Handbook I

Definition & Experiences of Strategic Heat Planning

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Project Information

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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 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 heating and cooling (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 Open Source License.
- **EU-28 compatible**: the tool will be applicable for cities in all 28 EU Member States

The consortium behind

Scientific partners

Pilot areas for developing and testing the tool

Bistrita Municipality

Executive Summary

This report provides guidance about how to carry out strategic heat planning activities within the EU-28 member states, in order to address three main challenges: reducing CO2-emissions, improving the security of supply, and improving the economic balance by circulating a larger share of energy costs within the European Union. Strategic heat planning may also address several local or regional issues, such as utilising local heat sources or improving air quality.

Strategic energy planning addresses issues with current energy supply and formulates strategies for transitions. It largely depends upon the technical, societal and economic context of the energy supply, as the actors involved, means of actions and available options will differ between situations.

Strategic heat planning activities are interdisciplinary activities carried out within established networks of actors and institutions. These networks include diverse agents such as public authorities on several organisational levels; private energy companies, incumbents supplying consumers and emerging companies delivering new technological solutions; established infrastructure, grids and supply methods; energy regulation, taxation and subsidies; resource availability, domestic as well as imported fuels, and, related to this; energy security issues; political agreements for future energy supply and the methods used to combat climate change; and the companies and consumers who have to adopt technologies and pay energy bills.

This report presents a three-phase framework for carrying out strategic heat planning activities. These phases may depend upon contexts and scopes of analysis. Before beginning the analysis, an initial process to define the scope and goals of the strategic heat planning activities should be carried out.

Phase 1: Construct technical scenarios for a strategic heat supply

In this phase, the possible technical scenarios are identified, evaluated and described. This process may follow the even-step procedure described below. Based on this procedure, a solution can be chosen to meet the strategic objectives.

Phase 2: Evaluate existing framework conditions and identify key stakeholders

In this phase, economic and political barriers and opportunities are identified. A part of this process involves mapping central stakeholders and analysing which roles they are likely to play in a transition process and what role they may play in future heat supply.

Phase 3: Make an implementation plan

In this final phase, the relevant authority searches for ways to modify or change existing regulations to support the best solution. This phase also involves considerations for shaping key organisations to transition and operate the heat supply system. This involves dealing with ownership and price models as described above for the purpose of ensuring consumer and citizen acceptance, mobilising capital, and creating an institutional platform for strategic actions and long-term planning. Part of the institutional platform for strategic actions and long term planning involves identifying or creating organisations responsible for taking action.

Connection to other Hotmaps materials

This report has been made within Work Package 5 (WP5) of the Hotmaps project. The work describes strategic heat planning practice, experiences among the EU-28, and provides guidance for local and national heat planners in the use of the Hotmaps toolbox. The reports describe the wider governance frameworks that can enable or restrict the utilisation of strategic heat resources and the deployment of district heat planning. The following reports are the result of WP5 and can be used in parallel.

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

Handbook 2 provides guidance and recommendations about how to carry out the comprehensive assessments in relation to Article 14 of the Energy Efficiency Directive, and also 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 have already, 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 in strategic heat planning
- Handbook 1: Definition and experiences of strategic heat planning
- Handbook 2: Guidance for comprehensive assessment on 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 for the Handbook in 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 via the following link: 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:(https://github.com/HotMaps/hotmaps_wiki/wiki)
- The heating and cooling strategies carried out within the Hotmaps project by the pilot areas.

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1 Introduction

Like the rest of the world, countries in the European Union are facing the challenge of decarbonising their energy supply. The European Union is also highly dependent on imported gas. Phasing out fossil fuels in the energy supply therefore holds a three-fold promise: it may reduce CO2 emissions, improve the security of supply and improve the economic balance by circulating a larger share of energy costs within the Union.

Heating and cooling accounts for about 50 percent of final energy use in Europe (Fleiter et al. 2017). Several research projects on a European scale have developed possible technical pathways for the European heat sector, for the purpose of realising the potential of phasing out fossil fuels and reducing CO2 emissions.

This report will focus mainly on strategic heat planning, as heat demands account for a significant proportion of total energy consumption, compared to cooling demands. There is also greater experience in heat planning on which to draw, as some countries have been addressing this issue for more than 40 years. This report will therefore primarily focus on how to carry out strategic heat planning, and these lessons can possibly also be translated into guidelines for how to approach the development of district cooling infrastructures.

The point of departure for strategic heat planning in Europe is the common European ambition of phasing out fossil fuels in the energy system. The heat sector is vital to policy with respect to these ambitions. At the same time, the scarcity of biomass resources is a condition that has to be taken into account in strategic energy policies and is an integrated part of the challenge of transitioning to a sustainable energy supply.

Research has demonstrated how this transition challenge can be met in the most efficient way by applying an integrated approach to energy system analysis. An integrated approach implies that heat, transport, gas and electricity sectors are assessed as one coherent system. The synergies between the different energy sectors can be uncovered in this way and the most efficient solutions identified.

One of the studies which has carried out an analysis of the European heat sector using an integrated energy system approach is the Heat Road Map Europe study. The Heat Road Map Europe study highlights district heating, and energy efficiency as technical measures for realising European potential through energy savings in buildings and individual heat pumps in areas where district heating networks are not economically viable (see e.g. Paardekooper et al. 2018).

Heating is, to a large degree, both a national and a local matter. As thermal energy cannot be transported over long distances, thermal networks are only viable in areas with high-density populations. Outside these areas, buildings rely on building-specific heating technologies. In addition to these technical constraints, heating infrastructures has developed historically with available resources, national legislation and political environments. This means that the 28 EU member states are today in different situations regarding their heating supply. These contexts must be taken into account when moving forward and seeking to realise the three-fold ambition of a heating supply transition.

The scientific literature has already demonstrated that implementing the relevant technical measures requires focused policy and planning, and it is therefore relevant to collect experiences of strategic heat planning in order to support the implementation of the technical solutions that may serve as a means for phasing out fossil fuels.

This handbook highlights main elements and formulates guidelines for the policy and planning task confronting Europe for use as a supporting tool in strategic heat planning in cities and nations. This handbook is supplemented by the Hotmaps appendix report *Case descriptions*, which describes cases of district heating planning carried out within different contexts across Europe. The *Hotmaps Handbook II: Guidance for the comprehensive assessment of efficient heating and cooling* also addresses recommendations for the comprehensive assessment of efficient heating and cooling with reference to Article 14 under the European Energy Efficiency Directive.

