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Guidance for the comprehensive assessment of efficient heating and cooling

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

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

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|  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 |

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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



Executive Summary

The Energy Efficiency Directive (EED) [1] seeks to promote energy security, to decrease the climate impact from energy consumption and to improve the economic balance. Article 14 of the EED seeks to identify potentials for increasing energy efficiency through cogeneration, district heating and cooling (DHC) and the utilization of excess heat sources.

According to Article 14, the MSs must carry out comprehensive assessments (CAs) of the potentials for increasing energy efficiency with high-efficiency cogeneration and efficient DHC. CA is a techno-economic methodology aiming at identifying potentials with a cost-benefit analysis.

This handbook aims to provide guidelines for the next round of comprehensive assessments that are to be carried out in 2019–20. Furthermore, this report aims at providing recommendations for updating the Article 14 framework for CAs at the European level. It thus addresses both the national and the EU level.

This report addresses four main issues with the CAs and provides recommendations for improvements. 1) The scope of comprehensive assessments should be expanded in both a temporal and energy system domain aspect. This ensures that the intermittency of variable renewables is captured in the analyses and energy sector coupling benefits can be found. 2) Economic assessments should be clearer in their use of assumptions and model inputs. 3) Data collection practices regarding H&C should be improved across the EU-28. 4) The methodological approach could be improved to promote comparable results across CAs, while MSs should still have the possibility to make relevant analyses for their respective areas and needs.

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 regulations.

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

The case descriptions in 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 heating and cooling
- ♥ 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 H&C mapping and planning is available from www.hotmaps.eu
- ♥ The Hotmaps manual documenting the toolbox and calculation modules. (<https://wiki.hotmaps.eu>)
- ♥ Video tutorials explaining the use of the tool are available (<https://wiki.hotmaps.eu>)
- ♥ The H&C strategies carried out within the Hotmaps project by the pilot areas.



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1 Guidance for comprehensive assessment of efficient heating and cooling

The objective of Article 14 in the Energy Efficiency Directive (EED) [1] is primarily to identify potentials for increasing energy efficiency through cogeneration, district heating and cooling (DHC) and the utilization of excess heat sources. The EED is part of the larger push towards a low-carbon Europe in 2050, in alignment with the Paris Agreement. Article 1 in the EED states that energy efficiency is a valuable means of addressing the three-fold energy challenge of Europe: It improves energy security and independence; it decreases the climate impact due to energy consumption and improves the economic balance.

The promotion of cogeneration, DHC and utilization of excess heat sources should be seen from this perspective, as a part of the larger transformation of European energy systems. The motivation for the comprehensive assessments (CAs) is found in the poor performing European energy systems that are characterized by unsustainable levels of carbon dioxide emissions and fuel imports.

Article 14 makes use of CAs, a techno-economic methodology for the assessment of increasing efficiency in heating supply. The purpose of making a CA of heating and cooling (H&C) is to increase the efficiency of thermal supply services in European society. Member states (MSs) have a central role in this policy area since heat is not traded over national borders. Efficiency parameters must, considering the current challenges, including both primary fuel efficiency and economic efficiency. Article 14 requires EU-28 MSs to take adequate measures to ensure the utilization of cost-efficient potentials. The article puts an emphasis on district energy but also highlights that other solutions should be analysed where district energy is not cost effective. The requirements for the MSs consists of three basic elements: 1) Identify technical potentials 2) Analyse costs and benefits of the available opportunities 3) Take adequate measures to ensure the development of the cost-effective potentials.

The first round of CAs was completed in 2015, and a new round is expected to be carried out during 2019–20. The experience from the first round of CA according to Article 14 shows great variety in country reports. The aim of this handbook is to provide guidelines for the next round of CAs and highlight critical main elements of an assessment that may serve as a basis for adequate political action. Furthermore, this report aims at providing methodological advice at the European level for updating the Article 14 framework for CAs. It is thus both relevant to the national level carrying out CAs and the EU level responsible for the methodological framework of Article 14.

1.1 Framework and approach for strategic heat planning

This section outlines the approach to strategic heat planning. The approach is based on the experience of strategic energy analyses carried out at Aalborg University since the 1970s. This report sees Article 14 as a framework for promoting strategic choices in the EU-28 heating sectors. Strategic planning relates to making choices in order to reach goals or solve challenges. The EED mentions energy security, climate change and the economy as three challenges that energy efficiency can be a strategic solution to. Several other strategic goals can promote and shape strategic heat planning. Specific national, regional or local concerns or potentials can influence and align with the EU 2050 goals.

