KeepWarm
Renewing district heating

Improving the performance of District Heating Systems in Central and Eastern Europe

Development of multi-level policy plans: Recommendations for the integration of district heating and cooling in the comprehensive assessment of the potential for efficient heating and cooling

Horizon 2020 (H2020-EE-2017-PPI) - Project N°784966

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List of Abbreviations

AP	Action Plan
AT	Austria
CA	comprehensive assessment of the potential for efficient heating and cooling
CBA	Cost-Benefit Analysis
CEE	Central and Eastern Europe
CHP	Cogeneration of Heat and Power
CoM	Covenant of Mayors
CRO	Croatia
CZ	Czech Republic
DH	district heating
DHC	district heating and cooling
DHS	district heating system
EC	European Commission
EE	energy efficiency
EED	Energy Efficiency Directive
EU	European Union
GHG	Greenhouse Gas
H&C	heating and cooling
LV	Latvia
MS	EU Member State
NECP	National Energy Climate Plan
RES	Renewable Energy Source
SECAP	Sustainable Energy and Climate Action Plan
SI	Slovenia
SRB	Serbia
UKR	Ukraine
WP	Work Package

Summary of the project

The project “KeepWarm - Improving the performance of district heating systems in Eastern Europe” is funded under the EU Horizon 2020 programme. Its objective is to accelerate cost-effective investments in the modernisation of District Heating Systems (DHS) in Central and Eastern Europe (CEE). KeepWarm is most active in seven countries: Austria (AT), Croatia (CRO), Czech Republic (CZ), Latvia (LV), Serbia (SRB), Slovenia (SI) and Ukraine (UKR). The project focuses on this region, and these particular countries, because in most cases DHSs are frequently still inefficient and for the most part overly reliant on fossil fuels (especially gas, coal or oil).

The aim of this initiative, launched in April 2018, is to modernise DHSs around the whole region in a more sustainable manner. By improving system operations and promoting a switch to less-polluting sources, like renewable energy sources (RES), KeepWarm will contribute to reducing greenhouse gas (GHG) emissions. The eleven project partners strive to ensure that best practices for environmentally-friendlier heating and cooling will be taken up across Europe, replicating KeepWarm’s approach in other countries and regions, even beyond the end of the project in September 2020.

Project objectives

KeepWarm’s specific objectives are:

At least 450 relevant stakeholders with increased capacities on technical, organisational, financial and managerial aspects – includes 150 DHS operators;

At least 95 **DHS operators** are able to **develop business plans** and to identify the most suitable **financial model** for modernisation of their own DHS;

At least 23 **business plans for the modernisation** of DHSs have been developed and **sources for investment** have been identified;

DHS network **retrofitting** is addressed in at least 10 local **energy plans** and 7 regional or **national strategies** or plans;

At least 23,300 **relevant stakeholders** (directly) and 125,000 (indirectly) **reached** across Europe in order to **replicate the project outputs** in primary and secondary target regions and ensure the project’s impact;

Support EU policies and initiatives, such as the Covenant of Mayors for Climate and Energy (CoM) and DecarbHeat, by exploiting key lessons from KeepWarm activities and pilots to disseminate best practices across Europe.

KeepWarm consortium partners

LOGO	PARTNER NAME	SHORT	COUNTRY
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	Deutsche Gesellschaft für internationale Zusammenarbeit (GIZ) GmbH	GIZ	Germany
FSB	University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture	UNIZAG FSB	Croatia
lk Landwirtschaftskammer Steiermark	Landeskammer für Land- und Fortwirtschaft in Steiermark	LWK	Austria
REGEA	Regionalna Energetska Agencija Sjeverozapadne Hrvatske	REGEA	Croatia
Jožef Stefan Institute, Ljubljana, Slovenia Energy Efficiency Centre	Jožef Stefan Institute, Energy Efficiency Centre	JSI	Slovenia
ICLEI Local Governments for Sustainability	ICLEI European Secretariat GmbH	ICLEI Europe	Germany
ASSOCIATION FOR DISTRICT HEATING of the Czech Republic	Teplarenske Sdruzeni Ceske Republiky	TSCR	Czech Republic
ZREA ZEMGALES REGIONĀLĀ ENERGĒTIKAS AĢENTŪRA	Biedriba Zemgales Regionala Energetikas Agentura	ZREA	Latvia
KSSENA	Zavod Energetska agencija za Savinjsko, Šaleško in Koroško	KSSENA	Slovenia
KT-ENERGY	LLC KT-Energy Consulting	KT-Energy	Ukraine
VINČA INSTITUTE OF NUCLEAR SCIENCES University of Belgrade NATIONAL INSTITUTE OF THE REPUBLIC OF SERBIA	Institut za nuklearne nauke Vinča	VINCA	Serbia

Content

Executive summary

The aim of this document is **to support an efficient and high-quality preparation of the comprehensive assessment of the potential for efficient heating and cooling** (CA) that Member States (MS) should prepare in accordance with Article 14 of Energy Efficiency Directive (EED), which refers to Annex VIII specifying the content and basis of CA. Complementary to a detailed description of the preparation process of the 2nd CA that is defined in EC recommendation 2019/1659 of 25 September 2019, this report provides specific recommendations and examples for its quality performance, addressing public authorities, contractors and district heating (DH) companies.

