opportunities

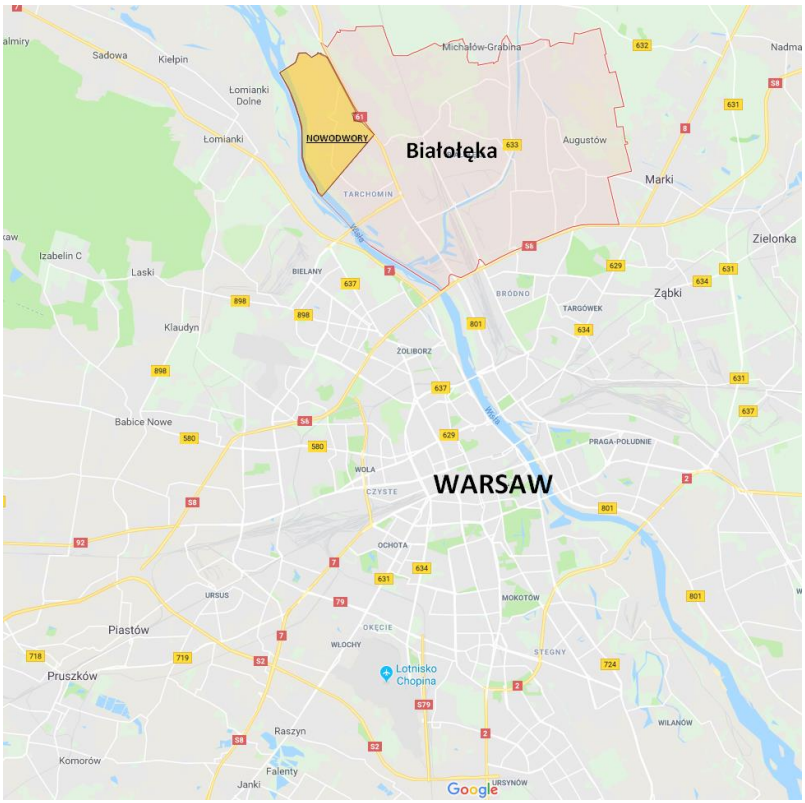
Taking into account that the district heating network in Warsaw is owned by a private company, the THERMOS tool could serve as an auxiliary tool for authorities for setting priorities for desirable directions of DHN development. In cities where the owners of the DHN are the City Administration, the THERMOS tool could be helpful in the decision-making process.

5.5 THERMOS Case Study

5.5.1 Objectives

Białołęka Nowodwory - Part of *Białołęka* District.

The *Białołęka* district is located in the northern part of the City of Warsaw. It is one of the districts with the highest number of new-built residential buildings and highest potential for development.



It is also the second district in terms of the number of buildings not connected to the district heating network and gas network, with almost 3,000 buildings, including single-family and multi-family residential buildings, office and public buildings. Because of that, the district can play a key role in improving air quality through the reduction of low-stack emissions by connecting buildings to the district heating and the gas networks.

In the north-western part of *Białołęka – Nowodwory* with area around *Czajka Wastewater Treatment Plant* is a residential area with significant anticipated growth in the next years due to its proximity to downtown Warsaw and its good transport infrastructure. This is an area where no district heating infrastructure exists at the moment. Currently heat for household sector is provided by gas boilers. Main objective is to analyse the usage of local heat sources

such as gas boilers and waste heat from sewage treatment plant as reserve heat suppliers for local users.

5.5.2 Key stakeholders

- Veolia Energia Warszawa – district heating network operator
- *PGNiG Termika* – producer of heat used in district heating network
- Warsaw City Hall - Architecture and Spatial Planning Department, responsible for creation of spatial policy in the City and Infrastructure Department, responsible for energy policy in the City

5.5.3 KPI indicators table

Key performance indicator	
Number and type of energy generation units	Please see section 5.2.1.1
Solar thermal energy generation (MWh/ year)	550
Heat pump energy generation (MWh/ year)	
Biomass energy generation (MWh/ year)	No data available
Waste heat potential (MWh/ year)	No data available
Buildings' energy consumption in the residential sector (MWh/ year)	213 224 (187 255*)
Buildings' energy consumption in the commercial sector (MWh/ year)	11 177 (6140*)
Buildings' energy consumption in the industrial sector (MWh/ year)	2 067 (526*)

*heat consumption

5.5.4 Financing status/ opportunities

The financing of the development of the district heating network rests on the operator – Veolia Energia Warszawa. In general, new networks and connections to the buildings are implemented where it is economically justified. It is also possible to utilize EU or national funds designed for the development of district heating networks and improvement of air quality.

For inhabitants of single-family houses or housing communities in multi-family building it is possible to obtain subsidies from Warsaw City Hall for the connection to the district heating

network. These subsidies do not include the building of the district heating network, so it is just possible to use them in the cases where the network already exists.

5.5.5 Exploitation of the opportunity

5.5.5.1 Barriers

As mentioned before, the main barrier for the connection of the buildings to the district to the network is the mismatch between heat supplier's development plans and Warsaw's energy strategy. The heat supplier, as a commercial entity, would invest in areas that guarantee a high internal rate of return, with social interest occupying a second place. In addition, it is difficult to identify and engage stakeholders.

5.5.5.2 Proposed solutions

Reliable information on economic circumstances from the THERMOS tool could constitute a strong support in the negotiation with suppliers on the direction of development of the district heating system.

6 Cascais

6.1 Introduction

Located in the Metropolitan Area of Lisbon, the municipality of Cascais is bordered to the north by the municipality of Sintra, to the east by Oeiras and to the south and west by the Atlantic Ocean. With an area of 97.4 km^2 and 206 429 residents, it is the 6th most populous city in Portugal.

With a mild climate, marked by an extensive coastline (30 km), it has many beaches and protected natural landscapes. Cascais is within the Lisbon's Metropolitan Area, located only 30 km from the centre of the capital.

Image: ATC Rui Cunha

In the early 20th century, in 1914, the visionary entrepreneur Fausto Figueiredo, with its project design for Estoril, marked the coastal area as the cradle of tourism in Portugal, an activity that by far exceeded the previous fishing vocation and gave Cascais international recognition as a top-quality tourist destination. The nobility has brought the bourgeoisie leading to the intensification of social life, and generating significant changes in lifestyle. The chalets and palaces are still a benchmark of the built heritage of the municipality.

Now identified as "The charm of the Atlantic Coast", Cascais seeks mitigation of the ecological footprint and focus on an increasingly sustainable tourism, promoting activities throughout the year in scenarios between the Sintra Mountains and the sea, which provide a unique landscape for sustainable tourism.

Currently, the Municipality has a consolidated infrastructure that brings higher quality of life for its residents, but also works towards economic investment.

With the strong goal of developing the economic structure of the municipality, Cascais has established partnerships fostering entrepreneurship through implemented projects aimed at developing the value chain and help them create wealth and job openings.

6.2 Heating and Cooling in the Local Context

6.2.1 Local energy system

6.2.1.1 Introduction

The final energy consumption in Cascais in 2015 reached 177 417 toe. Considering the resident population in Cascais in 2015, the final energy consumption per capita amounted to 0.84 toe/ inhab (or 9.8 MWh/ inhab. and 35.3 GJ/ inhab).

According to the provisional energy balance, the final energy consumption in Portugal in 2015 was 15 320 636 toe, corresponding to 1.5 toe/ inhabitant, a figure well above that estimated for the municipality of Cascais.

Table 3: Final energy consumption in Cascais by energy source (2015)

Type of energy	Final energy consumption			Percentage
	tep	MWh	GJ	%
Electricity	52 845	614 482	2 212 134	30%
Natural gas	20 412	237 353	854 470	12%
Butane	2 041	23 737	85 454	1%
Propane	2 687	31 241	112 466	2%
Gasoline	25 727	299 148	1 076 933	15%
Diesel	57 057	663 450	2 388 421	32%
Fuel	851	9 892	35 612	0.5%
Vegetable waste	15 520	180 462	649 663	9%
Others	277	3 222	11 599	0.2%
Total	**177 417**	**2 062 987**	**7 426 752**	**100%**

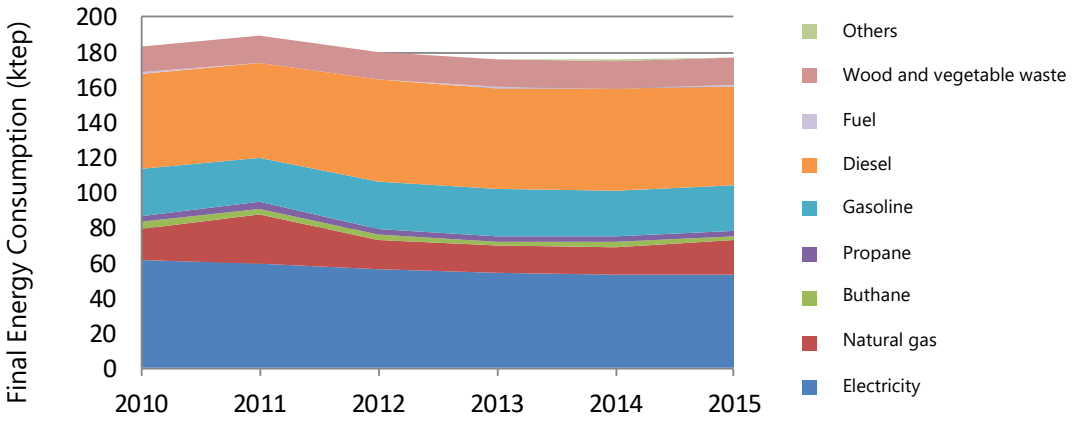
Source: Cascais energy matrix (2015)

Gas oil and electricity were the most consumed energy sources in Cascais in 2015 (accounting for 32% and 30% respectively), followed by gasoline and natural gas, with 15% and 12%

respectively. Firewood and vegetable waste and renewable resources have a very significant fraction (9%). Auto gas and heating oil are included in the 'Others' category.

The evolution of the final energy consumption by energy source in the period from 2010 to 2015 in Cascais is presented below:

Figure 22: Evolution of the final energy consumption in Cascais by energy source (2010-2015)



Source: Cascais energy matrix (2015)

The total final energy consumption decreased by about 3% in the period under study (2010 to 2015). The only energy sources whose consumption increased were diesel, which rose by 6% and natural gas, with an increase of 19%. The consumption of butane and propane decreased by 45% and 26%, respectively. These figures may indicate a shift in the gas supply in the domestic sector in Cascais from butane and propane to natural gas. With regards to electricity, the consumption reduction was of the order of 15%. Gasoline consumption fell by 6%, as firewood and vegetable waste (13% decline).

The following table shows the sectoral distribution of final energy consumption in Cascais in 2015.

Table 4: Final energy consumption in Cascais by sector

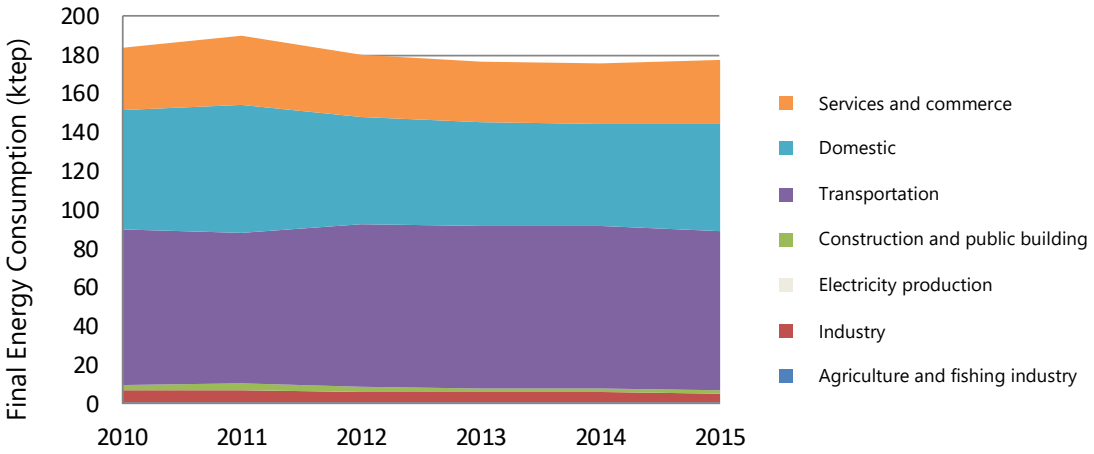
Activity sector	**Energy consumption final (tep)**	**Percentage (%)**
Fishing and agriculture	574	0.3%
Industry	4 270	2%
Electricity production	18	0.1%
Construction and public infrastructure	1 751	1%

Transports	82 138	46%
Domestic	55 726	31%
Service and commerce	32 941	19%
Total	**177 417**	**100%**

Source: Cascais energy matrix (2015)

The transport sector accounted for about 46% of final energy consumption in the municipality of Cascais in 2015. The domestic and commercial sectors and services (which represent buildings) accounted for about 50% of consumption. The remaining consumption corresponded to other sectors such as industry or construction and public infrastructure.

Figure 23: Evolution of the final energy consumption in Cascais by sector (2010-2015)



Source: Cascais energy matrix (2015)

6.2.1.2 Thermal energy supply and demand

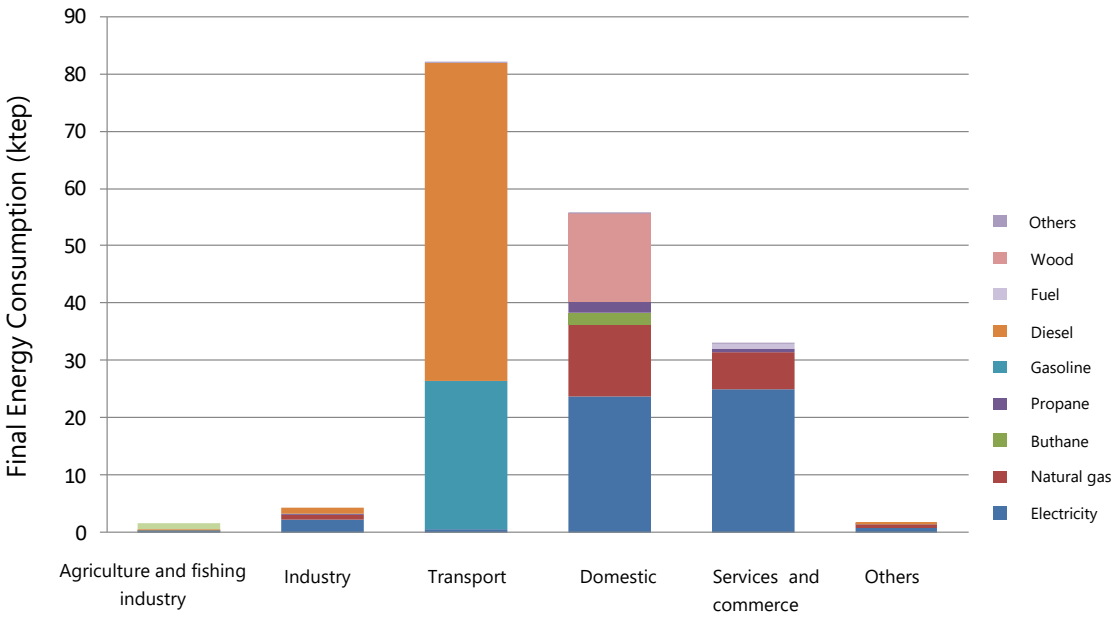
The final energy consumption in the domestic sector per accommodation in Cascais in 2015 amounted to 0.51 toe/ housing, slightly lower than in 2010 (0.57 toe/ housing).

When comparing the final energy consumption in 2010 and 2015, it is observed that in the electricity production sector there was a decrease of around 135% (from 42 toe to 18 toe), and in construction and public works the decrease was of the order of 67% (2 932 to 1 751 toe). However, these two sectors have residual consumption in the municipality of Cascais.