Any strategic heat planning is conducted in the context of an energy system analysis. An energy system analysis is meant as an assessment of energy supply and demand where energy services in terms of heat, transport and electricity are analysed as one coherent system.

While heat demand accounts for half of Europe's energy consumption, heat is also a low-value energy form in physical terms. Therefore, there is a lot to be gained by covering heat demand through synergies with other sectors. Waste heat from electricity production and industry has traditionally been an important source of heat supply from the perspective of a strategic energy systems approach. Research shows that in today's Europe, vast amounts of energy is wasted as a consequence of not integrating these strategic sources of heat supply in the energy policies and instead using high-value energy forms, such as natural gas, for meeting the low-value energy demand of heating [2]. The EED is an important step from the EU to accommodate these challenges.

As intermittent renewables are introduced in the electricity system, some European countries could gain flexibility from balancing the system by integrating the electricity system into the heat market. By means of thermal grids, thermal storages and large-scale heat pumps, excess electricity production from renewables can be stored cheaply as thermal energy, thereby replacing fuel energy used to cover heat demand. Likewise, energy efficiency also provides synergies for other sectors. By investing in energy efficiency measures, demand can be lowered, which translates into a lower installed peak capacity and, in the case of DHC networks, also lower network capacities. This synergy is why energy efficiency measures should be prioritized before investing in new capacity or technology. A holistic perspective including the full energy system is important for capturing these dynamics.

While the abovementioned systems address densely populated areas where district heating grids are viable, strategic heat planning also covers heat demand outside these areas. Again, the fundamental challenge is to identify individual heat supply solutions that minimise fuel consumption at an energy system level. Strategic heat planning must, from the outset, search for the solution as a balance between investments in energy supply and energy savings. Energy efficiency is a measure that can be applied everywhere.

2 Evaluation of the first round of comprehensive assessment

In this section, we provide a brief status and evaluation of the first round of comprehensive assessments in 2015. The purpose of this section is to highlight major learning points from the first round to be included in the guidance for the next round of comprehensive assessments.

The JRC has carried out an evaluation of the first round of CAs submitted by the MSs [3]. The main conclusions relate to three topics: First, the CAs were a major effort for some countries, primarily due to lacking data and experience about the H&C sector. Second, most MSs did not perform all required tasks and thus omitted certain topics. This related to the third topic, which is that the CAs differ significantly between MSs. Table 1 provides a summary of the main differences in the CAs, with some examples provided.

Table 1 Summary of CA differences and focus, based upon [1]

| | MSs assessments differ in: | Examples |
|--|---|--|
| 1. Establish heating and cooling demands | <ul style="list-style-type: none"> - Geographical scope - Sectors included - Base year | <ul style="list-style-type: none"> - AT: Buildings and industry at country level - IT: 12 subsectors, regional level |
| 2. Prepare demand forecasts | <ul style="list-style-type: none"> - Timeframe - Drivers - Methodology - Sector disaggregation | <ul style="list-style-type: none"> - IE: 2025, no sectors identified - FR 2030, only heating |
| 3. Spatial analysis of main supply and demand points | <ul style="list-style-type: none"> - Visualization method - Resolution - Public access | <ul style="list-style-type: none"> - PL: municipal resolution - ES: 0.01km² grid |
| 4. Technical potentials for HECHP and EDHC | <ul style="list-style-type: none"> - Technologies considered - Criteria used - Assessment of heat demand | <ul style="list-style-type: none"> - DE: heat recovery from industry - CY: CHP, Biomass, solar, heat pumps |
| 5. Establish economic potentials | <ul style="list-style-type: none"> - Different sectors covered - Methodologies | <ul style="list-style-type: none"> - LT: Only for DH networks |

| | MSs assessments differ in: | Examples |
|---|--|--|
| | <ul style="list-style-type: none"> - Different assumptions | <ul style="list-style-type: none"> - UK: 52 zones covering national heat demand |
| 6. Define strategies, policies and measures | <ul style="list-style-type: none"> - Limited focus - Current and/or future regulation covered - Public support measures largely missing | <ul style="list-style-type: none"> - DK: policies until 2020 described - FR: Existing policies described |

There are several reasons for these differences, such as the lack of a strict framework in Article 14, differences in H&C planning practice and methodologies as well as data collection. Comparisons of CAs across countries becomes difficult when methods, assumptions and scope differ. The technical and economic potentials reached are therefore difficult to interpret across countries.