2 Focus of the handbook

Strategic heat planning activities are interdisciplinary activities carried out within established networks of actors and institutions. These networks include diverse agents, such as public authorities on several organisational levels; private energy companies, incumbents supplying consumers and emerging companies delivering new technological solutions; established infrastructures, grids and supply methods; energy regulation, taxation and subsidies; resource availability, domestic as well as imported fuels and related to this; energy security issues; political agreements for future energy supply and the methods used to combat climate change; and the companies and consumers who have to adopt technologies and pay energy bills.

The aim of this handbook is to provide concrete advice to heat planners, who are in specific and context-dependent situations involving the above-mentioned factors. Heat planning is a local issue and therefore is subject to different mechanisms than, for example, is the case for electricity or gas planning. This results in a field where the main actors with the ability to promote sustainable heat supply options are local authorities, but these are located within regulatory and infrastructural frameworks shaped by historical transitions and national/international regulations.

Although heat supply strategies must be locally grounded, a top-down framework is needed which ensures the overall sustainability of the energy system. National authorities have an important responsibility in creating a framework for local planning which ensures that bottom-up activities do not aggregate into imbalances at the macro-level.

Providing a complete account of the technical, regulatory and institutional frameworks shaping strategic heat planning for the 28 member states is not the objective of this report. Rather, the focus is on providing ways for heat planners to identify their context, providing methods to quantify/conceptualise the issue of heat supply, giving advice on how to assess and promote alternatives, and identifying challenges and opportunities.

2.1 Delimitation and definitions

The handbook focuses on strategies for supplying energy in order to satisfy heat demand. Heat demand involves necessary comfortable room temperatures and hot water in residential and non-residential buildings, as well as heat supplies for various industrial processes. The comfort service for residential buildings can be satisfied through a combination of energy conservation and energy supply in the buildings.

The supply can be met through energy conversion units in individual buildings, or by delivering heat through collective grids. Collective heat grids are commonly known as district heating, where the distribution of hot water through pipes in the ground supplies hot water and space heating demands.

Individual conversion units may also be supplied with energy through grids in the form of gas and electricity. Gas grids are different from electricity grids, in that they have historically been planned and implemented in urban areas for the purpose of supplying heat demand. The ambient thermal grid is a rare hybrid solution where individual heat pumps, in addition to being connected to the electricity grid, achieve high efficiency by using the ambient temperature as the heat source.

On a broad scale, heating can be organised and delimited as shown in Figure 1. Heating can either be supplied by collective solutions or by individual technologies located in buildings. Collective solutions include gas grids that facilitate the transmission of gas from extraction to the point of consumption, and district heating, where the heat itself is produced in a central location and then transported to the consumer.

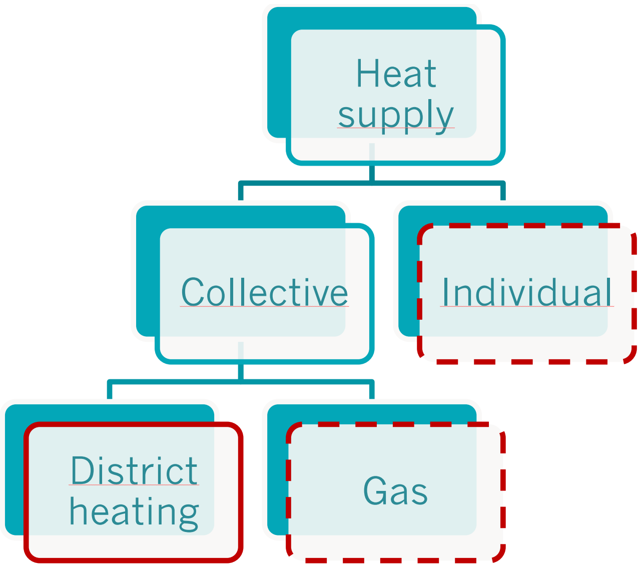


Figure 1. Delimitation of types of heating.

The handbook will primarily focus on planning issues related to collective heat supply with district heating, as this requires the highest levels of organisation and planning. Collective heat supply is defined as heat consumption supplied by shared infrastructures, such as heat or gas networks. This handbook focuses on thermal grids, however, since gas boilers in single buildings are not in line with EU 2050 goals. Although the electricity grid is also a shared infrastructure, electric heating is not regarded as a collective solution, as electricity grids are likely to be in place regardless of their use for heating purposes. Collective heating can be seen as in opposition to individual heating, where the operation of heating equipment is independent of collective infrastructures, such as oil or biomass.

A key step in heat planning is to identify the distribution of both individual and collective heat supply. A central part of grid planning is to identify the limits to the extension of the grid. Individual heating solutions are therefore an inherent part of heat planning, as they constitute an alternative to the grid, and the grid extension must be determined by comparing it to the alternatives on the margin. Similarly, it is vital for strategic energy plans to have policies for areas outside districts with the potential for collective supply. Policy goals for individual heating areas may be more easily obtained through price incentives and rules, however, while fewer of the coordination challenges associated with grid-based systems are present in case of individual heating. Conversely, countries without heat policies tend to be dominated by individual solutions.

Natural gas and district heating diverge in one basic parameter, which is the geographical location of supply. A key characteristic of district heating infrastructure is its collective and local foundation. While the gas grid is the distribution infrastructure for a distant resource, heat supply resources for district heating grids are local, partly because heat resources are distributed and available near cities across the continent, and partly because it is not economically viable to transmit heat over long geographical distances. While gas has been a top-down infrastructure, district heating is based, and dependent, on local heat planning and organisation in cities.

The handbook does not deal with the planning of gas grids for heating purposes, as this supply infrastructure is not in line with the strategic heat policy of Europe, however, experiences from past gas grid planning may be valuable in future planning to the extent that these experiences can be transferred to district heating.

3 Theoretical approach to strategic heat planning

Historically, strategic energy planning started as a response to the oil crisis of the 1970s, in order to decrease national dependency upon imported oil resources. Responses to the oil crisis varied among EU member states, and several states started to make strategic choices about national energy supply. A typical response was to start replacing the energy supply from oil with domestic resources.

Taking the Danish heating sector as an example, this meant a shift from oil-based heating to expanding district heating networks in densely populated areas and natural gas grids in medium dense areas. Low density areas continued to be heated by individual solutions. This transition was facilitated by a broad effort, including municipal energy plans, energy taxes to promote the use of preferred fuels, mandatory cogeneration by power plants with a certain capacity and the ability to require a connection to district heating networks in certain areas.

Strategic energy planning is thus about addressing issues with current energy supply and formulating strategies for transitions. It largely depends upon the technical, societal and economic context of the energy supply, as involved actors, means of actions and available options will differ between situations.