Existing and new district heating and cooling (DHC) systems are the key components in the development of a sustainable, competitive, secure and decarbonised energy system in Europe. DHC systems play an important role in the effective integration of energy sectors that can significantly reduce the cost of the transition to a carbon-neutral society. Considering the results of the KeepWarm and other EU projects, the focus of this publication is to properly address the current situation and to support the future role of DHC systems. MS should adequately assess their full potential in order to maximise their own benefits and contribute to the overall benefits of efficient heating and cooling (H&C) in Europe:

- **Quality assessment of heating and cooling demand** – mapping of demand and potential waste heat, and renewable sources with a special focus on densely-populated areas, which are most appropriate for DHC services. Several useful mapping tools and databases have been developed within EU projects and are publicly available.
- **A policy review is an ideal opportunity to assess the adequacy and effectiveness of implemented measures, especially in the area of DHC systems.** The KeepWarm project provides useful materials and reviews of its own, as well as a collection of relevant documents from other projects.
- **Evaluating the economic potential for efficiency in heating and cooling is the central and most challenging part of the analysis. Pay particular attention to the appropriate inclusion of DHC systems in alternative scenarios**: consider options for expanding and upgrading existing DHC systems - potential energy savings, use of new sustainable energy sources in the area (renewables and waste heat) and assess the potential for new DHC systems, which could be a very efficient solution for areas with heating/cooling densities above the typical economic thresholds for DHC.
- The results of the KeepWarm project confirm that there is great efficiency and RES potential in existing and new DHC systems. **The comprehensive assessment is an excellent opportunity to adopt the additional necessary policies and measures to create a stimulating environment to exploit this potential as soon as possible.**
- **The document provides a comprehensive list of available data sources** (technology data, energy prices, external costs, etc.), **tools** (heat and cold maps, databases, etc.) **and recommendations to support the quality implementation of the comprehensive assessment.**

Hints on a comprehensive assessment of the potential for efficient heating & cooling

The main objective of the preparation of the *Comprehensive assessment of the potential for efficient heating and cooling* (CA) is to identify potentials and support the uptake of effective and sustainable heating and cooling solutions in EU Member States (MS), as heating and cooling (H&C) is the largest energy end-use sector, accounting for about 50 % of total energy demand in the EU. The analysis approach of CA is technologically neutral – it considers all efficient heating and cooling technologies. The results and findings of the KeepWarm project from five EU Member States (Austria, Croatia, Czech Republic, Latvia and Slovenia) and two non-EU countries (Serbia and Ukraine) provide an on-the-ground basis for quality recommendations for CA preparation and updating, especially with regard to appropriate consideration and effective future development of district heating and cooling (DHC) systems.

Existing and new DHC systems are one of the key pillars of the European evolving sustainable, competitive, secure and decarbonised energy system. Both current and new systems can efficiently contribute to future energy supply. Existing DHC systems can exploit significant potential for efficiency improvements, as well as integration or even full conversion to renewable energy sources (RES) and waste heat. Meanwhile, new systems can provide sustainable H&C and contribute from the outset to effective integration of energy sectors and lower costs in the transition to a carbon-neutral society[1]. It is therefore important that, in the context of the CA preparation, adequate support and consideration of these systems are provided.

The contents of the 2nd CA has been defined with the Commission Delegated Regulation No. 2019/826 of 4 March 2019[2], amending Annex VIII to the Energy Efficiency Directive (EED) 2012/27/EU. Some of the key features of the 2nd CA include the identification of retrofits for related technological solutions used for H&C supply and that all data collected on H&C supply and demand should have a spatial dimension so that opportunities for synergies can be identified on the ground via publicly available heat/cold maps. Furthermore, it demands a mandatory provision of an economic potential analysis method in order to also take into account the reduction of heat losses in existing DHC networks.

The evaluation of the results of the first round of CA[3] (due at the end of 2015) across MS has revealed that the outcome differed significantly mainly because of the lack of a strict framework, differences in H&C planning practice and methodologies as well as lacking data and their collection[4]. A useful step towards a more harmonised approach is the European Commission (EC) recommendation to the content of the 2nd CA, which was issued on 25 September 2019[5]. It is also providing a reporting template. Although it is intended for voluntary use, it can be a very helpful tool as it gives some practical advice on how to cover

[1] Heat Roadmap Europe 4 (2018) - Quantifying the Impact of Low-Carbon Heating and Cooling Roadmaps - https://heatroadmap.eu/roadmaps/
[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0826
[3] Synthesis report on the evaluation of national notifications related to Article 14 of the Energy Efficiency Directive, JRC, 2018, https://publications.jrc.ec.europa.eu/repository/handle/JRC112225
[4] Guidance for the comprehensive assessment of efficient heating and cooling, Hotmaps project
[5] Commission recommendation (EU) 2019/1659 of 25 September 2019. Document provides detailed descriptions of the content of CA with general and specific recommendations on its phases, waste heat accounting, financial and economic cost-benefit analysis, external costs, additional sources of literature and voluntary reporting template; https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019H1659

the topics of the CA in a "harmonised way". Figure 1 shows the entire updated CA preparation process from the amended EED Annex VIII as presented in the above-mentioned EC recommendation. The following chapters illustrate and detail the four main parts/phases of the CA preparation process and the subsequent **Boxes** present the main recommendations of the KeepWarm project for CA providers to take into account the specificities of the DHC.