Lacking data about H&C consumption can provide a significant barrier to the implementation of DHC and cogeneration. As large-scale infrastructures have long lifetimes and high investment costs, it is important to have reliable knowledge about the project. Lacking data can result in higher uncertainties about the implementation of new technologies.

The status of the 2015 round of CAs is that the MSs have started identifying DHC and cogeneration potentials. While the first round was not exhaustive and methodological challenges exist; the MSs have started the process.

While Article 14 could have a more strict methodology for identifying technical and economic potentials according to [3], there is also a lack of focus from the MSs on implementation and policies. For some countries, this description of measures promoting DHC networks and high-efficient cogeneration is missing. One indication of the difficulties of implementation of DHC networks and cogeneration is that the share of district heating in EU-28 residential heat consumption has remained around 12% from 1990–2015 [4], and the economic potentials identified by the MSs in the CAs have not been reached [3]. Therefore, while the CAs likely created awareness of the potentials of high-efficiency district heating and DHC networks, there remains a gap between the identification of potentials and actual implementation.

3 Guidance for comprehensive assessment of efficient heating and cooling based upon strategic heat planning experiences

Before commencing the technical mapping, the strategic goals must be clear. The EU already has significant long-term goals of decarbonizing the energy sector and economy but it remains uncertain how these targets are translated to the national and local levels.

Nevertheless, the overall long-term goal of any strategic heat plan should align with a 2050 decarbonized energy system. If heat planning does not take these long-term goals into account, there is a significant risk of suboptimizing sectors and taking no-regret choices.

3.1 Components of a comprehensive assessment of efficient heating and cooling in relation to strategic heat planning practice

AT a minimum, a CA should consist of the following elements: a technical analysis, an economic assessment and an action plan. As an economic assessment, the cost-benefit analysis carried out must be based on technical quantification and be oriented towards taking action. The focus of the assessment should include the potentials for energy savings and district energy.

The role of the technical analysis is 1) to raise awareness of the opportunities 2) quantify their potential and 3) serve as a basis for a comprehensive economic assessment.

Prior to any technical and economic analysis, an analysis of the strategic challenges of the energy system must be conducted and strategic objectives identified and formulated.

Although the strategic challenges are given to some degree by the motivation of EED, it is important to highlight the existence of this analytical phase since a coherent economic valuation of alternative courses of action cannot be carried out without identifying the strategic values to society. Further, although carbon dioxide emissions are the common pan-European challenge, national and local regions may have additional strategic considerations that may be included in the national and local comprehensive assessment.

Once the strategic challenges and objectives have been identified, these then can be formulated in terms of quantifiable parameters that become the guiding landmarks in the subsequent technical and economic assessment.

As a final step, solutions are identified that answer to the strategic aims. The process is illustrated in Figure 1. This focus of this document is limited to the last phase where efficient solutions are identified.

