KeepWarm
Renewing district heating

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

Sustainable Adoption Roadmap

Lessons learned and recommendations to support modernisation of district heating systems

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

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List of Abbreviations

AT	Austria
CEE	Central and Eastern Europe
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
CoM	Covenant of Mayors for Climate and Energy
COV-2	Severe acute respiratory syndrome-related coronavirus
CZ	Czech Republic
DG	Directorate-General of the European Commission
DH(S)	District Heating (System)
DHC	District Heating and Cooling
EC	European Commission
EHP	EuroHeat & Power
EP	European Parliament
EU	European Union
ExH	Excess heat
GHG	Greenhouse Gas
GWh	Gigawatthour
HR	Croatia
IRR	Internal Rate of Return
KPI	Key Performance Indicator
LEC	Local Energy Concept
LV	Latvia
MW	Megawatt
NECP	National Energy and Climate Plan
NGO	Non-Governmental Organisation
RE	Renewable Energy
RES	Renewable Energy Source(s)
SECAP	Sustainable Energy and Climate Action Plan
SI	Slovenia
SRB	Serbia
TJ	Terajoule
UKR	Ukraine
WP	Work Package
WtE	Waste to Energy

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 (HR), 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 climate 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 December 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
	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	GIZ	Germany
	University of Zagreb Faculty of Mechanical Engineering and Naval Architecture	UNIZAG FSB	Croatia
	Landeskammer für Land- und Forstwirtschaft Steiermark	LWK	Austria
	Regionalna Energetska Agencija Sjeverozapadne Hrvatske	REGEA	Croatia
	Jožef Stefan Institute Energy Efficiency Centre	JSI	Slovenia
	ICLEI European Secretariat GmbH	ICLEI Europe	Germany
	Teplárenské Sdružení České Republiky	TSCR	Czech Republic
	Biedriba Zemgales Regionala Energetikas Agentura	ZREA	Latvia
	Zavod Energetska Agencija za Savinjsko Salesko in Korosko	KSSENA	Slovenia
	LLC KT-Energy Consulting	KT-Energy	Ukraine
	Institut za Nuklearne Nauke Vinca	VINCA	Serbia

Content

Executive summary

The aim of KeepWarm's Sustainable Adoption Roadmap is to consolidate lessons learned and on-the-ground experiences into a single, coherent format to support the sustainable adoption of project practices. Rather than merely summarising these points, its goal is to formulate concrete recommendations for a variety of decision-makers amongst target groups to move forward in implementing/facilitating district heating system (DHS)improvements.

The Roadmap provides a structured outline connecting local to European strategies and processes which are favourable and supportive to the adoption of the project's DHS retrofitting objectives, as well as identifying potentials and gaps for institutionalising the KeepWarm approach in various countries. Several cross-cutting dimensions (e.g. business, financial, technical, social, political, etc.) were addressed, incorporating lessons learned from the project, including from KeepWarm's DHS-Twinning programme and its 'Inspire' event series (https://keepwarmeurope.eu/online-seminars/).

This Roadmap consists of a set of main conclusions, successful procedures and specific recommendations to help individual target groups and decision-makers across Europe to find potential for improving their current approach and move forward in the modernisation of DHS investment. The individual recommendations are based on detailed analyses and results obtained from the DHS operators of pilot projects in various stages of KeepWarm.

Though the Roadmap has a distinct EU-oriented layer, the fact that the project's target countries include two non-EU Member States, and border with many more, necessitates more of a pan-European perspective. At the same time, the Roadmap also draws heavily on the distinct national dynamics particular to the project's seven target countries, as well as the Central and Eastern European (CEE) region in general. The end result is a valuable collection of concrete steps and recommendations which can form a framework for major target groups to translate into transformative actions wherever they may be located.

AUSTRIA

Austria is a developed country where the fuel portfolio for heating consists mainly of biomass and natural gas. Heat is produced mainly in small-scale facilities. The DHS's modernisation strategy in Austria is focused on increasing of the share of district heating and replacing of oil-fired individual furnaces with renewables by 2030. The main challenges for DHS retrofit are: reduced heat demand caused by improved building insulation, the associated profitability of small and medium-sized operators, the need to reduce grid temperature to integrate RES, high investment costs for RES technologies, maintaining high levels of staff training and insufficient national heating strategy. Despite these mentioned challenges, the share of DH supply in Austria is increasing due to a positive public opinion about this sector. KeepWarm proposes to overcome these challenges through action plans containing 20 key recommendations focused on the need for long-term heating strategies, emphasising the use of renewable heat (with a focus on biomass, green gasses and waste heat), supporting the implementation of the special

training programme for capacity building at the national level, and the need for long-term stable and predictable funding for DHS retrofitting. District heating retrofitting has been integrated into 3 regional and 4 national energy plans and strategies through Keep Warm. KeepWarm contributed to creation of 9 feasibility studies and 3 business models for the modernisation of district heating in Austria. Two pilot projects will start investing by the end of 2020 and the investment will reach EUR 7 800 000 by the end of the KeepWarm project. These pilot projects are focused on boiler replacements, complete reconstruction of the boiler room, expansion of heating networks and connection of new customers. As part of the twinning program, Austrian DHSs cooperated and exchanged experience with DHSs in Latvia. In January 2020, pilot DHSs in Austria organized a national inspire event, where the KeepWarm approach and the results of pilot projects were presented. The event was attended by 80 participants and included a study visit to the operation of the participating plants.

CROATIA

Heat production in Croatia is realized predominantly from fossil fuels, mainly from natural gas. Due to very old and inefficient systems, negative public opinion and ineffective current legislation, the sector is expected to decline in the future unless the situation changes in another direction. The DHS modernisation strategy is focused on increasing energy efficiency (pipeline renovation, heat production units' retrofits) and RES is slowly introduced. At present, the political will is in favour of the DH sector development, as it is considered a crucial alternative for future development towards decarbonised urban areas, especially with the use of cogeneration units and solar thermal energy. The main challenges for DHS retrofit are: reduction of thermal load due to better insulation of buildings, profitability of companies with decreasing heat demand, ensuring lower temperature in the network enabling integration of RES, lack of investment resources, high investment costs of RES technologies, dealing with uncertainty regarding the availability and cost of natural gas after the liberalisation of gas market in Croatia, lack of a legal framework for systematic decarbonisation of DH networks, provision of professional education of staff in connection with the development of new technologies. KeepWarm proposes to overcome these challenges through action plans containing 29 key recommendations focused on the need for clear long-term goals on local, regional and national level, utilising of RES (focusing on solar and geothermal energy), increasing energy efficiency in old heat distribution networks, as well as providing the necessary funding for sustainable modernisation and increasing the attractiveness of the DH sector. Representatives of KeepWarm participated in the integration of the DH retrofit into 3 regional and 4 national energy plans and strategies.

KeepWarm contributed to the creation of 12 feasibility studies and 4 business models for the modernisation of district heating in Croatia. Three of the pilot projects have already reached the investment phase and the investment will amount EUR 885 000 by the end of the KeepWarm project. These pilot projects are focused on the use of solar energy, renovation of thermal networks, thermal storage, expansion of thermal networks, connection of new customers. As part of the twinning program, Croatian DHSs cooperated

and exchanged experience with DHSs in the Czech Republic, Serbia, Slovenia and Ukraine. A KeepWarm virtual “Regional Study Visits” meeting was held in September 2020 and brought together over 30 participants. Project partners convened online to share and learn about the pilot projects that encourage energy transition, implementation of new solutions and green technologies.

CZECH REPUBLIC

District heating is very popular in the Czech Republic; the share of households using DHS is 41 %. The predominant fuel for district heat production is coal and natural gas, the share of RES is 8 %. The share of cogeneration is 75 %. The basis of the modernisation strategy for district heating is to increase energy efficiency in heat distribution, reduce the share of fossil fuels and increase the share of heat production from RES and energy accumulation, avoid disconnection of customers from DHS, negotiate state support for waste to energy and cogeneration plants, and thus ensure economic sustainability of DHS. State energy policy sets the target of at least 20 % of heat supply from DHS to be covered by RES and at least 60 % by heat from CHP by 2040. NECP presumes the highest share of RES by 2030 in the H&C sector. The main challenges for DHS retrofit are: heat price regulation, competitive environment in the heat market, economic discrimination of district heating industry and the vulnerability of DH systems and the consequences of their uncontrolled disintegration. To overcome these challenges it is necessary to increase the taxation of fossil fuels used for local heating to a level comparable to the burden that the heating plants included in the ETS have to bear or introduce a carbon tax. To prevent the breakdown of the DH system, which would inevitably lead to a reduction or cessation of cogeneration and thus reduction of the capacity of ancillary services to the electricity networks necessary for balancing the grid, it is essential the state to support the sustainability of DHS and cogeneration systems. District heating retrofitting has been integrated into 2 national, 2 regional and 2 local energy plans and strategies through Keep Warm.