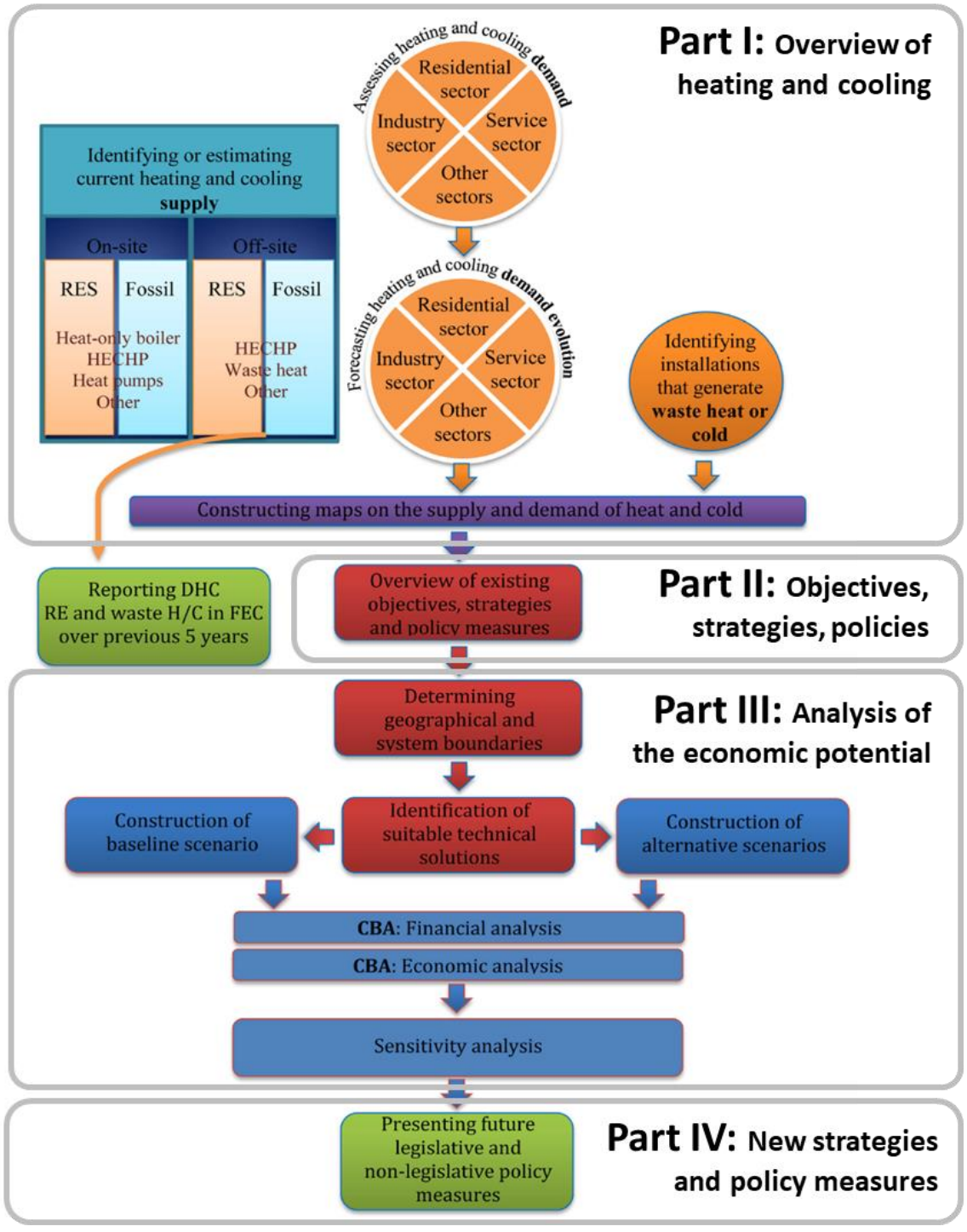

Figure 1: Process for CA (Source: Commission recommendation 2019/1659 of 25 September 2019 on the content of the CA)[6]

[6] The abbreviations used in figure are described in the list of abbreviations on the page 3.

Particular emphasis is placed on highlighting useful existing data and knowledge sources that can serve as efficient support for experts involved in the preparation of CA and all other relevant stakeholders. The selection of data sources provided by EU relevant for the development of DH systems is presented in Annex 1.

Part I: Overview of heating and cooling

The main objective of the first part of the CA - Overview of heating and cooling, is to provide quality data for conducting the analysis, which is essential for the quality and relevance of the results. The five steps of data collection, processing and presentation in the form of a heat and cold map are shown in Figure 2 and the highlights are described in Box I.