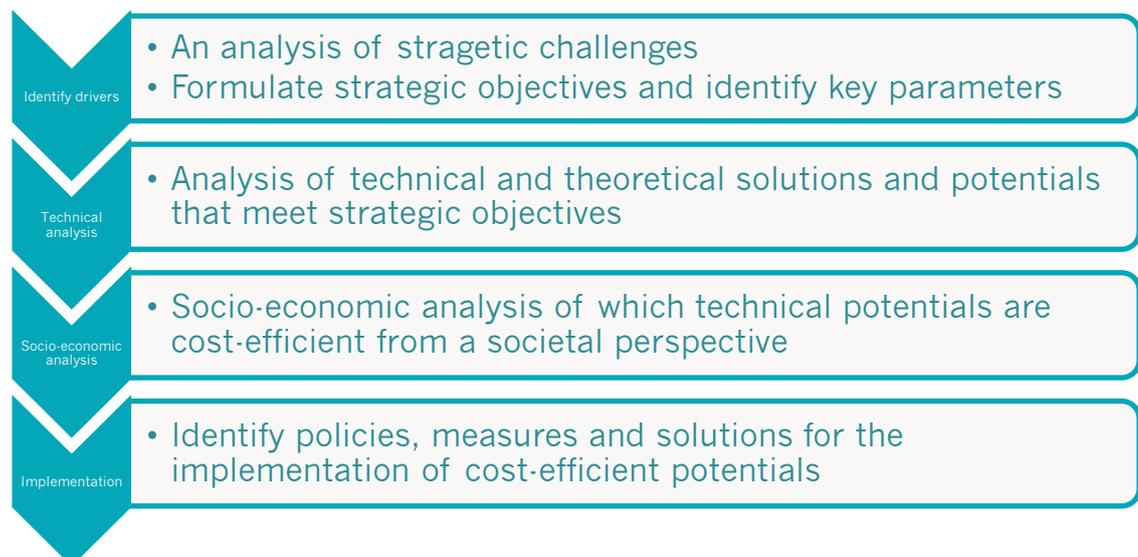


Figure 1 A four-step model for defining strategic heat planning challenges and objectives

This report has elaborated on the drivers and strategic objectives of carrying out strategic heat planning. The following sections will provide more detail on the following three parts of strategic heat planning, which also aligns with the steps necessary to take in order to carry out the CA in Article 14

3.2 The technical assessment of theoretical potentials

The primary objective of the technical step is to generate knowledge about heat supply and demand in the area covered—often on a national level in relation to Article 14. While electricity and gas supply and demand have historically been monitored, heating has been neglected in many MSs. This has resulted in a situation where most data about heat consumption and spatial distribution is estimated and not metered. Likewise, building data, such as building year and isolation levels, is often unknown. This makes it difficult to gain knowledge about energy efficiency and renovation potentials

It is important to establish credible knowledge about heat demand before investment decisions can be made. This importance is especially true for cogeneration and DHC infrastructure, which is characterized by high initial investments, long payback times and capacities depending upon current and future demands. The EU and MSs should increase the heat demand data collection on the national and local level where such information is lacking.

Before a data collection infrastructure is established, CAs and strategic heat planning can use the estimations in the HotMaps online toolbox¹. This will provide a credible estimation of heat demand for the area in question. Furthermore, the HotMaps toolbox allows for verification by uploading one's own data if more detailed quantifications are available.

Generally, more data is available for heat resources, such as power plants, waste incineration plants, industrial sites etc. Geothermal resources and more unconventional resources can be difficult to map (see the ReUseHeat project for the quantification of unconventional excess heat sources [2]).

When a credible baseline for heat demand, heat supply, building information and excess heat resources has been established, a two-step analysis can commence. First, it is important to assess the levels of feasible investment in energy efficiency to lower demand and not over-invest in capacity. Second, technical scenarios describing supply and demand for identifying a theoretical or technical maximum potential can be made. A 7-step model describing the first phase of strategic heat planning has been included here. The approach to strategic heat planning in this document is based on the 3-phase model, which has been outlined in Hotmaps Handbook I *Definition & experiences of strategic heat planning*.

- Phase 1: Construct 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 potentials for heat savings in buildings
 - 4) Identify a balance between investments in heat supply and investment in heat savings.
 - 5) Develop technical scenarios for a strategic heat supply plan
 - 6) Align with national/regional/local energy plans
 - 7) Iterate between step 4-5-6 in search for the best solution

Step 6 relates back to the defined strategic goals, in order to double check that the reached conclusion still aligns with the strategic objectives set out before the analysis.

The technical analysis is also the first step of the economic analysis. An economic analysis cannot provide any guidance if it is not founded upon quantifications derived from high-quality technical analysis. For the economic analysis to be coherent and adequate, the technical data that forms the basis for the economic evaluation must be carried out in an

¹ www.hotmaps.eu – the toolbox is a beta version at the time of publishing.

energy system context. This implies that the opportunity costs in the analysis are based on technical data that are generated in an energy system approach to heating solutions.

3.3 Method for economic assessment

The economic cost-benefit analysis is central in Article 14 and how it outlines the CA. An economic cost-benefit analysis can be a useful guiding tool for decision making provided the cost-benefit analysis is designed and approached from a coherent and adequate basis.

