Case descriptions

Appendix report to the Hotmaps handbook for strategic heat planning

Djørup, Søren Roth; Bertelsen, Nis; Mathiesen, Brian Vad; Schneider, Noémi Cécile Adèle

Publication date:
2019

Appendix report to the Hotmaps handbook for strategic heat planning

Case descriptions

Prepared by Søren Djørup, Nis Bertelsen, Brian Vad Mathiesen & Noémi Cécile Adèle Schneider

Reviewed by Per Alex Sørensen, Max Gunnar Ansas Guddat & Anders Odgaard

Date 29-03-19

Funded by the Horizon 2020 programme
of the European Union

Project Information

Project name	**Hotmaps** – Heating and Cooling Open Source Tool for Mapping and Planning of Energy Systems
Grant agreement number	723677
Project duration	2016-2020
Project coordinator	Lukas Kranzl Technische Universität Wien (TU Wien), Institute of Energy Systems and Electrical Drives, Energy Economics Group (EEG) Gusshausstrasse 25-29/370-3 A-1040 Wien / Vienna, Austria Phone: +43 1 58801 370351 E-Mail: kranzl@eeg.tuwien.ac.at **info@hotmaps-project.eu** www.eeg.tuwien.ac.at www.hotmaps-project.eu
Lead author of this report	Søren Djørup Aalborg University Phone: +45 9356 2365 E-mail: djoerup@plan.aau.dk

Legal notice

The Hotmaps project

The EU-funded project Hotmaps aims at designing a toolbox to support public authorities, energy agencies and urban planners in strategic heating and cooling (H&C) planning on local, regional and national levels, and in line with EU policies.

In addition to guidelines and handbooks on how to carry out strategic H&C planning, Hotmaps will provide the first H&C planning software that is:

- **User-driven**: developed in close collaboration with 7 European pilot areas
- **Open source**: the developed tool and all related modules will run without requiring any other commercial tool or software. Use of and access to source code is subject to an open source license.
- **EU-28 compatible**: the tool will be applicable for cities in all 28 EU Member States

The consortium behind the project

Scientific partners

Pilot areas for developing and testing the tool

Executive Summary

This document provides case examples of district heating activities carried out within the EU. The aim is to present the diversity of contexts and conditions that can influence district heating development projects. The cases have been chosen based on different starting points and contexts.

Amiens (France) and Vitoria-Gasteiz (Spain) are examples of cities that are developing new district heating systems within a large individual heating supply system. London (UK) and Rotterdam (The Netherlands) both have small district heating systems and seek to expand these. They also have large developed gas supply systems. Denmark and Lithuania provide examples of how countries with high amounts of district heating have adopted official policies and frameworks promoting and regulating these technologies.

Cases of new deployment struggle with consumer support and perception, unknown and risky market terms and a lack of regulative support. These socio-technical systems are not adapted to district heating technology. On the other hand, there are cases of countries that have long experience with district heating. Here it is a well-known technology, regulated by the public with more stable market terms. This can still produce barriers for the further development of the system itself, as new technologies might not fit into established regimes.

This report serves as a means of displaying the differences among cases, as one size fits all solutions are not likely to meet these differences. Instead, heat planners on national and local scales must adopt solutions to the specific conditions of useful technologies, user preferences, legislation and market designs.

Connection to other Hotmaps materials

This report has been made within work package 5 of the Hotmaps project. It is part of the wider Hotmaps work for enabling strategic heat planning and the deployment of district heating.

Handbook 1 focuses on local and national best practices for strategic heat planning. It provides guidance on how to carry out a strategic heat planning process, the role of different business models and ownership types, and rules and regulation.

Handbook 2 provides guidance and recommendations for how to carry out comprehensive assessments in relation to Article 14 of the Energy Efficiency Directive as well as proposes policy and framework improvements for the next stage of comprehensive assessments in 2019–20.

The case descriptions of the appendix report provide examples of concrete planning experiences from cities and countries that are trying to or already have deployed district heating systems.

The summary report contains important messages and highlights key findings from the handbooks and case descriptions.

- Summary of the Hotmaps Handbooks for strategic heat planning
- Handbook 1: Definition & experiences of Strategic Heat Planning
- Handbook 2: Guidance for comprehensive assessment of efficient cooling and heating
- The Hotmaps Wiki for applying the Hotmaps toolbox for strategic heat planning (https://github.com/HotMaps/hotmaps_wiki/wiki)
- Appendix report to the Handbook for strategic heat planning: Case descriptions

In addition to the reports above, the following resources are available from the Hotmaps research project:

- The Hotmaps toolbox for heating and cooling mapping and planning is available from www.hotmaps.eu
- The Hotmaps manual documenting the toolbox and calculation modules. (https://github.com/HotMaps/hotmaps_wiki/wiki)
- Video tutorials explaining the use of the tool are available at https://github.com/HotMaps/hotmaps_wiki/wiki
- The heating and cooling strategies carried out within the Hotmaps project by the pilot areas.

1 INTRODUCTION TO DISTRICT HEAT PLANNING EXPERIENCES............7
1.1 New district heating development cases............9
1.1.1 France / Amiens............9
1.1.2 Spain / Vitoria-Gasteiz............14
1.2 Cases of new district heating areas............16
1.2.1 The United Kingdom / London............16
1.2.2 The Netherlands / Rotterdam............20
1.3 Experiences from consolidated heat planning countries............23
1.3.1 Lithuania............23
1.4 Heat planning in Denmark: Top-down policies and bottom-up power............25
1.4.1 Overall planning regime............26
1.4.2 Planning processes............27
1.4.3 Ownership and price models............28
1.4.4 Challenges ahead............29
2 CASE ANALYSIS AND SYNTHESIS............31
2.1 Main project drivers............32
2.2 Main project barriers............32
2.3 Ownership and market situation for district heating............33
2.4 Planning Process............33
3 CONCLUSIONS............34
4 REFERENCES............35

1 Introduction to District heat planning experiences

This document presents cases of district heat planning carried out within different contexts. It serves to provide examples of how different the planning contexts, barriers and market designs can be. Actors operate within their specific frameworks and meet different barriers and opportunities. This document provides a few examples of planning district heating systems in different technological, regulative and societal environments.

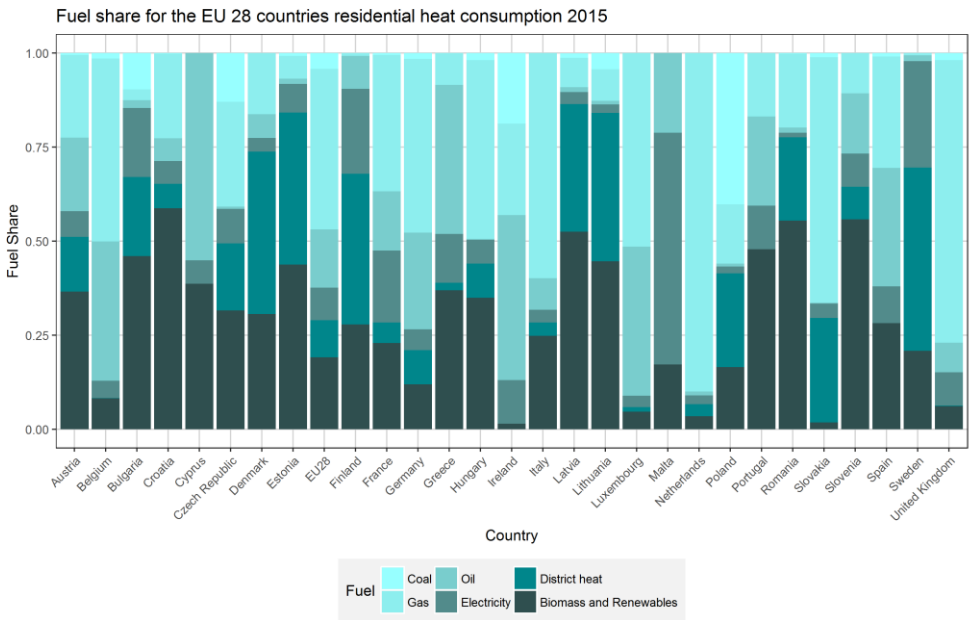

Figure 1 Fuel share for supplying residential heat consumption 2015 [1]

France and Spain are countries where heat is primarily supplied by individual solutions, with some amount of gas heating. These countries use a wide range of fuels, such as biomass, electricity, oil and small amounts of district heating. London and Rotterdam are cities where established gas grids traditionally have been an important infrastructure for heat supply. The UK and The Netherlands are dominated by natural gas for heating. Denmark, Sweden and Lithuania are examples of countries with established district heating systems, although coming from different planning traditions. Figure 1 shows the fuel share supplying heating in the EU-28 member states for 2015.

Table 1 Case studies presented in this report

New district heating in countries with individual heating	New district heating in countries with collective gas distribution	Refurbishment, renovation and expansion of district heating
Amiens (France) Vitoria-Gasteiz (Spain)	London (UK) Rotterdam (Netherlands)	Denmark Lithuania

Table 1 presents the case studies in this report. France and Spain are both countries with high amounts of individual heating, such as stoves, boilers or heaters in buildings. Here, two examples are provided of how the cities of Amiens and Vitoria-Gasteiz have worked with installing district heating systems. The UK and The Netherlands both have high amounts of heating supplied by another collective infrastructure, gas grids. Rotterdam and London are both examples of cities that have ambitious targets to decarbonize their energy supply. Denmark and Lithuania provide examples of countries with established district heating systems and corresponding regulation, frameworks and market designs.