In the same period, the domestic consumption decreased by 10%. On the other hand, the final energy consumption in the transport and trade and services sectors and in the agriculture and fisheries sectors increased by 2% and 42%, respectively. It should be noted that the consumption in this last sector is also residual, so this increase does not have a significant impact on the energy consumption mix in Cascais.

The graph below shows the final energy consumption by sector activity and by energy source in Cascais in 2015.

Figure 24: Final energy consumption in Cascais by energy source and by sector (2015)



Source: Cascais energy matrix (2015)

As for acclimatization, Cascais does not have quantified information about used solutions or energy sources.

It is widely known that most solutions correspond to heat pumps, AVAC systems, thermal solar panels and gas tanks at location (both propane and butane). There are some areas where heating is provided by natural gas as the infrastructure is relatively recent and located in denser areas. Finally, many houses still use fireplaces for heating.

The lack of information is a handicap for the municipality, but the energy demand of the domestic sector can be assessed from the energy matrix.

Key performance indicator	
Buildings' energy consumption in the residential sector (MWh/ year)	276 101
Buildings' energy consumption in the commercial sector (MWh/ year)	290 407
Buildings' energy consumption in the industrial sector (MWh/ year)	27 124

6.2.2 Key Heating and Cooling policy and legislation

The current legislation in Portugal related to heating/ cooling is closely linked to the issue of the national Energy Certification of Buildings.

With the introduction of the European Energy Performance Directive for Buildings (EPBD) in 2006, and with the first three Decrees in this area, the Portuguese Government published in 2013 a new Decree upgrading the quality of the previous ones and setting out the framework for National System for Energy and Indoor Air Quality Certification of Buildings (SCE):

- Decree n. º 118/2013 - Approves Energy Certification of Buildings, Regulation of Energy Performance of Residential Buildings and Regulation of Energy Performance of Trade and Services Buildings, implementing Directive n. º 2010/31/EU of the European Parliament and of the Council of 19 May 2010, on the energy performance of buildings.

Five other legislative documents (Portaria n.º 349-A/2013, Portaria n.º 349-B/2013, Portaria n.º 349-C/2013, Portaria n.º 349-D/2013, Portaria n.º 353-A/2013) were published. They are aimed at a wide range of topics such as: determining the skills of the managing body of the Building Energy Certification System (SCE), regulating the activities of the SCE technicians, establishing the categories of buildings, defining the methodology for determining the class of energy performance for the type of pre-certified and certified SCE, setting out requirements relating to the design of thermal quality of the environment and the efficiency of technical systems in new buildings, buildings undergoing major intervention and existing buildings and establishing minimum flow rates of new space for air and protection thresholds and reference conditions for pollutants inside buildings of commerce and new air services, subject to existing major intervention and assessment methodology. All of those documents were updated in the last years.

6.2.3 Heating and Cooling within urban development and renovation programmes

6.2.3.1 Heating and Cooling Objectives

There are currently no plans for collective or other infrastructure for heating or cooling. The main principles regard the further development of renewable energy sources.

6.2.3.2 Energy Efficiency Opportunities

The potential energy efficiency for heating and cooling can be assessed from an integrated approach in new buildings or new urban areas planned. There is, however, a general lack of knowledge for these collective solutions at planning and supply levels.

6.2.3.3 Renewable Energy Adoption and Potential

There is no significant renewable energy production in Cascais. Only some individual investments on microgeneration (namely solar and wind powered) have been performed.

Overall, thermal solar equipment on the domestic sector is the main source of renewable energy for water heating (sanitation and heating). These are mandatory on new buildings as previously mentioned.

6.2.3.4 Transport and infrastructure

The public transport in Cascais is managed by a private company which has the concession for urban bus. Also, there is a train line (the oldest in Portugal) which connects Cascais to Lisbon in just 20 km of line. This is managed by CP, a public owned company.

These concessions limit the range for action by the municipality. Nevertheless, Cascais heavily invested in the promotion of an innovative integrated approach for mobility. In 2016, the public network for mobility in Cascais (MOBY) was presented. It merges parking, train and bus services, bicycle sharing, electric car charging or internet services, among others, altogether with an application to manage the services.

This is a complementary service intended to find new solutions for mobility and to promote sustainable use of resources. (https://www.mobicascais.com/)

Image: City of Cascais - Cascais 2020

6.2.4 Financing Opportunities and Instruments

There is no available funding for thermal energy projects. Some EU-based programs (like H2020) might help us further the knowledge on these solutions. However, there is a general lack of knowledge and the service technology is duly matured with respect to this type of solutions in Portugal.

When public buildings or new residential areas are refurbished or qualified there is the opportunity for a service provider to develop a solution and help with the understanding on the savings on thermal infrastructure. It will also be possible for them to leverage the costs of implementation, so the investment will be payed according to the savings.

6.3 Stakeholder Identification and Engagement

6.3.1 Local stakeholders

6.3.1.1 Camara Municipal de Cascais

As the main promoter of urban management, the local government can push for more sustainable and efficient solutions to other stakeholders for new urban areas or for refurbishments. As the territorial manager, all other stakeholders need permission or share potential heating/ cooling responses when a building process is submitted for approval. Additionally, it is possible to promote a discussion between stakeholders as to surpass any barriers for this technology.

It is also relevant to mention that the Camara Municipal de Cascais, as a public body, has numerous buildings for public service that could become the reference to promote district heating and cooling. This could serve to boost testing and confidence on the financial and technological viability of these solutions between stakeholders.

6.3.1.2 Residents

Residents are the final consumers of the technology and they are the ones who demand the service or the solutions for acclimatization to equipment providers. If a given technology is available, they can use it if preferable to other solutions or they might be helpful to understand the demand needs and preferences.

6.3.1.3 Building and planning managers

As a new technology or service is available, the professionals from the building sector must propose new solutions to increase the added value for end users and clients. If properly involved, they might understand the solution as viable and build confidence to the whole chain value.

6.3.1.4 Energy sector business

Whether as service providers or energy suppliers, the energy related businesses must foresee the district acclimatization as a more efficient option to consider. Together, they can help validate or improve a business proposal for implementation of such technology as it might be more competitive than existing ones.

6.3.2 National stakeholders

6.3.2.1 ERSE, the Regulatory Entity for Energy Services.

As a regulatory body, they can help introduce or assess, or even validate, the technology and business models.

6.3.2.2 ADENE, the National Agency for Energy.

ADENE promote energy efficiency and renewable energy sources by engaging stakeholders and technology for this process. They are also responsible for energy efficiency certificates

which might help the understanding of any formal needs for the implementation of new projects.

6.3.2.3 ANMP, National network of municipalities

The ANMP represents local governments and promotes liaison activities and information sharing between each other. It is a national reach institution which can help through dissemination and capacitation of municipal staff.

6.3.2.4 IGOT-UL Faculty of Geography and Planning of Lisbon University

The IGOT-UL is the most renown planning superior school in Portugal. As far as GIS use, they provide training to future professionals on this sector and will also provide critic evaluation on THERMOS to ensure its broader reach.

6.3.2.5 FCT-UNL Faculty of Sciences and Technology of the new university in Lisbon

The FCT-UNL is a respectable university on environmental studies and is responsible for many courses on planning and energy efficiency (including engineering). They also have summer schools where we could easily benefit to introduce the THERMOS tool.

6.3.2.6 INTELI – SMART CITIES NETWORK

The INTELI Network has many partners, including smart city prone municipalities. They organize events to promote the dissemination of new technology and projects within the subject.

6.3.2.7 IST – Technical Superior Institute

The IST is one of the most renowned superior institutes for technology and engineering. With a reach for international students, they are also developers of technology and studies for urban and energy efficiency.

6.3.3 Local stakeholders

6.3.3.1 Cascais Ambiente

Cascais Ambiente is the municipal company for waste management, environment promotion and qualification of the ecological system. As such, it is a relevant partnership to help the local council to technically support stakeholders.

6.3.3.2 Cascais Próxima

Cascais Próxima is the municipal company for infrastructure (public) and transport management. As such, it is a relevant stakeholder to facilitate information and knowledge on infrastructure management and planning.

6.3.4 Existing stakeholder participation processes

There is no participation process for stakeholders to take part in. When proposals for new building or refurbishment of existing ones are submitted, the *Camara Municipal de Cascais* must approve the proposals according to existing ruling with some degree of leverage to demand more efficient solutions. However, this is limited as general ruling must apply to

proposed solutions which are more efficient or competitive (applied on many sectors such as water, infrastructure, green areas, etc.).

6.3.5 THERMOS Local Liaison Group

ERSE	Energy services regulatory body
APE	Portuguese Energy Association
ADENE	National Agency for Energy
ANMP	National network of municipalities
IGOT	Faculty of geography and planning of University of Lisbon
FCT-UNL	Faculty of science and technology of the New University of Lisbon
Cascais Ambiente	Municipal company of Cascais
Cascais Próxima	Municipal company of Cascais (infrastructure)
Instituto Superior Técnico	Faculty of technology of the New University of Lisbon
INTELI	Smart cities network (national)

6.3.5.1 Stakeholder roles towards THERMOS model replication

ERSE, APE and ADENE will have significant collaboration potential through dissemination and support for regulation to promote district heating and cooling. These, together with the ANMP and INTELI can also promote the THERMOS tool within the municipalities and other local government managers on heating/ cooling energy services as well as smart cities initiatives.

Cascais Próxima and Cascais Ambiente are both municipal companies responsible for environmental and infrastructures services and can help promote and even implement certain projects.

The faculties are related with the knowledge and scientific exploration. They can train future professionals and students working on energy solutions.

6.3.6 Stakeholder Engagement Strategies

ERSE, ADENE, ANMP and INTELI can help the dissemination of the THERMOS tool and the increase of model performance by engaging the municipalities and other end users.

The universities can help during the training process as the students are usually more found of new technology and are aware of state of the art tools that might be useful to compare with THERMOS.

The municipal companies can be constantly involved to help the collaboration of local stakeholders and promoters of infrastructure/urban projects and to evaluate the potential of new technology for heating and cooling.

All of them will be involved in presentation workshops and meetings to ensure their collaboration from the start of the project and their opinions will be considered during the development stage.

6.4 Towards THERMOS Uptake

6.4.1 Barriers

As Cascais is a well-established urban municipality, heating or cooling infrastructures have to be implemented by a refurbishment process and this is a costly process where our financial situation might not support the full implementation.

As there are many different owners, district infrastructure is an evenly distributed process and costs need to be divided. However, some agents (mainly investors) might not be up for the additional investment.

Secondly, planning, zoning and building regulation are not ready to promote these solutions. Building stakeholders follow the cheapest solution under the regulation to ensure a more competitive pricing for clients or to maximize their profit.

Finally, it is worth mentioning that all stakeholders involved prefer a matured technology which is already well experienced and where they have a confident work experience.

6.4.2 Proposed solutions

The financial aspect could be surpassed with funding of a test area where gains are well assessed and considered. This financial model is well seen by banks or national funding programs. Also, the assessment of gains has to be matured to give investors the confidence that this is the best solution at the medium and long term. We can even consider a joint application for funding based on energy efficiency (and gains) as well as environmental benefits.

The district networks are better considered in new urban areas or where a refurbishment's scale compensates the investments.

Best practice cases should be shared among professionals at EU level. The definition on new regulation must follow existing examples for quicker and safer implementation.

A network of professionals or investors in the heating business and IT tools could be created to cross check ideas and best practices. At this level, the participation of European partners is fundamental to explain the challenges and how to surpass them.

6.4.3 THERMOS exploitation opportunities

As technology progresses, so does the modelling. The THERMOS tool could provide an easy access to new forms of evaluating the return of investment and environmental and operational gains. The identification of the most suitable areas for this technology could also constitute a relevant first step for implementation.

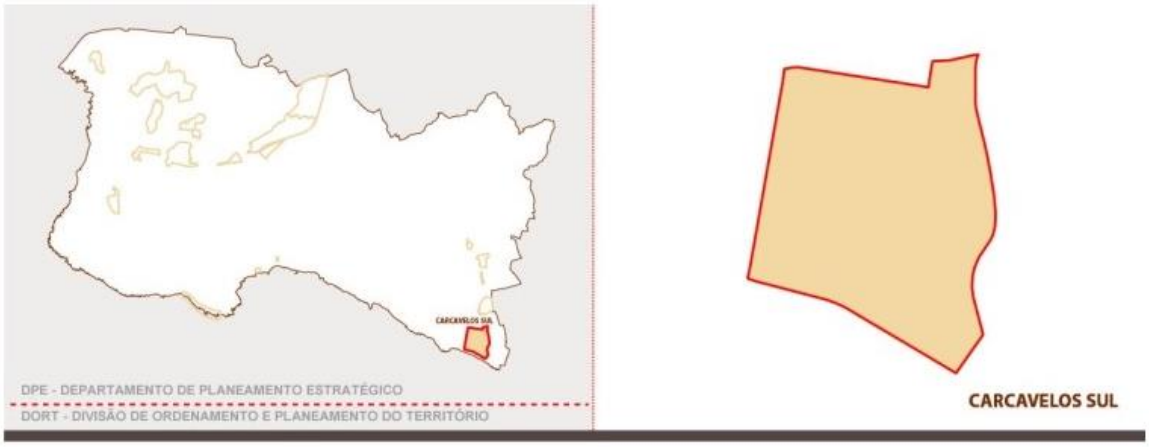
In addition, given that acclimatization is a significant percentage of housing consumption (namely half of it), it is widely seen as one of the most efficient issues to tackle when improving energy efficiency in buildings. One solution can have a greater impact on the overall consumption.

6.5 THERMOS Case Study: Carcavelos - Sul

6.5.1 Objectives

The Carcavelos-Sul urban area is a 54 hectares urban program that will build new housing and infrastructures, such as school, sports centre, cultural and social equipment as well as services and entrepreneurship centre. The process is already duly planned (the corresponding urban regulation has been completed and approved).

As a new urban area with denser occupation and relevant infrastructures, district networks might be a solution for this type of investment/ project. As investors, clients and promoters are working together with the Camara Municipal de Cascais. This can set an example and a benchmark on modelling these infrastructures. If we are able to provide evidence of the system's efficiency, it is possible to consider this solution for the whole area or at least one of the equipment.



6.5.2 Key stakeholders

- Camara Municipal de Cascais as the local government and territorial manager can demand, up to a certain extent, the inclusion of given technologies and consider infrastructure for future implementation.

- The investment promoter is the one who might implement the district acclimatization infrastructure. Together with the Camara and other technology partners there might be a chance to consider these solutions in this case or in future scenarios in other urban areas.

- Universities and energy sector partners can be useful to support technological proposals at the development/ planning stage.

6.5.3 Financing status/ opportunities

The implementation of the heating infrastructure is unfunded and not foreseen at the moment. As a new project, the promoter must ensure its implementation fully.

If the systems' efficiency and economic gains are well assessed, we could promote a financing solution to energy suppliers where savings (compared to a traditional individualized solution) are supported by users or promoters until the investment is amortized. As an energy efficient solution, the leverage by funding with the same process might be possible, only if the economic assessment is sufficiently solid.

6.5.4 Exploitation of the opportunity

6.5.4.1 Barriers

Cultural barriers can be identified, as regulation and service providers do not consider district solutions right from the start. Lack of overall knowledge and the desirable speed of process does not allow for a correct "introspection" on these solutions.

In addition, there are financial barriers. No allocated benefits at the moment might prevent a solution in due time.

6.5.4.2 Proposed solutions

Cultural barriers might be surpassed with a workforce that includes all stakeholders in finding a solution which is viable according to expected benefits (economic and environmental).

7 Alba Iulia

7.1 Introduction

The city of Alba Iulia has 63,536 inhabitants, according to the 2011 census. Situated in the Centre Region of Romania, Transylvania, the city has a total surface of 1,274 ha. In Alba Iulia the economy is based on tourism, due to the presence of the largest citadel in Romania and the second one in Europe after the citadel in Luxembourg. However, there is a diverse economic structure, with an attractive business environment for foreign investors. Thus, the city also relies on other important industries such as the porcelain industry, the largest in Romania.