Heat planning as part of transitioning towards decarbonised energy systems

Strategic heat planning is an intrinsic part of the over-arching term "strategic energy planning". This report addresses heating specifically, although still with the overall energy system in mind. It is important to identify synergies across energy domains, as a holistic approach results in a more efficient transition to decarbonised energy systems. When this report address heating specifically, it is because the planning and transition towards a decarbonised heat system differs significantly from other energy sectors. Heating remains both a local and national matter.

This report therefore seeks to address issues specifically related to the transition towards decarbonised heating systems.

Strategic heat planning is not business as usual

Strategic heat planning is defined as *action plans for realising long term visions of radical change in key parameters of the heat supply.* Historically, these key parameters include fuel demand, environmental factors and security of supply.

In our definition, we emphasise that the plans are oriented towards action, that this action is based on a long-term perspective and analysis, and that it strives for radical change. This definition is shaped for the current situation in Europe, where radical change away from a fossil fuel-based energy supply is required. Radical changes necessitate a strategic analysis of, and long-term perspectives on, single initiatives.

Current established energy systems are shaped and promoted by, and in turn have shaped, existing legislation, regulation, public perception, knowledge and understanding, as well as the technical setup of the infrastructure. Radical changes within these systems require changes in several of these components. Strategic heat planning therefore usually requires a broad perspective that combines the work of engineers, policy makers, economists and social scientists, etc. Depending on the level of change needed, the time frame for such projects can be long, and due not only to exhaustive construction but also policy changes or public acceptance.

As strategic heat planning is not a business-as-usual activity, such a process will meet significant challenges, and require action within several sectors. Strategic heat planning is therefore not usually associated with marginal improvements in established systems. Radical change in key parameters usually requires changes in the technical basis of heat supply, that is, changes in concrete technical installations. New technical solutions may often require new organisational models and business models.

These organisation and business models may in turn require facilitation through changes in national policies that regulate the sector. This change may involve changes in existing regulation regimes or the development of completely new regulation regimes if heat supply is a new area of policy for the relevant regulatory authority. Strategic heat planning is not usually about maintaining the status quo.

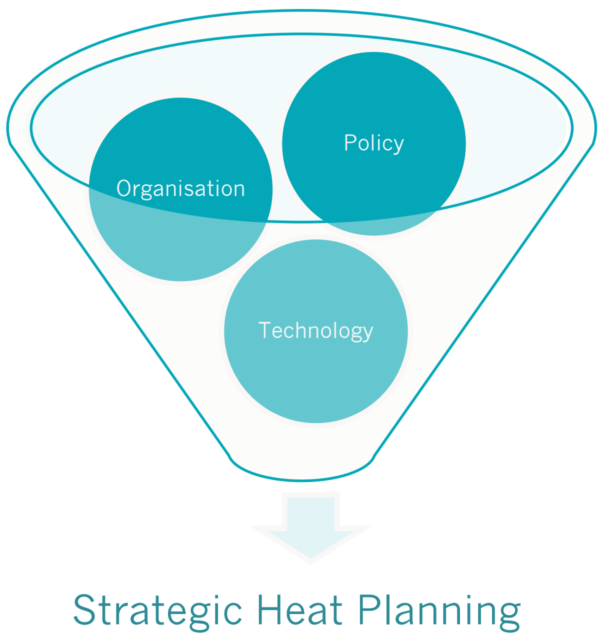


Figure 2. The main components of strategic heat planning. It involves changes at technical, organisational, and political levels.

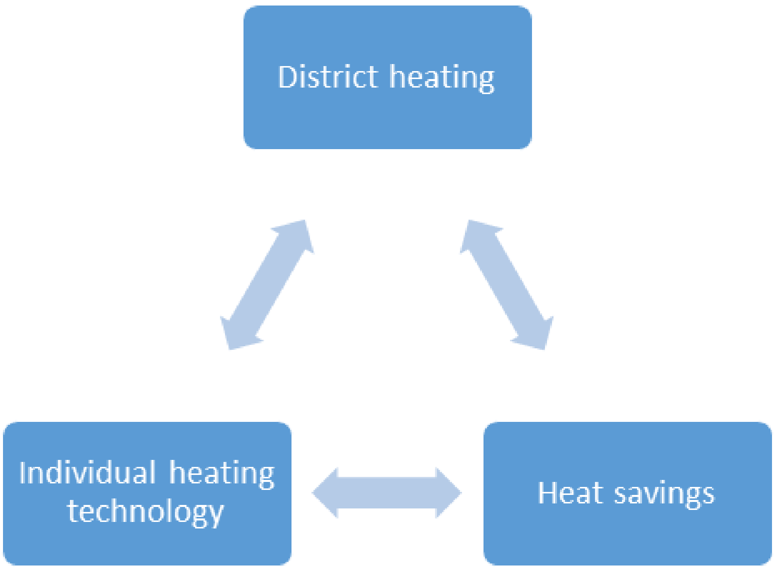
3.1 Main elements of strategic heat planning

In light of the challenges and motivation for European heat policies, the overall heat planning task is to identify and implement solutions for the heat sector considering a balance between district heating, individual heating and heating savings.

Planning and policies must address:

1) Strategic primary energy supply
2) Strategic demand policies

The overall challenge for the primary energy supply is to reduce fuel consumption. Fossil fuels have to be phased out and these can only be replaced by biofuel resources to a very limited extent, due to the scarcity of biomass.
A strategic heating plan must identify the balance between district heating, individual heating and heat savings in buildings which minimises fuel consumption in the primary energy supply.



As vast amounts of waste heat have been mapped on a European scale, local heat planning may have a natural point of departure in investigating the potential for a district heating system. Integrated district heating planning involves delimiting its extensions by comparing marginal efficiency with the efficiency of individual solutions.
Individual heat pumps are suggested as the benchmark when comparing district heating with individual solutions, however, other individual solutions might be relevant based on a local assessment.
Any supply side option must be continually compared and balanced with the potential for heat savings in buildings.

Given the identification of a technical strategy, including the potential of district heating, some basic organisational questions must be confronted, no matter the geographical context of the local project.

Across all technical solutions, strategic heat policies must include national schemes which provide economic incentives on the supply side, as well as incentivise the appropriate demand side reductions.
In urban areas which have not already established a district heating system, principles for the organisation, ownership and regulation of the heat network must be considered and developed in the early planning phase. A third procedure, following the strategic supply and demand, is therefore;

3) Strategic policies for ownership and price models

Figure 3 presents a model for conceptualising the different parts of the delivery chain, from energy input to energy consumption. Policies and strategies on ownership and price models usually focus on implementing changes in production, transmission and distribution, in order to enable transitions in relation to energy supply or consumption.