Interviews were carried out for most of the cases, except for Amiens and Denmark, and provide the main part of data used for the descriptions. Regulation and frameworks have been described using information from [2] as well as the National Renewable Energy Action Plans and National Energy Efficiency Action Plans delivered to the EU. Sources for the concrete cases are also provided for in-the-case descriptions.

Case	Interviewee
Vittoria-Gasteiz	Two municipal district heat planners
London	One district heat planner from London Greater Authority
Rotterdam	One municipal district heat planner
Lithuania	One representative from the Lithuanian District Heating Association

1.1 New district heating development cases

1.1.1 France, Amiens

Regulatory framework and support schemes

After the Second World War, electricity and gas networks in France were nationalised: EDF-GDF (Electricity and Gas of France) became the obligatory concessionaire for the distribution of electricity and gas—except for communities who chose to keep the local distribution companies that already existed. Between 2000 and 2010, EDF and GDF became two distinct public limited companies, and the Energy Regulation Commission was created. This Commission is responsible for ensuring the proper functioning of the energy (electricity and gas) market and for arbitrating differences between users and the various operators.
In 2014 the concessionary powers of the public distribution of electricity and gas, and the creation, development, operation and maintenance of district heating and cooling networks were transferred from municipalities to metropolitan areas and intercommunalities (urban communities). Thus, these communities replace the communes within the existing energy unions.
With the energy transition law in 2015, intercommunalities (communities of municipalities) became organising authorities for energy and it became mandatory for those of more than 20,000 inhabitants to produce a climate air energy plan. The plan must include a diagnosis, a territorial strategy, an action programme and a monitoring and evaluation system—particularly regarding the distribution and transmission networks of electricity, gas and heat—the issues of energy distribution and an analysis of the options for developing these networks [3].

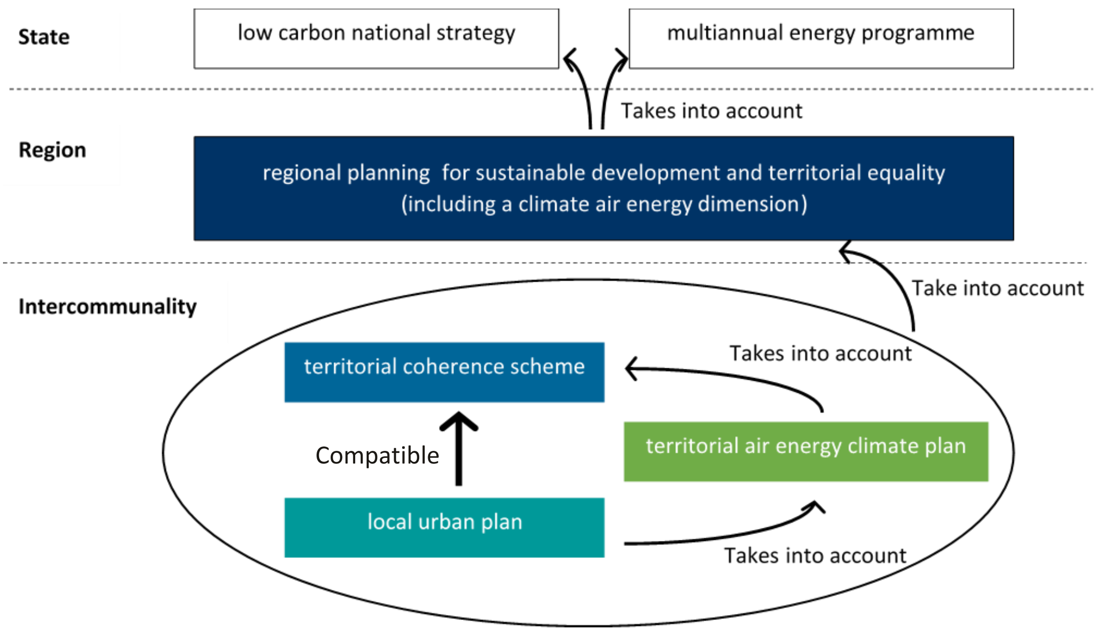

Figure 2 Simplified diagram of energy and climate governance in France.

Established by the energy transition law in 2015, the multiannual energy programme sets a trajectory for the energy mix, as well as action priorities for the management of all forms of energy in order to achieve the national objectives:

- Reduce greenhouse gas emissions by 40% between 1990 and 2030 and divide these emissions by four between 1990 and 2050;
- Reduce the final energy consumption by 50% in 2050 compared to the 2012 reference by aiming for an intermediate target of 20% by 2030;
- Reduce the primary energy consumption of fossil fuels by 30% in 2030 compared to the 2012 reference;
- Decrease the share of nuclear power in electricity production to 50% by 2035;
- Achieve an energy performance level in line with "low energy building" standards for the entire housing stock by 2050.

That notably means increasing the share of renewable heat to 38% of the heat sector[4].
To that purpose, subsidies for renewable heat production are available from a national Heat Fund. ADEME (Agency for Environment and Energy Management) subsidizes up to 60% of projects over 1.5 MWh/linear meter/year [5]. Regional and European Funds can also be mobilized. The energy transition law has also made it mandatory for a heating and cooling network master plan to be completed by the communities that own a heating network in service on 1 January 2009.
Renewable energy production equipment is eligible for reduced VAT if it complies with the support scheme. Regarding district heating, a reduced rate of 5.5% (instead of 20%) can be applied. Finally, a carbon tax (or climate-energy contribution) was put in place in France in 2014[6]. It is not a specific tax, but a component of internal consumption taxes proportional to the carbon content of fossil fuels (gas and oil). From an initial amount of 7€/tCO2, it will gradually increase to reach 100€/tCO2 in 2030.

Current main stakeholders

- The national government has set targets and delegated responsibility for heat planning to the intercommunalities;
- Electricity and gas grids are owned by municipalities or inter-municipalities, but their management is mostly delegated to energy unions (mostly at a departmental scale), which in turn put in place concession contracts with subsidiaries of EDF and Engie (the new name of GDF).
- District heating companies can be private, public or semi-public. Some district heating networks and heat production can be owned by (public) municipal agencies. Engie-Cofely (an Engie Group subsidiary) and Dalkia (an EDF Group subsidiary) are the main private[1] district heating companies in France.

[1] Though the French State still holds 30% of the Engie shares and more than 80% of the EDF shares.

Market situation

Since 1999, the French energy market has gradually opened to competition. This process of opening the market to competition was completed in 2007. From that date, all consumers are free to choose the operator of their choice.
Regarding district heating, the community or the energy union is the organising authority guarantor of the public service. It is, therefore, the city administration or the energy union that chooses to develop district heating. It can exercise this public service itself through a municipal agency, create a public-private joint venture, or delegate it to a private company through a delegation of public service concession or leasing.

- In a municipal agency, the community invests in the facilities and manages the operation.
- In leasing, the community makes the investments but entrusts the management to a company, which then pays a royalty.
- In concession, the community grants a private company (or a public-private joint venture) the realisation, operation and maintenance of the facilities. Concession is the most used management mode, accounting for 62% of district heating networks in France[7].

The Energy Regulatory Commission only has jurisdiction over the electricity and gas markets. The heat trade is a matter of local market laws, with less regular production costs, a potentially volatile clientele and with the additional constraint of the seasonal space heating part of consumption. Heat is thus locally governed as opposed to electricity and gas supply.