KeepWarm contributed to the creation of 9 feasibility studies and 3 business plans for the modernisation of DHS in the Czech Republic. Three of the pilot projects already reached the investment phase and the investment will amount EUR 222 400 by the end of the KeepWarm project. These pilot projects are focused on upgrade of the heat network, replacement of coal boiler with biomass boiler, construction of WtE unit and biogas unit, construction of hot-water feeder from NPP. As part of the twinning program, Czech DHSs cooperated and exchanged experience with DHSs in the Croatia and Ukraine. In September 2020, the District Heating Association of the Czech Republic organized a national inspire event in Hradec Králové, where the KeepWarm approach and the results of pilot projects were presented. The event was attended by 35 participants.

LATVIA

Latvia's portfolio of fuels for heat production consists mainly of natural gas and biomass.

Latvia produces heat in cogeneration, the sources are small and medium scale, and the modern ones belong to the 3rd generation of DH sources. District heating is the most common form of heating in Latvia, it is used by 80 % of households. DHS's modernisation strategy in Latvia is aimed at increasing the share of RES in heating, upgrading the installed capacity of biomass plants, increasing the capacity of installed heat pumps and increasing the use of solar energy in heat production. The main challenges for DHS retrofit are: increasing of energy efficiency of old DH systems, up-to-date technologies (heat accumulation, use of waste heat), including use of RES, in particular emission-free technologies (solar collectors, heat pumps), decreasing of consumer demand due to a variety of factors (demography, improved energy efficiency of the buildings), social attractiveness of DHS solutions (currently – low price of natural gas does not allow to attract new consumers), ensuring the competence of staff (development of new technologies), non-existing district cooling. To overcome the challenges Latvia's DHS needs to develop appropriate national policies and a regulatory environment that provides a stable basis and incentives for DHS development. The availability of direct or indirect subsidies and/or dedicated financial instruments and the availability of low-cost loans are crucial. District heating retrofitting has been integrated into 1 national and 2 local energy plans and strategies through Keep Warm.
KeepWarm contributed to the creation of 9 feasibility studies and 3 business plans for the modernisation of DHS in Latvia. One pilot project is already in the investment phase and the investment will amount EUR 79 000 by the end of the KeepWarm project. These pilot projects are focused on automation of fuel supply, installation of frequency changer for heat pumps, replacement of pipes, installation of new type of biomass boiler, change of gas boiler, and installation of additional gas boiler for summer loads. As part of the twinning program, Latvian DHSs cooperated and exchanged experience remotely with DHSs in Austria by presenting 3 video films about Latvian DHSs modernisation experience and plans. Latvia organised also series of 4 e-seminars on challenges & opportunities for the modernisation of DHS in Latvia. A total of 123 participants took part in these seminars.

SERBIA

The fuel for heat production in Serbia consists almost entirely of fossil fuels, namely natural gas, coal and heavy fuel oil. Only about half a percent of the fuel is biomass. The average age of the heat production plants is 28 years. District heating is considered as a reliable and safe mean of heat supply, both in the eyes of the government and of the citizens, currently a quarter of households are heated by district heating. The modernisation strategy of district heating consists in expanding the district heating system, reducing fossil fuels (heavy fuel oils and coal) and increasing the use of RES. The main challenges for modernisation of DHS networks are the unfavourable position of the DH sector compared to other individual heating options, lack of financial resources, high investment costs of RES technologies, a complex ownership structure between local authority units and DH companies, lack of adequate energy planning and a legal framework that would support appropriate development of the sector. KeepWarm proposes to overcome these challenges through action plans containing 23 key recommendations focused on the need

to set clear long-term targets at local, regional and national level, to implement appropriate energy planning, to use RES and increase the energy efficiency of buildings and heat distribution systems, to introduce innovative technologies for monitoring and optimisation processes, to provide the necessary funds for sustainable retrofitting and to increase the attractiveness of the DH sector. District heating retrofitting has been integrated into 1 national and 7 local energy plans and strategies through Keep Warm.
KeepWarm contributed to the creation of 12 feasibility studies and 4 business models for the DHS modernisation in Serbia. Two of the pilot projects have already reached the investment phase. These pilot projects are focused on the replacement of old fossil boilers for new biomass boilers with auxiliary equipment, fuel storage, integration of presently segmented grid into one unified system. As part of the twinning program, Serbian DHSs cooperated and exchanged experience with DHSs in Slovenia and Croatia. In September, the partners of the KeepWarm project (REGEA, VINČA and KSSENA) organized a successful online study visit to Serbia among 3 partner DHSs, which brought together 30 participants. This event was focused on current legislation and future obligations such as energy efficiency, integration of RES, transparency and improving general communication between district heating and local, regional and national authorities, with the aim to identify the main problems in the sector and their possible solutions.

SLOVENIA

More than three quarters of DHS heat sources in Slovenia are CHP using fossil fuel, mainly coal and natural gas, the rest being biomass. The share of households using district heating is 9 %. The modernisation strategy for DH assumes an annual increase of the RES share by 1 % until 2030. All coal sources are to be replaced by 2023. The use of excess or waste heat from industrial or service processes is at an early stage, but the volume of waste heat use is increasing and is expected to become one of the most important heat sources in the future. The main challenges for DHS retrofitting are: better insulation of connected buildings reduces the heating load, lower network temperatures so that more RES can be integrated into the system, how to ensure profitability and economic stability even if the heat demand of connected buildings decreases, dealing with uncertainty about the availability and cost of climate-neutral gas, lack of a legal framework and strategies for systematic decarbonisation of DH networks, permanent development of new technologies requires continuous training at increased level to ensure competence of staff. KeepWarm proposes to address these challenges through action plans that include 20 key recommendations, mainly focusing on the need for a strategic framework and objectives for H&C sector, targeted financing mechanisms and business models, supporting local authorities to develop a strategic approach to DH, focusing on improving the positive role of DH in energy transition and climate change policy-making processes, an incentive framework that supports investment in carbon-neutral heat, and properly defining fossil fuel taxation to support more investment in renewable heat generation. District heating retrofits have been integrated into 4 local and 3 national energy and climate plans and strategies by the effort of Keep Warm.

KeepWarm contributed to the creation of 9 feasibility studies and 3 business models for district heating upgrades in Slovenia. Two of the pilot projects have already reached the investment phase and the investment will amount to EUR 834 000 by the end of the KeepWarm project. These pilot projects focus on the renovation of pipelines and substations, the replacement of gas boilers with biomass and new heat storage facilities. As part of the twinning program, Slovenian DHSs cooperated and exchanged experiences with DHSs in Croatia and Serbia.

UKRAINE

District heat in Ukraine is produced mainly from natural gas, although the use of biomass is growing. District heating is very popular, the share of households using DHS is 40 %. DH infrastructure is well-developed in all major urban settlements, but it is characterised by outdated equipment, low energy efficiency and declining customers' base. The modernisation strategy of DH foresees the development of heat supply systems taking into account the economic feasibility of locally available fuel types, regional and national energy infrastructure, as well as increased efficiency of heat supply. The goals of state policy implementation in the area of heat supply include achieving a 40 % share of alternative energy sources and reducing energy losses to 10 % by 2035. The main challenges for DHS retrofit are: reform of the carbon tax mechanism, improvement of the legal basis for approving the level and structure of heat energy tariffs, incentives for the production of heat from RES and environmental requirements for the use of biomass in heat supply systems, reduced heat energy demand due to energy efficiency improvements in buildings, significant debts levels and lack of financial resources for capital expenditures. The approval of the national DH development strategy and action plan with specific measures is crucial to ensure a balanced implementation of the state policy and the modernisation of the DH sector, thus achieving the objective of transition to efficient DH in line with EU standards. State support should include financing programs at national and local level for DHS modernisation projects, a debt management strategy for DHS operators and cooperation with international financial organisations and other partners. District heating retrofitting has been integrated into 2 local and 3 national energy plans and strategies through Keep Warm.

KeepWarm contributed to the creation of 12 feasibility studies and 4 business models for the DHS modernisation in Ukraine. Three of the pilot projects have already reached the investment phase and the investment will amount EUR 3 300 000 by the end of the KeepWarm project. These pilot projects are focused on replacement of boilers, centralisation of heat generation, biomass CHP, complex modernisation of grid section with pipelines replacement and pumping equipment replacement. As part of the twinning program, Ukrainian DHSs cooperated and exchanged experience with DHSs in the Czech Republic and Croatia. KeepWarm project partner KT-Energy LLC organized a series of four online seminars on the modernisation plan in Ukraine, best practices in district heating and priority investment projects. The last seminar was also attended by twinning partners from Croatia and the Czech Republic. A total of 130 participants took part in the events.

Introduction

Comparing the various forms of energy need, there is none more significant than heating. The European district heating (DH) industry has a clear responsibility to provide 120 million customers across the European Union (EU) with their most fundamental energy needs. Today, heating accounts for roughly half of the energy consumed in the EU, and despite significant and essential measures aimed at reducing demand it is still expected to account for the largest share of demand in 2050.