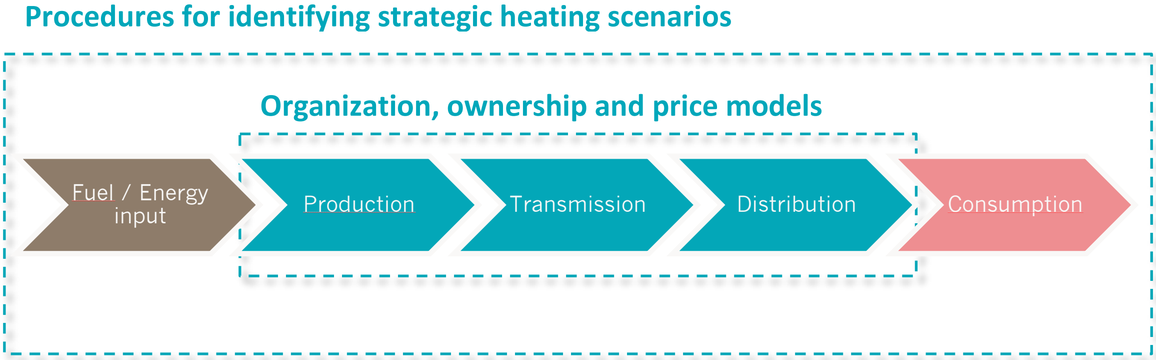


Figure 3. Main elements in strategic heat planning.

3.2 Policy context of strategic heat planning

Heating systems are planned and operated within several layers of institutional frameworks. These layers can be structured in two dimensions; a geographical dimension and a sector dimension.

The geographical dimension includes regulation and legislation at the European, national and regional/local levels. The sector dimension includes dedicated heating and district heating regulation, building regulation and energy sector regulation.

While the geographical dimension may appear to be obvious, it is also important to stress the sector dimension from a methodological perspective. Strategic heat planning must be conducted from a system perspective, and even more so in a renewable energy system. The technical synergies that flows from a system perspective on the heating sector must ideally also be reflected in the regulation and legislation.

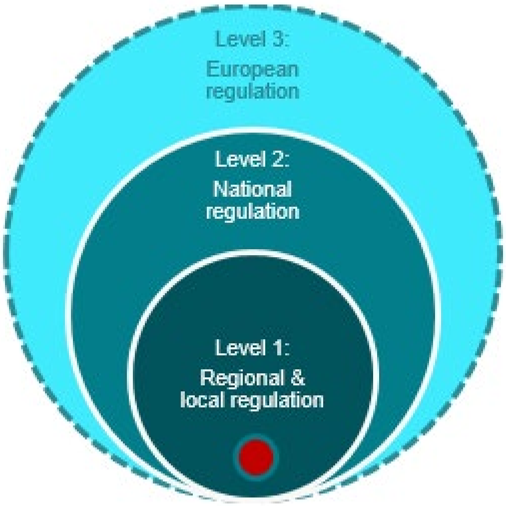


Figure 4. Geographical layers of regulation. The red dot indicates the location of the strategic heat planning project. Its viability is affected not only by local and regional policies but also by the national and European regulation within which it is embedded.

Strategic heat regulation must be seen from a system perspective. There is a sector dimension to energy, building and heat policy layers. Strategic heat planning projects are carried out within the building and heating sectors, again nested within the wider energy system.

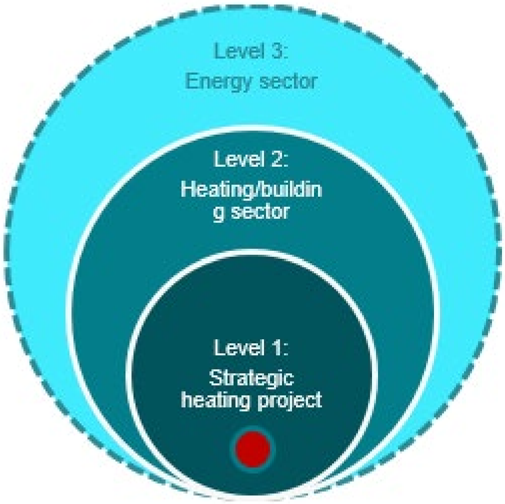


Figure 5. The sector dimension of heating regulation. The red dot indicates the location of a strategic heating project. The viability of a heating project is affected not only by dedicated heating regulation but also the building regulation and energy sector policies in which the district heating policies are embedded.

Figure 4 and Figure 5 show that strategic heat planning projects are nested within both layers of the energy system, as well as within the geographical scope of regulation.

Table 1: Illustrative figure for the regulative regime affecting strategic heat planning. A mapping of the public regulation framework for heat planning could be based on this matrix.

	Project regulation	Heat and building regulation	Energy system regulation
Local regulation			
National regulation			
European regulation			

Concrete heat plans are often shaped as local projects at city level, however, proper strategic heat policies must be embedded and coordinated at all levels of governance, across all energy related policy areas.

The institutional layers below EU level in the energy sectoral dimension and in the geographical dimension differ across Europe. This diversity delimits the level of detail that can be reached in European-wide guidelines for strategic heat planning and its organisation, however, certain general challenges related to the properties of the technology may be derived and a generic step-by-step guide may be formulated (as is done in Chapter 4). Secondly, lessons may be learned by providing examples from a varied set of planning contexts and situations[1].

3.3 Assessing the demand for heat

A main part of strategic heat planning is identifying the potential for changing heat supply. As heating is a local energy supply, this is closely connected to the spatial distribution of demand and potential supply sources.

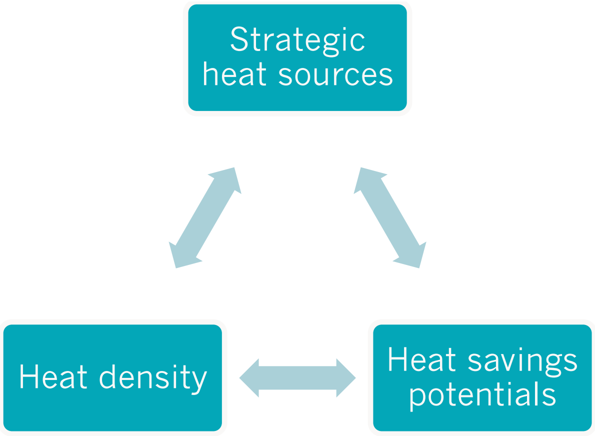
Heat density is a central parameter in the identification of viable heating systems. Heat density is defined as heat demand per area. High heat density can be a first indicator of whether a collective heat system or individual solutions are feasible.

Below a certain threshold, district heating systems would not be the most socioeconomically efficient solution. How low the heat density can be without undermining the viability of the district heating system depends on: 1) the costs of the heat source that feeds into the grid, 2) the costs of the grid, and 3) the costs of the alternative individual solutions. In areas with heat density that is too low, individual solutions such as heat pumps can be implemented.