- Coherency implies the heating sector is analysed in an energy system context.
- Adequacy is provided through a technical analysis, which serves as the basis for economic analysis.

The purpose of a CA is to inform policy change. A cost-benefit analysis should therefore not be embedded in existing policies. This relates to the use of socio-economic prices and the assessment of the economic costs of externalities. Externalities can prove difficult to quantify, and therefore, are often difficult and contested to include in calculations. Externalities are, per definition, not included in market prices, as they otherwise would be internalized and thus not an externality.

A coherent economic assessment must first apply a basic distinction between business costs and economic costs. An assessment exclusively based on existing market prices is based on business costs and thereby does not constitute an economic analysis. An economic assessment strives to include all relevant costs and benefits, both those internalised in and externalised from market prices. Which cost and benefits are relevant to include is a consideration related to the identified strategic aims.

While it is recommended to attempt to include the full costs and benefits, this is only possible in theory and not in practice. There will always be externalities, positive or negative, that are omitted from the analysis or assessed from a particular perspective. Two ways of dealing with this issue are recommended here.

- Include full theoretical and methodological assumptions in assessing and quantifying externalities. This will allow transparency and a democratic debate whether the assessments are reasonable and are in line with other targets and assessments.
- Carry out the technical and economic assessments step-by-step. This will ensure that the effects of including externalities become visible in the analysis. If the costs are included from the beginning, it will not be possible to debate the cost-structures or reasons why certain alternatives are more feasible than others.

To promote cost-efficient solutions, the cost-benefit analysis must be based on an opportunity cost approach. This means that alternatives to an assessed option are accounted for in the cost-benefit analysis.

The opportunity cost approach can only be applied if well informed by the technical analysis. The technical analysis is the basis for the identifying opportunities, and awareness of opportunities is the basis for identifying the economic costs of the chosen course of action.

Here, it is vital to realize that the relevant opportunity costs in a system perspective may not be entirely reflected in market prices.

In the cost-benefit analysis;

- The economic costs of resource use must be estimated from a system perspective.
- The economic benefit of the chosen solution must be estimated from a system perspective.

Some concrete illustrative examples pertinent to heat planning in Europe could be:

- Do current biomass prices reflect the full opportunity costs of consuming biomass for heating purposes when its potential value as a resource for green gas and fuel products is included?
- Are the benefits from potential synergies between heat pumps, heat storage units, and fluctuating renewable electricity production sufficiently valued in the economic analysis?
- Do current market prices for carbon dioxide emissions reflect the long run economic costs the carbon dioxide emissions impose to society?
- Does the discount rate applied in the cost-benefit analysis reflect the true alternative return to capital? Many European countries apply discount rates above 3 per cent in energy planning, even though interest rates and growth rates in general hardly exceed 2 per cent per annum. A discount rate significantly higher than the alternative yield of capital leads to an undervaluation of investments in the energy sector relative to competing employments of capital.

In a socio-economic approach, it is important that the analysis:

- Traces and identifies the cost and benefits of alternative heating solutions based on a technical analysis of how each alternative externalizes costs and benefits to other energy sectors.
- Includes the full long run economic costs of environmental effects.
- Applies a discount rate reflecting either long term interest rates or general growth expectations.

3.4 Analyse current legislation and markets - Outline policies that may promote efficient solutions

The last step in a strategic heat plan relates to promoting the implementation and transition of the identified solutions. The primary task is to analyse current barriers and promoters for the most efficient solutions. This must be based on an analysis of the concrete legislation, market rules, taxes, etc, that regulates the heat market.

A method for mapping legislative barriers is to carry out a business economic assessment of technologies that are identified as fulfilling strategic objectives. Article 14 mandates such analyses for certain investments, but the methodology is useful and can be applied for all types of technologies. If there is a significant mismatch between the economic assessment and the business cost-based assessment of a given technology, the given legislation and market rules can be perceived as a barrier for obtaining the strategic objectives and must, therefore, be changed. This could, for example, show that large-scale heat pumps prove socio-economically beneficial, but high electricity taxation limits the business economy, or that DHC network investments suffer from limited access to capital.

The process of identifying solutions is illustrated in Figure 2. The CA required in EED is recommended to include the following four steps: 1) Identify strategic objectives 2) Carry out a technical analysis 3) Carry out a cost-benefit analysis 4) Propose new market rules and legislation that can lead to the implementation of measures that may lead to the fulfilment of strategic objectives.