The energy community is now focusing its efforts on a vision of sustainable energy development by 2050 and on the ambition to create the world's first carbon neutral continent. This is a challenge as well as an opportunity for the DH industry. A challenge in the sense of transforming the sector to remain relevant in a rapidly changing energy market and an opportunity to use new technologies to develop modern and efficient heat-providing solutions and bring thereby sustainable energy to its customers. In Ukraine and Serbia, DH industry also plays an important role in covering energy needs and requires significant modernisation to be able to serve this purpose in efficient and sustainable way during the next decades.

The KeepWarm's Sustainable Adoption Roadmap serves as a summary of the most important findings and outputs achieved through the analyses and activities carried out during the project and which will have an impact even after the end of the project.

The real aim of the project is to trigger a Europe-wide effort of increased retrofitting and modernisation of DHS. This required two sets of action: (i) the formal recognition of the need for retrofitting of DHS in national and regional strategies and action plans; and (ii) a massive effort to disseminate successful practices in modernisation process using the most pertinent communication channels to reach DHS owners and operators throughout Europe and especially in Central and East Europe.

The first part of the document is devoted to a general description of the current state of the district heating (DH) sector, the evaluation of the potential for retrofits in individual participating countries, the role of DH in the decarbonisation process of the European energy system and key challenges in the modernisation process of the DH sector on national and European levels, with a closer focus on the CEE region.

The analytical part is devoted to the importance of DH and the prerequisites for the modernisation of this sector at national and European levels. Legislation is assessed which leads to the conditions, barriers and opportunities for DH-modernisation processes. The chapter is supplemented by an overview of stakeholders in terms of their roles and influence on the modernisation process.

The document further describes the overall replicability of the KeepWarm approach to DH modernisation in other countries and hints out how these sustainability trends can be maintained. It also summarises those measures necessary for the successful implementation of DH retrofits contributing to European decarbonisation objectives, key

challenges hindering DHS operators from upgrading their systems and critical risks influencing DH modernisation processes, as well as measures to mitigate or eliminate these risks. Additionally, it highlights pathways forward, as demonstrated by how KeepWarm addresses these challenges through its own activities like capacity building, business plan preparation, attracting/achieving investment for pilot projects and the effective integration of DH retrofitting principles and measures into strategic policies and action plans to exploit long-term political visions.

The final part consists of lessons learned from the project's approach, as well as concrete steps forward for public authorities, policy makers, potential investors and other key stakeholders. By showcasing successful cases, KeepWarm's Sustainable Adoption Roadmap is able to emphasise those frameworks and instruments deemed most effective for securing investments and supporting the process of modernisation of DHS infrastructure, operations and management so necessary in many parts of Europe. It remains our intent to show decision-makers a viable way forward to accelerate a sustainable DH transition.

KeepWarm Sustainable Adoption Roadmap

1. Overall context and modernisation process of the DH sector

In many European cities - especially in Eastern and Central Europe - the heating sector is still dominated by fossil fuels and obsolete, inefficient technologies. Despite various reasons including lack of capacity or knowledge, national or European legal frameworks that either conflict with or do not facilitate preferred local solutions, many municipalities owning district heating systems are struggling to modernise and contribute to the objectives set out in the Paris Agreement[1]. DH networks have an unmatched, proven and significantly underdeveloped potential to help these municipalities realise their ambitions of sustainable heating and to make the wider energy transition easier, faster and more cost-effective.

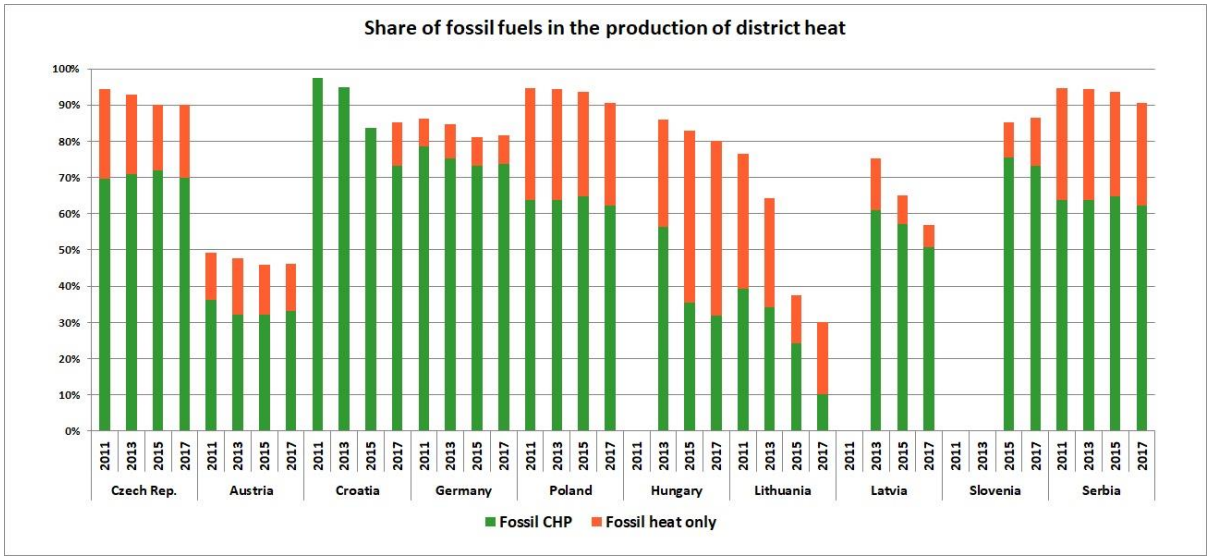


Figure 1: Share of fossil fuels in the production of district heating

Source: EHP Country by Country Survey (2011, 2013, 2015, 2017)

The European Parliament (EP) considers district heating and cooling (DHC) as one of the pillars of the European energy strategy based on reducing energy consumption and greenhouse gas emissions as well as developing renewable energy sources. It has stressed the importance of district heating systems as an alternative to more polluting individual heating systems. According to the EP[2], these networks represent particularly efficient and cost-effective means of sustainable heating and cooling supply that uses renewable energy, recovers heat and cold, and stores excess electricity at a time of lower consumption and thus provides flexibility to the distribution system.

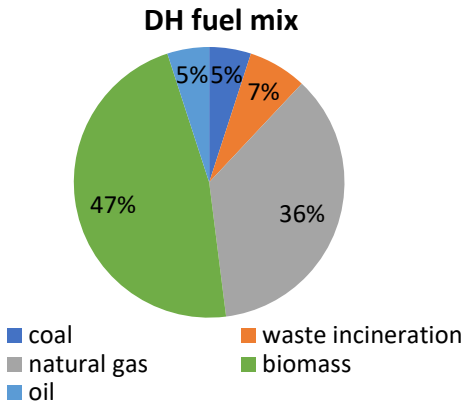
However, most district heating networks in Central and Eastern Europe urgently need modernisation to improve their energy efficiency. As fossil fuels are still the predominant

[1] Paris Agreement
[2] REPORT on an EU Strategy on Heating and Cooling

sources of energy, interventions are even more urgent. Many Central and Eastern European DH operators are faced with inadequate maintenance, high customer heating costs, and limited control options for users, thus undermining the district heating image. As a result, a significant number of customers disconnects from DHSs and install individual heating sources.

The renovation of Europe's ageing building stock and the provision of high energy efficiency in new buildings is a key to meet the EU climate targets. It is therefore of strategic importance for DHS to drive national and local policies forward, to assess individual conditions for the use of local low-carbon energy sources, to identify and map the potential for the use of low-carbon heating in buildings and to identify technologies that fully exploit this potential. DH systems offer promising solutions for the (combined) use of different energy sources and bring together different parts of the energy system in an integrated and thus more efficient way.

<table>
<tr><th>COUNTRY</th><th>GENERAL DESCRIPTION OF DISTRICT HEATING SYSTEM (DHS)</th></tr>
<tr><td>Austria</td><td>
Number of DHSs: 2300
Types: biomass, geothermal, natural gas
Scale: small-scale
Households connected: 28 % (= 2,246,000 citizens)
Length of pipes: 5,500km
Annual growth rate: 5%



The trend towards the use of more renewable fuels, which started in the 1980s, has continued dynamically during the last ten years. A very large proportion of Austrian society has a favourable attitude towards DHS. The political goal is to increase the share of DHS in Austria, as the aim is to replace about 700,000 oil-fired individual furnaces by 2030. On May 28, 2018, the Austrian federal government adopted a new climate and energy strategy entitled "#mission2030". This shows the way how to achieve the 2030 EU climate goals.
<table>
<tr><th>participating DHS</th><th>current DH generation[3]</th><th>retrofit technology/fuels</th></tr>
<tr><td>Eibiswald</td><td>3rd</td><td>inefficient biomass source</td></tr>
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[3] District heating - Wikipedia

	Ligist	3rd	inefficient biomass source

Croatia

Number of DHSs: 110

Types: fossil plants

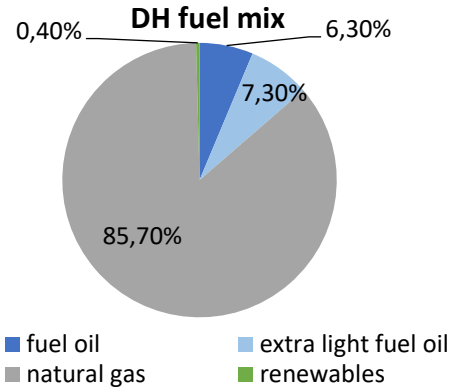
Scale: different sizes

Households connected: 11 % (= 436,000 citizens)

Length of pipes: 436 km

Annual growth rate: 3,8%

There has been no expansion of DH in the last 15 years in Croatia and there is a considerable need for refurbishment of existing networks in order to increase the trust of customers, energy efficiency and profitability.