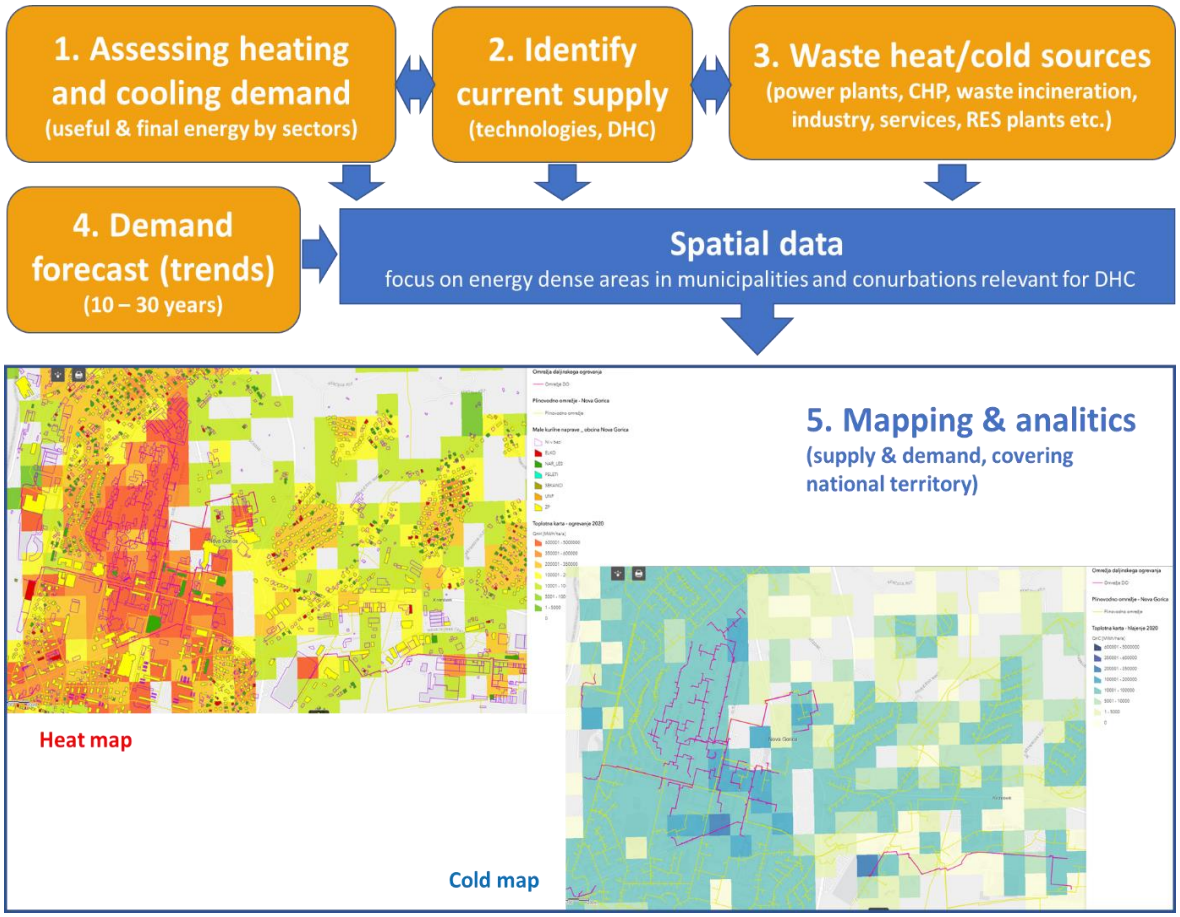

Figure 2: Overview of heating and cooling – data collection and mapping

This part depends essentially on a proper sectoral and geographical breakdown of supply and demand, which requires a robust data collection and processing, with different sub-sectors likely to require different approaches. In order to represent the geographical breakdown, spatial data attributes need to be ensured at appropriate territorial units such as municipalities, local administrative units, postcode areas, industrial parks or other (nationally) well-established district units.

Box I: KeepWarm recommendations on Overview of H&C (CA - Part I)

1. ***Assessing heating and cooling demand*:** combine a bottom-up and top-down approach in data collection with a special focus on densely populated areas (not only urban and suburban areas, but also other smaller compact settlements) that are best suited for DHC services.
2. ***Identify current supply by technology*:** provide detailed and accurate recent data on DHC systems' operation (statistics, regulator data, etc.). A distinction must be made between renewable and fossil energy sources.
3. ***Waste heat or cold sources identification*[7]:** focus on the area of existing DHC systems, and densely-populated areas relevant for new DHC systems and identify all existing (power plants, industry, CHP, waste incineration etc.), and potential future waste heat sources (data centres, H_2 electrolysers, biofuel plants etc.). The location of the potential sources that could satisfy demand in the future shall be shown on a map.
4. ***Supply and demand forecast* (in particular for the next 10 years, with the perspective for the 30 years):** consider a long-term renovation strategy, the National Energy and Climate Plan (NECP), and other action plans for an appropriate assessment of future heating and cooling supply and demand which is key for the long-term investments in DHC infrastructure.
5. ***Producing the heat and cold maps*:** When collecting data, try to spatially define as much data as possible in order to enable a high-quality production of a heat and cold map. Inclusion of data related to DHC systems (especially on infrastructure / networks and heat sources) is critical for their proper consideration. The resolution of the map elements (required according to point 3(a) in Annex VIII EED) must allow for the identification of specific areas of high H&C demand (particularly appropriate for DH supply). Beyond the scope of CA, the provision of quality spatial databases and mapping tools is of paramount importance for high quality planning at the local level, especially when it comes to plans for DHC infrastructure.

Several mapping tools and databases have been developed within EU projects and are publicly available, thus making access to data sources easier and enabling higher quality level.

HOTMAPS
www.hotmaps.eu/map

2050 Heat Roadmap Europe
A low-carbon heating and cooling strategy
https://heatroadmap.eu/peta4/

PLANHEAT
https://planheat.eu/

THERMOS
www.thermos-project.eu/thermos-tool/thermos-tool/

Further information about useful resources about heat/cold mapping is available on:
https://keepwarmeurope.eu/learning-centre/data-inputs

[7] The Commission Recommendation (EU) 2019/1659 (of 25 September 2019) in the Annex IV outlines the accounting of waste heat and cold to be considered appropriately for the 2nd CA.

Part II: Objectives, strategies and policy measures

The second part of the CA aims to identify the role of efficient H&C in the long-term reduction of greenhouse gas (GHG) emissions and to provide an overview of existing H&C policies and measures in line with the National Energy and Climate Plan (NECP) and any of its subsequent amendments or revisions.

The review of H&C strategies, targets and policies is an ideal opportunity to assess the appropriateness and effectiveness of the implementation of measures, especially in the area of DHC systems. Their impact on energy efficiency and GHG emission reductions needs to be clearly assessed and quantified. Such a detailed analysis has been carried out for seven KeepWarm pilot countries, and has been crucial for the preparation of targeted action plans and recommendations for the DHC sector (the publications listed in Box II-1). Several other useful resources have been gathered[8], most of which are directly related to current EU energy and climate policies and their implications for the DHC sector, while some provide insights into the use of specific renewable energy sources.

Member States must assess and appropriately quantify policies and measures in relation to H&C contributions to the five dimensions of the Energy Union – **decarbonisation** (e.g. uptake of RES in DHS), **energy efficiency** (e.g. retrofitting od DHC networks), **energy security** (e.g. high level of flexibility and diversification of heat supply in DHS), **internal energy markets** (e.g. DHC as key enabler of smart energy systems) and **research, innovation and competitiveness**. In addition to the examples on decarbonisation and energy efficiency dimensions (see Recommendation 2019/1659), some examples of the other dimensions are given in Box II-2, with a particular focus on aspects relevant to energy security and the internal energy markets.

Box II-1: KeepWarm recommendations on an overview of existing objectives, strategies and policies for H&C (CA – Part II)

The KeepWarm project provides useful materials and reviews of its own, as well as a collection of relevant documents from other projects, for example the following:

- **Regulatory framework and barriers review for retrofitting DHS**[9] – the document provides a comprehensive overview of the existing regulatory and policy framework relating to the H&C sector in the seven KeepWarm Central and Eastern European (CEE) countries (AT, CZ, CRO, LV, SI, SRB, UKR) that influence the retrofitting and modernisation process of DHS, including its strategic role and potentials. Furthermore, it outlines the highlights of the 1st CA in the countries studied, which results in the identification of weaknesses of the current policy arrangements and the opportunities in relation to improve strategies and action plans, leading to an enhancement of DHS retrofitting plans at national and regional levels.
- **Action plans for retrofitting of District Heating Systems**[10] – this document outlines the situation of the DH sector in the seven CEE countries and provides the

[8] https://keepwarmeurope.eu/learning-centre/
[9] https://keepwarmeurope.eu/fileadmin/user_upload/Resources/Deliverables/GA_784966_D5_1_Regulatory_Framework.pdf
[10] https://keepwarmeurope.eu/fileadmin/user_upload/Resources/Deliverables/KeepWarm_D5.2_Development_of_Multi-level_policy_Plans.pdf

series of national action plans (AP) which contain milestones and recommendations for measures and actions required to improve the process of retrofitting, upgrading and developing DHS.