In this context, it is important to note that the cost efficiency of heating options is also dependent on the insulation levels in buildings. On the one hand, heat savings in buildings may reduce heat density. On the other hand, large synergies can often be found in district heating systems through heat savings in buildings. Lower heat demand means the temperature levels

[1] Descriptions of case studies from various settings across Europe are provided in the Hotmaps appendix report "Case descriptions".

in the grid can be lowered, which increases the available heat sources and increases the efficiency of large-scale heat pumps. Both these effects are strategically important for many countries when phasing out fossil fuels. Access to larger amounts of excess heat from industries may directly replace and reduce fuel consumption, and higher heat pump efficiency increases synergies from integration with fluctuating renewable electricity generation.



The identification of available strategic resources is a key step in early phases of strategic heat planning. This goes together with assessments of heat saving potentials. Similarly, the extension of district heating grids can be approximated in this phase, having identified and quantified available strategic heat sources and heat savings potential. Mapping and GIS are helpful points of departure when considering heat density, as it includes a geographical dimension.

3.4 Main elements of district heating strategies

When assessing the role of district heating systems in strategic energy planning, the main questions to address are: 1) the feasible size of the system, and 2) the organisation and regulation of the system.

3.4.1 The feasibility of district heating systems

Earlier research has demonstrated that there is great potential for expanding district heating in Europe, however, the presence and limits to district heating potential in local areas must be based on a local assessment, so that heating grids are only established in areas where it is economic viable.

Frederiksen and Werner (2013) highlight three obligatory elements of a competitive district heating system: a suitable heat source that is relatively cheap, heat demand, and pipes that connect supply and demand. In order to minimise capital costs in pipes, the system must necessarily have a local nature (Frederiksen and Werner 2013).

Basically, a district heating system is economically viable if the heat density is high and/or the cost of the heat source is low enough to compensate for the costs derived from distributing the energy through the pipes.

The heat source may be either a primary energy supply or a secondary supply. Primary supplies have traditionally been fossil or biomass fuels. In the coming decades, they may increasingly be sourced from renewable primary sources such as geothermal, solar thermal or wind-to-heat energy, through large-scale heat pumps. Excess heat from electricity production and industrial processes is also a key component in the fundamental viability of district heating systems.

Strategic heat sources are heat sources that make district heating (socio-) economically viable. Distributing thermal energy in pipes involves energy losses and high capital costs. In order to make district heating systems viable, the heat source must therefore be superior to individual heat sources, with a significant margin. Heat sources that fulfil this requirement from a longer-term perspective are defined as strategic heat sources. Hence, a simple boiler will typically not provide a sufficient level of fuel efficiency to be a strategically viable basis for a district heating system. Its fuel efficiency is not sufficiently larger than the efficiency of individual boilers to bear the heat losses from the pipes from a socioeconomic perspective. Consequently, the overall efficiency gain provided by a boiler-based district heating system will typically not be sufficient to cover the investment cost of the pipes. Strategic heat sources are therefore heat sources that provide “extra value” which can finance the capital costs associated with the pipes.

Traditionally, strategic heat sources in Europe have primarily been excess heat from electricity production and industries (Werner 2017). Both of these are still relevant on a European scale. For countries where wind turbines and photovoltaics significantly reduce CHP production in the electricity system, excess heat from electricity production is reduced as a strategic heat source. Nevertheless, as intermittent renewable production will still require backup in future energy systems, some flexible CHP units remain useful and can be longer-term sources of heat. On a larger scale, however, the changes in the electricity system mean that new strategic heat sources are emerging, such as excess wind energy converted to heat through large-scale heat pumps. Other strategic heat sources in a renewable energy system may include geothermal, solar thermal and low temperature excess heat made viable in district heating systems by means of energy savings in buildings.

On a European scale, there is abundant availability of strategic heat sources. Heat Road Map Europe estimates the total amount of non-utilised excess heat as greater than the total heat demand in Europe. Similarly, the emergence of new renewable technologies enhances the strategic basis for district heating systems. The viability of a specific district heating project, however, must always be based on an assessment that considers the local conditions.

Although not a heat source as such, heat savings in buildings is a strategic focus point for the heat supply sector. Partly, it is a focus point because lower energy demand directly reduces primary energy supply, and thereby also reduces the necessary generation capacity. Further, it is a focus point because lower heat demand in buildings enables a decrease in distribution temperatures in the grid. A lower distribution temperature increases the competitiveness of the strategic heat sources in a renewable energy system. Lower distribution temperatures make larger amounts of low temperature excess heat sources economically viable for distribution. Similarly, lower distribution temperatures increase the efficiency of heat pumps, solar thermal plants and CHP units. Heat saving in buildings is therefore a strategic focus point which applies everywhere.

3.4.2 The organisation of district heating systems

The establishment of a grid structure entails an economic condition of 'natural monopoly'. The natural monopoly condition is derived from the large investment costs, which mean that having competing district heating network pipes in the same area is too costly.

The natural monopoly condition can to some extent be limited through competition from individual heating units. In some country policies, the district heating grids are subject to such competition, however, other countries have historically protected heat networks from such competitive conditions by establishing an obligation to connect in dedicated areas in order to reduce the risk of network investment and allow long term planning. The risk for grid investments in competition with individual units should also be seen in light of the large investment costs that are associated with district heating. These costs mean that it can be difficult to achieve the most efficient solutions through direct competition with individual heating units.

The natural monopoly condition is a fundamental condition that needs to be handled by the regulatory and/or organisational structure in which the technology is embedded. This includes the choice of ownership model for the systems and design of the price regulation. The challenge is to ensure that the investing organisation or firm faces reasonable low risk, with the large investment cost in mind, while at the same time maintaining consumer protection. In a condition of natural monopoly, it is difficult to empower consumers through the buying power which is normally assumed to be present in markets. An alternative to market buying power is power through state regulation or power through ownership.

This issue has empirically been handled through various institutional means. The case examples in the appendix report describe various empirical models. Chapter 4 outlines a guiding framework for ownership and price models.

3.5 Summary of section

Strategic heat planning involves radical change, and specifically for contemporary Europe, it involves radically reducing the carbon dioxide emissions from energy consumption, of which heating accounts for around 50 percent.

It is important to emphasise the balance between investing in supply capacity and investing in reducing heat demand in the investment strategies for transitioning the heat sector.

The potential for district heating systems can be identified based on the mapping of heat density. Heat planning for areas with lower heat densities must be included as an integrated part of identifying the potential of district heating. The alternative individual solutions must be defined in order to evaluate the marginal relative efficiency of district heating grids. Similarly, the strategic heat sources must be identified in this phase, as this determines the absolute efficiency of the district heating systems.