The existing systems in Croatia require substantial investments for their revitalisation and modernisation aiming to increase the reliability and security of heat supply. A lack of energy planning is a significant obstacle to the new development and DHS modernisation. Current DHS sector is regulated by several Acts such as the Energy Act and Act on thermal energy market, as well as by numerous terms, rules and decrees which regulate market activities (production, distribution, supply and selling). On the other hand, ambitious measures have been included in the National Energy and Climate Plan which is a direct translation of European Directives in the Croatian legislation.

participating DHS	current DH generation	retrofit technology/fuels
Zaprešić	2nd	inefficient distribution network natural gas
Velika Gorica	2nd	inefficient distribution network natural gas, oil
Samobor	2nd	inefficient distribution network natural gas
Zagreb	1 - 2nd	partially steam network natural gas

Czech Republic

Number of DHSs: 2000

Types: CHP coal and natural gas

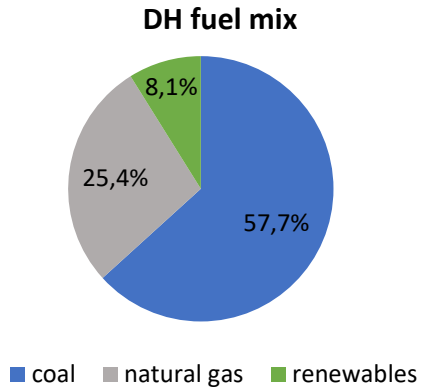
Scale: large-scale

Households connected: 41% (= 4,100,000 citizens)

Length of pipes: 7,700km

Annual growth rate: 0.4 %

On May 18, 2015, the Government of the Czech Republic, through its resolution, approved an updated State Energy Policy for the next 25 years. One of the stipulated priorities is to preserve (economically and energetically) efficient DHS. State energy policy sets the target of at least 20 % of heat supply from DHS to be covered by renewable energy sources and at least 60 % by heat from CHP by 2040. The Draft National Energy and Climate Plan of the Czech Republic was prepared on the basis of the Regulation of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action and it contains the main targets and policies in all five dimensions of the Energy Union for the period 2021–2030 with a view to 2050.



participating DHS	current DH generation	retrofit technology/fuels
Brno	1 - 2nd	partially steam network natural gas
České Budějovice	1 - 2nd	partially steam network coal
Písek	1 - 2nd	partially steam network coal

Latvia

Number of DHSs: 808 (in 2019) (boiler houses + cogeneration plants)

Types: CHP natural gas, biomass

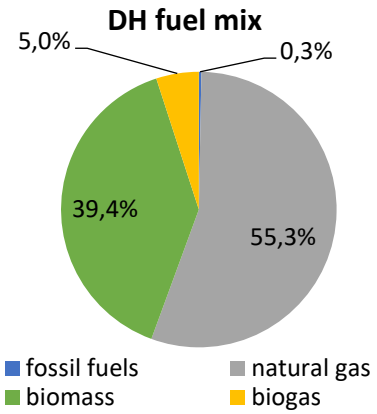
Scale: small and medium scale

Households connected: 80 % (= 1,536,000 citizens)

Length of pipes:2000 km

Annual growth rate: 1,7 %

The DH sector does not have a dedicated strategy or plan, where specific targets are set. Improving the energy efficiency of heat networks and promoting the use of renewable energy resources in district heating is an important step in achieving Latvia's national climate and energy objectives. Cogeneration plants and boiler houses still use natural gas, meaning there is a lot of potential for RES and no emission technologies (heat pumps, solar collectors) in district heating and that means DH has an essential role in delivering EU objectives. An improvement of energy efficiency in DHS has been delayed due to limited investments and capacity of local governments to obtain funding as well as the slow capital turnover rate. The political opinion in Latvia regarding the social and economic upgrade of DHS is positive and supportive. Latvia's energy policy is implemented in accordance to the EU energy policy.



participating DHS	current DH generation	retrofit technology/fuels
Jekabpils	3rd	biomass source, partially natural gas
Lielauce	3rd	inefficient distribution network small biomass heat source
Bene	3rd	old heat supply grid biogas

Serbia

Number of DHSs: 58

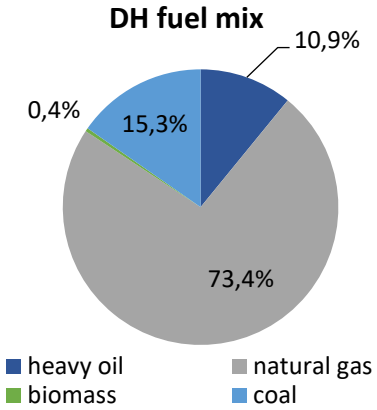
Types: old fossil plants

Scale: 1 – 116 MW (heat production units)1-2,856 MW (DHS production system capacity)

Households connected: 25 % (= 1,750,000 citizens)

Length of pipes: 2,354 km

Annual growth rate: 0.24 % (newly connected 2018 – 2019)



District heating is considered as a reliable and safe mean of heat supply, both in the eyes of the government and of the citizens (consumers). The average age of the heat production plants is 28 years. DH utility companies receive significant support from the state and municipalities since they represent an important energy stability

factor countrywide. The Energy Development Strategy plans to expand existing district heating systems, with a reduction in the use of petroleum products and coal, and an increase in the use of biomass and natural gas, by 2030. In many Serbian strategic documents (energy sector development strategies and implementation and action plans on country, regional and local level) the following is stressed in regard to the DH system: modernisation and enlargement of the existing district heating systems with the aim of increasing energy efficiency in generation, transport, distribution and heat use, reduction of the share of liquid fuel and coal and higher use of RES, and combined production of electricity and heat.

participating DHS	current DH generation	retrofit technology/fuels
Priboj	2nd	oil sources
Nova Varos	3rd	inefficient distribution network old oil sources
Šabac	3rd	natural gas sources
Bajina Bašta	3rd	inefficient distribution network old oil and coal sources

Slovenia

Number of DHSs: 93

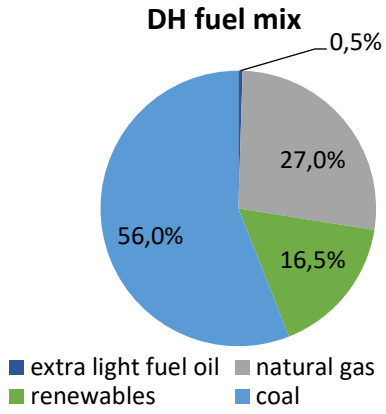
Types: CHP fossil plants, RES

Scale: 1 – 500 MW (heat production units)

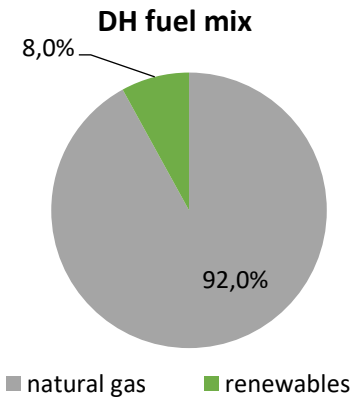
Households connected: 9 % (= 190,000 citizens)

Length of pipes: 893 km

Annual growth rate: 1% (2018 – 2019)



The district heating (DH) sector remains one of the important pillars of heat supply in Slovenia, particularly in densely populated urban areas. The Energy Act, which transposed Directive 2012/27/EU supports the development of DHS, which currently produce heat mainly from coal, natural gas and biomass in CHP plants or in gas and biomass boilers. The DHC development strategy assumes a 1 % annual increase in the RES share by 2030. The government regulation specifies the way in which the funds collected from the contribution of “heat production from renewable energy sources” will be used, and how these funds will be used as incentives or subsidies for the construction of new facilities for the production of District Heating and Cooling. All coal sources are to be replaced by 2023 (exception is DHS Velenje, which is tied to the use of waste heat from the coal-fired power plant).