Amiens local context and project

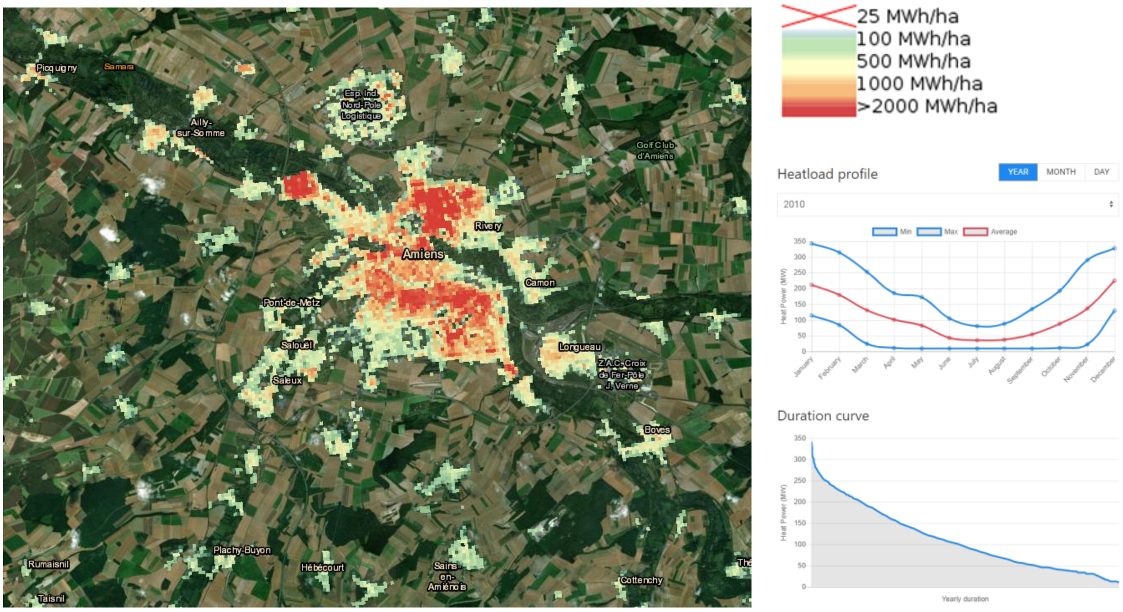

Figure 3 Amiens heat density and heat load profile

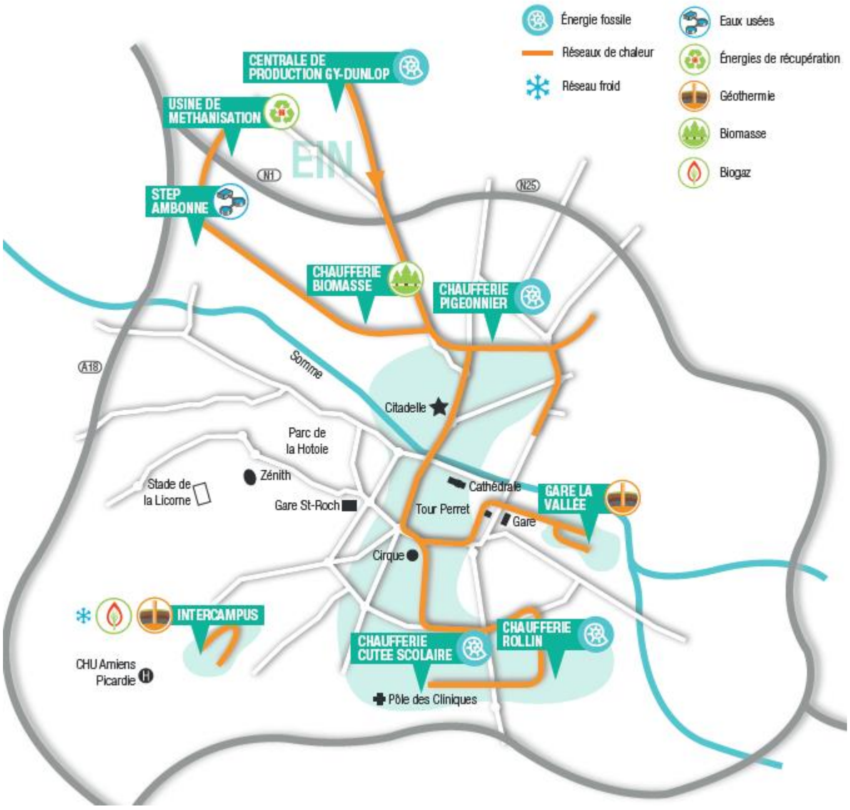

Figure 4 Amiens Energies district heating network layout . Source: Amiens Energies (http://www.amiens-energies.com).

District heating is a strong axis of Amiens energy transition strategy. The city of Amiens created an SEMOP (Société d'Economie Mixte à Opération unique), a public and private joint venture dedicated to the modernization and development of district heating in Amiens. This new legal form allows the community to be a real player in its networks, thus controlling the activity and adequacy of the service for the interest of Amiens.

The SEMOP of the city of Amiens, called Amiens Energies, is a first in France in the field of energy. The city of Amiens will be the first city in France to be equipped with a district heating network based on a unique energy mix combining five sources of local renewable energy:

- heat recovery from wastewater,
- recovery of the heat produced by the biogas plant for household waste,
- geothermal energy: the installation of heat pumps will make it possible to value the energy contained in the groundwater,
- biomass: local biomass resources will complete the energy mix by building a high-performance boiler plant,
- biogas: on the same principle as the recovery of the heat produced at the biogas plant, local biogas plants will be used to produce biogas.

The future network will also benefit from the latest digital technologies with an intelligent system including remote monitoring and control of facilities to guarantee maximum efficiency and responsiveness.

Main drivers

In addition to the national legislative and incentive framework, the Hauts-de-France Region, where Amiens is located, has initiated a ‘Third Industrial Revolution’ masterplan[2], one of the pillars of which is energy transition: the goal is to provide 100% of final energy consumption using renewable energy by 2050.
Another action driver at the local level is the establishment of an electric bus network in the City of Amiens. Amiens had the opportunity to share the road works necessary for the deployment of the bus network and the district heating network.
Finally, public service delegation in the form of a SEMOP has the advantage of offering secure, safe financing for the city: operational risks are fully transferred to a private company, through conventions that protect the city from any risk related to the execution of the service.

Main barriers

The main difficulty encountered is securing subscription contracts. Despite subsidies aimed at making the energy supplied by the heat network competitive with fossil fuels, competition with gas, in particular, is difficult. Potential subscribers connect to the heat network only if it provides them with savings.

Project planning

Following a call for tenders, the proposal from the consortium led by ENGIE Cofely was selected and resulted in signing the contract with the city in December 2016. This contract, concluded for a period of 25 years, focuses on the design, production, operation and marketing of its future district heating networks.

[2] https://rev3.fr/

1.1.2 Spain, Vitoria-Gasteiz

Vitoria Gasteiz local context and project

Vitoria-Gasteiz is the capital of the Basque Country with 240,000 inhabitants. Vitoria-Gasteiz, as with the rest of the Basque Country, relies almost completely (more than 90%) on importing fossil fuels both for direct use (natural gas, petroleum products) and for electricity generation. A natural gas network is available throughout the city and is widely used in the industrial, residential and service sectors. Cogeneration units are installed in a few public buildings such as hospitals, and to a minor scale in some residential buildings. Biomass fuel is used in some public buildings and swimming pools, but its use remains very low in percentage.

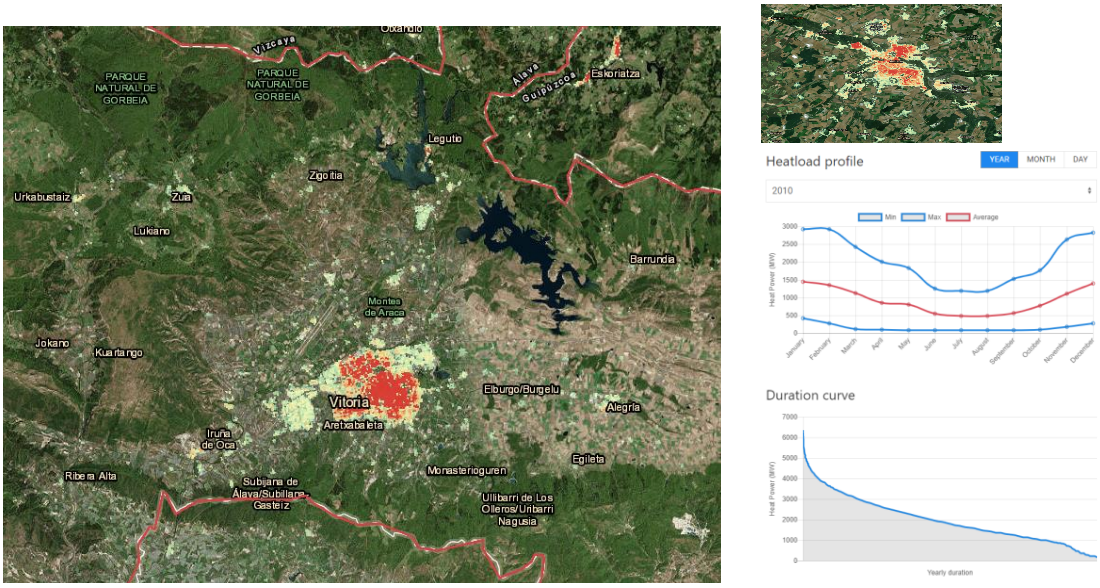

Figure 5 Vitoria Gasteiz heat density and heat load profile

As a Lighthouse City of the SmartEnCity project, Vitoria-Gasteiz aims to 1) demonstrate building retrofitting: 750 dwellings (60,000 m^2) in the Coronation district will be insulated, and their energy systems replaced with a connection to the district heating, and 2) create integrated infrastructures: a new biomass (wood chips) district heating network will be deployed, and integrated energy management systems will optimise efficiency at the home, building and district level.

The district heating system will be a public-private partnership with the ownership shared between the energy department of the Basque Country and the private developer and operator, Veolia, with 50% each. This enables the public to have an influence on the decisions and operation of the system and is a novel organization of heating infrastructure in Spain, where heat supply usually is privately owned. Energy is supplied by Veolia through a direct contract with citizens and owners of the buildings. Nevertheless, there is an agreement with the energy retrofitting promotor to add retrofitting and energy supply in the same invoice.

Regulatory framework and support schemes

Legislation promoting renewable energy started in the late 1990s in Spain. These were redesigned after 2010 as Spain was dealing with the international economic crisis. The legislation redesigned the former measures in order to control the overall subsidy cost of supporting renewable energy.

The Renewable Energy Action Plan of Spain sets an overall target of a 20.8% share of energy generated by renewable sources in gross final energy consumption, including 18.9% of heat consumption met by renewable sources in 2020.

Regarding the heating and cooling sector, a comprehensive set of measures are established depending on the technology (biomass, solar thermal, heat pumps). These measures cover grants to investment, soft loans, and technical assistance.

Main drivers for district heating in Vitoria-Gasteiz

Vitoria-Gasteiz aims to reduce its energy consumption by rationalizing energy use and promoting the use of more efficient technologies, such as district heating and micro-cogeneration, as well as greater energy efficiency in new and refurbished buildings. At the same time, the city aims to promote renewable energy sources such as solar power, geothermal systems, wind farms and biogas from urban waste. In line with these objectives, the city council adopted a climate change prevention strategy in 2006 and agreed to cut emissions 16% by 2012. In 2009, it signed up to the Covenant of Mayors and in 2010, approved the Plan against Climate Change, promising more ambitious reductions. The city's long-term objective is to become carbon-neutral, with an interim goal of cutting emissions in half by 2050 through actions in different sectors and public education.

Main barriers

Citizen engagement was needed for the district heating solution to be a success. What is more, district heating is crucial for the project in economic terms. As the area and urban impact of the solution are considerable, citizen engagement has been of key importance in order to explain its benefits and the comfort of controlling the heating supply.