- **Recommendations for support of DHS retrofit integration in multi-level policy plans**[11] – this publication serves as an overview and guide for public authorities and other stakeholders involved in energy planning on approaches to the effective and timely integration of DH aspects into strategic planning documents. It also reflects the most effective policy development approaches and communication strategies with responsible stakeholders to influence the process at all levels, from national to local, and summarises the key issues and steps for integrating DH into strategies and action plans. Furthermore, the document provides guidance on (1) how stakeholders can support each other's efforts and (2) how coordinated strategic energy planning at different levels can be used to design objectives and actions that meet the needs of local communities, while working together towards overarching national goals.
- **The KeepWarm Policy Spotlight**[12] summarises the revised EU Renewable Energy Directive (REDII) and highlights how the new regulations affect the DHC sector. The main elements about its further development are addressed in Articles 23 and 24.

Box II-2: Examples on aspects related to Energy security and internal energy markets (CA – Part II)

The review of **energy security**[13] dimensions may encompass:

- **Availability**: entails procuring a sufficient and uninterrupted supply and minimizing (foreign) dependency on fuels (related aspects: energy sources, suppliers and spatial diversification, the provision of uninterruptible services);
- **Affordability** and equitable access of energy services: the proportion of income spent on energy services; levels of energy poverty; the energy price stability; the range of quality energy fuels and services;
- Energy and economic **efficiency**: innovation, research, and development, leading to new or improved energy technologies that enhance the quality of energy services and reduce the negative externalities and costs associated with energy supply/use;
- **Sustainability** and environmental stewardship: how current resource consumption is balanced with the resource requirements of future generations; regeneration rates of RES; waste emissions lower than assimilative capacities of ecosystems; water and land consumed for energy production.

[11] https://keepwarmeurope.eu/fileadmin/user_upload/Resources/Deliverables/D5_3_Retrofit_recommendations.pdf
[12] https://keepwarmeurope.eu/fileadmin/user_upload/Resources/Policy_spotlights/KeepWarm_Policy_Spotlight_N_1.pdf
[13] The approach towards energy security characterisation can be very complex and based on many interconnected factors, such as energy efficiency, diversification of supply, minimization of price volatility, energy research and development, the pricing of services without disruption, access to reasonably priced energy services without disruption, the integrity of the grids, securing energy resources and infrastructure. More information about the defining and measuring energy security: https://www.annualreviews.org/doi/pdf/10.1146/annurev-environ-042509-143035.

Internal energy markets[14]:

- **Improving sectoral integration and flexibility**: use of the complementarities that exist between the differing generation mixes, considering renewables, waste heat, high efficiency cogeneration, heat storage, power-to-heat, that provide flexible and competitive energy supply by taking account of energy price signals (e.g. electricity and other fuels);
- **Accelerating the uptake of new DHC systems**: strengthen and develop frameworks to support new small and micro DHC systems, assist and work with diverse local groups such as energy cooperatives to grow the DHC market;
- **Build Heat Synergy Region**: regions where urban and rural areas combine their renewable energy and waste heat potentials across their political boundaries to optimise and create the most sustainable and low-carbon energy infrastructure;
- **Distribution infrastructure**: integration of areas with high renewable energy potential with main consumption areas; duration of planning and building of new or upgrading existing DHC infrastructure;
- **Competitively priced and involvement-oriented consumer policy**: introduction of meters and accurate measuring of actual consumption; consumer protection measures; demand response;
- **Energy poverty**: indicators for measuring and monitoring; how this is taken into account when devising energy efficiency obligation schemes.

Part III: Analysis of the economic potential for efficiency in heating and cooling

This part is the central, most demanding and challenging part of the comprehensive assessment, as it includes consideration of the relationships between the heat demand and supply components of the national energy system, in particular the more dynamic aspects, which increases the complexity of the modelling and analysis.

Each MS is free to choose the economic potential analysis methodology, but it must meet the following criteria: (1) it covers the entire national territory, (2) it is based on cost-benefit analysis (CBA) and uses net present values as an evaluation criterion, (3) it includes baseline and alternative scenarios, (4) it considers a range of technologies, and (5) it takes socio-economic and environmental factors into account. The four main steps of the economic analysis are shown in

Figure 3.

It is worth noting that the grid connection rate can play the most important role in achieving high economic potential of DHC systems, especially due to the high upfront costs of building the network (pipes and their installation) and connecting the consumers. The

[14] https://ec.europa.eu/energy/sites/ener/files/documents/report_of_the_commission_expert_group_on_electricity_interconnection_targets.pdf

annual heat load factor (the variation of heat demand over the year) is another parameter that indicates the potential and suitability of DHS for implementation.

Estimating the cost of DHC networks is very complex due to the combination of many factors, e.g. costs depend on the configuration and other specifics of the actual site, the consumer portfolio, the availability and parameters of heating/cooling sources, or the impact of climate change on H&C demand. Often, considerations of perspective areas are based on estimating current heat densities, without considering perspective heat demand or considering the combination with increasing cooling demand.

As noted above, the cost of DHS implementation depends on the expense of pipelines (installation) and substations (connection to the grid), so it is particularly important to use techno-economic data specific to the location of demand (sample data and other useful resources can be found in the JRC publication[15]).