	<table><tr><th>participating DHS</th><th>current DH generation</th><th>retrofit technology/fuels</th></tr><tr><td>Slovenj Gradec</td><td>2nd</td><td>old natural gas sources</td></tr><tr><td>Ptuj</td><td>2nd</td><td>old natural gas source</td></tr><tr><td>Velenje</td><td>1 - 2nd</td><td>inefficient steam distribution network old coal sources</td></tr></table>
Ukraine	**Number of DHSs:** 1,600 **Types:** natural gas, biomass **Scale:** medium and large scale, 50-5000 MW (DHS heat generation capacity) **Households connected:** 40 % (= 16,800,000 citizens) **Length of pipes:** 21,000 km **Annual growth rate:** N/A (stable or slightly declining) Ukraine has a well-developed DH infrastructure in all major urban settlements, but it is characterised by outdated equipment, low energy efficiency, and declining customers' base. As a rule, DH systems are managed by municipal DH companies that provide heat to private and public clients under the supervision of either local municipalities or the National Commission for State Energy and Public Utilities Regulation. Local municipalities often subsidise their DH companies' operational activities while considerable investments in modernisation projects are executed with the active participation of international financial institutions. The energy strategy of Ukraine foresees the development of heat supply systems taking into account the economic feasibility of locally available fuel types, regional and national energy infrastructure, as well as increased efficiency of heat supply. The goals of state policy implementation in the area of heat supply include achieving a 40 % share of alternative energy sources and reducing energy losses to 10 % by 2035.  <table><tr><th>participating DHS</th><th>current DH generation</th><th>retrofit technology/fuels</th></tr><tr><td>Bila Tserkva</td><td>2 - 3rd</td><td>inefficient distribution network natural gas</td></tr><tr><td>Zhytomyr</td><td>2 - 3rd</td><td>inefficient distribution network</td></tr></table>

		natural gas
Ternopil	2 - 3rd	inefficient distribution network natural gas
Khmelnytskyi	2 - 3rd	inefficient distribution network natural gas

Table 1: General description of district heating systems
Sources: KeepWarm[4], EHP Country by Country Survey

As part of the modernisation process (Annex 1 - Modernisation process in the district heating sector) KeepWarm uses existing measures and tools to replace first generation and improve second and third generation DHS. For Central and East European countries, the regional focus of KeepWarm, the fourth generation of DHS is less relevant for the moment given the lack of highly efficient buildings and smart energy systems. Here the focus lies especially in overcoming current challenges to district heating systems:

- Low heat production efficiency and sustainability
- High heat production costs
- High transmission losses
- Obsolete technology used
- Oversized network coverage
- Lack of heat production and utilisation control (technical rigidity)

[4] KeepWarm •• Countries in focus

2. Analysis of conditions and stakeholders in the area of interest

2.1. Pre-conditions in Central and Eastern Europe

DHC have become the visible part of EU Strategies on Heating and Cooling, Energy System Integration and the Renovation Wave, whereas the transposition of EU directives (RED, EED, EBPD) to national legislation provides an opportunity to establish its even stronger future role. These policies build on each other and their feasibility and effectiveness can only be achieved if they are implemented as a comprehensive package. It is essential that there is a link between the national and local levels in such a way that data, information, experience or other feedback relating to the implementation of the plans can be shared. This mechanism allows for the follow-up of activities and the planning of adjustments needed to meet the strategic objectives.

The comprehensive review of existing strategies and policies related to DHC planning, including the progress of their implementation, should lead to the identification of the changes and additional policies which are required to improve the DHC systems retrofitting and sustainable development. The “KeepWarm” review of the regulatory framework and barriers for retrofitting of DHS[5] shows that the role of DH in energy planning is often underestimated or even overlooked at a policy level. Furthermore, strategic frameworks for H&C are not available in the countries studied. It was reported that the lack of a strategic framework or its vagueness causes a number of obstacles to the development of the DH sector and its decarbonisation.

Decarbonisation of the H&C is essential to achieve the EU’s ambitious climate and energy targets. District heating (DH) is a key to the vision for the future of heating in Europe and enables countries to (1) use energy more efficiently, (2) increase the possibilities for renewable and low-carbon heating and (3) facilitate the transition to smart energy systems.

2.2. Analysis of conditions for retrofit

For the purposes of this project, we divided the participating countries (AT, HR, CZ, LV, SRB, SI, UKR) into two groups according to the conditions for modernisation of district heating such as fuel mix for heat production, size and age of production sources, and strategic approach to modernisation process. This division was also used to assess pilot projects and provide feedback within the twinning program.

[5] KeepWarm •• Regulatory framework and barriers review for retrofitting DHS

The first group consists of countries whose portfolio consists more of fossil fuels, have older and larger facilities. Their modernisation strategy is focused primarily on increasing production efficiency and restoring obsolete inefficient technologies. This group includes Croatia, the Czech Republic, Slovenia, Serbia and Ukraine. The second group consists of countries whose heat is largely produced from renewable sources, their facilities are rather small-scale and their technologies are at the level of the 3rd DH generation. Their strategy focuses mainly on decarbonisation and the use of renewable resources. This group includes Austria and Latvia.

KeepWarm also assesses how its target countries address district heating retrofitting challenges in their local, regional and national strategies and encourage their proper integration into forthcoming policy documents (Regulatory frameworks for retrofitting of DHS in participating countries[6]), as well as the development of national or regional action plans for district heating renovation[7].

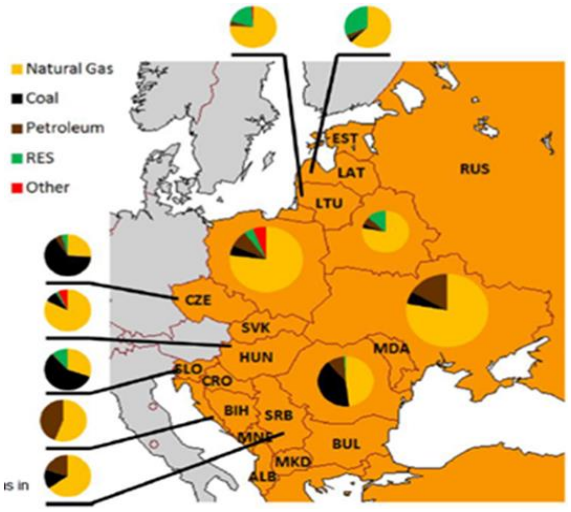


Figure 2: DH fuel sources

Each country has its own specific conditions and policies to adapt, the obstacles it faces and the opportunities that may be exploited. The switch from a fossil fuel and/or inefficient DH system to clean and renewable alternatives with a low level of losses is a challenging task. Moreover, other competitive heating solutions in the sector make it difficult for DH to compete. Alternative solutions are often unable to provide appropriate value of their services from a technical, environmental, social as well as economic perspective.

In the following table, areas that significantly limit the DH modernisation process, based on KeepWarm partner countries, are identified:

AREAS THAT SIGNIFICANTLY LIMIT THE DH MODERNISATION PROCESS							
	AT	HR	CZ	LV	SI	SRB	UKR
Technical capacity to develop and implement projects (technology suppliers, supply of fuels, energy providers, know-how, space/land, infrastructure…)	❍	❍	❍	❍	❍	❍	❍
Financial and economic barriers (access to finance, profitability, bankability, funding, subsidies, investments, …)	❍	❍	❍	❍	❍	❍	❍

[6] KeepWarm •• D5.1 Regulatory framework
[7] KeepWarm •• D5.2 Development of Multi-level policy Plans

Administrative barriers (approval processes, regulatory authority, laws, regulations, rules, legal system…)		❍	❍				
Customers (stable prices, low costs, low carbon heat, stable supply and security of supply, city development, disconnections during refurbishment, environmental effect – noise, dirt…)		❍			❍	❍	❍
Political influence (national, regional governments, national authorities, regulatory authority, local policy, negotiation of state aid …)	❍	❍	❍	❍	❍		❍
EU influence (approach, objectives, restrictions, legal framework, CO_2 allowances, ...)							
Public (public opinion, education, attitude to environmental protection, trends, standard of living, media…)		❍				❍	❍
Human capacity to develop and implement projects (experts, technical planners and engineers, skilled labour, maintenance staff…)	❍	❍	❍	❍	❍	❍	❍
Communication and relationships (awareness campaign, community engagement, influence of non-governmental organisations (NGOs), education of the public, …)		❍				❍	❍
Management and organisation (company strategy and mission, targets, planning, insufficient processes setup, responsibility for outcomes…)	❍	❍			❍		

Table 2: Areas that significantly limit DH modernisation process

The analysis of district heating systems' regulatory framework in pilot countries showed/ represents that on policy level district heating is in general considered as an important infrastructure for heat supply, while action plans lack clear goals and more concrete measures and instruments to establish practical improvement of DHS. Based on the analysis of the seven KeepWarm partner countries it is possible to say that:

- local/regional energy concepts are not very effective and the links with other plans and acts of local communities are weak
- local planning tools and data do not exist (except LV)

- tax incentives do not exist (except CZ, LV)
- energy savings obligation scheme is not in place (except LV, SI)
- obligatory share of RES or CHP in heat supply is not in place
- obligatory connection to DHS is not in place (partially in AT, SI)
- a complex process of developing a DHS is often disabled by a lack of knowledge and experience within local government institutions

There is obviously divergent technical state of the art of DHSs through pilot countries, wherein those with longer DHS tradition (~ 30 years; Brno, České Budějovice, Písek, Zagreb, Samobor, Zaprešić, Bajina Bašta, Nova Varoš, Ternopil, Zhytomyr, Bila Tserkva) mainly report higher grades of systems' disrepair, poor energy efficiency, stronger dependency on fossil fuels and larger technical potential for improvement. As a rule, DH is considered economically viable in areas with higher heat demand density, however there is an impression that planning support (e.g. software tools, data, methodologies, etc.) is not available or has very limited practical use in many countries. This is indicated by absence of practical implementation examples. Another limiting factor regarding the implementation of DHS refurbishment is a combination of high investment costs with large infrastructural projects (like networks/systems improvement or extension projects) and a lack of attractive financial instruments or funds, as well as low financial performance of DHS operators in some countries, which makes public involvement necessary for further system development.