Veolia assessed that 750 buildings were the minimum to connect to a district heating system before the project would be profitable.

District heating constitutes a novel organization of heating infrastructure and relies on new connections and institutions among citizens, the public sector and private companies. Two local heat planners explain that a considerable amount of time used in the project was spent explaining the benefits of a district heating system to citizens and prospective consumers. As the heat consumers were used to individual heating where they themselves were responsible for the functioning, district heating provides an uncertain new organization. With this technology, consumers are not themselves in control of the supply. Pricing was also mentioned as an issue, as district heating constitutes a natural monopoly.

This required new skills and new responsibilities of the district heating planners of Vitoria-Gasteiz. From being infrastructure engineers designing the technical specifications, this new technology and new concerns also demanded new work and roles of them.

1.2 Cases of new district heating areas

The following two cases will present examples of how local heat planners work with establishing new thermal grids in cities where there is established gas infrastructure. These cities and member states have some experience with implementing large-scale infrastructure, but also have to manage the existing infrastructure and related planning regimes in the move towards district heating.

1.2.1 The United Kingdom, London

London local context and project

The city of London has a total heat demand of 57 TWh/year [8]. An extensive gas network supplies the majority of heating, while buildings off the natural gas grid depend on other solutions, such as electricity and oil.

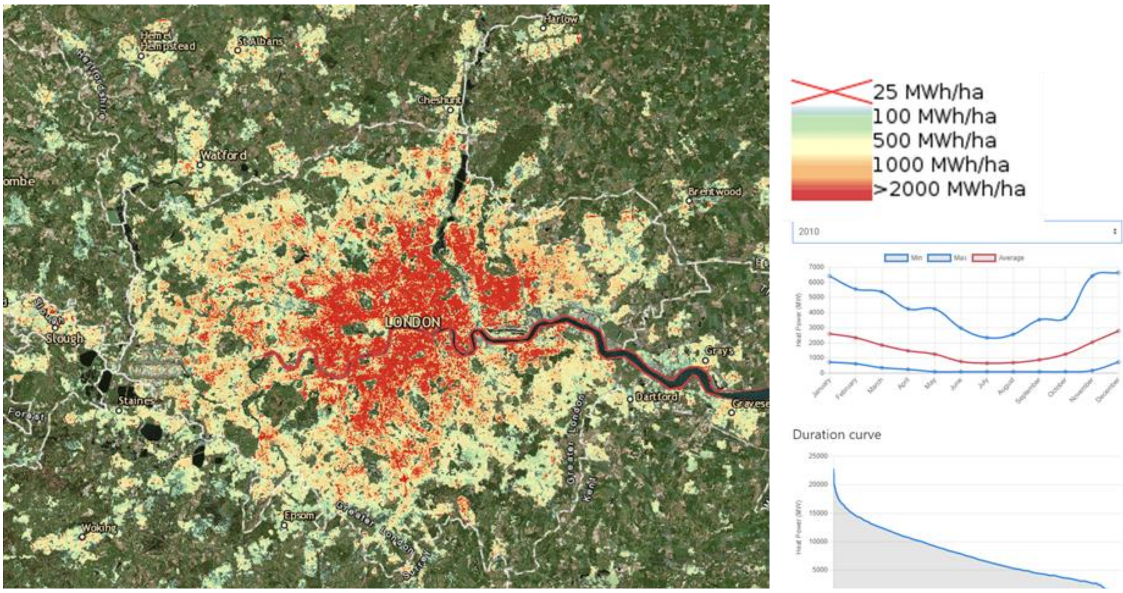

Figure 6 Heat demand density and heat load profile of the city of London

As London moves towards zero-carbon, decarbonisation of the heating sector is an important part of its strategy. Several technical solutions are being considered as alternatives to gas heating:

- Hybrid heat pumps, biogas, hydrogen: those technologies have the advantage that they can use the existing gas networks,
- Electric heat pumps,
- District heating.

District heating networks are deemed viable where the heat density is concentrated enough[3], which also allows the system to re-use energy and excess heat. Electrification of heat supply

[3] Research undertaken for Department of Energy and Climate Change has estimated that areas with a heat density of less than around 26 kWh/m2/yr are unlikely to support a viable heat network (Poyry

(heat pumps) can supply parts of the city, which are not suitable for heat networks. While the use of green gas or hydrogen could potentially be future options, they are currently not readily available.

Market situation

The UK energy market was privatized in the 1980s. The Office of Gas and Electricity Markets is the only electricity and gas market regulator in the UK and facilitates a market in which consumers may choose their supplier based on price and service.

District heating in the UK is thus an open market in the regard that customers are free to move to other supply forms. Nevertheless, it is obviously not possible to shift to technologies that require large investments in infrastructure if it is not already established. The private sector (private utilities and energy service companies) develops heat networks site-by-site (at building level and site level), and public communities (London Boroughs) tie heat networks together or develop less profitable areas for district heating. Developers work on both connecting new construction sites and existing buildings. If the building stock should be decarbonized, there is a need for connecting existing buildings to heat networks. But there are challenges to connecting buildings in already "utility congested" areas—where a lot of utilities already exist.

Developers prefer site-by-site developments and use the anchor heat load method: they develop the most profitable sites first, where there are higher heat demands and stable heat loads, which usually are public sector demands (swimming pools, schools, offices, block buildings etc.). The strategy is to get the easy connections that enable them to establish a viable heat network from which they can grow and connect to other buildings later. The idea is that it is easier to initiate dialogue with and convince buildings owners and developers once there is an existing heat network. Those anchor heat loads are therefore used to mitigate risk. Local authorities are taking an active role in the development of heat networks and can invest themselves. This differs among local authorities as some are more keen on investing than others. Usually, the public and private sectors are not in competition, as the public would not build where private utilities are building. Local authorities will then mostly build where it is not profitable for private companies or attempt to establish connections between smaller district heating areas.

National regulatory framework and support schemes

No price regulation exists in the UK, although the Competition and Markets Authority recommends that district heating utilities should be price regulated.

There are support measures at the national level:

---

and Faber Maunsell, 2009). The Potential and Costs of District Heating Networks: A report to the Department of Energy and Climate Change). This value is used in the report Decentralised Energy Masterplanning: A manual for local authorities produced by Ove Arup and Partners in 2011 as part of a commission from the London Borough of Haringey under the DECC funded Local Carbon Frameworks Programme.

- Heat network delivery unit: this decentralized energy enabling programme provides technical, commercial, and financial support to projects, through identifying projects and developing business cases.
- Renewable heat incentive: an investment fund was created (Department for Business and Energy and Industrial Strategy), proposing an investment programme for heat networks and providing development support for utilities and local authorities. In addition, the Renewable Heat Incentive, introduced in 2017, provides quarterly payments to heat installations such as solar thermal, heat pumps and biomass stoves and boilers.

Main drivers

London's strategic heat planning is driven by energy and climate strategies at different scales:

- At a national level: the UK government published its Clean Growth Strategy in 2017, an ambitious blueprint for Britain's low carbon future, in the context of the UK's legal requirements under the Climate Change Act (UK carbon account should decrease at least 80% compared to the 1990 baseline by 2050)[4]. Three governmental strategy documents lay out the plan for building renovations and heating strategy: The Energy Efficiency Plan, The Carbon Plan and The Future of Heating. The focus is on lowering heat demand through increased insulation, improving boiler efficiencies and supporting the use of renewables.
- At a city level: the Mayor's London Environment Strategy was published in 2018. It promotes the target of renewable energy and district heating supplying 15% of London's energy demand by 2030, and that by 2050, London will be a zero carbon city—with a zero emission transport network and zero carbon buildings.

Main barriers

A barrier to the current district heating development toolbox is risk-mitigation. The development of district heating is a risk-prone investment, as there is no mandatory connection to the heat network. This results in capital-intensive district heating network projects being high-risk investments for private investors. It is currently difficult to provide certainty for investors as there are no mandatory connection regulations, and consumers can postpone the choice of heating technology until after the heating networks are built. The London Boroughs and London Greater Authority can use their strategic position and facilitate risk-mitigation measures to promote district heating projects.

Project planning

The general project planning to develop district heating in London follows 3 main steps. First, mapping and identification of suitable areas; second, stakeholder mapping and involvement; and third, business model establishment.

---

[4] One week after the publication of the Intergovernmental Panel on Climate Change special report on the consequences of a 1.5°C warming, the British, Scottish and Welsh governments formally requested the Climate Change Committee outline the strategies by which the UK will sufficiently reduce its greenhouse gas emissions to help stabilize warming within 1.5–2°C.

Step 1: mapping and technology identification

The mapping is delegated to the London Boroughs, 32 local authority districts that carry out Energy Master Plans and provide heat density maps from where district heating feasibility is assessed. Heat density is used for guidance: above 50 kWh/m2 is a good opportunity for heat networks (though depending on whether it is a new development area or an existing one). Figure 7 above is from one such Energy Master Plan, where 7 clusters of high heat demand

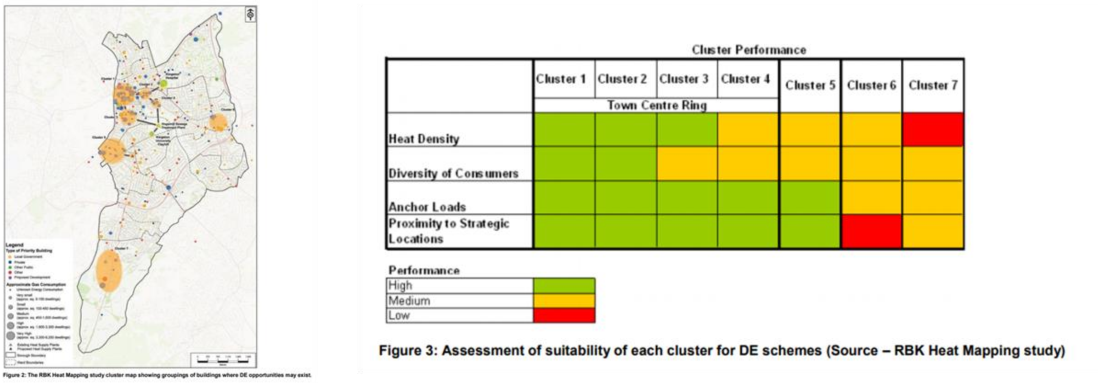

Figure 7 Example from Energy Master Plan of Royal Borough of Kingston upon Thames.

were identified, and assessed the feasibility of a heat network by analysing heat density, diversity of consumers, anchor loads and proximity to strategic locations. Elsewhere, heat pumps are recommended.