Alba Iulia, also known as 'The Other Capital', bears a heavy name in the history of Romania due to important historic events which have left their mark on the city. Alba Iulia is a city of national importance and was nominated in 2012 as a European Destination of Excellence by the EDEN programme administered by the European Commission.

Alba Iulia Municipality is a local public authority which provides a democratic local government of the city of Alba Iulia. Some of the main objectives of the municipality are: to ensure the provision of public services for the inhabitants of Alba Iulia Municipality in a sustainable manner respecting the equality of chances, to promote social and economic development, to promote a safe and healthy environment, to encourage the involvement of citizens and of non-governmental organisations in the matters of local government and to make sure the citizens of Alba Iulia Municipality benefit from a healthy living environment and from good living conditions.

The Development Strategy of Alba Iulia underlines the importance of reaching a sustainable development of the local economy and improving the quality of citizens' life. The strategy puts forward three important approaches for Alba Iulia: 'Alba Iulia of the residents' - improving quality of life; 'Alba Iulia of the tourists' - cultural tourism development and advertisement of the town's brand and 'Alba Iulia of the investors' - promoting businesses. During the last years, Alba Iulia Municipality is paying more attention to the situation of public, private and residential buildings in the city, how efficient they are in terms of energy waste and how to encourage a more responsible attitude of stakeholders about environmental challenges. In this respect, the Municipality of Alba Iulia has managed to thermally rehabilitate 3 residential blocks with a total of 264 apartments, using European funding under the Regional Operational Program.

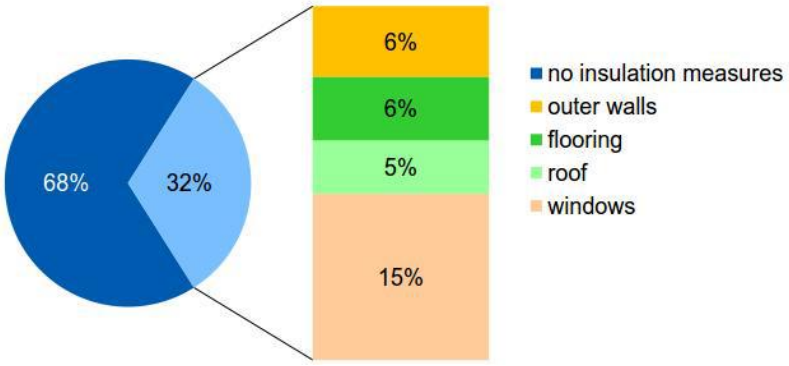
7.2 Heating and Cooling in the Local Context

7.2.1 Local energy system

7.2.1.1 Introduction

The residential energy consumption in Romania is much higher than the average energy consumption in EU countries. This can be explained by the pronounced energy waste from buildings: for instance, a 2-bedroom apartment in Romania consumes 2 times more heat than a 4-room apartment in Germany. This is explained by the fact that for a long time, residential buildings were built with a low thermal protection degree using low-quality insulating materials, as shown in the figure below:

Figure 25: Building insulation status in Romania

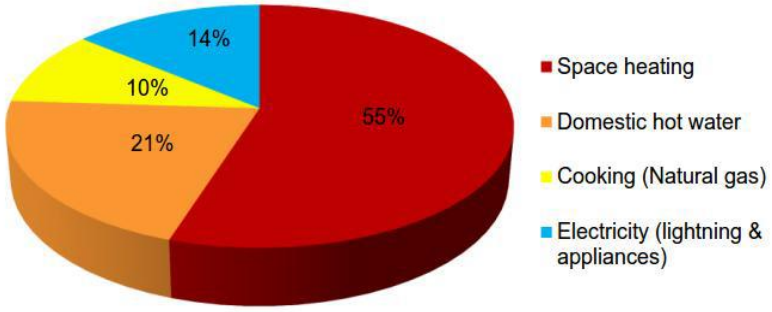


Source: National Institute of Statistics

In Romania about 35-40% of total residential buildings (about 3,000,000 apartments) correspond to apartments in blocks of flats. Almost all of them were meant to be connected to district heating systems, although now less than half of them are still connected to DH

networks. The following figure shows the distribution of the energy consumption of a typical apartment:

Figure 26: Distribution of energy consumption of a typical apartment (block of flats built between 1950 - 1990)



Source: National Institute of Statistics

According to the 2011 census, the average useful area of dwellings (excluding common areas in multi-family buildings) is about 48 m^2/dwelling in municipalities and cities, being 47 m^2/dwelling the national average. According to available data for blocks of flats, the useful heated area per apartment including common areas ranges between 45 and 65 m^2/apartment with an average value of 55 m^2/apartment.

The analysis of the energy consumption from the SEAP – Covenant of Mayors, performed in 2008, shows that, at Alba Iulia Municipality level, the highest energy consumption is registered in the residential segment and in the tertiary sector (both together account for 75% of the total consumption). The table below shows the main findings of the analysis, from which the following facts stand out:

-the private and commercial transport sector account for 22% of the total energy consumption
-natural gas is the main source of energy, 63% of it being used for heating the living spaces
-electricity consumption represents 12% of the total energy consumption and is foreseen to increase especially in the tertiary sector, for producing air conditioning.

Results of the energy consumption analysis in 2008 (SEAP- Covenant of Mayors)	
Activity domain	**Consumption in Alba Iulia 2008 (MWh)**
Buildings, equipments/ municipal installations	17,038
Buildings, equipments/ tertiary installations	219,719
Residential Buildings	363,939
Municipal Public Lighting	2,761
Municipal own transport	332
Public transport	6,679
Private and commercial transport	163,833

Total	**774,301**

CO_2 emissions on domains	
Activity domain	**CO_2 Emissions [t]/ equivalent CO_2[t]**
Buildings, equipments/ municipal installations	4,292
Buildings, equipments/ tertiary installations	61,560
Residential Buildings	97,685
Municipal Public Lighting	1,935
Municipal own transport	85
Public transport	1,783
Private and commercial transport	42,348
Total emissions	**209,689**

7.2.1.2 Thermal energy supply and demand

Key performance indicator	
Number and type of energy generation units	1,714 photovoltaic panels
Solar thermal energy generation (kW generation)	257 kW
Heat pump energy generation (MWh/ year)	No local data available
Biomass energy generation (MWh/ year)	No local data available
Waste heat potential (MWh/ year)	No local data available
Buildings' energy consumption in the residential sector (MWh/ year)	365,939
Buildings' energy consumption in the tertiary sector (MWh/ year)	219,719
Municipal Buildings energy consumption (MWh/ year)	17,038

7.2.2 Key Heating and Cooling policy and legislation

Law 372/2005 regarding the energetic performance of building, amended with law 159/2013, OUG 13/2016 and other orders in 2010, 2012, 2016, regulates the heating and cooling networks.

Additional to these regulations there are calculation and implementation methodologies for buildings, from the Ministry of Regional Development.

In addition, there is relevant legislation on energy efficiency. The main pieces of legislation on this topic are listed below:

- Law no. 121/2014 on energy efficiency - Transposes Directive 2012/27 / EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125 / EC and 2010/30 / EU and repealing them of Directives 2004/8 / EC and 2006/32 / EC.
- GD no. 122/2015 approving the National Energy Efficiency Action Plan (2014-2020).
- In accordance with the provisions of Law no. 121/2014 on energy efficiency within the Authority National Energy Regulation, the Department for Efficiency has been set up Energy Agency (DEE), through the ANRE President Order no. 95/2014, published in OJ No.737 / 2014.

7.2.3 Heating and Cooling within urban development and renovation programmes

7.2.3.1 Heating and Cooling Objectives

From 1993 the activity of producing and distributing heat through centralized systems in Alba Iulia was managed by a company which in 1999 became Dalkia Romania Branch Alba Iulia. The company had as its objectives the management of production, transport and distribution of thermal energy for domestic hot water and heating, with heat generated in the block heating stations. In 1993 the company managed a total of 31 district heating plants and a network of district heat systems, providing heat networks spanning 24.35 kilometers and serving 16,635 apartments in Alba Iulia and its surroundings.

However, fuel prices went up gradually and owners decided to disconnect buildings from networks. In 2011, 29 district heating plants were closed. In 2012, the last two functional district heating plant became non-functional. Nowadays, more than 18,500 apartments have a central heating system and 10% of these are estimated to be equipped with air conditioning systems.

Therefore, Alba Iulia is facing some key challenges in the development of heating and cooling systems and district networks:

- Improving thermal insulation of the envelope for residential buildings from Alba Iulia City (external walls, windows, doors, upper floor, floor above the basement), roofs and covers and, if applicable, including measures on structural strengthen of buildings;
- Improving indoor comfort of thermal rehabilitated flats;

- Reducing energy consumption by at least 30% after thermal rehabilitation of the residential buildings (housing blocks);
- Reducing the maintenance costs for heating and hot tap water;
- Reducing pollutants emissions generated by the production, transport and consumption of thermal energy.

In addition, the City Hall of Alba Iulia Municipality has signed the Covenant of Mayors and the new Covenant of Mayors for Climate and Energy, voluntarily committing to increasing energy efficiency and the use of renewable energy sources in their territories. By their commitment, Covenant signatories aim to meet and exceed the European Union 30% CO_2 reduction objective by 2030. Moreover, Alba Iulia Municipality has developed the Sustainable Energy Action Plan (SEAP), which is aimed at reducing the environmental impact of urban activities, increasing the quality of public utility services and the economic competitiveness in order to transform the city into a "green city".

Pursuant to the provisions of this Strategy and as a signatory city of the Covenant of Mayors, Alba Iulia Municipality has already materialized several investment projects aimed at improving the environmental conditions of the city. Thus, Alba Iulia has installed PV panels producing renewable energy in 4 public institutions (the Technical College 'Dorin Pavel', the Nursing Home for the Elderly, the Day Centre for the Elderly and the Programmes Department of the City Hall) through the 'Ensuring the energy sustainability of 4 public institutions of Alba Iulia Municipality' project. The 1,714 photovoltaic panels installed, with a cumulative installed capacity of 257 kW, are now impacting the electricity and gas bills, saving 80,000 euros a year. This project was co-financed by the European Union and the Romanian Government.

7.2.3.2 Energy Efficiency Opportunities

Alba Iulia Municipality will try to access European funding for thermal-insulation of residential blocks. Private investment is also needed from people living in the residential block. Through the association of residents, citizens will contribute to co-finance the projects.

Energy efficiency is a priority for Alba Iulia Municipality and this is reflected in different strategic instruments of Alba Iulia Municipality:

Original language	English	Link
Overall city strategic documents		
Strategia de dezvoltare a Municipiului Alba Iulia – Strategia Integrată de Dezvoltare Urbană (SIDU)	The Integrated Urban Development Plan 2014-2023 of the Municipality of Alba Iulia	http://www.apulum.ro/ro/pdf7/SIDU_-_versiune_consolidata_august_2017.pdf

Alba Iulia – Prioritizarea Proiectelor pentru perioada 2014-2020	Alba Iulia Project Prioritization for 2014-2020	http://www.apulum.ro/images/uploads/fisiere/Alba_Iulia_Project_Prioritization_for_2014-2020.pdf https://www.youtube.com/watch?v=CkPgstbjcxc
Raportul Băncii Mondiale cu privire la capacitatea instituțională a Municipiului Alba Iulia pentru planificarea dezvoltării urbane și atragerea de resurse de finanțare pentru politici și proiecte urbane	Report released by the World Bank concerning the institutional capacity of Alba Iulia Municipality for planning urban development and attracting financing resources for urban policies and projects	http://www.apulum.ro/images/uploads/fisiere/Alba_Iulia_MRA_EN.pdf
Studiul de caz privind Consolidarea capacității de planificare spațială, precondiție pentru dezvoltare urbană sustenabilă, planificarea spațială, Alba Iulia, realizat de către experții Băncii Mondiale în anul 2013	Case Study on Strengthening Spatial Planning Capacity, Prerequisite for Sustainable Urban Development, Spatial Planning, Alba Iulia, conducted by World Bank experts in 2013	https://www.dropbox.com/sh/78egyhprzfxpmvv/AAAmyPVEVlFRm9TAldp-UQjra?dl=0
Studiul Smart Cities elaborat de către Siemens	Smart Cities Research elaborated by Siemens	-
Planul de Acțiune pentru Energie Durabilă (PAED) al municipiului Alba Iulia	Sustainable Energy Action Plan of Alba Iulia Municipality (SEAP)	-

7.2.3.3 Renewable Energy Adoption and Potential

From 2010 Alba Iulia Municipality is implementing the 'Ensuring the energy sustainability of 4 public institutions of Alba Iulia Municipality' project, which focus on the Technical College 'Dorin Pavel', the 'Community Center for Elderly', the 'Daylight Center for Elderly' and the 'Programs Direction of the City Hall'. Throughout the project, 1,714 photovoltaic panels have

been installed for a cumulative installed capacity of 257 kW. The project is being co-financed by the European Union and the Romanian Government.

7.2.3.4 Transport and infrastructure

The city has one of the most modern urban public transportation in Romania (in 2013, the Public Transport Society of Alba Iulia won the IRU Bus Excellence Award for best bus operator in Europe), 85% of schools and kindergartens are thermally insulated, over 17 hectares of urban green areas have been landscaped in the last two years and more than 15 kilometres of bicycle routes have been, 90% of the city is connected to the sewage system and a new wastewater treatment station is currently under construction. Another initiative conducted by Alba Iulia Municipality is the modernization of the public lighting on several streets of the city.

Alba Iulia Municipality adopted its Sustainable Urban Mobility Plan in November 2016, focusing its future mobility on smart multi-modal transportation at the level of the core city and the Functional Urban Area (FUA), changing the current shift from conventional and motorized transportation to alternative and non-pollutive transport means.

Alba Iulia is located in the centre of Transylvania. Road access is via the A1 motorway (350 km from Bucharest). Alba Iulia is crossed by one of the main Romanian railways (Bucharest-Arad) connecting Alba Iulia directly with Budapest. Alba Iulia is located at the intersection of two highways under construction, which will be completed in the next two years, namely Pan-European Corridor 4 Bucharest-Nadlac and the Sebeş-Turda highway linking A1 and A3 (Bucharest-Bors or Transylvania Highway), ensuring the connection of Alba Iulia with the other regions of the country, as well as with the corridor and the road transport networks that connects with Europe through Hungary.

The local public transportation is organized at conurbation level within the FUA. The FUA is composed by one urban administrative unit - Alba Iulia Municipality (which is the core city of the FUA) and other seven rural administrative units. Alba Iulia Municipality is also the lead partner for the AIDA LT Association, representing an intercommunity Association for transport development. In this way the geographic boundary delimitation of AIDA LT and FUA represent the same area.

The main advantage of AIDA – LT is that they are delegated to provide integrated public transportation services within a well-defined area, having a single information service provider, a unique charging system and a single transportation schedule, according to EC Regulation no. 1370/2007 of the European Parliament and of the Council from 23rd of October 2007 concerning the public transportation services by means of road and rail.

In Alba Iulia, from September 26, 2015, the Alba Carolina Fortress can be visited from a state-of-the-art electric minibus that gives tourists a complete experience in the historic city of Alba Iulia. Minibus-guided tours are a way of transportation for tourists highly use in cities such as London, Paris or Rome. The decision of the municipality to introduce this electric vehicle for the first time in Alba Iulia comes as a first solution for visiting less accessible tourist attractions in *Cetate*.

Additional to these means of transportation, Alba Iulia Municipality tested an electric public bus with an autonomy of 250 km for several days in 2015. The SOR EBN 10.5 circulated on the

most crowded bus routes in Alba Iulia (lines 103 and 104) and is was tested for several days to see how it functions in city traffic conditions. During the test, passengers travelled free of charge since one of the purposes of this experiment was the determination of the autonomy of the bus loaded with passengers and under normal operating conditions.