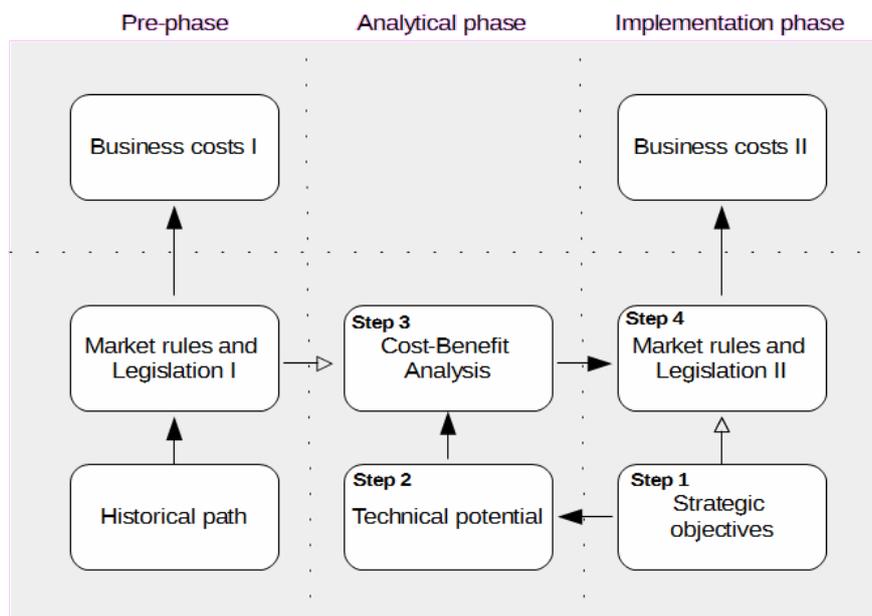


Figure 2 Process for identification of changes to market design, market rules and legislation

The historical path is the current situation and strategic objectives marks where society wants to go. The current market rules and legislation are tied to the historical path and produce the business costs that sustain investments in the historical path. This also relates to the discussion about using market prices as socio-economic prices above. Such prices are produced in a market that is designed for past solutions and thus, most likely, does not include externalities relevant for future systems.

Obtaining the strategic objectives, therefore, requires a change in market rules and legislation to create a new business cost environment that promotes investments in technologies that leads to the fulfilment of strategic objectives. However, as a necessary basis for re-shaping market rules and legislation, a CA includes technical analysis of possible alternative routes to the strategic objectives. Informed by the technical analysis, a cost-benefit analysis can be carried out, prioritizing among the solutions discovered in the technical analysis. Based on this analysis, market rules and legislation can be changed to promote investments that move society towards its strategic objectives.

This analysis should depart from a broad understanding of market design, and include the different actors, organizations and institutions present in the current system, in addition to taxation, tariffs, subsidies, access to capital, planning legislation etc. Changes in market design will likely promote new roles while limiting influence from other actors.

3.5 A framework for strategic heat planning on a national scale

The sections above presented a model for strategic heat planning focused on the national levels of the EU-28 MSs. It is divided into four stages: 1) Identifying drivers and strategic objectives, 2) technical mapping and quantification, 3) socio-economic assessments of cost-efficient solutions, and 4) identifying barriers in current market design and suggesting policies for transitions.

Article 14 of the EED, describing how to carry out CAs, is such a framework promoting strategic choices for heating in the EU-28 heating sectors. In the following section, the current methodology of Article 14 is presented and then compared to the strategic heat planning framework.

4 Article 14 content and methodology

Article 14 of the EED specifies that MSs must carry out a CA of the potentials for high-efficiency cogeneration and efficient DHC. Annex VIII of the EED outlines the topics that the CA should cover, which the European Commission (EC) propose follow these six steps [3]:

- 1) Establish heating and cooling demands
- 2) Prepare 10-year forecasts
- 3) Spatial analysis of main supply and demand points
- 4) Technical potentials for high-efficiency cogeneration and efficient district H&C
- 5) Establish economic potentials
- 6) Define strategies, policies and measures

The methodology can be split into three parts. Steps 1-4 cover a technical assessment of energy system demand, supply and technical infrastructure. Step 5 involves the economic assessment of alternatives with a cost-benefit methodology and step 6 focuses on policies and measures for implementation. In the following, the Article 14 methodology will be elaborated under these three headings.