Step 2: stakeholder involvement

Stakeholder involvement is centred on the Energy Master Plan identifying potentials and opportunities. It serves to raise awareness of heat networks. The main stakeholders are:

- London Greater Authority;
- London Boroughs;
- Utilities (also sewage, water);
- District heating companies.
- Consumers

The London Greater Authority and the London Boroughs have a key role in stakeholder involvement and planning as they identify viable projects and aim to mitigate risk, as mentioned above.

Step 3: business model

When a viable area for district heating supply and the stakeholders are identified, the business model and specific project proposal can be carried out. Several private projects in London are site-specific and thus centre on establishing connections and heat supply between a few buildings or an area. Public projects focus on projects with a wider aim, as they attempt to bring together several heat networks or establish heat networks in areas not feasible for private developers.

1.2.2 The Netherlands, Rotterdam

Rotterdam local context and project

Rotterdam had a total heat demand of 7.7 TWh in 2015 [8], mainly supplied by gas, plus some district heating, electricity and oil. Rotterdam was bombed during World War II, and district heating was included in the build-up of the city in central areas. The 1950–60s started to roll out natural gas infrastructure due to the availability of a cheap local energy resource and the

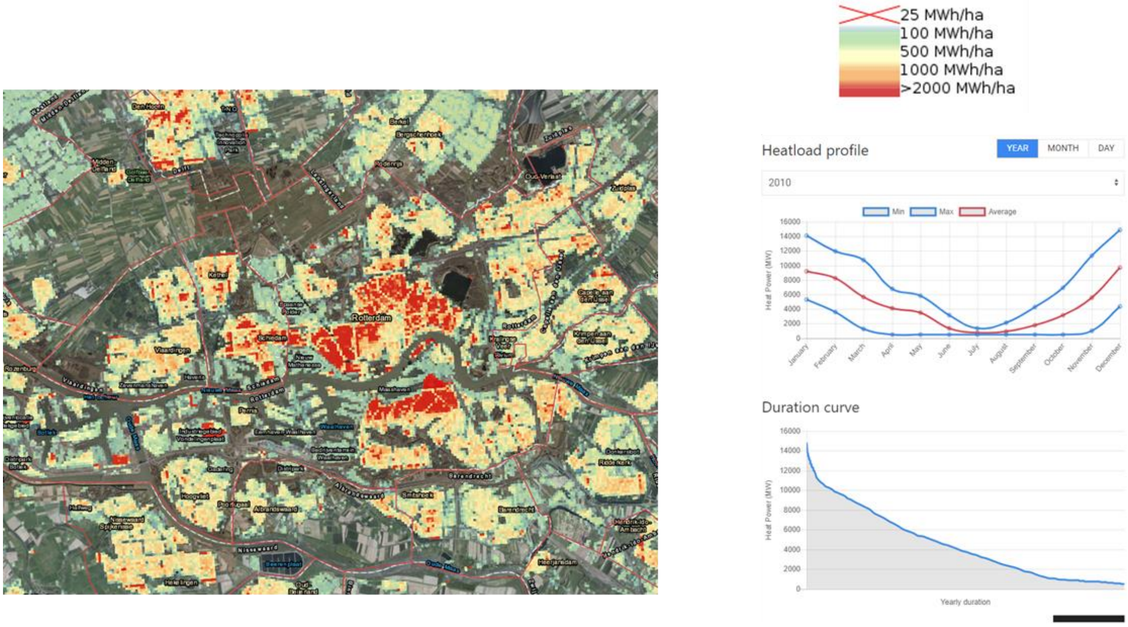

Figure 8 Heat demand density and heat load profile of the city of Rotterdam

expectation that nuclear energy would be available in the future. The idea was to capitalize the gas reserve as quickly as possible, and for as long as it was valuable. Natural gas, therefore, replaced coal for cooking and improved air quality. This transition happened over 10–15 years. Today most households are connected to the natural gas grid. Rotterdam is currently looking for options to transition away from natural gas: district heating systems at different temperature levels, either 90 degrees or low-temperature from 70 degrees; electrical individual solutions as heat pumps and cold storage; or biomass, biogas or hydrogen individual solutions.

A feasibility study considering the per area costs of heating, energy efficiency levels and costs as well as the costs in infrastructure, such as district heating grids or reinforcements of electricity grids, analysed the potentials for individual heat pumps and district heating. In most areas of Rotterdam, district heating would be the cheapest option based on this analysis. An important factor in this analysis is the level of housing insulation. The housing stock of Rotterdam is not insulated enough to utilize low-temperature heating, and the costs of improving energy efficiency are too high compared with a district heating solution supplying heat at 90 degrees, or 70 degrees after some renovation work. This mapping analysis points towards district heating as a feasible heat supply option in Rotterdam.

National regulatory framework and support schemes

The Dutch housing sector is targeted to be free from natural gas in 2050 due to earth tremors in the Groningen gas field and climate change mitigation targets. No new buildings are to be built with gas supply after 2020. This established national target delegates the responsibilities for implementing changes in the heating supply to local authorities.

In 2016 the investment subsidy sustainable energy (ISDE) scheme was implemented for supporting the transition from gas heating towards more sustainable heating technologies and energy savings. It supports solar thermal, heat pumps and biomass boilers.

The expectation is that new regulatory and financial instruments will be in place in 2021 to support the transition away from gas.

Stakeholders

The main stakeholders involved in developing district heating in Rotterdam include the following:

- The national government has set targets and delegated responsibility for heat planning to the city administrations;
- City administration is a central actor due to the knowledge of local systems, conditions of housing stock, and system maintenance, but lack some instruments;
- Electricity and gas grids are city / publicly owned and tightly regulated in terms of return on investments (consensus on the transition away from gas);
- Excess heat producers (waste incineration plants, industry, etc.)
- District heating companies are private and own both the networks and heat production.
- Consumers and citizens

Market situation

District heating companies are private and thus concerned with making a profit. They are allowed a profit, but the amount is regulated on a company level. This means that the district heating company as a whole is not allowed profit above a certain level. This does not apply on a project level, where the return on investment can be higher. Consumer heat prices are capped at the price of natural gas, which means that alternative heating cannot exceed the price of heating from natural gas. Taxation could be shifted from electricity towards gas, making heat pumps more competitive than gas boilers. The idea of the city of Rotterdam to expand district heating is to organize concession areas for heat supply and to do tenders for them. Heating companies can then bid for this area concession. Several problems arise here:

- The market maturation and number of actors available to make bids in the markets.
- The transfer from one baseline technology to another in the heat-price cap setting: unsure how a change from capping district heat costs at the natural gas price to, for example, a heat pump reference will change district heating consumer prices.
- Distribution of district heating network costs among consumers when networks are built in different stages.

Main drivers

The main project driver is the need to transition away from natural gas and move towards low carbon alternatives. Today two reasons drive the transition away from natural gas heating: 1) earth tremors in Groningen from Dutch natural gas sites and 2) climate change. These drivers provide momentum for the local authorities, as actors orient towards these goals and targets. Public ownership of gas infrastructure also enables a consensus on the transition away from natural gas in heating.

Main barriers

The Dutch government set a target to stop the production of Dutch natural gas in 2030, but there is no consensus on which technical alternatives should be the replacements. While the City of Rotterdam has conducted analyses of which heat supply options are feasible and certain project planning aspects, there is also a lack of regulatory instruments to promote district heating. There is a consumer protection regulation, but no legislation allowing the city administration to roll out district heating. There exist no regulatory possibilities to designate areas for district heating and thereby make sure that district heating will be developed to cover the socio-economical optimal areas. Currently, Rotterdam sees a risk that district heating companies only will connect “the low hanging fruits”; large buildings with high heat demand or demand close to the already existing grid, while avoiding connecting to other, more expensive buildings. By designating district heating areas, these buildings could be pooled together to a feasible business case by including more buildings.

Project planning

Rotterdam has implemented a twofold strategy that is directed at both the national policy level and local development experiments. Rotterdam currently lacks regulatory tools for developing district-heating projects, and therefore pushes for two options for national legislation enabling city administrations to promote district heating:

- The option to make transition plans describing where and when the technological changes would happen. This could include a mandatory disconnection year from the natural gas grids.
- The option for the city administration to promote a specific solution in an area. If residents prefer other solutions, it is possible, but no organizational help will be available.

In addition to this push for national regulatory tools, Rotterdam is conduction mapping exercises and stakeholder analyses as experiments of how to enable district heat planning. The mapping focus on heat density, building energy efficiency and potential heat supply. An important part of the analysis is the optimal investments in energy renovations and heat supply. As buildings increase in energy efficiency and lower their use temperatures, individual heat pumps gain a more competitive position compared to district heating. The stakeholder process includes grid and infrastructure actors, the national government, private district heating companies and residents. A main project planning strategy in Rotterdam is to combine district heating grid expansion with other maintenance work, such as sewer or water renovation work.