Moreover, within the Alba Iulia Smart City 2018 pilot project, the municipal fleet of Alba Iulia Municipality has received an electric vehicle, as donation from Kaufland Romania.

7.2.4 Financing Opportunities and Instruments

The City Hall of Alba Iulia has received significant financial support from the European Union in the last few years and has implemented European projects with a total value of more than 150 mil Euros, although they were not focused on energy-related matters.

The European Regional Development Fund (ERDF) and other grants constitute a possible finance source for DH networks. Alba Iulia will apply for grant within the Regional Operational Program for the thermal insulation of more than 70 blocks of flats, as presented in the following sections within this document. The required documentation is under preparation. However, the Alba Iulia Smart City Pilot project 2018 could also be a resource.

Alba Iulia Smart City 2018 is a pilot project which aims to integrate smart city solutions in Alba Iulia starting with the occasion of celebrating 100 years of the unification of Romania. The pilot project is implemented by the Municipality of Alba Iulia in partnership with the Ministry of Communications and Information Society. This project is unique in Romania since it is the first smart project developed between the national government, a local public authority and private companies and because all the smart city solutions proposed by companies are or will be implemented on the costs of the private companies involved and will ensure the interoperability with other smart city solution providers in the future.

The pilot project is focused on implementing smart, innovative and compatible solutions at local level, developed by the private sector, in a wide range of areas such as: smart lighting system, smart parking, smart mobility, smart citizens, e-governance, smart administration, 5G networks, smart energy consumption, smart businesses, applications using beacons for tourism promotion, free WIFI access in all touristic public spaces, smart education projects, LORA technology, or innovation labs, among others. Alba Iulia Municipality intends to establish independent partnership agreements with the representatives of the private sector who want to be involved within the project, so that all smart solutions are well integrated and compatible one with another.

So far, the Municipality has established an official partnership agreement with Orange, a large company who proposed an open and interoperable platform that can be extended and adapted to the changing needs of citizens and municipalities and recently with Microsoft but is in direct communication also with other companies.

The project will greatly benefit the inhabitants of Alba Iulia Municipality, together with the business investors and the tourists visiting the city. The project Alba Iulia Smart City benefits from the technical support and interest of over 60 companies, some of which are world renowned companies. In addition, advanced discussions are being conducted with companies such as like IBM, CISCO, ZTE, Xerox, Phillips, Telekom, Vodafone, FastOrder, 14 IT companies within the CLUJ IT CLUSTER, and others.

The Ministry of Communications and Information Society has elaborated the *Guide of the Smart City Concept in Romania*, a compendium of solutions and technology based smart ITC applied at local and regional level, which can transform local communities into smart cities, having access to quality products and services, modern health systems and education and transparent public administration for local citizens, The guide can be downloaded at the following link: https://www.comunicatii.gov.ro/?p=8532

The solutions are meant to be entirely financed and supported by the companies involved with the occasion of celebrating 100 years of Unification of Romania which was signed in Alba Iulia.

None of the project is financed through EU programs such as Horizon 2020 but of course all parties involved in the partnership are looking for funding opportunities to support as well other innovative solutions that could contribute to Alba Iulia Smart City Project 2018. For the moment, this project is not benefiting from any governmental, local or European Funding.

7.3 Stakeholder Identification and Engagement

7.3.1 Local stakeholders

The local stakeholders are representing several institutions/organizations from Alba Iulia in charge of the urban development of the city, representatives of the municipality, of the local

agencies or energy providers but also private stakeholders in charge of providing public services to citizens, such as:

7.3.1.1 Alba Iulia Municipality - City Manager`s Office

The Municipality has been working on attracting EU funds, grants and other external funding for the sustainable development of the city.

7.3.1.2 Alba Iulia Municipality - Investment Department

The Investment Department of the Alba Iulia Municipality coordinates all the investments of AIM financed through EU funds and local budget.

7.3.1.3 Local Agency for Energy Alba

The Alba Iulia Municipality is working close with the Local Agency for Energy Alba for different events, but also for collecting and processing data in energy field. They are active in European Funded projects, in organizing events dedicated to energy efficiency, active in helping cities to adopt the Sustainable Energy and Climate Action Plan for the covenant of mayors.

7.3.1.4 Public Transportation System – STP

STP is the most modern transportation company in Romania and is based in Alba Iulia.

7.3.1.5 E.ON Energy Romania

E.ON Energy Romania is a gas and energy provider at national level.

7.3.1.6 ENEROM INSTAL SRL

ENEROM INSTAL SRL is a private company for energy.

7.3.1.7 SC Electrica Distribution SA

SC Electrica Distribution SA is the main energy provider at Alba Iulia level.

7.3.1.8 Flash Lighting

Flash Lighting is a private company in charge of the public lighting at AIM level.

7.3.1.9 VEGACOMP Consulting

VEGACOMP Consulting is a company focused on the junction between Telecommunications and Energy as Telecom needs Energy and Energy services need communications services

7.3.1.10 '1 Decembrie 1918' University Alba Iulia

'1 Decembrie 1918' is a national university with more than 5,000 students/year with which Alba Iulia Municipality has a 10 years collaboration.

7.3.1.11 Residents Associations

The Residents Associations is composed by administrators helping residents to organize better their home utilities and services.

7.3.1.12 I`VELO

I`VELO is company for bike sharing at national level, managing a bike sharing point in Alba Iulia Municipality.

7.3.1.13 Creative Quarter Carolina – CCC

CCC is a group of creatives and artists, joining an association for contributing to the development of creative industries at AIM level, as well as of the culture and digital future of the city.

7.3.1.14 Alba Iulia Municipality - Alba Iulia 2018 Smart City Team

The Alba Iulia 2018 Smart City Team is working close to private companies in order to develop smart city solutions at local level.

7.3.2 National stakeholders

The main national stakeholders that could help adopting the THERMOS tool are:

7.3.2.1 National Regulatory Authority for Energy

7.3.2.2 Ministry of Energy

7.3.2.3 Ministry of Regional Development

7.3.3 Existing stakeholder participation processes

Each year, the Local Agency for Energy Alba is organizing in partnership with local authorities the Fair Renewable energy sources.

Other activities where the municipality is participating for raising awareness include the Mobility week (which consists on different events organized with NGOs) and a traffic snake game in collaboration with schools.

7.3.4 THERMOS Local Liaison Group

Name of organization	**Type of stakeholder** *(primary target audience)*	**Main topical engagement**
E.ON ENERGY ROMANIA	Industry and investors in thermal energy	Energy Distribution
SC Electrica Distribution SA	Business	Energy Distribution
Flash Lightning	Business	Energy Services
Residents Associations	Associations and NGOs	Integration
Public Transportation System - STP	Public and/or private utility	Mobility/Transport

I`VELO	Associations and NGOs	Mobility/Transport
ENEROM INSTAL SRL	Industry and investors in thermal energy	Urban Planning
Alba Iulia Municipality - City Manager`s Office	Political decision-makers	Stakeholder engagement
Alba Iulia Municipality - Investment Department	Public administration	Stakeholder engagement
Local Agency for Energy Alba Iulia	Energy Agencies	Stakeholder engagement
'1 Decembrie 1918' University Alba Iulia	Science and research institutions	Stakeholder engagement
VEGACOMP Consulting	Business	Stakeholder engagement
Creative Quarter Carolina - CCC	Associations and NGOs	Stakeholder engagement
Alba Iulia Municipality - Alba Iulia 2018 Smart City Team	Public administration	Other (please specify): Intelligent Solutions

7.3.4.1 Stakeholder roles towards THERMOS model replication

Working as a local support group the stakeholders will have the role of identifying the elements from the THERMOS pilot cities which could be replicable at Alba Iulia Municipality level and, when possible, to test the transferability.

7.3.5 Stakeholder Engagement Strategies

Working in groups and continue information updating of the ongoing activities of the THERMOS project. Continue monitoring and evaluation of the participation and the involvement of the stakeholders will be ensured.

7.4 Towards THERMOS Uptake

7.4.1 Barriers

The main barriers to the development of district heating networks are:

- There is no district heating plant, which implies that the individual ownership of apartment heating and cooling system is not under the control of the municipality.
- The owners are affected by the high costs of apartment heating systems modernization and development

7.4.2 Proposed solutions

In order to overcome the barriers identified, it would be necessary to first achieve:

- Thermal insulation of residential blocks
- Awareness raising
- Mapping the current situation
- Involving different stakeholders

These are solutions which are also included in the Development Strategy of Alba Iulia Municipality.

7.4.3 THERMOS exploitation opportunities

The THERMOS tool could serve as an auxiliary tool for authorities for setting priorities but also for increasing the efficiency of stakeholders' involvement.

7.5 THERMOS Case Study

Alba Iulia Municipality will focus on the rehabilitation of the 74 residential blocks of flats. The thermal rehabilitation measures are to be analysed:

- External walls insulation
- Replacing the existing windows and entrance doors with thermal-glazed windows and thermal-glazed doors
- Roof insulation
- Floor (over the basement insulation)

7.5.1 Objectives

As mentioned before, the objective of this case study is the rehabilitation of 74 residential blocks of flats.

It is expected that the thermal rehabilitation of 30 of the 74 residential buildings results in the natural gas consumption for heating decreasing from 9,777 MWh/year to 5,563 MWh/year after the thermal rehabilitation, for a total energy saving of about 43%.

The natural gas consumption in the other 44 residential buildings is expected to decline from 25,309 MWh/year to 15,075 MWh/year after thermally rehabilitating the building, which means an energy saving of about 40%.

7.5.2 Key stakeholders

- Apartments owners
- Residents Associations
- Local Agency for Energy Alba
- Employees of the municipality

7.5.3 KPI indicators table

Key performance indicator	
Number and type of energy generation units	No local data available
Solar thermal energy generation (MWh/ year)	No local data available
Heat pump energy generation (MWh/ year)	No local data available
Biomass energy generation (MWh/ year)	No local data available
Waste heat potential (MWh/ year)	No local data available
Buildings' energy consumption in the residential sector (MWh/ year) for the 74 blocks	35,086

7.5.4 Financing status/ opportunities

The project could be funded from ERDF funding, the Alba Iulia Smart City project or other external funding:

ERDF funding is a dedicated operational program for 2014-2020 for rehabilitating the residents owned buildings but also for public buildings, in order to enhance the energy efficiency and the quality of living for the residents.

Alba Iulia Smart City project is an initiative which could contribute in attracting other resources in terms of smart solutions for buildings (residential, tertiary, public)

In addition, other funding could be available in the coming years, different funds, grants but as well, if regulated in the near future, the PPPs or financial instruments such as municipal bonds.

7.5.5 Exploitation of the opportunity

7.5.5.1 Barriers

The main gaps/ barriers within local framework of the energy system that may prevent the uptake of the opportunity are:

- General market barriers for heating and cooling
- General market barriers for building-scale heating and cooling solutions like HPs, solar thermal, biomass, etc
- General market barriers for collective heating and cooling solutions like DHC and gas grids
- Specific market barriers for heating/cooling savings in buildings
- Specific market barriers for heating/cooling savings in industry

These barriers can affect the project in the following ways:

- Scepticism of owners for the co-financing of the project
- Lack of incentives for owners in order to stimulate them to invest in new systems for heating and cooling their apartments
- Competitive applications for ERDF funding does not guarantee the funding

7.5.5.2 Proposed solutions

- Good communication between the municipality and the residents associations and the owners and with other stakeholders
- Local working groups to overcome barriers
- Experienced project managers and implementation team

8 Berlin

8.1 Introduction

Berlin is the capital of Germany with a population of about 3.4 million people. It is located in the north-east of Germany and with 892 km² is the largest city in the country. The climate in Berlin is warm and sometimes humid in summers with average temperatures around 25°C and cool winters with average temperatures around 0°C. Berlin's built-up area covers about 42% and forests and trees make up another 18%. This leads to microclimates where temperatures in the city centre can be up to 4°C higher than in the suburbs.

Source: ©Shutterstock/AR Pictures

From 1948 until 1990 the city was divided into East and West Berlin. Germany consists of 16 states and with the reunification on 9 November 1990 Berlin became one of three city states in the country.

The political system in Berlin consists of the House of Representatives (Abgeordnetenhaus), and the executive body, which is the Senate of Berlin (Berliner Senat, or Landesregierung). Berlin is divided into 12 boroughs (Bezirke) where each borough is made up of several sub districts or neighbourhoods. These boroughs have their historic roots in much older municipalities and were urbanised and incorporated into the city only with the formation of Greater Berlin in 1920. Each of the 12 boroughs is in charge of their administrative tasks and has their local mayor. Furthermore these 12 boroughs are divided into 96 sub districts, which are made up of several smaller residential areas or quarters.

Source: Senatsverwaltung für Stadtentwicklung und Wohnen (2017)

Berlin's economy has seen a substantial increase in both in terms of economic growth and rise in employment. The service sector is the dominating sector with around 84% of all companies doing business in services. Important economic sectors in Berlin include public service, education and health services, industry, commerce, transport and logistics, hospitality, consulting services, property development, communication and media, finance and insurance, and arts and entertainment.

Berlin is furthermore one of the main start-up and innovation hubs in Europe. The start-up scene is booming and in 2015 start-ups in Berlin raised more venture capital than start-ups in London. Out of the top 30 rated start-ups in Germany 20 have their headquarters in Berlin.

8.2 Heating and Cooling in the Local Context

8.2.1 Local energy system

8.2.1.1 Introduction

The energy sector consists of three main subsectors: electricity, heat and gas. Berlin's two largest energy providers for private households are the Swedish Company Vattenfall and the Berlin-based company GASAG. Both offer electric power and natural gas supply. Vattenfall is operating and holding the largest part of the existing district heating networks in Berlin – the central and some local networks. A much smaller share of heating networks is operated by smaller companies such as Fernheizwerk Neukölln AG, BTB GmbH, Harpen EKT GmbH and EAB

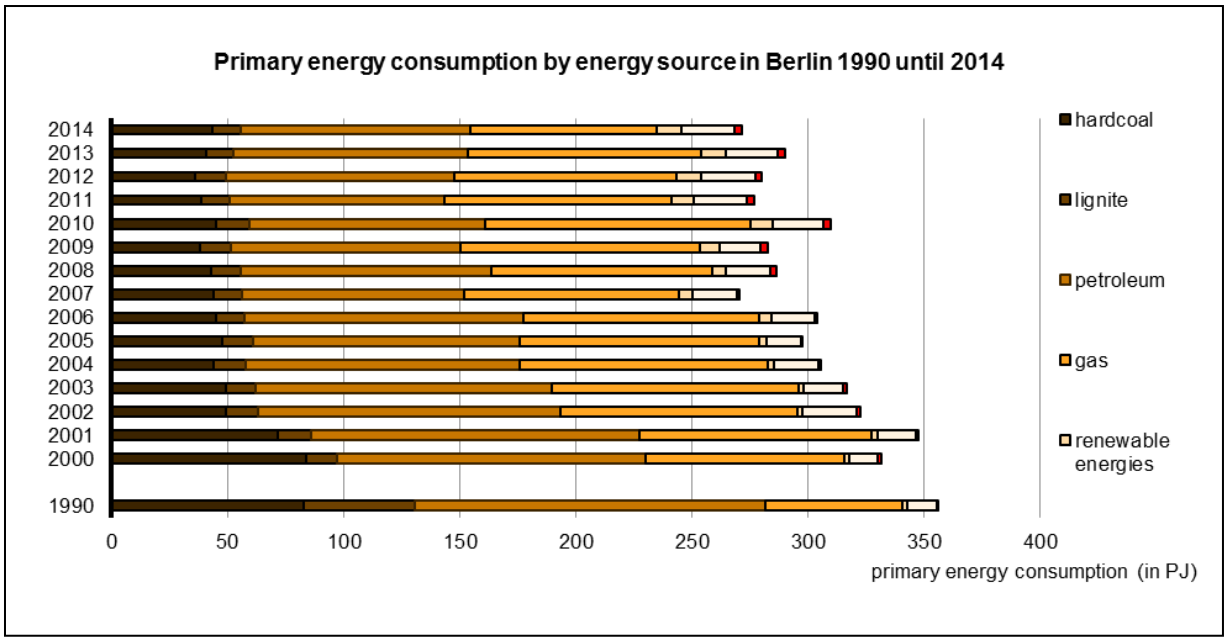
Fernwärme GmbH. Berlin's district heating network is about 1,800 km long and supplies about 1.2 million households with heat. Due to the division of Berlin until 1990 there has been a different development in local heat supply. Up until today district heating is much more prominent in East than in West Berlin.