The various stages and long-term nature of DHS project development require strong support and firm relationship among stakeholders, as well as a determined initiator to mediate the process. The role of municipalities in this context is inevitable, particularly as its ambition to reduce GHG emissions and ensure sustainable energy supply of the community but can be strongly dependent on the existence of an efficient DHS. In line with the limitation process of DH modernisation KeepWarm also identified the greatest opportunities for improvements and benefits, as shown in the following table:

OPPORTUNITIES FOR IMPROVEMENT AND BENEFITS OF THE DH MODERNISATION PROCESS							
	AT	HR	CZ	LV	SI	SRB	UKR
Extension of DH infrastructure	✓	✓		✓	✓	✓	
Increase of security of heat supply	✓	✓					
Reduction of primary energy consumption	✓	✓	✓	✓	✓	✓	✓

Reduction of CO_2 and GHG emissions	✓	✓	✓	✓	✓	✓	✓
Increase energy efficiency of resources	✓	✓	✓	✓	✓	✓	✓
Balanced energy mix, replacement of fossil fuels with RES	✓	✓	✓	✓	✓	✓	✓
Use of excess heat	✓				✓	✓	✓
Use of WtE technology					✓		✓
Reduction of heat production costs	✓	✓	✓	✓	✓	✓	✓
Replacement of obsolete technological equipment and improved reliability of new DH technologies		✓		✓	✓	✓	✓
Savings due to reconstruction of the heat distribution network	✓	✓	✓	✓	✓	✓	✓
Retain existing customers or acquire new ones	✓	✓		✓	✓		✓
Increased level of knowledge of DH employees	✓	✓	✓	✓	✓		✓
Future support for the DH sector from national and regional authorities	✓	✓		✓			✓

Table 3: Opportunities for improvement and benefits of the DH modernisation process

2.3. Roles of stakeholders

Supplementary to the pre-conditions it is of great importance to understand the roles and attitudes of individual stakeholders in the modernisation process for further negotiations on supporting new projects to develop DHS.

DH plants are a major driver in deciding whether to start the transition of DHS to more sustainable forms of energy, but they are not alone in this position. The engagement of special types of stakeholders is essential. Actors at local, regional and national level play a significant supporting role in the transition to ecological DH, regardless of the specific types of sustainable energy used.

PUBLIC SECTOR:

- Local authorities, even if not (co-)owners of the DHS, should streamline procurement and permit procedures and prioritise sustainable DH within the legal

framework and all planning processes (e.g. SECAPs[8], smart city strategies, circular economy plans, new zoning, business development, etc.), including with dedicated budget lines.

- Regional authorities, depending on their mandate within the country, might play a similar role to local counterparts, but can at least already integrate green-DH into their Smart Specialisation strategies and other development programs, as well as capitalise on Structural and/or Just Transition Funds in a strategic manner to finance a sustainable heating which is affordable to all.
- National authorities should ensure that both RE/ExH-DH and DHS-retrofits are adequately prioritised in all relevant national policies (i.e. NECPs[9], circular economy strategies, etc.) and the national legal framework, including with special funds/grants set up just for green-DH in order to support their contributions to national climate goals.

PRIVATE SECTOR:

- Banks, financial institutions and other investors should support environmental improvements and set up special funding mechanisms/instruments and preferential conditions (e.g. low-interest rates) and green-prerequisites for loan-approval to encourage DH companies' sustainability ambitions and to kick-start bankable DH projects and accelerate their transition to more sustainable practices.
- Companies supplying RE technology/fuel or ExH sources should be pro-active in promoting the synergetic opportunities and (mutual) benefits they can offer as best solutions to DH companies, while also building the capacities of DHS staff, public authorities, investors and other actors to understand the value of integrating their sustainable solutions.
- Real estate owners/developers and construction companies, whether working on individual buildings or whole neighbourhoods, should be sure that they already integrate technologies and infrastructure prepared for RE/ExH-DH, in order to support DHS connections and expansions from the start.

OTHER EXPERTS:

- Energy agencies are often key advisors and capacity-builders, not only to DH companies, but also to public authorities (e.g. supporting SECAP development), and therefore should serve as general expert consultants on DH transitions, as well as liaisons between DH companies and public/private actors.
- Researchers, universities, think-tanks and (private) consultancies can fill some of the same roles as energy agencies, but are particularly suited to providing in-depth studies with comprehensive data/analyses (i.e. on local/regional resource availability or cost-benefits) which DHSs rely on for decision-making.

[8] Sustainable Energy and Climate Action Plan
[9] National Energy and Climate Plan

Impact of individual stakeholders on the process of DHS modernisation in Europe

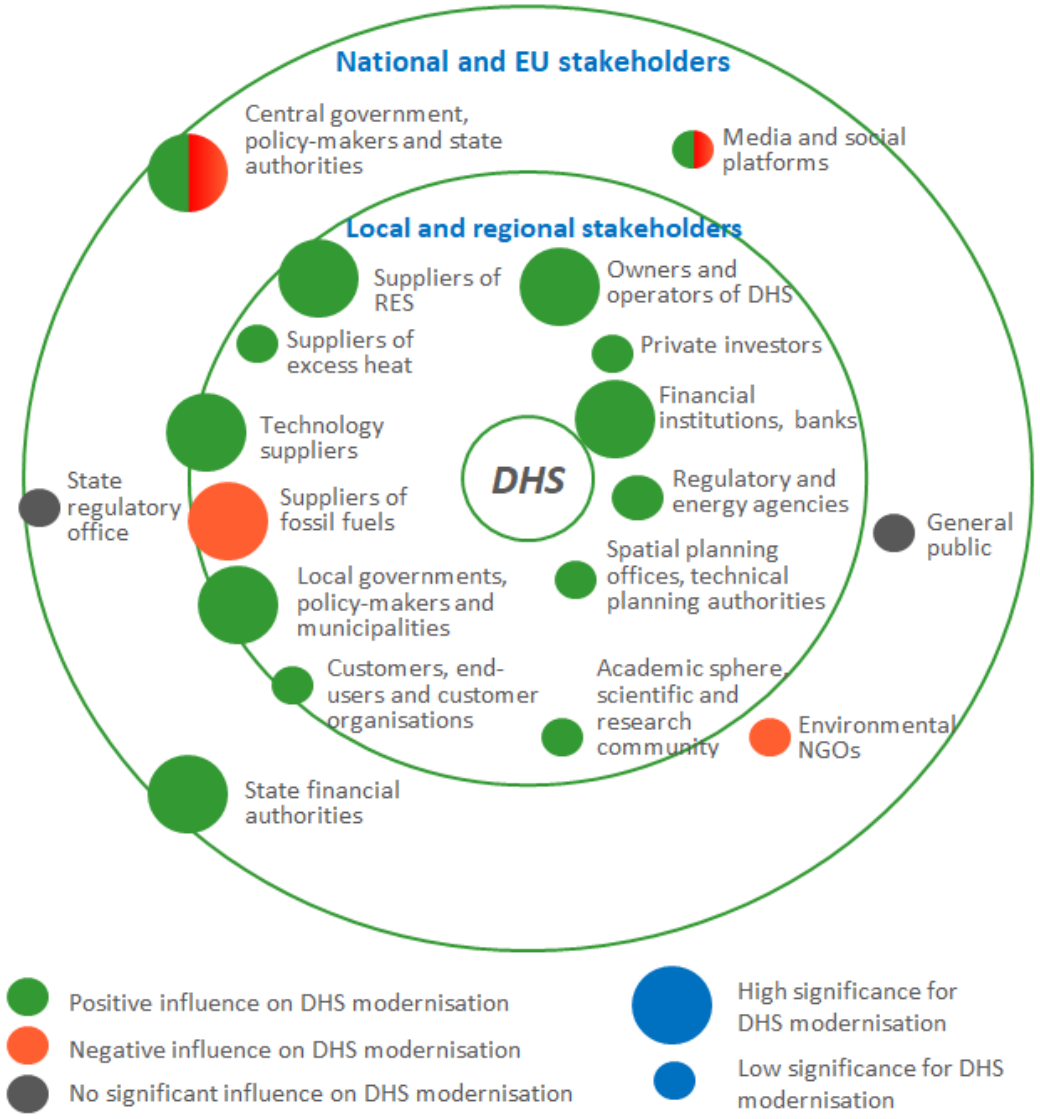


Figure 3: Impact of individual stakeholders on the process of DHS modernisation in Europe

Impact of individual stakeholders on the process of DHS modernisation in Austria

The DHS sector in Austria is growing since decades. The reason for that is on the one hand that DHS is very popular among customers and also it has a high approval among different stakeholder groups, especially if we talk about renewable DHS. Therefore, most stakeholders support the modernisation of DHS and the change to RES as a fuel. Also, the authorities on local, regional and national level see the importance of DHS as a key factor in the renewable heat transition process. However, the stakeholder process with real estate developers has significant room for improvement, as often district heating is not considered as heating method because competitive offers are just more economically advantageous.