1.3 Experiences from consolidated heat planning countries

1.3.1 Lithuania

Lithuania has a total heat demand of 15.8 TWh/year [8], largely covered by district heating and renewable energy (biomass).

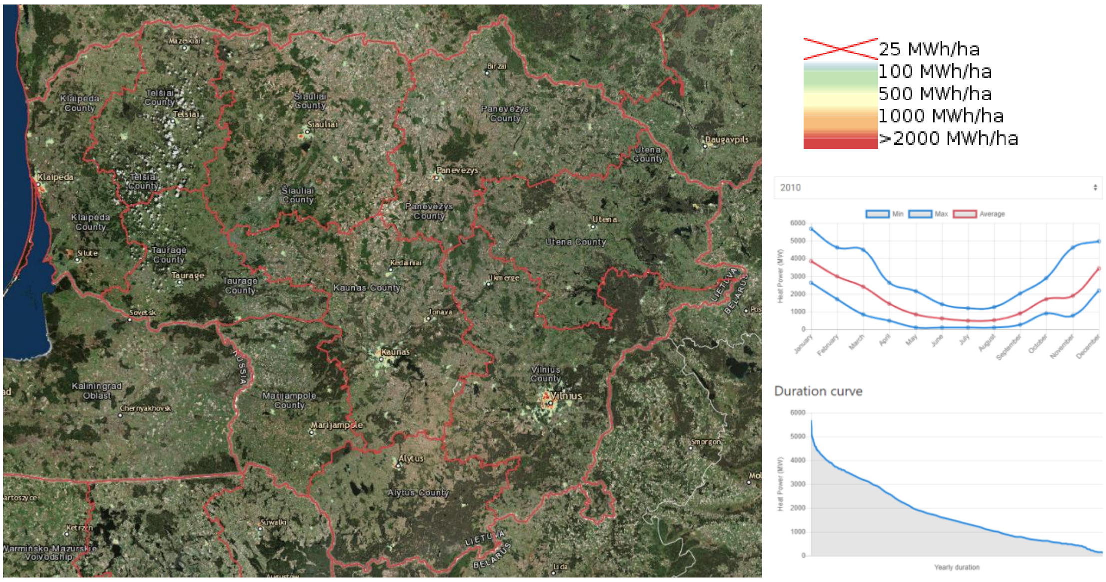

Figure 9 Heat demand density and heat load profile of Lithuania.

The Soviet Union promoted district heating as a way to use local energy sources and exclude foreign influence from oil and gas prices in order to provide stable heat prices. Today this infrastructure provides opportunities to meet contemporary challenges: CO2 emission reductions, renewable energy, energy independence.

Main drivers

In 2012, the Parliament of Lithuania adopted the National Independence Energy Strategy. Revised in 2018, the Strategy provides for four main directions of Lithuanian energy policy: energy security, the development of green energy, efficient energy consumption, and competitiveness and innovation. Regarding heating, the main objective is to increase energy efficiency by utilizing waste heat, heat consumption efficiency and increasing biomass use. The main driver to redesign district heating in Lithuania is available European funds for investments in energy efficiency, building renovation and new technologies. This availability attracted other investments, commercial loans and funding options. As a result, building and network renovations have improved efficiencies—for example, biomass boilers are equipped with condensing economizers. Heat network losses improved from 35% to 15% since the Soviet times, and heat production efficiency improved 10-15%.

Main barriers

The main problem in Lithuania is the poor quality of buildings and building standards, combined with a lack of temperature control resulting in either too high or too low temperatures, depending on building standards (and lack of thermostats) and also on the pipelines and substations, with heat losses as a result. In addition, the heat pricing structure is based on the number of square meters and not actual consumption. This resulted in a very negative view and perception of district heating, and many cities in Lithuania experienced high disconnection rates.

Municipal Energy Plans

According to the Danish example, heat planning and zoning have been introduced. Municipalities can introduce heat zones according to connection, heat density etc., where disconnections are restricted. Formally, municipalities must have these plans, but not all of them have one today. Either they have expired (which happens after 7 years) or they have not been carried out. There is a push from the Lithuanian District Heating Association to make the national government prioritize these plans and ensure that municipalities make and assess them. They provide part of the basis for district heating development, planning of networks, production units etc. As infrastructure is a long-term investment, security and long-term development are needed.

Market situation

Until 1997, district heating companies were state-owned. After 1997 the ownership moved to the municipalities. But the municipalities lacked the knowledge of how to operate the district heating systems so that several models for operation and privatization were used. Some companies were privatized, and some were partly privatized by selling shares. The most used model was concession agreements with private operators for 15–25 years. A concession can be defined as:

- The grant of exclusive privileges (such as to be the only supplier of a service) for a fixed term by a government authority to a private sector operator known as a grantee (or a "concessionaire"). In return for the privilege, the concessionaire pays the government authority a certain percentage of the earnings.

The concession agreements allowed municipalities to learn how to operate district heating systems and gain experiences from each other. Therefore, as the concession contracts run out, many of them are being taken back and operated by municipalities.

Suppliers are obligated to purchase and distribute heating generated from renewable sources if it is cheaper than alternative generation and is of comparable levels of quality and meets supply security.

Regulatory framework

District heating supply is subject to regulation by the national control commission. They check energy efficiency status, benchmarking (notably with gas heating) and carry out comparative analyses. If the efficiency is poor or below thresholds, the district heating company must improve it. The control commission can withhold financial resources for the district heating companies if they do not meet the targets. Access to European funds is also determined by these efficiency measures and is limited to those who can improve their performance characteristics. All investment projects must, therefore, be approved by the municipalities and are nationally regulated. Project owners must prove that the investment is necessary for efficiency, economical and reliable. Profits are allowed but regulated. The Heat Law was approved in 2003 and introduced incentive pricing. For a five year period, all fixed costs are frozen in the district heating companies, only adjusting for inflation and fuel prices. By improving operations, efficiencies etc, companies can improve profits. After five years, companies are checked for “overprofits” and if this exceeds a certain threshold (50%), the profit must be returned to the customers (although this has never happened in Lithuania). Municipalities can set district heating areas where only licensed district heating companies are allowed to operate and new customers must be connected to the grids. Additionally, disconnection from district heating is restricted in these zones. Finally, a VAT of 9% instead of 21% is applied to the heating cost for households connected to district heating. All these measures—regulation of disconnection, social support schemes for vulnerable consumers, special subsidies, investment subsidies—directly promote district heating.

1.4 Heat planning in Denmark: Top-down policies and bottom-up power

Some of the countries that have the highest share of district heating are Denmark and Sweden. The measures highlighted by HRE has been successfully implemented in these countries with 50–60 per cent of heat demand met by district heating services.

The following will outline the case of Danish heat policy, which is based on an established heat planning framework. Parallels will also be drawn to the Swedish system, which differentiates from the Danish case at certain key regulatory parameters. Although the neighbouring countries are quite alike when judged on the large share of energy efficient district heating systems, their experience and tradition of district heating regulation differ.

For Denmark, the connection rate to established district heating systems within district heating areas is 82 per cent, which is relatively high [9]. District heating covers 50–60 per cent of total heat demand.

The development in the Danish heat sector did appear out of abstract ‘market forces’ but is the result of conscious policies that addressed national challenges with the involvement of a broad range of energy actors, including local stakeholders and authorities.

Heat planning in Denmark had a beginning. The first national heat plans were initiated as a consequence of the oil crisis in the 1970s when almost all of the Danish energy supply was based on the oil. At the time there was no developed institutional framework for energy policy and planning, as the first governmental body to react to the oil crisis was in the

Ministry of Trade. When introducing the first heat law in 1979, the district heating share of heat demand was around 30 per cent [10]. 15 years later, the share was around 50 per cent of heat demand [10]. In the same period, individual fossil fuel boilers lost around 20 per cent of the market share [10].

In Denmark, there is relatively large local autonomy for local energy actors, which is most clearly institutionalized in the heating sector. Municipalities carry out heat plans and have a high degree of involvement in heat planning. This role of municipalities was first introduced and required by national law in 1979.

The local planning activities and power must be understood in the national framework. It is through national laws that municipal planning power is granted.

Further, the municipal planning regimes are supported through national recommendations and requirements. This includes technical and economic standards that are issued by the Danish Energy Agency. Likewise, the national building codes have been the tool for improving the building stock.

The strategic role of national regulation was to define targets and long-term goals. At the same time, national regulation granted local actors the freedom and responsibilities to meet the targets

1.4.1 Overall planning regime

The overall heat planning regulation in Denmark consists of legislation and responsibilities at several governmental levels. The central legislative initiative at the national level has been the heat supply act of 1979, legislation directly aimed for regulating heat supply. This was the first legislation directly aimed for regulating the heat sector and requires municipalities to analyse its local heat demand and local heat resources [9]. The central role of local authorities has also been highlighted in the development of the Swedish district heating systems [11]. Additionally, the electricity supply act of 1976 has played a role, as it required all new electric capacity to be combined heat and power plants [9].