Some of the city´s electricity is imported from nearby power plants in southern Brandenburg. Larger power plants with capacities up to 750 MW in Berlin are mainly fuelled by fossil resources. In 2015 a biomass cogeneration plant started operating in *Reinickendorf* with an output of 18 MW_{th} and 5 MW_{el}. It is the first Vattenfall combined heat and power plant in Berlin to use 100% natural wood chips. Around 70,000 tons of sustainably produced biomass - primarily from the region - enable CO_2 savings of up to 26,000 tons per year. The plant supplies around 30,000 households, which belong to the properties of GESOBAU, one of the largest housing companies in Berlin. All of the large power stations in Berlin generate electricity and heat (to supply district networks) at the same time.

The waste-treatment-plant *Ruhleben* of *Berliner Stadtreinigungsbetriebe* (BSR) is amongst the most modern ones in Europe and forms the core of Berlin's waste management. About half of Berlin's annual household waste (about 500,000 tons) is being treated in this plant. Five incineration lines supply the neighbouring *Reuter* power plant with high pressure steam where it is converted into electricity and heat. The heat is then fed into the district heating network. Operator Vattenfall plans to stop hard coal burning at the *Reuter* power plant by 2020. For hot water production, a new power-to-heat plant is to be realised at this site. The construction of this plant, which will have a capacity of 120 MW_{th} and will produce district heating for 30,000 households, started in early November 2017. In addition, the construction of a modern combined heat and power plant in *Marzahn-Hellersdorf* is ongoing. When completed by 2020, the new combined cycle power plant will have a capacity of around 230 MW_{th} for district heating supply and around 260 MW for electricity generation.

Development of primary energy consumption

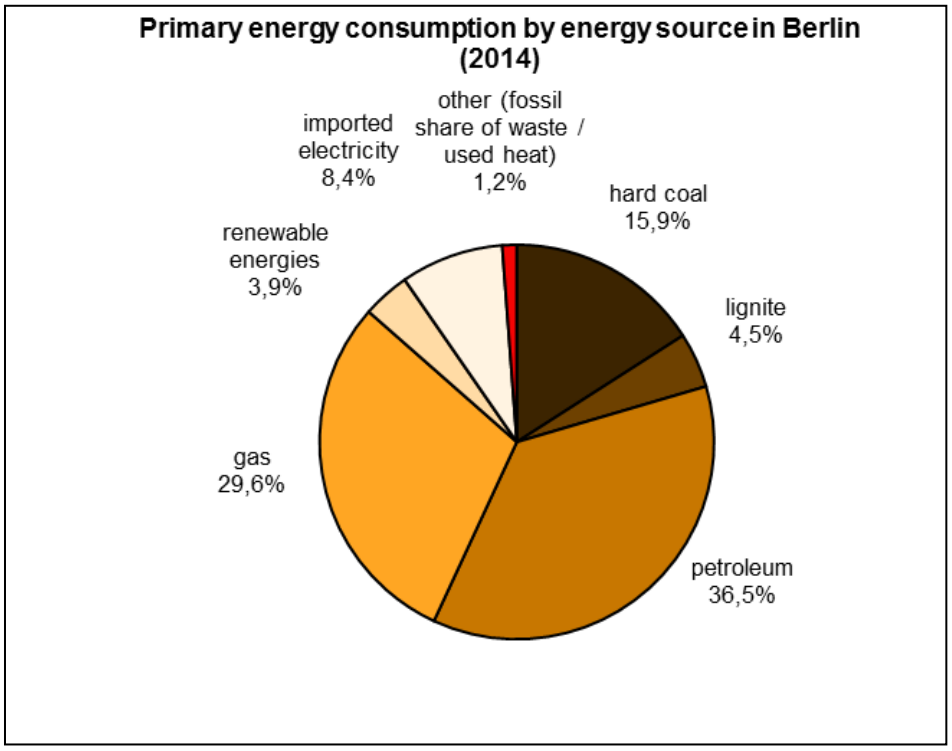
The primary energy consumption of the state of Berlin in the year 2014 was 271.5 petajoule (PJ). This represents a decrease of 23.8% compared with the base year of 1990. In 2014 Berlin accounted for 2.1% of Germany's total consumption.



Source: Amt für Statistik Berlin, Brandenburg, 2017

Primary energy consumption in Berlin in 2014

Hard coal consumption (43.2 PJ) has significantly decreased by 47.8% compared to the base year 1990. Likewise, the consumption of lignite has declined by 74.4% compared to 1990. In 2014 both hard coal and lignite accounted for 20.4% in Berlin's energy consumption. Natural gas and mineral oils represented, with 66%, the largest group in primary energy consumption in the state of Berlin in 2014.



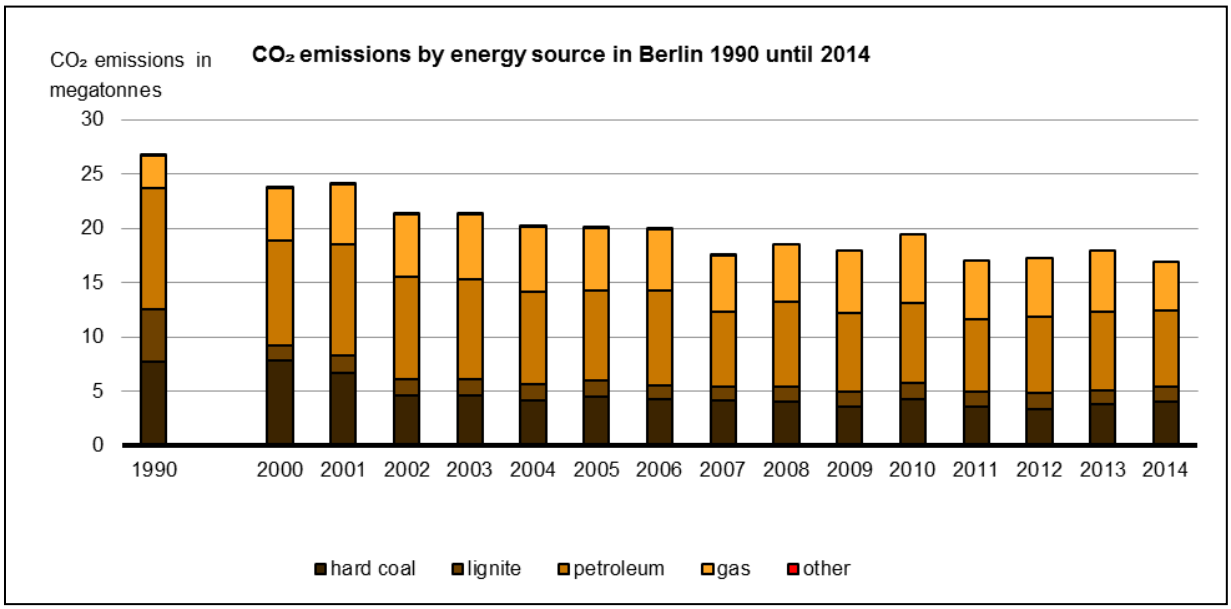
Source: Amt für Statistik Berlin, Brandenburg, 2017

The share of renewable energies in primary energy consumption increased to 3.9% or 10.6 PJ in absolute terms. The share of electricity that was not produced in the state of Berlin and had to be imported rose to 22.9 PJ in 2014. The "other" category includes fossil parts of waste and used heat.

CO_2 emissions based on primary energy consumption

The CO_2 emissions based on primary energy consumption totalled 17 million tons in the state of Berlin in 2014. Overall the output fell by 36.6% compared to 1990.

The emissions from consumption of mineral oils or petroleum, hard coal and burned lignite fell by 36%, 47.7% and 72.6%, respectively, as compared to 1990. Emissions from natural gas consumption increased by 48.6% (to 4.5 million tons) compared to 1990.



Source: Amt für Statistik Berlin, Brandenburg, 2017

8.2.1.2 Thermal energy supply and demand

Energy supply

Berlin's energy supply is currently characterised by a high proportion (more than 90%) of fossil fuels, including a few older large-scale power plants. While Berlin is considered as the CHP capital, a large proportion of electricity is still generated uncoupled.

Berlin's electricity generation and district heating production and supply are covered by large combined heat and power plants, which are partly hard coal-fired. The share of cogeneration in the district heating supply in 2014 was 81.2% (29,593 terajoule).

Share of cogeneration in Berlin's electricity generation and district heating supply

Indicator	Unit	2005	2010	2011	2012	2013	2014
Total gross electricity generation	**TWh**	**9,109**	**9,108**	**8,407**	**8,121**	**8,215**	**7,817**

from cogeneration	TWh	4,856	5,797	5,228	5,067	5,001	4,463
share of cogeneration	**%**	***53.3***	***63.7***	***62.2***	***62.4***	***60.9***	***57.1***
Total gross district heating supply	**TJ**	**41 919**	**47 355**	**39 847**	**40 355**	**42 174**	**36 449**
from cogeneration	TJ	33 870	37 081	32 103	31 944	31 930	29 593
share of cogeneration	**%**	***80.8***	***78.3***	***80.6***	***79.2***	***75.7***	***81.2***

Source: Amt für Statistik Berlin, Brandenburg, 2017

Berlin has got a huge potential in basing its CHP production on natural gas. In the decentralised heat sector, oil is also playing a significant role. This shows that there is a significant CO_2 saving potential in the shift from about 70,000 oil heating systems to gas or alternative sources - despite very favourable oil prices.

In general Berlin's share of renewable energies is still low, with the proportion of primary energy and final energy used at around 4% and 2%, respectively. As a result, central and decentralised emission factors are currently rather high both in Berlin's electricity and heat generation. The main challenges for Berlin's energy transition is to exit coal and oil in the medium term, to convert energy more efficiently and to continuously increase the share of renewable energies. In order to achieve this, the existing infrastructure needs to be adapted as well (e.g. reduced temperature levels of heating networks, integrated heat storage) and flexibility options (such as Power to Heat, Power to Gas and Demand Side Management) need to be developed or expanded.

District heating balance of Berlin

Indicator	**Unit**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**
Gross district heating supply	**TJ**	**41 919**	**47 355**	**39 847**	**40 355**	**42 174**	**36 449**
Self-consumption and losses	TJ	1 007	1 039	889	665	3 738	3 763
Statistical differences	TJ	0	202	221	1 290	997	1 415
Final heat consumption	**TJ**	**40 912**	**46 518**	**39 179**	**40 980**	**39 417**	**34 024**
manufacturing / processing trade	TJ	1 433	1 165	1 451	987	1 097	1 000
households	TJ	37 550	43 742	36 912	39 333	37 396	32 133
Trade, commerce, services and further consumer	TJ	1 929	1 611	816	660	925	891
Fuel provided for district heating in total	**TJ**	**41 318**	**43 766**	**36 696**	**38 865**	**40 477**	**34 160**
Hard coal	TJ	***11 976***	***11 572***	***8 838***	***8 207***	***9 572***	***9 065***
Lignite	TJ	***7 843***	***7 794***	***6 681***	***7 185***	***6 755***	***7 180***
Mineral oil / petroleum	TJ	880	764	381	660	439	251
Natural gas	TJ	19 341	20 457	17 120	19 215	18 994	13 849
Renewable energies	TJ	767	1 217	1 297	1 553	1 933	1 825
Other	TJ	511	1 962	2 379	2 045	2 784	1 991

Source: Amt für Statistik Berlin, Brandenburg, 2017

Energy demand

The district heating balance of Berlin shows that only a minor share of the total supplied district heat is consumed by manufacturing, trade, commerce and services. In 2014 households consumed 94% of the total final district heat supply.

The building sector accounts for almost 50% of the total CO_2 emissions in Berlin, according to the Berlin CO_2 balance based on the polluter-pays principle. CO_2 emissions in this sector amount to 10.3 million tons and are distributed between residential (~60%), non-residential (~34%) and industrial (~6%) segments. Nearly 200 million m^2 (gross floor area) are attributable to residential buildings, 66 million m^2 to non-residential buildings and only 12 million m^2 to industrial buildings.

In the housing sector, when it comes to refurbishment, the high proportion (about one third) of Wilhelminian style buildings can be a challenge. Their architectural and cultural value needs to be preserved and there tends to be a small-scale ownership structures (flats in the same building are owned by different people), which adds to the complexity of refurbishment and retrofitting projects. Also, the amount of buildings that have been put under preservation order (17.5% of the housing stock based on gross floor area) play an important role when it comes to refurbishment. Average energy consumption in these buildings in 2012 was about 200 kWh per m^2 net floor area and year. This high heat demand is due to low refurbishment rates and low building standards as well as inefficient heat supply. Here, the heat supply itself must be made more efficient and less CO_2-intense (fuel switch). Additionally, heat losses have to be drastically reduced in Berlin's buildings.

Key performance indicator	
Number and type of energy generation units	Appl. 750,000 heating energy generation units in residential and non-residential buildings
Solar thermal energy generation (MWh/ year)	40-45,000 MWh/year (very rough estimate)
Heat pump energy generation (MWh/ year)	110,000 MWh/year (very rough estimate)
Biomass energy generation (MWh/ year)	Figures not available yet
Waste-to-energy generation (MWh/year)	appl. 640,000 MWh/a district heat (*Ruhleben*)
Waste heat potential (MWh/ year)	Figures not available
Buildings' energy consumption in the residential sector (MWh/ year)	8.9 million MWh/year (heat only)
Buildings' energy consumption in the commercial sector (MWh/ year)	250,000 MWh/year (heat only)

Buildings' energy consumption in the industrial sector (MWh/ year)	280,000 MWh/year (heat only)

Source: estimates by dena, 2017 and Abgeordnetenhaus Berlin

8.2.2 Key Heating and Cooling policy and legislation

8.2.2.1 Federal policy / legislation

8.2.2.1.1 Combined Heat and Power Act (KWKG)

Combined heat and power plays an important role in achieving Germany's emission reduction goals. In order to increase efficiency in the area of electricity and heat generation, the German Federal Government supports the expansion of combined heat and power, which is regulated in the Combined Heat and Power Act (KWKG). In addition to the electricity tariff for CHP plants and the promotion of heat and cold storage, the KWKG also includes support for investments in heating and cooling networks.

The maximum amount of funding per project is 20 million euros. At least 75% of the heat supplied to consumers connected to a new or upgraded heat network has to come from CHP. Alternatively, support applies if 50% of the supplied heat comes from a mix of CHP and renewables or CHP and industrial waste heat if within these 50% the part of CHP accounts for at least 25%. The required quota must be reached within 36 months from the commissioning of the heating network. CHP plants that are connected to existing heat networks are also eligible for support.

8.2.2.1.2 Heating network systems 4.0 (model projects)

The "model project heating network systems 4.0" is Germany's first promotion scheme where an entire system is being supported rather than just single components or technologies. In order to be eligible for funding these heat networks need to run on lower temperatures or a higher share of renewables or use waste heat in a particularly efficient way compared to conventional networks. Subsidies amount up to 600,000 euros for feasibility studies and up to 15 million euros for the realisation of a 4.0 heating network system.

8.2.2.1.3 KfW energy efficiency program - waste heat

Waste heat recovery and utilisation projects by commercial enterprises are promoted through investment subsidies as part of the "push towards waste heat recovery" programme in the National Energy Efficiency Action Plan (NAPE). This programme supports Investments in the modernisation, expansion or new construction of plants that either prevent or use waste heat (e.g. if waste heat is being fed into an existing heat network, the pipes leading up to the connection point are eligible for funding).