4.1 Technical assessment

The first step of the technical assessment relates to the establishment of a baseline of H&C demands. Article 14 Annex VIII does not specify the type or resolution of data that should be used, but the European Commission suggests to use measured data when available [3]. Time resolution is not mentioned, but it is widely recognized that high-resolution data is preferred, as this includes daily and seasonal variations. This is important when analysing energy system synergies.

The second step is to analyse demand forecasts for a 10-year period, with a particular focus on industry and buildings. The third step is to carry out a spatial analysis of the location of heat supply and demand points. Annex VIII provides several threshold values for areas and sites to consider. Demand points include municipalities with a plot ratio² above 0.3 and industrial zones with an annual demand above 20 GWh. Supply points include power plants with an annual electricity production above 20 GWh, waste incineration plants and existing and planned cogeneration facilities.

Finally, the technical or theoretical potential is established by assessing the amount of heat demand that potentially could be supplied by the identified supply points, high-efficiency cogeneration and efficient district heating.

² Plot ratio refers to the ratio between building floor area and land area in a specific location.

4.2 Cost-benefit analysis

The cost-benefit analysis (CBA) aims at identifying the economic potential, a subset of the technical potential. The CBA addresses the societal level and should include socio-economic and environmental factors. Scenarios can include all relevant alternatives, but can be limited to high-efficiency cogeneration, efficient district H&C and efficient individual H&C.

The net present value (NPV) criterion should be used as the criterion for evaluation of alternatives, and relevant investment periods should be used. Information about assumptions should be provided, such as prices on the major inputs and outputs such as investment costs and energy prices, as well as the discount rate used. The discount rate should be set according to European or national guidelines and take data from the European Central Bank into account. Prices should reflect true socio-economic costs and benefits including externalities, while Annex IX also indicates that market prices can be used when they sufficiently include externalities.

Article 14 differentiates between economic and financial analyses. The above methodology is the economic assessment of potentials for the MSs, while a financial CBA should be carried out for specific projects. Article 14(5) specifies which projects trigger a financial CBA. A new thermal electricity generation installation with a thermal input above 20 MW must carry out a financial CBA to assess high-efficiency cogeneration potentials for the installation. Significant refurbishment³ projects of thermal electricity generation installations or industrial installations with a thermal input above 20 MW must assess the potential of converting to high-efficiency cogeneration plants or utilizing waste heat during refurbishment. Likewise, when new DHC networks are planned or when new capacity with a thermal input above 20 MW is planned in existing DHC networks, a financial CBA must be carried out to assess potentials for utilizing waste or excess heat from nearby installations.

4.3 Implementation

MSs should define strategies, policies and measures that promote the implementation of the identified economic potential through the CBA. Article 14(4) requires MSs to take adequate measures to develop high-efficiency cogeneration, efficient DHC infrastructures and use excess heat and renewable sources.

Local and regional levels should be taken into account in the definition of strategies. Article 14(2) specifies that the potentials for developing local heat markets should be assessed.

³ Refers to refurbishment costs that exceed 50% of the costs of a new comparable unit. Article 2(44)

5 Conclusions and recommendations for strategic heat planning from Article 14

The section above presented the methodology and workflow as described in Article 14. Here, recommendations are discussed for improving Article 14.

Overall, the EED and Article 14 provides an important framework for creating awareness about the potentials for cogeneration, DHC and the utilization of waste and excess heat. The overall topics of analyses in Article 14 fit well with the strategic heat planning framework presented in section **Fejl! Henvisningskilde ikke fundet.**, as both cover technical, economic and policy/implementation topics.

5.1 Scope of comprehensive assessments

The scope of analysis is broader in the strategic heat planning framework in both an energy system domain and time perspective. Here, it is recommended to include cross-sector energy system effects while focusing on the heating sector. It is very difficult to capture synergies across sectors if not considering entire energy systems. Annex IX(b) specifies that an “integrated approach to demand and supply options” should be taken, but these considerations are not included in the technical mapping part. It is recommended to already deploy a holistic energy systems point of view at the beginning of the analysis.