The work with banks and financial institutions is very positive. Especially on heat only projects, with a solid business model. Financing is not a problem. However, for the projects based on CHPs it is harder to obtain funding, because of dependency on subsidies and bad experience from the past, which make a bad reputation.

Impact of individual stakeholders on the process of DHS modernisation in Croatia

Since DH sector is present in most of bigger continental cities (including capital city Zagreb), development of this sector is of vital importance. However, due to very old and inefficient systems, public opinion and current legislation, this sector is heavily impacted and expect to drop in future if the situation is not turned in a different direction. DH owners recognised the situation and are focused on increasing energy efficiency (pipeline renovation, heat production units' retrofits), while RES is slowly introduced (but not on a satisfactory level). Although the sector is growing due to expansion of DH Zagreb, other urban areas have experienced decrease due to disconnections (current building regulation). Currently, political will is in favour of DH sector development as it is seen as a vital option for future development towards decarbonised urban areas, especially by utilising CHP plants and solar thermal energy. However, the current legislation is the opposite and is changing very slowly. The biggest threat is perceived in natural gas industry which is promoting individual heating options, such as small gas boilers which are installed in urban areas instead of connection to DH network. From the financial side, projects can be implemented, but due to dealing with national DH company, the process is often intense due to bureaucracy and current legislations.

Impact of individual stakeholders on the process of DHS modernisation in the Czech Republic

Almost all stakeholders in the Czech Republic are aware of the advantages and benefits of the district heating system and support its sustainability and modernisation in the form of increasing the efficiency of heat production and replacing fossil fuels with renewable sources. The exception in this approach are coal suppliers, they still have a very large impact on the heat market, as it is the cheapest fuel. There are still large deposits of brown and black coal in the Czech Republic. A special group are NGOs, which are strongly criticising issues related to energy production. DHS owners and operators are looking for opportunities and ways how to make heat production more efficient and compliant with environmental protection regulations. The public and political authorities support the modernisation of district heating, although the process of DHS modernisation is complex in the Czech Republic, approval procedures are lengthy and legislative support is insufficient.

As part of KeepWarm action plan, TSCR proposed specific measures, such as simplification of approval processes (Building Act), the need to obtain a building permit to change the method of heating, in which the builder must prove with an energy report that using heat from district heating is not economically acceptable. Furthermore, TSCR initiated protection of consumers against unfair competitive offers in the heat market. TSCR

provided an incentive to adjust the economic conditions for entities outside the EU ETS, i.e. to increase the taxation of fossil fuels used in local heating to a level comparable to entities included in the EU ETS. TSCR negotiated a reduction in the VAT rate on heat from 15 % to 10 % with effect from 1 January 2020, partially offsetting the social impact of the increase in heat prices due to the additional cost of purchasing emission allowances.

Impact of individual stakeholders on the process of DHS modernisation in Latvia

As 80 % of inhabitants of Latvia are using district heating, all stakeholders are interested in DHS modernisation process. Needs and requirements of different stakeholders regarding DH modernisation are different. From national level stakeholders' impact in general is positive – as far as possible, regarding provided funding and loans because through DH sector there are planned certain goals to be achieved in terms of use of RES and non-emission technologies by 2030. On the other hand, there is also negative impact from national stakeholders regarding regulatory conditions that hinder the modernisation process of DHS such as inefficiency of EU funding allocation systems, tariff regulation policy and price rigidity (too low tariffs weaken DHS and may entail the risk of rapid increases in future tariffs). Local stakeholders mostly are interested in modernising their DHS as well, in providing cost effective utilities services, including district heating to inhabitants. A substantial role in promotion of DHS modernisation plays regular communication of government in Latvia with district heating association of Latvia, which unifies large part of Latvian DH companies, experts, and technology providers. In general, the tendency of DHS modernisation is ongoing, meaning that it is positively impacted from different stakeholders.

Impact of individual stakeholders on the process of DHS modernisation in Serbia

The national strategy documents[10] confirm that heat production has the highest potential for increasing energy efficiency (EE) compared to all other energy activities. The high level of air pollution in 2019, when individual heating was identified by authorities as one of the causes, has also influenced the increase of awareness of the importance of development and revitalisation of the DH sector and the necessity to connect a greater number of individual consumers to DHS. Therefore, it can be stated that main stakeholders (national, regional and local authorities, DHS owners and operators etc.) in Serbia generally support district heating modernisation projects aiming to increase the efficiency and sustainability of operation and security of heat supply. The exception in this approach are fossil fuel suppliers which have a large impact on the heat market, since DH sector of Serbia is based on fossil fuels. In addition, there is a lack of a coherent national policy and regulatory environment as well as the necessary financial support to provide a stable ground for incentives for the development of district heating systems.

The following sectoral (H&C) strategic objectives are defined: (1) to provide heat for secure supply of households and industry in strict compliance with environmental standards; (2) to increase energy efficiency in generation, transport, distribution and heat use; (3) to

[10] Energy Sector Development Strategy of the Republic of Serbia for the Period by 2025 with Projections by 2030 (Official Gazette of the Republic of Serbia, No. 101/2015)

increase the use of RES; (4) to ensure sustainable business operation of heat producers. The following strategic measures are planned to achieve these objectives:

• Continuous modernisation of the existing district heating systems;

• Establishing and applying unique tariff system for heat production, distribution and supply;

• Institutional connection of systems;

• Extension of the existing district heating network.

Impact of individual stakeholders on the process of DHS modernisation in Slovenia

The district heating sector in Slovenia is characterised by a great diversity of systems in terms of heat generation and supply technologies, settlement and network structures, heat demand densities, length of the network, age of the facilities, share of losses, number and structure of consumers, ownership structures, etc. There are many actors that support or hinder DHS retrofitting, but some are very important in these processes. Awareness of the need for system modernization for higher energy efficiency, in particular in terms of increased use of renewable energy and waste heat, is presenting the majority of DHS utilities, but many lack solid development visions, political and strategic support at the municipal level, human resources, and capacity and resources to implement the system upgrade. National authorities have not yet developed a clear national strategic framework for (district) heating and cooling and a corresponding action plan, which is the fundamental barrier to predictable long-term energy planning at the local level. The rules set by the state regulator regarding eligible costs of heat production and distribution do not allow DH utilities to finance the retrofitting and development of DH systems. Low awareness of the potential and benefits of DH amongst spatial planners is often the reason why DH operators/suppliers are excluded from planning activities. Demand for renewable energy may require legislative adaptation, which is often a lengthy process without balanced consideration of the stakeholders involved. The good practise examples show the importance of coordination between the main stakeholders (local authorities, customers, operators and owners of DHS) and facilitating projects, which are generally successfully implemented by local energy agencies. Financial institutions are crucial in the project preparation phase, which is usually the turning point in the project implementation process.

Impact of individual stakeholders on the process of DHS modernisation in Ukraine

Main stakeholders in Ukraine generally support district heating modernisation projects aiming to increase the efficiency and sustainability of operation and security of heat supply. However, there is a lack of specific policy measures and financing sources from policy-makers, state authorities, and financial institutions to support effective district heating development. Thus, some of the key stakeholder groups could have both positive and negative influences on DHS modernisation. Negative influences could be caused by the current inefficiencies of many district heating systems, controversial tariff policy and

relatively high heat price levels, political priorities and customer preferences tending towards individual heating solutions. There is also a lack of awareness about the benefits of efficient and sustainable district heating systems among general public, media and local environmental NGOs, which limit the support of district heating modernisation.

State authorities should support DHSs in attracting financial resources in modernisation projects. Due to the large-scale and long-term investments, it is necessary to develop targeted financial mechanisms and business models which will support stable development of the DHS. Modernisation of DHSs brings numerous co-benefits apart from energy efficiency and energy security improvements, including GHG emission reductions, improved air quality, green jobs and health benefits. Therefore, public investment should support even projects with lower economic feasibility, as they bring non-economic public benefits.