8.2.2.1.4 KfW Market Incentive Program

As part of the Market Incentive Program (MAP), the *Kreditanstalt für Wiederaufbau* (KfW) supports investments for using heat from renewable energies. The KfW "Renewable Energies Premium" programme supports, among other things, the construction and expansion of heat

networks, including the construction of substations, if the main source of heat generation is renewable.

8.2.2.2 Policy /legislation in Berlin

The Berlin Information Center (BIK) is the main platform to give an overview of the diverse climate protection activities in the city.

Berlin's overarching objective is to become CO_2 neutral by 2050. The pathway on how to achieve this is being developed and defined in the Berlin Energy and Climate Protection Programme 2030.

8.2.2.2.1 Berlin Energy and Climate Protection Programme 2030

Berlin's climate and energy objectives are legally defined in its *Berlin Energy and Climate Protection Programme 2030* (BEK 2030) which was passed by the Berlin Senate in June 2017. The BEK is currently in the House of Representatives for consultation and its final approval is expected for early 2018. The BEK is looking at implementing an integrated approach to climate protection and energy and includes about 100 measures in the fields of climate protection and, climate change adaptation. The main focus of these measures lies on the efficient use of electricity, heat and fuels as well as an increased energy generation from renewable energies. In accordance with the *Berlin Energy Transition Law (EWG Bln)*, the implementation of the BEK is to be evaluated scientifically on a regular basis and updates will be made where needed.

8.2.2.2.2 Berlin Energy Transition Law (EWG Bln) of 22 March 2016

In April 2016 the Belrin Energy Transition Law (EWG Bln) entered into force. It sets the city's climate protection targets and stipulates that the Senate of Berlin had to develop the BEK with concrete measures and programmes to achieve these targets. At the same time, the law aims at contributing to international, European and national efforts to mitigate climate change.

Berlin's climate goals

Berlin set the target of reducing its CO_2 emissions by at least 40% by 2020, by at least 60% by 2030 and by at least 85% by 2050 compared 1990. In addition, all other greenhouse gas emissions are to be reduced in a comparable manner.

Establishment of climate-friendly energy generation and supply

The Senate of Berlin strives for a secure, affordable and climate-friendly supply of electricity and heat, which shall increasingly be based on renewable energies. Energy production from lignite will be ceased by the end of December 2017 and from hard coal by 2030.

The Senate supports research, demonstration and development of production capacities with regard to the expansion of renewable energies and high-efficiency cogeneration plants, as well as the increase of energy efficiency. It also supports options to make energy supply systems more flexible, including the development and use of storage technologies and smart grids.

The Senate of Berlin developed strategies and measures for the gradual reduction of heat demand in the building sector in the BEK 2030, taking into account potential savings and future heating requirements.

The Senate is furthermore committed to implementing the energy transition in Germany at the federal level. In doing so, it needs to take into account the costs of energy production and its fair distribution in society.

Increased generation and use of renewable energies

The federal State of Berlin aims at increasing the generation and use of renewable energies in public buildings and other public areas. Roofs of public buildings suitable for the production and use of renewable energy shall be used for the installation of solar or thermal energy generating facilities, if not contrary to public law.

District heating – connection

According the amendment to the EWG Bln by Berlin's Parliament, which entered into force in November 2017 the Senate of Berlin is authorised to order a mandatory connection to heat networks in certain areas or order the mandatory use/consumption of heat from heat networks. This can be ordered for certain areas for resource and climate protection.

The obligation to connect and use shall be limited to newly build buildings. An exemption will be made if an area or building is already connected to a heating or cooling system that leads to significantly lower CO_2 emissions than what the district heating facility can provide. Another exemption can be made if the mandatory connection or use leads to social or economic hardship.

The ordinance can lay down specifications with regard to technological standards and the feed-in of renewable energies shall be made possible.

8.2.3 Heating and Cooling within urban development and renovation programmes

8.2.3.1 Heating and Cooling Objectives

Berlin's heating and cooling strategy is currently being formulated in the Berlin energy and climate protection plan.

Independently from this plan, Berlin committed to becoming coal free by 2030 the latest. Therefore Vattenfall and other partners, together with the government of Berlin, are working in a feasibility study to guarantee that the coal shift and the decarbonisation of the city's heat supply will be completed by 2030.

8.2.3.2 Energy Efficiency Opportunities

There is huge technical potential in realising energy efficiency opportunities through refurbishment in the city of Berlin. However, there are several factors limiting and hindering extensive refurbishment works and progress. Low fossil fuel prices have a huge impact on the economic viability of refurbishment projects. Furthermore, there is still a lack of social

acceptance and small-scale ownership structures can have a negative impact on refurbishment rates.

8.2.3.3 Renewable Energy Adoption and Potential

% renewable energies gross electricity consumption (2014)	2.2%
Share of renewable energies primary energy consumption (2014)	3.9%
Number of installed heat pumps (under MAP promotion scheme) (2016)	68
Renewable heat supply in district heating networks (2014)	468 m kWh

Source: Föderal Erneuerbar, Bundesländer mit neuer Energie

8.2.3.4 Transport and infrastructure

Public transport services in Berlin are offered in four different modes of transport: bus, tram, underground trains and city trains. The city trains are running on 100% renewable energy since December 2017. The electricity amount used by these trains amounts to 400 GWh (400 million kWh). Another area with a growing renewable electricity use is the power consumption for the train stations. Installed solar panels with a yearly production of 8000kWh and additional small wind turbines at Südkreuz, one of Berlins biggest stations, are the first steps in achieving electric self supply for train stations. For the bus system the carrier is aiming to increase electrification. The first bus lines are already operated only by electric busses and, according to the company's statement, have saved 150 tonnes of CO_2 emissions. (Renewable electricity efforts for tram and underground system are set to be reinforced in the future.)

8.2.4 Financing Opportunities and Instruments

Renewable energies are predominantly promoted by instruments at the federal level e.g. renewable energy law (EEG), KfW Market Incentive Program (MAP), etc.

The Investitionsbank Berlin (IBB) offers financing opportunities in the field of renewable energies, energy efficiency and climate protection. In addition to programmes for economic development, funding in the field of energy building refurbishment for private investors, housing companies or cooperatives is offered. IBB offers low-interest loans for landlords and investors to be used for new constructions, to purchase properties or for modernisation and refurbishment projects focusing on energy-related measures.

8.3 Stakeholder Identification and Engagement

8.3.1 Local stakeholders

8.3.1.1 Senate of Berlin

Berlin is governed by the Senate of Berlin consisting of the governing Mayor and up to ten senators. Since 2014 Michael Müller (social democrats) has been the mayor of Berlin, heading a coalition of social democrats, the left party and the greens, which was formed as a result of the election of the House of Representatives on 18 September 2016.

The Senate is divided into different administrations, which would be the equivalent of ministries on a national scale. These Senate administrations relevant for the THERMOS project are:

- Senate Department for Economics, Energy and Business
- Senate Department for Urban Development and Housing
- Senate Department for Environment, Transport and Climate Protection

8.3.1.2 Institute for Ecological Economy Research (IÖW)

The Institute for Ecological Economy Research (IÖW) was founded over 30 years ago with clients from the public and private sector and cooperations with international partners and clients such as the European Union or the United Nations Environment Programme (UNEP).

The IÖW was involved in preparing the feasibility study "Climate Neutral Berlin 2050", which was released in 2014. In 2015 a report with recommendations for the later adopted Berlin Energy and Climate Protection Programme 2030 was prepared on behalf of Berlin's Senate Department for Urban Development and the Environment.

Currently (June 2016 until May 2019) the research project "*Urban Heat Shift - Participatory Transformation of Coupled Infrastructures, Focusing on Heat Supply in Berlin*" supported by the German Federal Ministry of Education and Research (BMBF) is managed by IÖW as project leader. Cooperation partners are the Berlin Senate Department for Environment, Transport and Climate Protection, the Technical University of Berlin with the Department for Economic and Infrastructure Policy and the University of Bremen, Department for Resilient Energy Systems. The project Urban Heat Shift aims at developing an environmentally and socially acceptable heat supply in cities intelligently linking other infrastructures, such as gas and power. Different transforming options for the urban heat supply from various sustainable perspectives are being evaluated, using Berlin as a case study.

8.3.1.3 Wohnraumversorgung Berlin (WVB)

Wohnraumversorgung Berlin (WVB) is an unincorporated and private institution under public law in the state of Berlin, which provides advisory services to the Senate and the six state-owned housing companies (*Wohnungsbaugesellschaft Berlin-Mitte, Gesobau, GEWOBAG, HOWOGE, STADT UND LAND, Degewo*). The central task of the WVB is to formulate political guidelines for the implementation of the housing contract and the corporate structure and corporate governance of these housing companies. The WVB is a subordinate institution of the

Senate Department for Urban Development and the Environment. It was created by law on 1 January 2016 by the Berlin Housing Provision Act (WoVG Bln).

8.3.1.4 Degewo AG

Degewo is a German housing company based in Berlin, founded in 1924, that manages more than 70,000 apartments and 1,500 commercial units in Berlin.

8.3.1.5 GESOBAU AG

GESOBAU AG, founded in 1900, is a housing association that belongs entirely to the State of Berlin and is one of the largest housing companies in Berlin and the whole of Germany. It provides homes for 100,000 people mainly in urban settings and neighbourhoods. As a municipal housing company, GESOBAU actively contributes to providing affordable housing for broad sections of the population in Berlin. Through new construction and purchase, it aims to expand its housing stock from the current 41,000 apartments to approximately 52,000 apartments by 2026.

8.3.1.6 GEWOBAG AG

With around 60,000 apartments and commercial properties, *GEWOBAG* manages around 100,000 tenants. Berlin is growing and in the last three years *GEWOBAG* has expanded its portfolio by around 8,200 apartments. In the medium term it plans to expand the portfolio by 14,600 apartments, including 10,200 apartments through new construction.

8.3.1.7 HOWOGE Wohnungsbaugesellschaft mbH

HOWOGE is an important municipal housing company in the state of Berlin with its own housing stock of around 59,000 apartments.

HOWOGE was the first German housing association to use air-water gas absorption pumps for the sustainable generation of heat as part of a flagship project. This allowed for gas consumption to be reduced by around 275,000 kWh a year. The reduction in carbon dioxide emissions is around 49 tonnes a year.

8.3.1.8 STADT UND LAND

STADT UND LAND Wohnbauten-Gesellschaft mbH is in charge of 43,300 apartments, more than 770 commercial units and manages about 13,400 rental units for third parties. The housing stock is expected to grow to a total of 55,500 apartments by 2026 through new construction and purchase. Since 2012, around 3,900 residential units have been purchased and around 1,900 new apartments are currently under construction. The company is also continuously investing in the refurbishment and modernisation of its properties, supporting numerous social projects and initiatives to strengthen neighbourhoods.

8.3.1.9 WBM Wohnungsbaugesellschaft Berlin-Mitte mbH

WBM Wohnungsbaugesellschaft Berlin-Mitte mbH (WBM) is the largest municipal real estate administrator in the inner-city of Berlin. 70% of the objects are prefabricated buildings. They include listed ensembles of the GDR post-war modernism and also the GDR standard multi-family house, so called "Platte".

8.3.1.10 BIM Berliner Immobilienmanagement GmbH

BIM Berliner Immobilienmanagement GmbH (BIM) emerged in 2015 from the merger of *Liegenschaftsfonds Berlin* and BIM. BIM is responsible for the letting, management, optimisation and sale of approximately 4,500 state-owned properties, on behalf of the State of Berlin. The State of Berlin uses around 1,600 buildings for its public administration. All of them are combined in the "Real Estate Assets of the State of Berlin" (SILB) and are managed by BIM on behalf of the State of Berlin.

8.3.1.11 Vattenfall Europe Wärme AG

Almost one third of apartments in Berlin are currently connected to district heating and use heat generated from *Vattenfall's* generation plants. Most of the district heating networks are located in densely populated inner-city areas. However, Vattenfall also supplies housing estates in suburban areas. If district heating pipelines are not located nearby, Vattenfall offers decentralised heating options. V*attenfall Wärme AG* generates nearly 90% of its heat through combined heat and power. Small and large combined heat and power plants - from 100 kilowatts to 750 megawatts - form the core of Vattenfall's heat supply, which contains nearly 2,000 kilometres of pipelines, 18 pumping stations and 19,000 substations - Europe's third-largest district heating network after Moscow and Warsaw.

Climate protection agreement between Vattenfall and the State of Berlin

Vattenfall is working together with the State of Berlin to reach the objective of becoming carbon neutral by 2050. Measures that Vattenfall is implementing in order to achieve the agreed CO_2-savings are the modernisation its heating plants with regard to efficiency and lower emissions fuels, flexibility as well as the expansion of the district heating network and the construction of new combined heat and power plants.

In May 2017, the last lignite-fired power plant went off the grid. By 2030 the three hard coal power plants still in service are to be also closed.

By replacing conventional boilers with district heating each newly connected Berlin residential unit saves on average around one ton of CO_2 per year. Vattenfall's objective is to achieve a reduction in annual CO_2 emissions of a total of 200,000 tons in the Berlin heating market by 2020 through new connections to the district heating supply. Every year around 20,000 new apartments are connected to district heating.

Renewable energies and heat storage

Vattenfall has started to replace the hard-coal-fired block of the Reuter CHP plant in Berlin's district *Spandau* with Europe's largest power-to-heat plant, which will have a capacity of 120 MW_{th}. Vattenfall furthermore wants to use wind and solar power surpluses around the city to generate district heating. Heat storage systems will complete this combination for more flexibility.

Use of biomass

The biomass cogeneration plant "*Märkisches Viertel*" of Vattenfall, which was put into operation in 2014, generates heat and electricity from natural woodchips. In addition, two hot water generators produce district heating from natural gas. Furthermore, solid biomass is also used in co-incineration. In the coal-fired heating power plant Berlin Moabit natural biomass (woodchips) is used for combustion in larger quantities.

8.3.1.12 FHW Neukölln AG

In Berlin's district *Neukölln* the FHW *Neukölln* AG, whose main shareholder is Vattenfall, supplies around 40,000 residential units in the *Neukölln* and *Kreuzberg* districts with heat. Berlin's largest heat storage system as of 2017 allows for the use of environmentally friendly combined heat and power (CHP) to generate electricity and heat. The heat storage also facilitates the integration of renewable electricity generation. Ff there is a lot of wind power in the grid in winter, connected CHP plants can be regulated down without endangering the heat supply. A power-to-heat system ("Electricity to District Heating") with a capacity of 10 MW_{th} in combination with the heat storage system is a highly flexible unit that contributes to the stability of the electricity grid by providing control power.

A 22-meter-high tank stores heat in form of 10,000 cubic meters of hot water for a time-delayed use for district heating. Due to the temporal decoupling of district heating production and supply, electricity can be produced even if there is low heat demand. Conversely, the heat supply is secured also without electricity production. This solution results from fluctuating electricity generation from wind power and photovoltaic plants in and around Berlin. In addition, the power-to-heat plant is a technical solution to integrate renewable energy into district heating. Operating like a giant immersion heater, it can convert excess electricity from renewable electricity generation into heat.

8.3.1.13 GASAG

GASAG is one of the oldest and biggest gas supply companies in Europe. Founded in 1847 it was originally responsible for providing gas for Berlin's gas lightning. In 1923 it was transformed into a stock company, which was completely owned by the city of Berlin. For the time that the city of Berlin was divided, GASAG was covering West Berlin. After the reunification in 1990 GASAG took over its Eastern counterpart BEAG.

It wasn't until 1993, that the Senate decided to sell its shares and privatisation was completed by 1998. After liberalising the German gas market the former monopolist GASAG lost customers to competition but is still the biggest gas supplying company in the Berlin area today. Today the shareholders are E.ON (36.85 %) and Vattenfall (31.575 %) and the internationally acting company Engie (31.575 %)- each owning around one third of the shares.