The district heating system is an infrastructure for utilising strategic heat sources. A strategic heat source is a potential energy source which is viable for distribution through a thermal grid in order to reduce primary fuel consumption.

Strategic heating planning is carried out in the context of several institutional layers. There is a matrix of policies relevant to a concrete strategic heating project in all energy sectors due to the potential synergies between the sectors, as well as policies at all governmental levels.

A good and coherent policy framework for strategic heat planning applies a holistic approach including all policy dimensions.

The distribution part of a district heating system is a monopoly structure. It is therefore a key step in strategic heat planning to develop and implement legislation concerning the organisation of the system, especially regarding ownership models and price regulation. These organisational models should provide access to financial capital, ensure consumer acceptance and enable long term planning.

4 Guidelines for strategic heat planning

This chapter summarises and formulates guidance for strategic heat planning based on the material in the previous chapters. The chapter divides the guidance into four parts:

- A three-phase approach to strategic heat planning. This approach outlines the procedure which can be applied for strategic heat planning in a situation of radical change. It consists of three parts; a technical analysis, an analysis of existing institutional and organisational conditions, and an implementation plan.
- A seven-step approach to the technical analysis that can be applied in search for the system suitable for strategic aims.
- A framework for dealing with key institutional and organisational elements.
- An overall outline of the division of responsibilities between different governmental levels in strategic heat planning.

4.1 The approach to strategic heat planning

Before the strategic heat plan

Any strategic heat planning starts with a pre-phase of strategic considerations of the problems facing the current heat supply system, and where changes should be achieved. Generic drivers can be climate change, energy security or pollution. These considerations are then translated into key objectives that the future technical system should meet. On this basis, a technical analysis of available alternatives for realising the strategic goals can be carried out. This entails an analysis comparing alternatives, usually to a baseline scenario, in order to decide upon a feasible technical scenario.

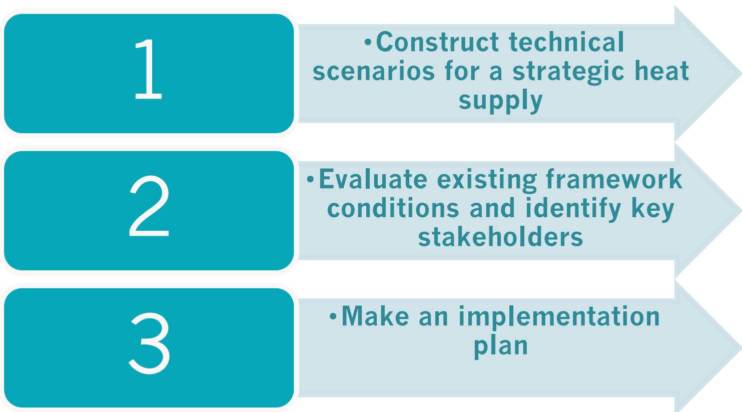
The process of identifying and formulating strategic objectives is not only a technical and bureaucratic exercise. If the strategic heat planning is to be politically feasible, the strategic objectives must be politically accepted and formulated in a procedure where main stakeholders are involved.

The preparation for the procedures outlined in the three-phase model below would therefore probably also involve the identification and mapping of stakeholders.

After identifying and formulating strategic objectives, the actual steps in constructing a strategic heat plan can be carried out.

A three-phase approach to strategic heat planning

A synthesis of the generic steps in strategic heat planning is presented below. The parts are based upon the section above, and provide a synthesis of these guidelines. The steps are described in three parts, but will likely be part of an iterative and continuous process.



Existing framework conditions can have an effect on the choice of technologies, and in some cases it could be useful to involve key stakeholders early in the process. On the other hand, it can also be beneficial to start with technical assessments, so as not to be limited by existing policies and the interests of local stakeholders. The latter approach could also be applied to build an awareness of possible technical scenarios as a preparation for the involvement of stakeholders. Stakeholder involvement, however, would typically be most beneficial before decisions are made in order to improve the quality of the decisions, to make them politically viable, and to create a broader ‘ownership’ of the process and the aims of the project among key stakeholders.

The completed implementation plan will feed back into the process of viable technologies and provide input for future heat planning projects.

Phase 1: Construct technical scenarios for a strategic heat supply

In this phase, the possible technical scenarios are identified, evaluated and described. This process may follow the seven-step procedure described below. A solution can be chosen based on this procedure that can meet the strategic objectives.

- 1) Quantify heat demand
- 2) Assess and quantify the availability of heat resources in the area
- 3) Assess and quantify the potential for heat savings in buildings
- 4) Identify a balance between investments in heat supply and heat savings
- 5) Align with national/regional/local energy plans
- 6) Develop technical alternatives and scenarios for a strategic heat supply plan
- 7) Repeat Steps 4-5-6 in search for the best solution

Phase 2: Evaluate existing framework conditions and identify key stakeholders

In this phase, economic and political barriers and opportunities are identified. A part of this process is to map central stakeholders and analyse which role they are likely to play in a transition process, and what role they may have in a future heat supply.

- Identify economic and political barriers
- Identify economic and political opportunities
- Identify key stakeholders (if not already done in the preparation phase)
- Develop ownership and business models that align with strategic objectives

Phase 3: Make an implementation plan

In this final phase, the relevant authority searches for the potential to modify or change existing regulation to support the best solution. This phase also involves considering the shape of key organisations in transitioning and operating the heat supply system. This involves dealing with ownership and price models as described above, for the purpose of ensuring consumer and citizen acceptance, mobilising capital, and creating an institutional platform for strategic actions and long-term planning. Part of the institutional platform for strategic actions and long term planning is to identify or create organisations responsible for taking actions.

- Identify which framework conditions that can be changed by the relevant planning authority

- Design new regulation and framework conditions
- Identify opportunities to involve stakeholders that can play a constructive role in realising the heat plan
- Design/redesign organisations to deal with planning and coordination challenges.

4.2 Procedure for identifying strategic heating scenarios

The most efficient alternative technical solutions can be identified through a technical analysis that includes synergies between both heating supply and energy savings, but also between the heating sector and other energy sectors. The search for available alternatives in strategic heating planning can follow a seven-step model, as outlined below.

Seven-step procedure for constructing technical scenarios for a strategic heat supply

1) Quantify heat demand

2) Assess and quantify the availability of heat resources in the area

3) Assess and quantify the potential for heat savings in buildings

4) Identify the long-term balance between investments in heat supply and heat savings

5) Align with national and EU energy plans and objectives

6) Develop technical alternatives and scenarios for a strategic heat supply plan

7) Repeat Steps 4-5-6 in search of the best solution

This list should be adopted to local conditions and is not a one-size-fits-all solution. It does provide some generic advice applicable in many situations. Heat planners start by using mapping and quantification exercises, to gain knowledge of the challenge and potential. By following the seven-step guide, heat planners can assess demand, local supply and the potential for savings in one systematic process.