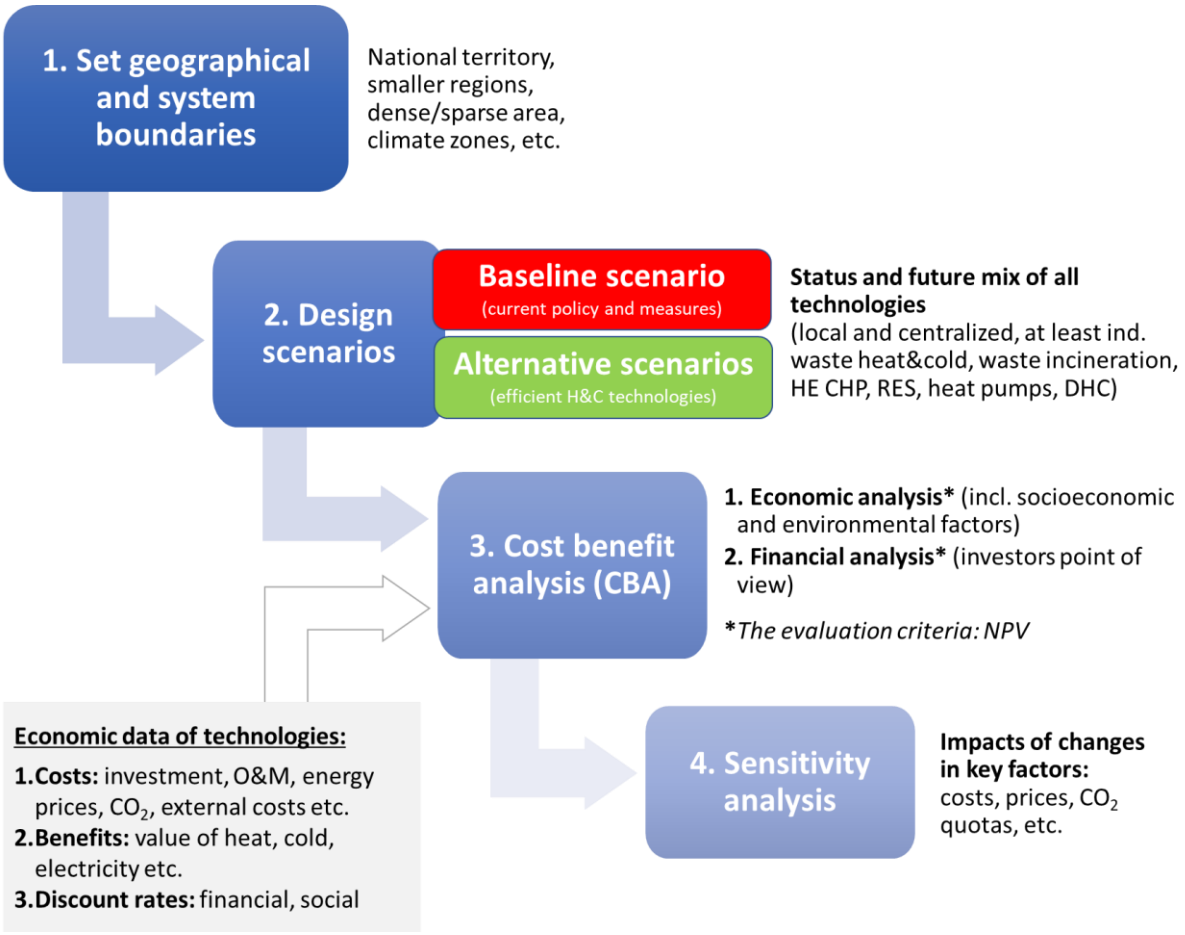

Figure 3: Key steps of the analysis of economic potential for efficiency in heating and cooling

[15] Best practices and informal guidance on how to implement the Comprehensive Assessment at Member State level, https://publications.jrc.ec.europa.eu/repository/bitstream/JRC98819/d1,%20dec%202015.pdf

Box III: KeepWarm recommendations on the analysis of economic potential of efficient H&C (CA – Part III)

1. *Establishing geographical and system boundaries*

- The choice of boundaries determines the group of entities (e.g. networks, heat generation plants, waste heat sources, heat consumers, etc.) and the aspects of their interaction that must be covered by the analysis. System boundaries describe much more a local concept, which is very important to DHS, but is often too detailed to be covered in the CA;
- Determine the area based on the available data and the level of details you want or are capable to implement in the CA, seeking a balance for the "right" amount of details to include enough, but not too much, thus not losing the sight of the whole situation and important factors of the analysis;
- **Keep a special focus on densely-populated areas with expectedly high heating demand** which are most relevant for DHC solutions. Use standard indicators such as heat density (linear or area) to identify the most relevant and economically perspective dense areas in your country. Assess all perspective sites or at least major urban areas, otherwise make a general assessment at national level if appropriate tools or sufficiently detailed data are not available.

2. *Scenario design*

Pay particular attention to the appropriate inclusion of DHC systems in alternative scenarios design:

- **Existing DHC systems -** consider potentials and different options:
  - **Evaluate the potential for energy savings through energy retrofitting of the network** (the reduction of water losses, insulation retrofit, decrease of temperature levels etc.);
  - **Increase of heat demand through network expansion and connection of new consumers** in nearby areas with high heat demand density**;**
  - **Connection potential to new sustainable energy sources in the area** (e.g. RES and waste heat);
  - **Identify typical cases of DH,** depending on how many of such systems exist in your country, classify them and define relevant typical parameters for a more general scenario analysis.
- **New DHC systems** – from micro to larger DHC systems - could be a very efficient and economically feasible solution in dense areas, particularly by integrating RES and waste heat recovery:
  - **Use heat mapping to identify areas with heat/cold density above the typical economic thresholds** for DHC (useful guidance on setting thresholds and quantifying the potential of DH is provided by the Stratego project[16]);
  - **Use software tools to identify cost-optimal networks** (e.g. provided by THERMOS project, see Annex 1);
  - **Review local and regional energy and climate plans** (SECAPs, etc.) for DHC systems already planned.

[16] https://heatroadmap.eu/wp-content/uploads/2018/09/STRATEGO-WP2-Background-Report-6-Mapping-Potenital-for-DHC.pdf

3. *Cost-benefit analysis (CBA)*

Collecting input data for demand and supply analysis and economic data of different potential technologies is crucial for the quality of the results. Gathering relevant data for DHC systems is often much more difficult compared to standard individual heating solutions, but it is the key to perform the CBA correctly.