Today GASAG is also involved in innovative technologies and is driving forward the expansion of renewable energy. It set up products such as the virtual power plant "EcoPool", energy solutions for entire neighbourhoods and energy consulting. GASAG furthermore bundled its expertise in energy services at *GASAG Solution Plus GmbH*. As of April 2017, the new subsidiary within the GASAG Group offers infrastructure and energy services for major projects such as

supplying the EUREF Campus, a 55,000 m^2 project area in Berlin promoting renewable city concepts, with district heating from a cogeneration plant. One of the projects in said area will also include GASAG implementing a power to heat/cooling plant.

8.3.1.14 BTB GmbH

Blockheizkraftwerks- Träger- und Betreibergesellschaft mbH (BTB) produces and supplies district heat mainly in East Berlin for apartments, industrial, and commercial properties. Examples are the scientific and business hubs in Berlin-*Adlershof* and the heating area further south in Berlin at the BBI Business Park at Berlin-Brandenburg International Airport. BTB's district heat is generated by more than 90% from combined heat and power. Another part comes from the use of renewable energies. Solar, wind and fuels such as wood and biogas are the main sources of energy.

8.3.1.15 Naturstrom AG

With its foundation as a stock company in 1998 Naturstrom became one of Germany's first independent providers of green electricity. Naturstrom has been growing continuously over the last 20 years. In 2009 they reached 50,000 customers and by 2016 that number grew to 260,000. The focus of Naturstrom's economic activity has been lying on power generation and trade. In 2009 Naturstrom expanded its business area to also include biogas generation and trade.

Since its beginnings the corporate identity has been to offer sustainable energy solutions, not only focusing on renewable energy sources, but also considering economic and social sustainability. The company's most recent approach is connecting energy generation and consumption and keeping both at a local level. This idea has been incorporated in projects for decentralised district solutions, which Naturstrom has started in the Berlin area. In these project districts Naturstrom is offering not only electricity but also heating and cooling options to the residents. In the 18,000 m^2 area of the *Holzmarkt* this will be achieved for example through combination of photovoltaics, geothermal energy and biogas. The energy supply is taking into account local circumstances e.g. using existing water tanks as heat storage.

8.3.2 National stakeholders

8.3.2.1 Federal Ministry for Economic Affairs and Energy (BMWi)

BMWI is the Federal Ministry for Economic Affairs and Energy in Germany. It was founded in 1949 together with the country of West Germany. First only concerned with economic affairs it added technology issues in 1998 and all energy related topics in 2013. In its current organisational structure two of ten departments are working on energy topics, one of those is the department "Heat and energy efficiency". In 2016 its share of the government budget contained 7.6 billion €.

The Ministry has several associated authorities. Most notable for are the Federal Office for Economic Affairs and Export Control (BAFA), Germany Trade and Invest (GTAI), Federal Network Agency (Bundesnetzagentur) and the Federal Cartel Office (Bundeskartellamt).

8.3.2.2 German Association of Energy and Water Industries (BDEW)

The German Association of Energy and Water Industries (Bundesverband der Energie- und Wasserwirtschaft- BDEW) represents companies active in the field of natural gas, electricity and district heat, water and wastewater (BDEW represents 1,800 companies). The companies differ widely in terms of their sizes and forms of organisation. The spectrum of the Association's members ranges from local and municipal utilities to regional and inter-regional suppliers. The companies of the energy and water industry supply electricity and water to almost all 40 million households in Germany. Furthermore, about 20 million German households are supplied with natural gas and five million with district heat.

BDEW was founded in autumn 2007 to combine the competencies of five different associations. BDEW is the main point of contact on all issues relating to natural gas, electricity, district heat as well as water and wastewater.

8.3.2.3 Energy Efficiency Association for Heat, Cooling and CHP (AGFW)

The Energy Efficiency Association for Heat, Cooling and CHP (AGFW) is an association of companies that operate CHP plants and district heating networks in Germany. The association sees it as its task to support the member companies through industry lobby in the fields of politics, law, technology, business administration as well as organisation and work safety.

The association is a consortium of more than 500 companies supplying heat or cold. These companies operate over 1,300 networks with a total length of 19,100 km. More than 80% of the heat is generated in combined heat and power plants. The same plants also supply about 7% of the German gross electricity generation. The heat input in Germany is around 57,000 MW. Of these, over 53,000 MW are statistically recorded by AGFW.

8.3.2.4 Verband kommunaler Unternehmen (VKU)

The Verband kommunaler Unternehmen e.V. (VKU) is the German Association of Local Utilities of municipally determined infrastructure undertakings and economic enterprises. These are companies, which provide services of general interest in Germany within the framework of local self-government. Therefore the VKU members do not primarily pursue private commercial objectives but are guided by public welfare obligations. They operate under local self-administration to serve "citizen value", i.e. to meet the needs of the local community. The type of capital they form and secure is a community-oriented asset (Resolution of the VKU Executive Committee of 26 February 2008).

The VKU represents the interests of the local public utility sector in Germany, which includes energy and water supply as well as disposal services. With its nearly 1,500 member companies it employs over 260,000 people, generating a combined revenue of 115 billion €.

8.3.2.5 German Association of Towns and Municipalities (DStGB)

The German Association of Towns and Municipalities (Deutsche Städte- und Gemeindebund - DStGB) represents the interests of the German cities and communities. At the provincial, federal and EU level, they form the representation of interests and address the issues of local citizens.

17 different associations with 11,000 large, medium and small municipalities are united in the DStGB. The DStGB works independent of parties and without state subsidies.

The German Association of Towns and Municipalities works as:

- special interest group for municipal representations
- information network
- coordinating committee

8.3.2.6 Association of German Cities

The Association of German Cities (Deutscher Städtetag) is advocating the opinion of cities and the national local-authority association of cities. As the interest group of cities it represents the idea of local self-government to Federal Government, Federal States (Bundesländer), European Union, governmental and non-governmental organisations. The work and services of the Association of German Cities are primarily geared to the needs and interests of the direct member cities and their citizens.

8.3.2.7 Ifeu Institute

The ecological research institute Ifeu is operating research projects and providing consultancy service worldwide in relation to all major environmental and sustainability issues. Ifeu is part of an interdisciplinary research network. Their team is working with state of the art modelling tools.

The approach to current research topics aims to integrate practical and societal aspects. An efficient energy system primarily based on renewable energy requires efforts and measures across all sectors, i.e. for electricity supply and demand, the heat market, the transport sector, but also in the context of societal change. Ifeu currently employs 80 staff members in Heidelberg and Berlin.

8.3.2.8 Institute for housing and environment (IWU)

The Institut Wohnen und Umwelt GmbH (IWU) - institute for housing and environment - is a non-profit research institute. The institute is working on both basic and applied research, with an emphasis on interdisciplinary work. In 1971, the work in Darmstadt was taken up on housing policy and urban development issues. Since 1985, the institute is also doing research on the rational use of energy in buildings.

The institute has three fields of research in which different projects are assigned. The research field *housing* focuses on topics concerning housing supply, housing industry, city development and mobility research. The research field *energy* has its emphasis on the efficient use of energy in buildings. The research field *integrated sustainable development* is composed of interdisciplinary projects on different levels of space, e.g. city / region, neighbourhood and building.

8.3.3 Existing stakeholder participation processes

8.3.3.1 Innovation Center Energy of the TU Berlin

The Innovation Center Energy (IZE) bundles and brings together the activities of the Technical University Berlin in the field of energy research. It links the expertise of the IZE with energy and provides a central platform for communication and collaboration with industrial and external research partners. The IZE promotes and supports junior researchers in the field of energy and strengthens and integrates energy research in the capital region Berlin / Brandenburg.

8.3.3.2 Berlin 21 e.V. network

Berlin 21 e.V. is an association that supports and promotes innovative project approaches and learning processes by bringing together actors from various areas of society on key issues such as sustainable energy. As part of the Berlin 21 e.V. network, various interest groups work together to promote the sustainable development of the city region.

8.3.3.3 Network natural gas Berlin-Brandenburg

Network natural gas (Network Erdgas) is a platform that brings together stakeholders from Berlin and Brandburg who are active in the natural gas sector.

8.3.3.4 Cluster Energietechnik Berlin-Brandenburg

The two federal States Berlin and Brandenburg created the Cluster Energietechnik Berlin-Brandenburg in 2011.

With more than 6,000 companies and over 56,000 employees the Cluster aims at contributing to and supporting the transnational innovation potential around the core topics of renewable energy, energy efficiency, networks & storage as well as turbomachinery and power plant technology.

8.3.3.5 Berlin NetworkE

In this network, companies are working together on topics related to energy efficiency and renewable energies. The network management lies with the Berlin Energy Agency. The Berliner NetzwerkE sees itself as part of the Smart City strategy of the state of Berlin and focuses on practice-oriented solutions for the interaction of people and technologies in the field of energy management. The network partners jointly develop innovative concepts, products and services for more energy efficiency and implement them in model projects. Since the end of 2008, more than 20 model projects in the field of energy efficiency and renewable energies have been launched with the help of the Berliner NetzwerkE network.

Over the past nine years, the Senate Department for Economics, Energy and Enterprises has been funding the network through the Joint Task "Improving Regional Economic Structure". Members of the board are, amongst others, from Berliner Immobilienmanagement GmbH (BIM), Berliner Stadtreinigung (BSR), GASAG, HOWOGE, Vattenfall and WISTA MANAGEMENT GMBH.

8.3.4 THERMOS Local Liaison Group

8.3.4.1 Stakeholder roles towards THERMOS model replication

Local Liaison Group		
Name of Organisation	**Type of stakeholder**	**Role within LLG**
Senate of Berlin	Public administration	• stakeholder engagement • testing the THERMOS tool in the context of current policy developments or programmes in Berlin. Urban planning tools such as the THERMOS software could be key to meeting the goals of decarbonisation in Berlin.
Institute for Ecological Economy Research (IÖW)	science and research institution	• stakeholder engagement • further THERMOS trainer • testing the prototype THERMOS software at up to three potentially sites in Berlin for district heating development in 2018 • dissemination of the THERMOS tool
Naturstrom AG	utility	• testing the prototype THERMOS software at a potentially Berlin-site for district heating development in 2018 • dissemination of the THERMOS tool
GASAG Solution Plus GmbH	Energy service provider	• testing the prototype THERMOS at a potentially site for district heating development in 2018

		• dissemination of the THERMOS tool

8.3.5 Stakeholder Engagement Strategies

The Berlin Senate is interested in testing the THERMOS tool in the context of current energy and climate policy developments or programmes in Berlin (further policy development e.g. the BEK 2030 is described above) and is potentially able to assist in maximising the THERMOS project's impact at European level through existing international networks of the city.

The Institute for Ecological Economy Research (IÖW) is interested in testing the prototype THERMOS tool at up to three potentially sites for local district heating development in 2018 and is potentially able to increase stakeholder engagement. Using and testing the THERMOS prototype may support the planning of potential district heating solutions at the three sites in Berlin and would also contribute to additional developments in the project "Urban Heat Shift - Participatory Transformation of Coupled Infrastructures, Focusing on Heat Supply in Berlin".

Naturstrom AG is interested in testing the prototype THERMOS tool at one potentially site for a local district heating network solution within their project portfolio in Berlin in 2018 and is potentially be able to assist the dissemination of the THERMOS tool at national level.

GASAG Solution Plus GmbH is interested in testing the prototype THERMOS tool at one potentially site for a local district heating solution in 2018.

8.4 Towards THERMOS Uptake

8.4.1 Barriers

One barrier to the uptake of THERMOS in Berlin is the fact that the Berlin Energy and Climate Protection Programme 2030 (BEK) is still in the final political consultation rounds. This means that concrete measurements for increased efficiency and a larger share of renewable energies and the prioritisation of them is still missing.

Furthermore, the heat network in Berlin is owned in large parts by Vattenfall. Even though the Senate of Berlin is working on a feasibility study on exiting coal by 2030 together with Vattenfall, it will still take some time for concrete measures to be implemented. The supporting work that the THERMOS tool can play in this endeavour will therefore be pushed back.

8.4.2 Proposed solutions

The aim is to work very closely with the Berlin local liaison group and guarantee that as soon as the next steps in communal heat planning are being taken, THERMOS will be used as a supporting tool.

8.4.3 THERMOS exploitation opportunities

In Berlin, opportunities for the application of the THERMOS tool are within projects of the local liaison group. Existing members of the Local Liaison Group like Naturstrom AG and GASAG

Solution Plus GmbH can use the THERMOS tool within their project pipeline in Berlin and intent to continue using it after the test phase throughout Germany.

8.5 THERMOS Case Study

8.5.1 Objectives

The THERMOS case study in Berlin will consist in a "confirmation/reality check". Real planning data coming from a heating network currently under construction by GASAG Solution Plus GmbH will be compared with the results of the THERMOS tool. The foreseen heating network will supply heat to an entirely new residential neighbourhood.

This check will generate valuable feedback for the results of the THERMOS tool. The following central question about the tool will be answered: are the results from the THERMOS tool similar to those of other planning tools that are already in use? What are the main similarities and differences? In addition to testing the planning data results of THERMOS, further tests regarding operating data of the given heating network will be undertaken.

A final decision concerning the timeframe of the testing of the THERMOS tool in 2018 will be taken in the next months, once the THERMOS tool is developed.

9 Greater London Authority

9.1 Introduction

London is the capital and most populous city in England and the United Kingdom, as well as the largest city in the European Union. It accounts for 13.4% of the UK's population. Greater London is a region of England which forms the administrative boundaries of London. London is organised into 33 local government districts[8]: the 32 London boroughs and the City of London. The Greater London Authority, based at City Hall in Southwark, is a strategic regional government body and consists of the Mayor of London and the London Assembly. The region covers 1,572 km^2 and had a population of 8.7 million in 2016. Greater London is under the strategic local governance of the Greater London Authority (GLA). It consists of an elected assembly, the London Assembly, and an executive head, the Mayor of London. The headquarters of the GLA is at City Hall in Southwark. The Mayor is responsible for developing a number of Strategies including the London Plan, Transport Strategy, Economic Development Strategy and the Environment Strategy. The GLA family also include: Transport for London, the London Fire and Emergency Planning Authority, Mayor's Office for Policing and Crime, London and Partners, London Legacy Development Corporation and Old Oak and Park Royal Development Corporation.

9.2 Heating and Cooling in the Local Context

9.2.1 Local energy system

The vast majority of London's energy demand (approximately 94 per cent) is currently sourced from outside of the city. London can never be fully self-sufficient in energy even if energy demand is reduced and more renewable energy is generated within the city boundaries, because of limited space. That's why London's zero carbon scenario is intrinsically linked to the decarbonisation of the UK's electricity and gas grids.

In London, electricity demand accounts for almost half of the total CO_2 emissions. This fraction has been decreasing rapidly in recent years due to decarbonisation of the national electricity grid. Total UK renewable electricity generation has increased to record levels of around 25 per cent in 2015, up from 19 per cent in 2014, while coal generation has reduced from 30 per cent of generation in 2014 to 22 per cent in 2015. There is a proposed national pathway to further

[8] Image from http://directory.londoncouncils.gov.uk/images/boroughmap.gif

decarbonise the electricity grid, with generation from renewable and nuclear energy sources projected to double by the early 2030s.

There is, however, no equivalent pathway towards the decarbonisation of the national gas grid, making gas, and by association heat one of the major challenges in realising a zero carbon future. Gas use in London represents around half of total energy consumption, contributing 30 per cent of London's total emissions. Most of this gas is used for heating in buildings.

A key way to support decarbonisation of both electricity and gas grids in London is by increasing the proportion of renewable and local decentralised energy. Local energy generation and communal heating networks currently supply the equivalent of six per cent of London's energy, with approximately a quarter of this from renewable generation including solar and wind power.