The legislative framework regulating heat planning in Denmark, distribute power, and responsibilities across all governmental levels. In general, high-level governmental bodies outline binding goals and/or overall regulative framework while the power to make concrete decisions to meet national goals are taken at lower levels of governance. An overview is given in the figure below:

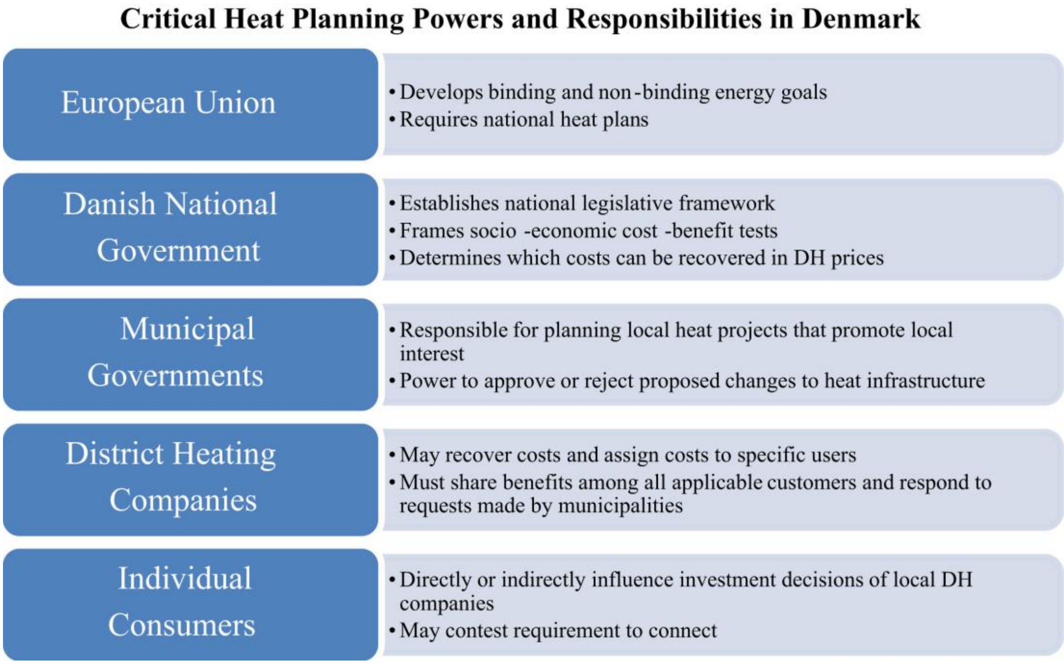

Figure 10 Different levels of government involved in Danish heat planning [9]

1.4.2 Planning processes

A key characteristic of planning in the district heating sector is the requirement of socioeconomic calculations. Founded in the heat law regulating the sector, investments in the district heating sector can only be made if demonstrated to socioeconomic viable. This means that district heating cannot act upon business economic incentives alone.

For a prospective investment project, the district heating company carries out a socioeconomic analysis of the project. The calculation is based on data and guidelines on methodology provided by the national energy agency. It is the role of the municipality to assess the socioeconomic analysis and evaluate whether the project is socioeconomically viable according to the methodological principles issued by the national energy agency. Based on this assessment, the municipality approves or rejects the project proposal. If approved, the district heating company can realise the investment project.

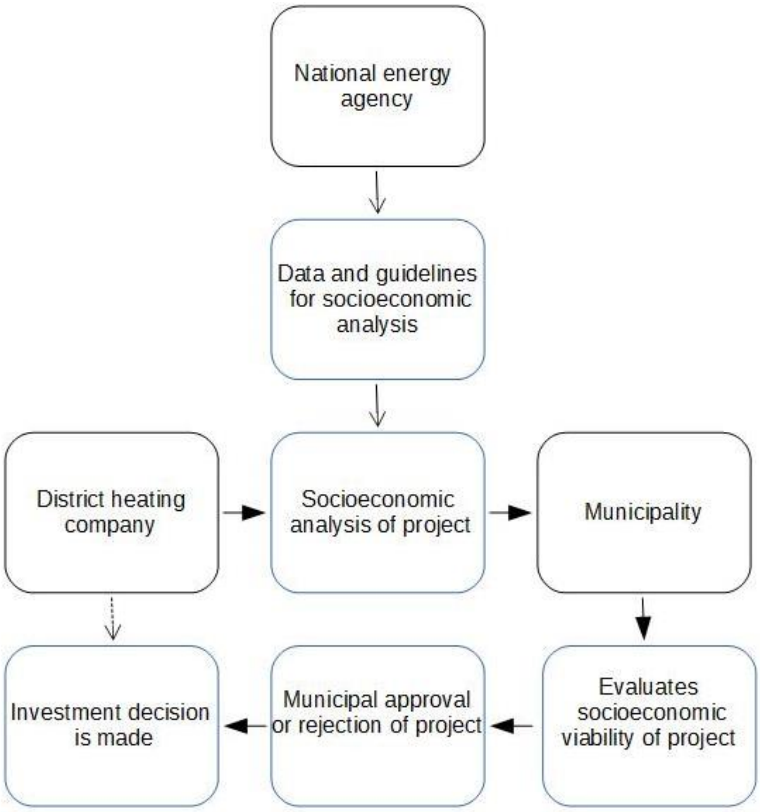

Figure 11 Illustration of how socio-economic assessments are instiutionalised in Danish heat planning.

The strength of this systematic use of socioeconomic evaluation is that it institutionalises socioeconomic considerations in the investments—as opposed to decisions made purely on business economic incentives. However, a byproduct of the institutionalisation is that methodology and analytical assumptions become political arenas. Naturally, the guidance and methodological requirements provided by national authorities may become a target for lobbyism by energy companies. Hence, the procedure is not stronger than the quality and independence in the methodological guidelines for socioeconomic evaluation carried out at the company level.

1.4.3 Ownership and price models

The challenge of regulating the monopoly infrastructure in district heating systems has historically been successful.

The basis for making large investments in the grids has been 1) access to financial capital through governmental bodies and 2) the obligation for buildings in dedicated areas to connect. In combination, this has allowed heating companies to achieve long-term, relatively cheap financing of the large capital costs. In addition, the obligation for consumers to connect has provided the needed certainty for long term planning in the heat companies.

The obligation for consumers to connect has been counterbalanced by giving large democratic influence to heat consumers. Most district heating companies are owned by the consumers and some are owned by the municipalities. Only a very few have been subject to commercial private ownership.

The price regulation has been a 'non-profit' or 'true cost' principle. This principle implies that heat companies cannot charge more for the heat than it costs to produce. This price regulation has proven to work best in combination with democratic ownership structures. In an analysis from the Danish energy regulation authority, consumer-owned companies were the cheapest and municipal companies were the second cheapest. Accounting for relevant factors, private commercial ownership has shown to result in the highest consumer prices under the true cost principle [12]. The problem is that authorities can have difficulties in monitoring the true costs in heat companies if the heat company is not inclined to reveal the true costs. In a consumer-owned company, on the other hand, the owners and consumers have a common interest in low heat prices. This case illustrates that the price regulation model must be fit to the ownership model that is applied to the sector.

Experiences from Sweden show that ownership structures may influence the institutional capability to carry out strategic heat planning. The privatisation of municipal heating companies in Sweden has, in some cases, weakened the institutional capability to carry out long term heat planning [13]. These experiences show the question of ownership structures is not 'only' about securing access to capital and maintaining low consumer prices but also should be considered from a long term strategic perspective.

1.4.4 Challenges ahead

The Danish case illustrates a heat planning regime that has succeeded in building up a large share of district heating, thereby improving the overall efficiency in energy supply.

However, Denmark is also a case showing that strategic heat planning is still needed despite that the heat sector is relatively advanced in comparison to other European countries. The energy system around the district heating sector is changing and the heat sector needs to adapt. One central consequence of this change is that CHP units get fewer operation hours as they are being replaced by renewables in the electricity sector. Thus, a traditional strategic competitive advantage for the district heating sector based on the efficient use of fossil fuels is vanishing. Research within 4^{th} generation district heating has identified the role of district heating in a renewable energy system [14][15]. The research concludes that the benefits of district heating systems are still in place in a renewable energy system, but the district heat sector must change. This change involves large-scale heat pumps, new renewable non-fuel heat sources, and a continued focus on excess heat from industrial processes. The change also involves large heat storages and lower distribution temperatures which enables larger amounts of excess heat from industrial processes to be utilised and larger efficiencies of large-scale heat pumps and other production capacities.

Besides the historical lessons, the Danish case, therefore, also illustrates the permanent importance of reassessing national strategies. Current development seems to lack an integrated approach where the policies are redesigned from an energy systems approach [16] While the bottom power still exists and is applied, the national targets and regulation have not been sufficiently updated to the strategic aims for a 100 per cent renewable energy system. This highlights the importance of a coherent cross-sector regulation. Denmark needs to redo the historical process that builds up the CHP based heat supply to transform the system into a renewable energy-based system. In other words, the strategic heat sources are changing —from excess heat from CHP to excess wind energy from the electricity system combined with new renewable direct heat sources such as solar thermal and geothermal energy—and the strategic heat planning needs.

2 Case analysis and synthesis

Fejl! Henvisningskilde ikke fundet. below presents an overview of the main ownership structures, price models and the challenges and benefits found. There is a high diversity in the organizational structures, drivers and barriers identified. Several cities and countries have no price regulation, while Denmark uses the true cost principle, and Lithuania deploys a company cap on profits. In the Netherlands, the price is capped at the reference price of natural gas. The main drivers and barriers are also presented in the table and will be

Table 2 Overview of ownership, price models, experiences, challenges and strengths of the cases

elaborated in the sections below.