The recommended timescale also differs from the strategic heat planning framework and Article 14. Strategic heat planning suggests a departure from the long-term strategic objectives, which here are suggested to be decarbonized energy systems in 2050, in alignment with the Paris agreement and EU targets. Article 14 suggests forecasting heat demand for 10 years and using relevant investment horizons for technologies. This opens up a risk for making choices today that do not align with overall energy system infrastructure in 2050. By backcasting from 2050, roadmaps can be constructed that ensure strategic investments today support energy system decarbonisation as well as exploit possible synergies, both present and future.

5.2 Economic assessment and assumptions

The CBA method described in Annex IX could be more explicit on the definition and identification of externalities. As mentioned above, an existing market price does not guarantee that all externalities are covered. It has proven very difficult to agree on price-levels that cover the actual impact of externalities, such as CO₂ emissions.

While the policy and implementation part of Article 14 mandating MSs to take adequate action for the implementation of identified cost-efficient levels is an important part of promoting change, it is lacking a detailed framework for the necessary policy changes. This report has suggested one such method, by using the financial CBA for specific investments to identify socio-economically beneficial investments that do not present positive business economics. In these cases, the concrete barriers towards making these investments profitable should be identified and used to inform policy change.

It remains unclear which different assumptions have been used in the CBAs from the MSs. Therefore, it is difficult to assess how the different potentials were reached. Annex IX (part 1 point g) specifies that MSs shall provide detailed methodologies and assumptions, but these are largely lacking from the CAs. Enforcing this in the next round of assessments will increase transparency about results and improve comparability.

Assumptions used in the CA's should be readily available and justified. This includes the discount rate, fuel prices, scope of analysis, time frame, energy technology costs, demand curves etc. By making these inputs publicly available, it will increase the transparency of the conclusions. It will also make it clear how the CAs and analyses relate to strategic and societal goals.

The EU could provide a baseline dataset that can be used when lacking more detailed data. This should include energy technology costs, fuel prices, infrastructure costs etc. Obviously, there are large differences across the EU-28, but a simple baseline technology catalogue could prove beneficial for new analyses.

The JRC published a dataset on small-scale heating and cooling technologies for individual buildings with data from four countries, Northern Europe (Denmark), Eastern Europe (Hungary), Southern Europe (Portugal) and Central Europe (Germany) [4]. This dataset does not include information about cogeneration or large-scale collective supply technologies. A complementary dataset for these technologies could be made, following the Danish example of a technology data catalogue for electricity and district heating generation [5].

5.3 Data collection and availability

Gaps in data availability and data collection for heat demand, heat sources, cogenerated heating, building age and isolation are a barrier towards quantifying the potentials for cogeneration and DHC networks across Europe. These processes should be encouraged by the EED and effective data collection infrastructures should be established in those areas where they are not sufficient. MSs with effective practices, such as Denmark, could provide best-practice guidance. The deployment of smart meters could provide a means to improve this knowledge gap.

The collected data should be publicly available for academics, businesses and consumers to improve knowledge, provide new business models and awareness of energy consumption.

Time resolution is an important aspect of the data collection, and to be beneficial in energy system analyses, a high temporal resolution is necessary. Hourly or daily values are preferred regarding heat production and consumption data.

Before reliable data is collected and verified, estimation can be used. The HotMaps toolbox provides the tools to estimate heating demand and heating supply options for Europe on a local scale.

5.4 Comparability of results

The expected results from CAs should be communicated more clearly. If the goal is comparable analyses across countries, then the EU should provide a more detailed methodology and assumptions to carry out the analysis.

Several methodological discrepancies and unknowns result in difficulty comparing CAs across countries, as mentioned above. Comparisons are important for measuring progress and ensuring that all socio-economic potentials are activated. Therefore, it is recommended to increase the use of similar assumptions or input estimation, method transparency and system boundaries.

With this in mind, it is also important to remember that the purpose of Article 14 is to create awareness of the potentials of cogeneration, DHC and the utilization of excess heat. The MSs should be able to make relevant analyses that remain useful in their territory. Therefore, a too strict methodology can also provide risks for becoming a mandatory task and not activate the real potentials for increasing energy efficiency in H&C. If the goal is to increase awareness of cogeneration and district heating among member states, then it is more important that the member states make analyses that are relevant to them and not strictly guided by specific methodologies.

6 Literature

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