When demand, energy saving potential and extant heat resources have been established, the plan should compare them in different scenarios. As there will usually will be a heating infrastructure in place, alternatives should be compared to a baseline scenario.

Consider the whole energy system, not only the heating sector

Considerable synergies are available when looking at energy planning from a holistic point of view. Although heat planning is the focus of this document, it is important to include other energy domains such as electricity and gas; as well as the demand for electricity, transport and cooling. This is in order to identify synergies across sectors and also possible bottlenecks of limited resources.

- Synergies: Flexible CHP plants are able to supplement and balance considerable amounts of fluctuating renewable production from wind and solar energy in a fuel efficient way. Electric heat pumps can also be deployed for flexible demand, facilitating the integration of wind and solar energy. The heating sector can thus provide important integration and flexibility measures for the electricity sector.
- Bottlenecks: Only limited amounts of sustainable biomass are available for consumption in Europe, and this should be allocated where it is most useful. Usually, this does not entail heating demands, as these can be supplied by alternative technologies. A holistic energy system perspective can identify the sustainable amounts available and where these should be most appropriately allocated.

Align scenarios with future long-term goals

Investments in heating infrastructure typically have long lifetimes, and the district heating networks and cogeneration plants build today in particular, could be in place after 2050. It is therefore important to align investments and strategic decisions with climate goals, such as the EU 2050 climate targets and the Paris Agreement. Investments in other technologies might result in stranded assets or operation under other political regimes.

Socio-economic methods

There is an important distinction between the economic and financial assessment of technologies. A socio-economic perspective is necessary in order to meet strategic societal objectives.

Socioeconomic assessment is often based on a standard cost-benefit analysis approach. When identifying costs and benefits, it is important that the heating system is assessed to largest degree possible from an energy system perspective. This implies that positive synergies with other energy sectors or externalised costs from the heating sector are included in the analysis.

The exact quantification and valuation of spill-over effects from the heating sector to other sectors will rely on a technical analysis specific to the local project.

Departing from the strategic objectives of the heat plan, it is central to the economic assessment that the strategic parameters are included and valued correctly.

For example, the ETS price for European CO_2-trading has historically not sufficiently accounted for the socioeconomic costs of carbon dioxide emissions. While the prices in the CO_2 trading scheme have decreased to 5 EUR/ton, an appropriate valuation of CO_2 emissions would be at least 70 EUR/ton.

It may also be useful to include other emissions and environmental effects in the assessment. This will rely on judgements made in the specific project.

The interest rate used to discount future costs and benefits – called the discount rate - is an important choice and the appropriate level for the assessment of technologies that meet societal goals can be discussed. Taking general growth rates and contemporary long-term interest rates into account, a social discount rate should not exceed two percent pro anno.

4.3 Organisation, ownership and price regulation

This section mainly addresses concerns regarding collective heat supply, as this entails some variations in cooperation between stakeholders.

The objectives of an organisation model are threefold:

- Ensure consumer acceptance
- Ensure financing of long-term investments
- Ensure the long-term ability to undertake strategic heat planning

For the purpose of establishing an overview of these different solutions, it can be helpful to establish a two-dimensional framework. One dimension involves an ownership model, and the other dimension includes a price regulation model. A matrix model illustrating the possible combinations is found below.

Table 2: A matrix model illustrating possible combinations of ownership and price regulation.

	Consumer ownership	Municipal ownership	Private commercial ownership
True Costs			
Price cap			
No price regulation			

A third dimension of the organisational model is the degree of unbundling between different stages of the system; from heat generation to transmission and distribution, to heat consumption. Figure 6: Main elements of district heating supply system.illustrates the three main elements of the system. In principle, the two-dimensional framework above can be applied to each main element of the supply system depicted in the figure below.

Figure 6: Main elements of district heating supply system.

The question of unbundling ownership also relates to the question of third-party access. For example, it has been proposed that district heating could be subject to the same unbundling policy as established in the electricity systems of many European countries, where the grid, as a technical monopoly, is owned by a public entity while production facilities are operated by private commercial interests, possibly in an organised market.

The diversification of ownership is common - especially in larger systems, however, there is no widespread experience with combining unbundling with a market competition in production similar to the market organisation developed in the electricity sector.

A critical issue to consider when comparing the heat sector to the electricity sector is the local nature of thermal grids. The local nature of district heating grids implies a smaller volume in the respective markets, and therefore, it may be more difficult to establish a significant competitive environment in the heat sector, to avoid markets with relatively large market power concentrated on one or a few suppliers. A formalised spot market should be expected to be most viable in the largest urban areas, if anywhere.

In practice, many district heating systems operate with third party access based on bilateral contracts negotiated between suppliers and the grid owning company. Some of the largest economic and environmental potential for district heating grids involves third parties, such as industries producing excess heat. Third party access would therefore be an important element of the optimal utilisation of district heating grids across Europe.

Three types of ownership

As represented in Table 2, three basic forms of ownership models can be defined. In practice, hybrids of these three models may be observed or developed, however, the three following types are the most common.

Consumer ownership

Consumer ownership is a private ownership model where the heat consumers own the system. This model can take different forms, where the main characteristic is that consumers control the local district heating supply company through democratic procedures.

Municipal ownership

In the municipal ownership model, the district heating system is controlled through a company controlled by the municipality, or directly by the municipality itself.

Private commercial ownership

This category of ownership involves ownership models where the district heating system is controlled by a private company operating on commercial conditions.

Three types of price regulation models

As represented in Table 2, three basic forms of price regulation models can be defined. In practice, hybrids of these three models may be observed or developed, however, the three following types are the most common.

True costs

The true cost principle implies that consumers can only be charged a heat price equivalent to the cost of delivering that heat. The true cost principle can also be called 'the consumer profit principle' as any efficiency gains are distributed as profit to the consumers through lower heat prices.

Price cap

Price capping is a principle where district heating companies are allowed to charge a heat price based on some reference price. For example, this reference price can be based on the cost of alternative heat supply options, such as natural gas, or, it can be based on the benchmarking of other and similar district heating companies.

No price regulation

Prices are controlled through the market forces which happen to be present at a given time and space. The power of monopoly can be delimited through competition from individual alternatives.

Strategic considerations for the choice of ownership and price models

Empirically, each subcategory in both dimensions has many variations. The specific design that is chosen must address three priorities: 1) ensuring consumer acceptance of the system, 2) ensuring access to capital, and 3) ensuring a basis for carrying out strategic heat planning. Priorities 2 and 3 can possibly be provided through complementary institutions.