Case	Ownership & price model for production	Ownership & price model for the grid	Experienced challenges and/or strengths
Amiens	Municipal ownership (concession agreement to a public-private joint venture) No price regulation	Municipal ownership (concession agreement to a public-private joint venture) No price regulation	Challenge: reconcile private and public interest Benefit: risk mitigation
Vittoria-Gasteiz	Private commercial ownership No price regulation	Public-Private Partnership	Challenge: citizen engagement, planning strategy with ownership unbundling Benefit: reduce energy consumption and contributing to climate goals
London	Private commercial ownership No price regulation	Private commercial or municipal ownership No price regulation	Challenge: risk mitigation, planning strategy with ownership unbundling Benefit: Contributes to London's climate goals
Rotterdam	Private commercial ownership Price cap based on natural gas price	Private commercial ownership Price cap based on natural gas price	Challenge: market maturation and connection of low-profit areas Benefit: Transition away from natural gas
Lithuania	Municipal ownership (concession agreement to private companies) Cap on profits	Municipal ownership (concession agreement to private companies) Cap on profits	Challenge: Low building quality, low energy system performance and lack of temperature controls and effective pricing schemes. Benefit: Potentials for improvement, available European funds
Denmark	Municipal, consumer-owned or private True costs	Municipal, consumer-owned or private True costs	Challenge: adopting existing regulation and policies to new technological systems Benefit: Energy efficiency, integration of renewables, sector coupling

2.1 Main project drivers

Most drivers share the fact that they are a set of external or top-down priorities that the local authorities can orientate towards and can give local policy and action direction and momentum. External drivers can have different roots, such as earth tremors in the Netherlands, climate action or available funding. London is a case of a local administration setting more ambitious targets than given from national level but still aligned with the national framework.

Drivers usually include targets, criteria or other measures setting a direction. In order to receive the EU structural funds, Lithuanian district heating companies must show energy efficiency improvements. Rotterdam implemented target years of 2030 and 2050 where national gas production and use will stop, respectively. These targets set a direction and context for the local administration and are the first step towards strategic heat planning.

Other drivers also exist in addition to those mentioned here, such as the EED Article 14 where member states are asked to perform comprehensive assessments of potentials for efficient district heating and cooling. These activities can help create awareness at a national level, in countries without a tradition for heat planning activities.

Local authorities can also themselves set the targets to drive projects forwards, and many cities today are more ambitious than their national governments. Cities are in closer contact with citizens, utilities and companies enabling them to conduct experiments, make new coalitions among stakeholders and involve citizens in projects. However, as has been presented and will be elaborated below, cities and local authorities also often find themselves in regulatory, legislative and market settings promoting the heat supply options of the past.

While having different roots, these drivers are important for strategic heat planning. They move projects forward and allow the actors to build alliances with other stakeholders moving towards the same targets. Whether grounded in action against climate change, keeping energy prices affordable, improving energy security or utilizing local resources, it is important for local heat planners to find and align strategic planning with local causes. Most often, these drivers will be the main cause to start the strategic heat planning activities.

2.2 Main project barriers

A range of barriers were mentioned in the case studies, usually involving the local context and heat sector situation. This is not surprising as heating is locally situated and therefore depends on local conditions. It is important to acknowledge that strategic heat planning is not carried out in a vacuum, but within already existing heat supply systems, established building stock, user preferences, incumbent production and supply companies and regulation shaped to the current and not future system etc. Lock-in forces can, therefore, be found within several of these aspects. User perception of district heating, low building standards, high investment risk and a lack of regulatory tools were mentioned in the case studies.

It can also be noted that the national political discourse regarding public involvement in heat supply influences what is regarded as a barrier. In London, the uncertain connection rates for new projects is perceived as an economic risk and thus a market barrier, while in Rotterdam the same challenge is seen as a regulatory problem. While London deploys a market-oriented approach to overcome barriers, the strategy of Rotterdam is to influence national regulators to allow for more regulatory tools.

Local authorities facing barriers towards implementing low-carbon heat supply options should note that it could be difficult to find areas with similar challenges. This is not to discourage heat planners, but to prepare them for a reality with a plethora of challenges that likely are shaped by local conditions.

2.3 Ownership and market situation for district heating

The cases presented here show different schemes of market and ownership organization between public and private actors. No simple organizational methods were found, but rather different configurations of public-private partnerships. The cases present several ways of organizing ownership and different implications from these choices. Rotterdam especially has considerations about the market governance of how to align private developers, reasonable energy prices and a socio-economically feasible district heating coverage. This entails a careful organization of pricing mechanisms, ownership structures of both grids and production sites as well as regulation and incentives to connect larger areas that might not be feasible from a strictly business-economic viewpoint.

Lithuania and the Netherlands both have profit regulations, where a surplus is allowed but within a certain margin. The Netherlands regulate the allowed profits on a company level, and specific projects can, therefore, differentiate from this threshold. The consumer price of district heating is capped at the price of natural gas heating. This consumer price regulation is useful if there is a proper benchmark available, but the choice of natural gas has proven difficult in The Netherlands after the choice of phasing the fuel out. It is likely that choosing a new threshold, such as for example heat from heat pumps, will result in adjusted district heating prices to the new level. As such, this pricing model does not necessarily reflect the costs of production and does not incentivize improving energy efficiency in itself. The UK deploys a market-liberal approach of free price setting, under the assumption that competition will keep prices low. The risk is that, due to high connection costs, district heating companies will be able to exercise some sort of monopoly power towards consumers.

2.4 Planning Process

The planning processes covered in the cases follow similar patterns from mapping exercises, stakeholder identification and involvement to the business case and implementation stages. Similar steps are taken in other research projects, such as Heat Roadmap Europe, as well as in the Comprehensive Assessments of the EED, where mapping heat demands, excess heat sources, technological potentials and energy efficiency status and possibilities are carried out. This entails the first step of a strategic heat planning process. The mapping stage is important, as this will frame the possibilities and alternatives considered further in the process, as well as the stakeholder involvement. Both Rotterdam and London discuss the share of heat pumps and district heating considering their heat demand mapping. The mapping exercise, therefore, impacts which solutions are considered later in the process and which stakeholders to involve, as different actors are responsible for heat pump or district heating solutions.

The next step after mapping is usually stakeholder involvement, as they form part of defining the following steps. In the Rotterdam and London case, it is planned that private companies will do the majority of construction and implementation, and they are thus part of the initial process. A consideration for local authorities is when to involve private developers, as there can be a mismatch between the optimal levels of district heating seen from public and private viewpoints. Local authorities should consider keeping the ability to plan for the socio-economic optimal share of heating supply options and energy efficiency.

The next steps concern business plans and implementation strategies. Are concessions or tenders used? Is regulation available to disconnect areas from the fossil fuel supply and mandate the use of heat networks or heat pumps? Are local authorities able to present feasible areas for district heating connection to private companies? These steps entail new stakeholders as other implicated parties should be included. Utilities, transport management and local citizen organizations should be included in the planning of construction work for new piping, district heating connections and substation implementations. Both time and money, as well as considerable amounts of annoyance, can be saved by scheduling maintenance and implementation across utilities.

3 Conclusions

This document presented case studies of several cities working with introducing or expanding district heating systems. The cases are organized from novel situations where district heating is an innovative technology, to cases where district heating is an established and well-known heat supply method.

Cases of new deployment struggle with consumer support and perception, unknown and risky market terms and a lack of regulatory support. These socio-technical systems are not adapted to the district heating technology. On the other hand are the cases of countries that have long experience with district heating. Here it is a well-known technology, regulated by the public with more stable market terms. This can still produce barriers for the further development of the system itself, as new technologies might not fit into established regimes.

This report served as a means of showcasing the differences among cases, as one size fits all solutions are not likely to meet these differences. Instead, heat planners on national and local scales must adapt solutions to the specific conditions of useful technologies, user preferences, legislation and market designs.

4 References

[1] Odyssee-Mure. Odyssee 2017.

[2] Fouquet D, Allena M, Barrett E, Bartek-Lesi M, Benito P, Bernatonis V, et al. EU Energy Law Volume III. 2ndEdition ed. Deventer: Claeys & Casteels Law Publishers; 2018.

[3] Reseau Action Climat France. Nouvelles compétences climat-énergie 2016.

[4] LOI n° 2015-992 du 17 août 2015 relative à la transition énergétique pour la croissance verte n.d.

[5] ADEME. Fiche descriptive Fonds Chaleur 2018, section reseaux de chaleur – ADEME n.d.

[6] Bulletin Officiel des Finances Publiques-Impots. Article 278-0 bis du Code Général des Impôts n.d.

[7] Cerema. Fiche Cerema "Acteurs des reseaux de chaleur" 2016.

[8] HotMaps. Toolbox 2018.

[9] Chittum A, Østergaard PA. How Danish communal heat planning empowers municipalities and benefits individual consumers. Energy Policy 2014;74:465–74. doi:10.1016/j.enpol.2014.08.001.

[10] Werner S, Frederiksen S. District Heating and Cooling. Lund: Studentlitteratur AB; 2013.

[11] Magnusson D. Between municipal and regional planning: The development of regional district heating systems in Stockholm from 1978 to 2010. Local Environ 2011;16:319–37. doi:10.1080/13549839.2011.573472.

[12] Energitilsynet. Store forskelle i varmepriserne – hvorfor ? 2013.

[13] Magnusson D. District Heating in a Liberalized Energy Market: A New Order? Linköping University, 2013.

[14] Lund H, Werner S, Wiltshire R, Svendsen S, Thorsen JE, Hvelplund F, et al. 4th Generation District Heating (4GDH). Energy 2014;68:1–11. doi:10.1016/j.energy.2014.02.089.

[15] Lund H, Alberg P, Chang M, Werner S, Svendsen S, Sorknæs P, et al. The status of 4th generation district heating : Research and results 2018;164. doi:10.1016/j.energy.2018.08.206.

[16] Hvelplund F, Djørup S. Multilevel policies for radical transition: Governance for a 100% renewable energy system. Environ Plan C Polit Sp 2017;35:1218–41. doi:10.1177/2399654417710024.

www.hotmaps-project.eu

Funded by the Horizon 2020 programme
of the European Union