- **DHC system costs** can take into account (1) capital costs of plant and equipment, as well as associated heat distribution or energy networks, (2) energy costs, (3) variable and fixed operating costs, and (4) environmental and health costs, where possible:
  - Consider "economy of scale" for RES and waste heat use in DHC systems compared to the costs of individual utilisation technologies, taking into account indirect infrastructure costs (e.g. empowerment of the electrical distribution grid required for a larger number of individual heat pumps). High DHC investment costs do not automatically mean more expensive heat supply to the end-user.
- **All benefits associated with DHC** – consider all direct and indirect benefits:
  - Lower cost of heat for consumers (competitiveness is key for DHC),
  - External benefits such as environmental (e.g. reduction of GHG emissions) and health benefits (e.g. air pollutants).
  - Energy system integration benefits (heat storage, power-to-heat, ancillary services through flexible CHP, etc.) that support extensive RES electricity integration at lower costs.
- The following **data sources on costs and benefits** may be particularly useful for your work**:**
  - Heating & Cooling outlook until 2050, EU-28 – scenario design by the Hotmaps toolbox[17];
  - Hotmaps – Open Data Set for the EU28 – EU 28 data on technologies[18];
  - KeepWarm – list of useful resources on DHC costs (energy prices, technology costs, etc.) business models and market uptake[19].

4. *Sensitivity analysis*

- **Consider important factors influencing DHC systems** (e.g. fuel/electricity prices, investment costs, heat distribution losses, discount rate, connection rates, CO_2 emission allowance prices, etc.) **and assess their impact on the results.**
- **Sensitivity analysis provides very useful information for the quality design of effective support policies and measures** through a better understanding of the key influencing factors and associated support instruments.

[17] https://www.hotmaps-project.eu/wp-content/uploads/2018/05/Hotmaps_D5-2_v16_2019-03-01.pdf
[18] https://www.hotmaps-project.eu/wp-content/uploads/2018/03/D2.3-Hotmaps_for-upload_revised-final_.pdf
[19] https://keepwarmeurope.eu/learning-centre/business-models-and-funding/

Part IV: New strategies and policy measures

Based on findings of the CBA and the economic potential assessments, it is recommended that MS, with the support of H&C stakeholders, develop additional strategies and measures to those in place (see Part II) to realise the potential identified. For additional policy measures, it is necessary to (1) assess and quantify their contribution to GHG emission reductions, (2) primary energy savings, (3) impact on the share of high-efficiency cogeneration, (4) impact on the share of RES (national mix and in the H&C sector), (5) required financial resources and expenses, etc. These new (planned) measures shall be integrated into the NECP in the next update (at the latest by June 2024).

The results of the KeepWarm project confirm that there is great potential for energy savings in existing DHC systems, as well as for increased use of waste heat and RES. Part IV of the 2nd CA is an excellent opportunity to adopt additional necessary policies and measures and to create a stimulating environment to exploit the important potential in DHC systems as soon as possible.

Box IV: KeepWarm recommendations on new strategies and policy measures (CA – Part IV)

The KeepWarm project provides an analysis of barriers to retrofitting or upgrading DH systems in seven countries and proposed possible solutions, including relevant measures and actions that can be replicated or used as inspiration for creating policies and measures in other countries (see Box II-1). They can serve as relevant inputs for the design of new policies that leverage the benefits of DHC, such as the ability to link local demand with renewable and waste energy sources and support the optimisation of supply and demand across different energy carriers and sectors. However, it is strongly recommended that the proposed measures establish a good link between the strategic and operational levels, set a timeframe for action and ensure the involvement of key stakeholders.

Examples of proposed measures related to DHC:

- The relevant national authorities (ministries), in close collaboration with various stakeholders, should **elaborate the national Heating and Cooling Strategy and Action Plan** and clearly position DHC and its role in the future energy system. The goal is to improve the energy efficiency of DHC by expanding existing capacities, reducing losses and optimising operations, increasing the use of RES and waste heat, and reducing emissions. The role of prosumers and effective principles of cooperation with DHS are to be defined/established.
- **Establish a body to co-ordinate support for DHC development** across a range of national and local programmes and develop a DH strategy programme for local authorities to accelerate the growth of DHC networks. The coordinating body would be responsible for strategic planning, knowledge and best practise sharing, identifying collaborative opportunities, managing the heat/cold mapping initiative, identifying funding opportunities and financial support, and providing technical advice and assistance.
- National authorities **create the framework for heat/cold mapping** (supply and demand) **and instrumentalise its implementation and roll-out at all levels**

(national to local). This will allow local authorities to identify the sources of both heat supply and demand, enable transparent and objective spatial planning, identify potential DHC projects (construction, expansion, refurbishment), promote their implementation and thus support the realisation of the national strategy and objectives.

- National authorities need to **provide guidance on both national and local aspects of planning for district heating**. Local authorities should identify areas, based on heat/cold maps, where new development or refurbishment should be assumed to provide DHC. These local heat planning processes should be used to examine the potential for expanding the heating networks and converting the heating networks to renewable energy. Development plans should consider the benefits of allocating and co-locating heat/cold supply and demand, and should support networks where they are feasible, particularly where they implement low carbon solutions through renewables.
- Authorities **set targets for connecting public sector estate** (covering a widest possible range of public organisations nationally and regionally) to a heating network where there are public buildings located in areas that are practical and economically viable for DHC. The review should also highlight where public buildings can be important as anchor loads to catalyse heat networks implementation.
- Considerable **potential for heat generation based on (shallow) geothermal energy** (with a focus on large-scale heat pumps) to be investigated in more detail and exploited as soon as the appropriate economic framework and conditions are in place. Pilot sites have to be identified – presumably by the municipalities, suitable demonstration projects must be selected and implemented, and the funding programme (financing) has to be created.
- Long-term heat storage is a key element for the decarbonisation of heating networks, therefore a detailed **assessment of the site conditions to build thermal storage facilities needs to be carried out** at the municipal level. The identification of pilot sites shall be followed by the selection of demonstration projects at national level and further implementation.
- In addition to renewable energies, the **possible use of industrial/commercial waste heat should also be examined** in a structured manner and further promoted. The **establishment of a (national) waste heat register** is recommended.
- Require producers/generators of significant amounts of heat to **explore options for capturing and using their waste heat and to facilitate the injection of waste heat into a network** where economically viable. This applies to all electricity generation and industrial plants, which are required to carry out a cost-benefit analysis for heat use. DHC utilities also need to carry out a cost-benefit analysis where potential industrial heat sources are available.
- **Investigate a potential for setting up smaller DHS using RES in rural areas** and develop the specific strategy for DH sector.
- A**ppropriate definition/setting of a CO_2 tax on fossil fuels for individual heating** to make heat network solutions more attractive. Taxes on fossil fuels for DH supply need to be examined, with the aim of appropriate price signalling to encourage more investment in renewable heat generation. The interaction with GHG emissions