Energy infrastructure will need to be transformed so that it is smarter and more effective. This will enable supply and demand of energy to be better matched, reduce consumption and enable people to take advantage of cheaper electricity.

While this is a national issue, in London the supply of more local, decentralised, low carbon energy can be maximised. Decentralised energy ranges from small production, such as electricity from solar PV panels, to larger scale systems based on local energy resources utilising heat pumps that supply communal or district heating (or cooling) through a network of underground pipes connecting it to homes and buildings.

For London to become zero carbon by 2050, the energy system will need to move away from using natural gas to being fuelled more from municipal waste, renewable energy and the heat that is wasted from industrial and commercial processes.

The changing nature of energy supply will mean that the way energy is used, and the infrastructure that supports supply, will need to become more flexible integrating different types of energy and responding to demand at different times of the day. A smart approach is therefore required which uses real-time data and technologies such as smart meters to ensure that the energy system can operate in a way that will reduce system peaks. Combined with the increasing use of energy storage and balancing electricity, heat and cooling demand with the available supply, a smart system will deliver the optimum cost savings, reduce resource consumption and promote environmental benefits. The Mayor will work to increase delivery of decentralised energy in London and identify and map the opportunities to create a smart, flexible energy system.

9.2.2 Key Heating and Cooling policy and legislation

In addition to what was already mentioned by the London Borough of Islington with regards the heating and cooling legislation in the UK and the current London Plan, the Mayor is taking a range of actions to improve the environment now, setting London on the path to create a better future.

The state of London's environment affects everyone who lives in and visits the city – it helps Londoners to stay healthy, makes London a good place to work and keeps the city functioning from day to day. Today London is facing a host of environmental challenges. Toxic air, noise pollution, the threat to our green spaces, and the adverse effects of climate change, all pose major risks to the health and wellbeing of Londoners.

With the aim of tackling the most urgent environmental challenges facing our city as well as safeguard London's environment over the longer term, in August 2017 the Mayor has published the draft London Environmental Strategy. This is the first strategy to bring together approaches to every aspect of London's environment and is divided into the following areas:

- Air quality
- Green infrastructure
- Climate change mitigation and energy
- Waste
- Adapting to climate change
- Ambient noise

This Strategy has several objectives, policies and proposals that impact on heating and cooling in London, with particular regards to decentralised energy and district heating, and including but are not limited to:

- Objective 6.2 – Develop clean and smart, integrated energy systems utilising local and renewable energy sources
  - Policy 6.2.1 - Delivering more decentralised energy in London
    - Proposal 6.2.1a - Help implement large scale decentralised and low carbon energy projects, including stimulating demand from the GLA group
  - Policy 6.2.2 - Planning for London's new smart energy infrastructure
    - Proposal 6.2.2a - Encourage the identification and planning of decentralised energy in priority areas
    - Proposal 6.2.2b - Undertake demonstration project and trials to improve London's energy systems
- Objective 8.4 – London's people, infrastructure and public services are better prepared for and more resilient to extreme heat events
  - Policy 8.4.4 - Reduce the impacts of heat on streets

- Proposal 8.4.4b - The Mayor will work with TfL to put in place initiatives that will minimise heat on the underground and bus networks

In addition to the LES and the London Plan currently in force, the Draft New London Plan (DNLP) is currently open for consultation. This will be a new plan and will run from 2019 to 2041. In developing this strategy, in accordance with the legislation and associated regulations, the Mayor has had regard to a number of topics, including climate change and the consequences of climate change.

Policy SI3 of the DNLP – titled Energy Infrastructure – requires the following conditions:

A. Boroughs and developers should engage at an early stage with relevant energy companies and bodies to establish the future energy requirements and infrastructure arising from large-scale development proposals such as Opportunity Areas, Town Centres, other growth areas or clusters of significant new development.

B. Energy masterplans should be developed for large-scale development locations which establish the most effective energy supply options.

C. Development Plans should:

1. identify the need for, and suitable sites for, any necessary energy infrastructure requirements including upgrades to existing infrastructure
2. identify existing heating and cooling networks and opportunities for expanding existing networks and establishing new networks.

D. Major development proposals within Heat Network Priority Areas should have a communal heating system

1. the heat source for the communal heating system should be selected in accordance with the following heating hierarchy:
   a. connect to local existing or planned heat networks
   b. use available local secondary heat sources (in conjunction with heat pump, if required, and a lower temperature heating system)
   c. generate clean heat and/or power from zero-emission sources
   d. use fuel cells (if using natural gas in areas where legal air quality limits are exceeded all development proposals must provide evidence to show that any emissions related to energy generation will be equivalent or lower than those of an ultra-low NOx gas boiler)
   e. use low emission combined heat and power (CHP) (in areas where legal air quality limits are exceeded all development proposals must provide evidence to show that any emissions related to energy generation will be equivalent or lower than those of an ultra-low NOx gas boiler)
   f. use ultra-low NOx gas boilers.

2. CHP and ultra-low NOx gas boiler communal or district heating systems should be designed to ensure that there is no significant impact on local air quality.
3. Where a heat network is planned but not yet in existence the development should be designed for connection at a later date.

The DNLP promotes the use of the London Heat Map and all other relevant mapping tools from the GLA group.

9.2.3 Heating and Cooling within urban development and renovation programmes

Nearly three quarters of the energy used in London's homes is for heating and hot water, and the overwhelming majority of this demand is met using gas-fired boilers. Already one in ten electricity substations are approaching full capacity and the redevelopment of large parts of the city will increase demand for energy and the infrastructure required to distribute it. One in ten households in the city currently lives in fuel poverty.

On the other hand, climate change is set to lead to heatwave conditions every summer by the middle of the century, and the Urban Heat Island effect makes the centre of London up to 10°C warmer than the rural areas around the city. Increasing heat risk could make homes, workplaces and public transport uncomfortable for all and dangerous for the most vulnerable. Increasing demand for cooling may put stress on power supply networks, threatening London's sustainability and increasing emissions.

The objectives, policies and proposals mentioned in Section 9.2.2 aim at ensuring that the supply of more local, decentralised, low carbon energy in London is maximised by adopting highly efficient generation systems coupled with district heating schemes, or individual building heat pumps where the installation of heat networks is not feasible.

District heating networks and renewable energy supply account for approximately half of London's decentralised energy systems, delivering the equivalent of two per cent of total demand. There is the opportunity to increase this type of energy supply to 15 per cent of demand by 2030. There are a number of opportunities for further decentralised energy projects including large-scale solar PV installations and heat networks utilising technologies such as heat pumps in combination with secondary heat sources.

Amongst the several programmes and initiatives being delivered by the Mayor, it is worth mentioning Sharing Cities[9], a European Commission initiative that aims to make and put in place new and innovative solution to city issues and showcase them in three cities of London, Milan and Lisbon.

A range of smart technology is being piloted such as smart lampposts, infrastructure for electric vehicles and Sustainable Energy Management Systems, which promotes sustainable and energy saving projects.

[9] For more information please visit http://www.sharingcities.eu/

9.2.4 Financing Opportunities and Instruments

To facilitate implementation the Mayor will provide support to boroughs and the private sector through the Decentralised Energy Enabling Project (DEEP)[10].

Over the next two years, this programme will help implement large-scale decentralised energy projects in London, which the market is currently failing to develop. DEEP will provide technical, commercial, financial and other support services to assist public and private sectors to develop, procure and bring into operation these large-scale projects.

The redevelopment of the London Heat Map[11], expected to be completed by the end of 2018, will also fall under the remit of DEEP.

This new version of the London Heat Map will be updated and improved to reflect the changes in technology since its first launch in 2009 as well as be made more user friendly for the user. Some of its features may be related to, or developed in conjunction with, the THERMOS tool.

9.3 Stakeholder Identification and Engagement

9.3.1 Local stakeholders

9.3.1.1 London Boroughs

The 32 London boroughs and the City of London Corporation own and manage across the Greater London territory a large number of existing and proposed buildings with significant heat loads. A vast proportion of such buildings are, or will be through planning requirements, communally heated and represent a major base heat load for decentralised energy project in London.

9.3.1.2 Developers

Both the London Plan and the draft London Environmental Strategy pose conditions on new developments to connect to local heat networks where feasible.

9.3.1.3 Housing Associations

Housing associations are private, non-profit making organisations that provide low-cost "social housing" for people in need of a home. They provide a wide range of housing, some managing large estates of housing, and are now the United Kingdom's major providers of new housing for rent[12].

[10] DEEP will provide technical, commercial, financial and other advisory and support services to assist public and private energy suppliers to develop, procure and bring into operation larger-scale DE schemes that deliver significant greenhouse-gas emission reductions at market competitive prices. It will deliver CO_2 reductions of 17,400 tonnes per annum by September 2019 through projects it directly supports, and aims to enable 90 MW of capacity installed by 2023. It will prioritise key locations where the feasibility is most suitable. For more information please visit https://www.london.gov.uk/what-we-do/environment/energy/energy-supply

[11] https://www.london.gov.uk/what-we-do/environment/energy/london-heat-map/view-london-heat-map

[12] Text from https://en.wikipedia.org/wiki/Housing_association

9.3.1.4 ESCOs

Energy Services Companies (ESCOs) provide a range of energy solutions including design, finance and implementation of energy projects.

9.3.1.5 Thames Water

Thames Water Utilities Ltd, known as Thames Water, is the monopoly private utility company responsible for the public water supply and waste water treatment in large parts of Greater London, Luton, the Thames Valley, Surrey, Gloucestershire, Wiltshire, Kent, and some other areas of the United Kingdom[13].

9.3.2 National stakeholders

As mentioned above in Section 3.3.2, the main national stakeholders are the Department for Business, Energy and Industrial Strategy (BEIS), with its Heat Network Development Unit (HNDU) and Heat Network Investment Project (HNIP), and the Association for Decentralised Energy (ADE), a trade body for district heating providers.

The Heat Trust, operated by Heat Customer Protection Ltd - a not-for-profit company – is a customer protection scheme for heat consumers connected to a district heating network and could represent a valuable stakeholder.

Distribution network operators (DNOs) are companies licensed to distribute electricity in Great Britain by the Office of Gas and Electricity Markets. UKPN and SSE hold licences in the areas in and around London[14].

9.3.3 Existing stakeholder participation processes

GLA engages with a range of district heating stakeholders through the London Heat Map and the planning process where large developments that are referred to the Mayor have to submit energy statements to illustrate how its energy demand is being minimised and the residual demand is being met. Relationships with district heating related stakeholders have got closer since the GLA developed its Decentralised Energy Project Delivery Unit (DEPDU) and then its successor the Decentralised Energy Enabling Project (DEEP). These projects have worked with a range of public and private stakeholders involved in district heating to support them in developing district heating projects.

9.3.4 THERMOS Local Liaison Group

The initial members of the London Local Liaison Group (LLG) members have been identified in addition to the GLA and are detailed in the table below. The local authorities are those covering the heat network priority zones for London.

ADE	Trade body for decentralised energy in the UK
BEIS	Government department responsible for heat networks
Brent Council	Local authority in London

[13] Text from https://en.wikipedia.org/wiki/Thames_Water

[14] For more information please visit https://en.wikipedia.org/wiki/Distribution_network_operator

Camden Council	Local authority in London
G15	Group of the largest non-council social housing providers in London
Greenwich Council	Local authority in London
Hackney Council	Local authority in London
Haringey Council	Local authority in London
Sutton Council	Local authority in London
Waltham Forest Council	Local authority in London
Westminster Council	Local authority in London
Islington Council	Local authority in London

9.3.5 Stakeholder Engagement Strategies

The GLA, with the joint support of the London Borough of Islington, will help promote and roll out the use of THERMOS, with regular workshops to borough officers, developers and consultants.

9.4 Towards THERMOS Uptake

9.4.1 Barriers

The most significant barrier for the implementation of decentralised energy (DE) projects is finance. Other barriers, particularly within local authorities, are represented by general the lack of know-how in all phases of the project implementation, from specification writing, to understanding the planning requirements, to procurement.

Then the barriers to THERMOS will be that users are not aware of it, how it can be used, how it can help them and how it can feed into the pre-feasibility and feasibility work that they will be doing to develop optimum routes for heat networks in any given district or neighbourhood.

9.4.2 Proposed solutions

Since 2009, with the launch of the London Heat Map and the roll-out of a number of programmes and small-grant schemes, the GLA has provided continuous support to local authorities and other entities to facilitate the development and delivery of DE projects. As part of this work it will widely promote and extol the virtues of the THERMOS Tool to relevant stakeholders.

The THERMOS tool would allow borough officers to carry out a first technical and financial analysis and option appraisal of potential DE projects; the GLA would represent a key stakeholder in delivering a thorough training programme to local authorities to ensure an effective rollout of the tool.

The GLA and the London Borough of Islington will deliver a training programme aimed at facilitating the promotion and dissemination of the THERMOS tool to the relevant stakeholders.

Such training programme is thought to commence in Autumn 2018 and will continue throughout the THERMOS implementation programme.

9.4.3 THERMOS exploitation opportunities

The THERMOS tool will allow the relevant stakeholders to carry out preliminary techno-economic appraisals and prioritisation of DE opportunities which may arise in heat network priority zones, such as OAPFs.

The GLA will continue to promote the use of the tool at events it attends to raise awareness of how it can help stakeholders in the district heating sector to understand and make maximum benefit of the THERMOS Tool. It will also be linked to the London HeatMap so that organisations that use the London HeatMap can also explore how THERMOS could support their activities a swell.

9.5 THERMOS Case Study: DEEP - Decentralised Energy Enabling Project

9.5.1 Objectives

DEEP has been established to provide public sector intervention and support to larger-scale DE projects in London that the market is failing to develop and realise.

DEEP procures strategic, technical, commercial/financial and legal advisory support services through an OJEU framework to help beneficiaries bring larger-scale DE schemes into operation in order to significantly reduce CO_2 emissions at market-competitive prices and increase renewable energy generation capacity in London.

9.5.2 Key stakeholders

To be developed – ALL DISTRICT ENERGY RELEATED STAKEHOLDERS PUBLIC AND PRIVATE

A procurement briefing document has been provided describing how to procure a supplier from a sub-lot of the framework.

9.5.3 KPI indicators table

It is expected that DEEP will deliver CO_2 reductions of 17,400 tonnes per annum by September 2019 through projects it directly supports, and aims to enable 90 MW of capacity installed by 2023.

Key performance indicator (core scheme)	
Number and type of energy generation units	n/a
Solar thermal energy generation (MWh/ year)	n/a
Heat pump energy generation (MWh/ year)	n/a
Biomass energy generation (MWh/ year)	n/a
Waste heat potential (MWh/ year)	n/a
Buildings' energy consumption in the residential sector (MWh/ year)	n/a
Buildings' energy consumption in the commercial sector (MWh/ year)	n/a

Buildings' energy consumption in the industrial sector (MWh/ year)	n/a

9.5.4 Financing status/ opportunities

The £3.5m-project is 50% funded by the European Regional Development Fund (ERDF). The framework is available to use and the contract award is published.

Beneficiaries can call off services from the framework which – subject to GLA agreement – will be funded by the project. The project will fund all work [not capital] related to DE projects from early stage heat mapping/energy master planning, taking project ideas from concept through to feasibility, business case, procurement and commercialisation.

9.5.5 Exploitation of the opportunity

Prospective beneficiaries interested in receiving services from the project should sign a Support Agreement (SA). From signing a SA and agreeing a scope of works with the GLA that aligns with Mayoral priorities – as well as beneficiary priorities – a specification will be jointly written between the DEEP project and beneficiary.

Please note that all public bodies within England & Wales can make use of the framework for their own procurement activities.

In 2017 DEEP commissioned 5 pieces of work with at least 1 other organisation outside London utilising the framework for its own DE procurement undertaking. We expect to commission at least another 3 pieces in early 2018 with further mini-competitions taking place throughout the year.

Information updates on the project are made periodically in the London.gov website.