It is important to note that both the ownership model and the price model should be seen in relation to each other. The choice of ownership model cannot be evaluated coherently without considering the price regulation that complements it. Similarly, the properties of a price model must be seen in light of the ownership model.

An example of the interdependence between both dimensions is found in the Danish case, where the true cost principle has worked well in combination with consumer ownership, but worked badly in combination with private commercial ownership. The problem with applying the true cost principle to private commercial ownership seems to be that asymmetric information makes it difficult for regulators to monitor costs, and there seems to be no efficient measure for ensuring that commercial companies do not extract profit through inflated service costs bought from the mother company. A problem with the basic economic incentive in this combination is that commercial companies lack the motivation for operating the system efficiently if profits cannot be gained.

The properties of the true cost principle are different when owned by the consumers. Consumer ownership adds a profit element to the model, as the owners of the system are those who receive lower prices if efficiency gains are realised. This introduces an economic incentive for the owners of the system to search for the most efficient operation.

Municipal ownership under the true cost principle has also seemed to work, although some empirical numbers may suggest that it is not entirely as cost efficient as consumer ownership. consumers may have indirect power here, however, as well through the political system.

The price cap model may be a price model that theoretically works across different ownership forms. It can be perceived as a compromise between true costs and no regulation as it allows a controlled level of profit to be extracted which motivates owners to improve efficiency while limiting the possibilities of exploiting consumers.

In practice, the weakness of this model is found in the bureaucratic and administrative burden associated with this price cap principle. This burden appears to involve both the designing and calculating of price caps, as wells as monitoring and administration. Price caps are often negotiated between regulators and operators in order to identify a proper price level. This task may be difficult and costly for the regulator since owners have the advantage of possessing information about the true costs of operation.

In price regulation, prices are controlled through the market forces which happen to be present in a given time and space. Monopoly power can be limited through competition from individual alternatives, however, this requires that the heating regulation does not operate with an obligation to connect to the system and the individual alternatives are not excluded through other regulations. Removing these regulatory measures may, on the other hand, increase risk and thereby the price of financial capital, and weaken the platform for long term planning which is often important from a strategic perspective.

Institutional context for strategic heat planning

Concrete heat plans are often shaped as local projects at city level, however, proper strategic heat policies must be embedded and coordinated at all levels of governance across all energy related policy areas. Similarly, the institutional structure and policy elements affecting the viability of the concrete local project must be identified in the strategic heat planning process. Identifying and mapping relevant policy elements affecting the concrete project is part of Phase II in the three-phase model for strategic heat planning outlined earlier.

As explained in the theoretical chapter, the mapping of policies affecting strategic heat planning has two dimensions, a geographical dimension and a sector dimension. For example, a concrete district heating project might be subject to legislation directly aimed at district heating projects. This project regulation might originate and/or be implemented in local, national and European legislation. Further, the particular project is also affected by general heating and building regulation as well as legislation at the energy system level. All these policies are also shaped by legislation at all governmental levels.

The table below is a possible framework for both dimensions of regulations which can be used in Phase II of strategic heat planning when mapping the policies and institutional structures.

Table: Illustrative figure for the regulative regime affecting strategic heat planning (Similar to Table 1 above).

	Project regulation	**Heat and building regulation**	**Energy system regulation**
Local regulation			
National regulation			
European regulation			

4.4 Responsibilities in heat planning

Based on the experiences of strategic heat planning in various contexts, some general guidelines for responsibilities in the strategic heat planning process may be outlined.

National and European governance structures are in place for formulating and implementing long-term strategic goals.

Local authorities often possess knowledge of local conditions, and given that heat supplies often are local in nature, the local authorities will often be the initiators and responsible for the concrete heat planning.

If national authorities provide a structural framework within which the local planning process is carried out then the quality and direction of the local heat planning are increased. This can, for example, be a heat supply act that outlines the process for developing district heating projects, and specifies the tasks for municipalities. Such legislation can also establish the overall strategic indicators which the local policies should fulfil. As an example, the Danish national heat supply regulations place responsibility with municipalities, but also outline some overall requirements regarding socioeconomic viability and environmental priorities. Rules regulating the monopoly structure of district heating grids should also be initiated nationally, concerning ownership models, company structures, price regulation and the obligations and rights of consumers.

National and European governmental bodies can also promote local energy and heat planning by supporting the process through the provision of data and guidance on methodology. This may further be coordinated with overall strategic objectives regarding sustainability and socioeconomic viability.

In addition to this distribution of responsibilities, it is recommended that forums are established where experiences are exchanged between local and national planning agencies. Knowledge about regulatory barriers experienced at the local level can be conveyed to the central level where regulations can be changed.

When regional governmental bodies are present, they can play an important role as coordinators of municipal heat plans in order to avoid local sub-optimisation in the energy planning. Regional energy plans where the heating strategies are constructed in an energy system analysis are recommended. Resources such as biomass often have conflicting uses across energy sectors, as well as municipal borders. Similarly, the development of fluctuating renewable energy sources would benefit from being part of a coordinated strategic plan across energy sectors and municipalities.

5 Summary

This document outlines guiding principles for strategic heat planning. These are general guidelines that in principle can be followed at all levels of governance, including local, regional and national levels.

At which level the actual heat planning will be carried out is highly dependent on the governance structure of the individual countries. As highlighted in the document, the potential of each technology is very dependent on the local conditions. At the same time, bottom-up local planning cannot be carried out without internalising top-down insights regarding the overall sustainability of the system.

The most efficient approach to heat planning would therefore involve and coordinate all levels of governance. The role of local governance is to carry out strategic heat planning based on the best available information. The role of national governance is to expand and improve the information provided for the local governance, to outline the overall strategic framework within which the local assessments are carried out, and make sure the overall framework and the provided information is aligned with the EU’s 2050 targets.

The guidelines emphasise that strategic heat planning in contemporary Europe should involve radical change, focusing on minimising fuel consumption for the purpose of heating. This necessitates a technical analysis which is not limited by the policies and institutional structures inherited from the fossil fuel-based energy supply. Strategic heat planning requires changes at technical, organisational and institutional levels. The three-phase model outlined in this chapter is a possible procedure which can be followed to support and facilitate the strategic heat planning process.

It is important in the technical analysis to take an energy system perspective of heat planning in order to avoid suboptimisation. Similarly, the search for solutions should involve a long-term, socioeconomic perspective.

The establishment of district heating systems as an infrastructure for utilising sustainable heat sources requires policies addressing the organisation of the systems. This includes questions about ownership models for monopoly structures and price regulation. It is key that these regulatory elements should be seen holistically for the purpose of ensuring consumer acceptance, access to capital and the organisational ability to maintain a long-term focus on heat planning.

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