trading (to which larger DH producers are subject) needs to be examined in line with the objective of carbon neutrality by 2050.

- In order to achieve a high level of customer acceptance, which is a prerequisite for the further development and expansion of DH, it is necessary **to improve the legal framework to protect consumer interests and to increase transparency**.
- National (state) and local (municipal) authorities should **support the development of new business models** for the refurbishment and expansion of heat networks.
- **Establish financing programmes and secure appropriate funding** to stimulate and promote the reconstruction and sustainable development of DHC systems with the aim of increasing efficiency and competitiveness (optimisation of operations, expansion of grids), increased use of RES and waste heat, promotion of high-efficiency CHP in DH systems and sectoral integration (e.g. through energy storage and "power-to-heat").

Conclusion

Although the second round of the comprehensive assessment (CA) builds on the experience of the first assessment (carried out in 2015), new challenges arise from the amended Annex VIII of Directive 2012/27/EU, which now includes "assessments of the potential for efficient heating and cooling" and thus goes quite far beyond the initial scope of "assessment of the potential for the application of cogeneration and district heating". The new requirements make it a complex task and thus a challenge for all Member States. However, a high-quality execution of CA in cooperation with all relevant stakeholders can bring many benefits to national and local H&C energy policies and is undoubtedly worth additional efforts. The use of relevant data, tools and knowledge on efficient and sustainable H&C technologies is essential for the usefulness of the results of CA.

One of the key initiatives of the European Green Deal was highlighted in the new *Strategy on Energy System Integration* presented in July 2020. The integration of a high share of variable renewable energy requires more flexibility, which can only be achieved by exploiting synergies between sectors, technologies, infrastructures and energy carriers. DHC systems are increasingly recognised as a key enabler of flexibility and storage capacity in a future energy system, not only as a local heat supply solution but as a strategic asset on a European scale. A DH network also allows the use of heat from many sources, but its future lies in decarbonised supply, based on local renewables, waste heat from industrial or commercial operations and waste incineration, and heat from cogeneration. There are promising opportunities and potentials for increased use of DHC in the future, but major efforts are needed to realise them. First, current DHC solutions and technologies need to be improved to adapt to future conditions related to renewables and low heat demand buildings, which requires a comprehensive approach to both planning and implementation. The process and results of CA can contribute significantly to a faster realisation of this potential, and these recommendations of the KeepWarm project aim to facilitate and support this process.

Annex 1: Useful data sources

The selection of data sources provided by EU projects, relevant to the development of DH systems

KeepWarm Renewing district heating	The list of EU energy and climate policies affecting DH sector: https://keepwarmeurope.eu/learning-centre/policy-recommendations/ (KeepWarm Learning Centre); Sustainable energy sources used for DH: https://keepwarmeurope.eu/learning-centre/sustainable-energy-sources/ (KeepWarm Learning Centre); Business models and funding assessment (energy prices, costs of heating and cooling etc.): https://keepwarmeurope.eu/learning-centre/business-models-and-funding/ (KeepWarm Learning Centre); other Project materials: https://keepwarmeurope.eu/project-materials/
HOTMAPS	Guidance for the comprehensive assessment of efficient heating and cooling: https://vbn.aau.dk/da/publications/guidance-for-the-comprehensive-assessment-of-efficient-heating-an How to use Hotmaps for the Comprehensive Assessment: https://www.hotmaps-project.eu/wp-content/uploads/2020/07/Hotmaps_Final_Conference_Comprehensive-Assessment_.pdf
Heat Roadmap Europe 2050 A low-carbon heating and cooling strategy	Heating and cooling strategies (national heat roadmaps) of 14 EU countries: https://heatroadmap.eu/roadmaps/ Pan-European Thermal Atlas (Heat maps of 14 EU countries): https://heatroadmap.eu/peta4/ Recommendations for regional and local policy makers: http://vbn.aau.dk/files/290996848/HRE4_D7.17_LR_vbn.pdf Business Cases and Strategies to Encourage Market Uptake: http://vbn.aau.dk/files/290997081/HRE4_D7.16_vbn.pdf
THERMOS	THERMOS is a web-based software for optimisation of local district heating network planning processes and results according to user and project specific requirements such as budget, climate and energy targets: www.thermos-project.eu/thermos-tool/thermos-tool/
PLANHEAT	Easy-to-use tool to support local authorities in selecting, simulating and comparing alternative scenarios for heating and cooling: http://planheat.eu/the-planheat-tool e-learning platform: http://planheat.geonardo.com/announcement-board
REUSEHEAT	Overview of waste heat sources: https://www.reuseheat.eu/category/waste-heat-recovery/ Project's scientific publications on waste heat recovery: https://www.reuseheat.eu/scientific-publications/
upgradeDH	Best practice instruments and tools for diagnosing and retrofitting DH networks : https://www.upgrade-dh.eu/images/Publications%20and%20Reports/UpgradeDH_Del2.3_CatalogueOfInstrumentsAndTools.pdf Best practice examples on upgrading the performance of DH networks: https://www.upgrade-dh.eu/images/Publications%20and%20Reports/D2.1_2018-12-03_Upgrade%20DH_final2_AGFW.PDF