3. The KeepWarm approach to DH modernisation

Figure 4: KeepWarm approach to DH modernisation process

This chapter summarises the key challenges that hinder DHS operators from modernising and upgrading their systems and describes how KeepWarm has addressed these challenges. The KeepWarm project has followed an incremental and participatory approach that encourages active engagement with related national projects and with key players in the district heating value chain.

The project partners' strategy has been sharing of mutually successful approaches, tools, processes, instruments and methods to improve the current situation in all participating countries so that all can benefit from learning opportunities as they present themselves during project implementation. The aim of this guide is to present how to achieve a successful implementation of modernisation process leading to an efficient DH system. This guide is meant to be replicable and sustainable in the long term and also to be able to work at different types, sizes and development levels of DH operators across Europe.

3.1. Capacity building of DHS operators and other stakeholders

The KeepWarm project promotes energy community goals to increase the energy efficiency of the DH systems and to reduce greenhouse gas emissions by promoting a switch from fossil fuels to renewables. The first step in reaching these goals is **knowledge sharing and capacity building**[11]**.** "Lack of expertise and training affects all sectors" is indicated in the EU Strategy on Heating and Cooling. "Too few professionals have the required expertise in energy efficient construction and in applying efficient and renewable energy technologies"[12]. This problem occurs particularly in the Eastern European context which, in the last three decades, did not have an opportunity to invest in retrofitting or extending DHSs. This indirectly also reduced the demand for certain knowledge.

The KeepWarm project filled the gap and provided 746 hours of tailor-made training to address specific objectives and capacities, clustered in five groups, for target stakeholders, like public authorities or development and energy agencies.

- Capacity development on technical concerns;
- Capacity development on the utilisation of RES, waste and excess heat;
- Organisational capacity development;
- Financial concerns and;
- Managerial concerns

Based on a preliminary assessment of the capacity development needs (Annex 2 – Training needs topic questionnaire, Questionnaire on the training preferences) in 7 partner countries[13], suitable subtopics and training methods were individually chosen.

The KeepWarm training approach is flexible and enabled the partners to adapt the training to their national context. A broad range of relevant topics was covered, and multiple training methods were used such as lectures, exercises, software presentations and study visits. The most appreciated training aspects among all participants were concentrated on practical approach, networking and open discussion with relevant stakeholders (Annex 3 – Training evaluation form). The inclusion of other stakeholders besides DHS operators, such as energy and development agencies, as well as technology providers, proved to be very beneficial and in many cases provided foundations for future cooperation. KeepWarm confirmed an increase of capacities through a long-term questionnaire (Annex 4 – Long-term evaluation questionnaire).

[11] KeepWarm •• Resources
[12] An EU Strategy on Heating and Cooling
[13] KeepWarm •• Training needs assessment and training plan

The summary of KeepWarm training approach is presented on the following figure

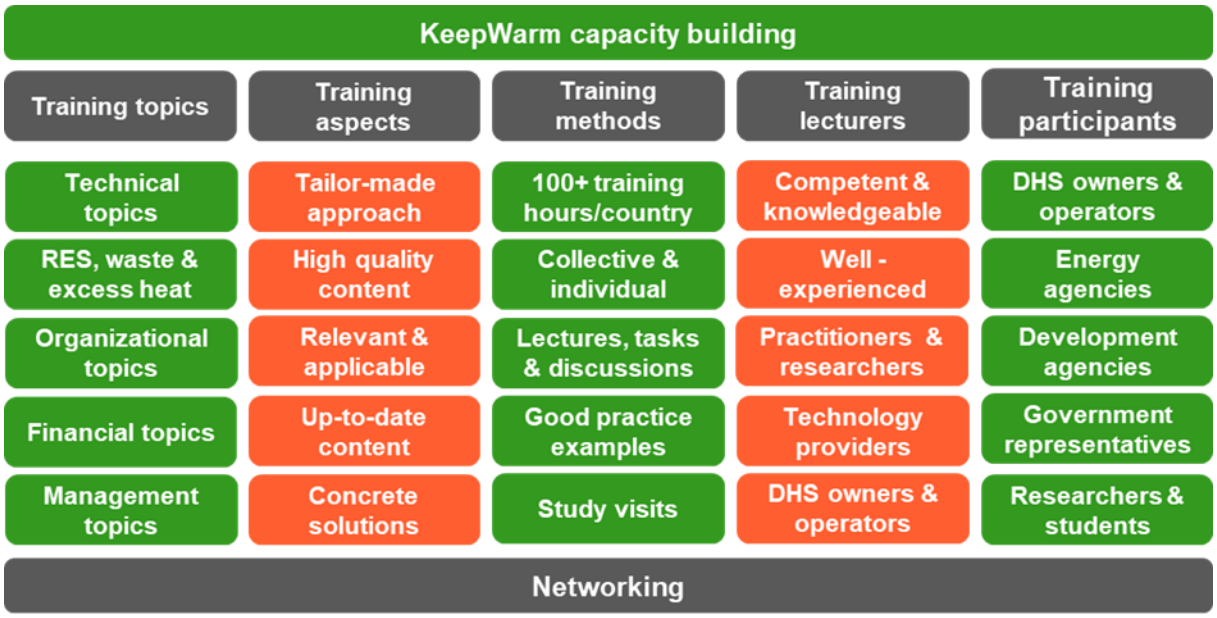


Figure 5: KeepWarm training approach

The training materials used for the conducted capacity buildings are available on the KeepWarm website (KeepWarm Learning Centre) and a detailed description of the conducted trainings can be found under Project results in the Learning Centre[14].

3.2. Developing business plans and attracting investment

[14] KeepWarm •• Report of trainings conducted

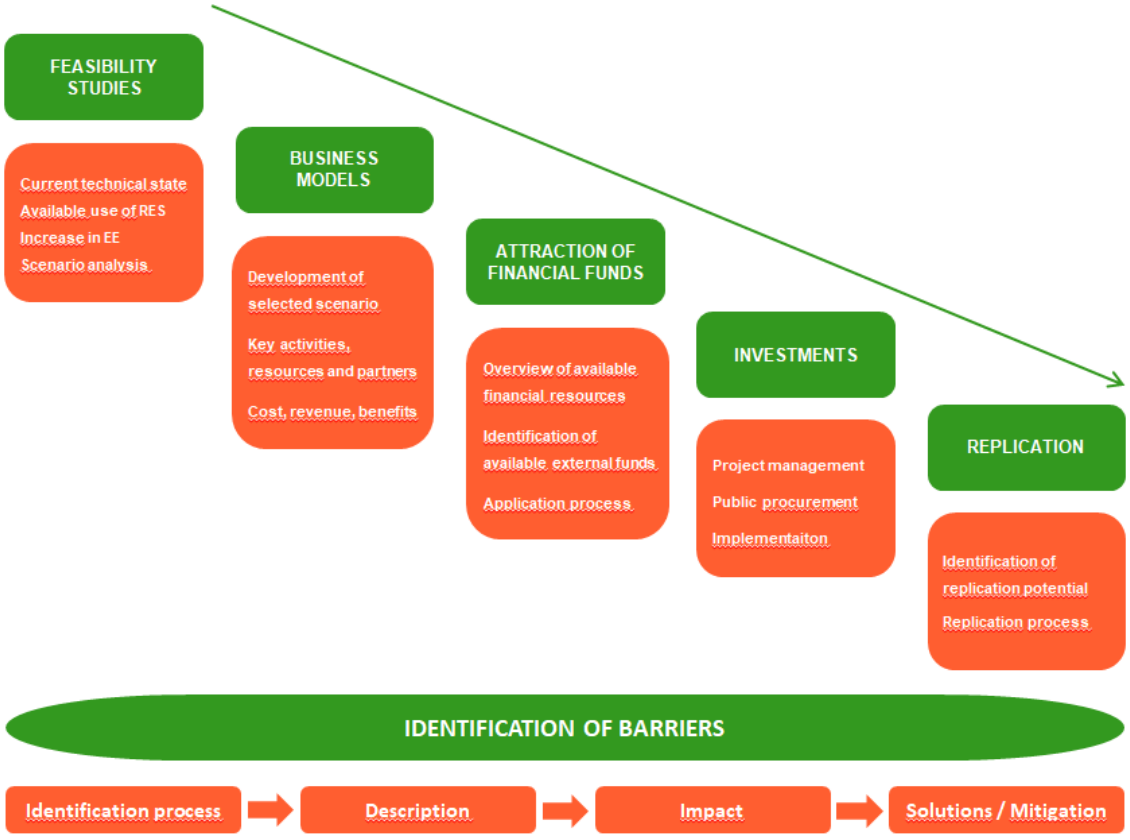


Figure 6: KeepWarm assessment and evaluation process

Following up on the increased capacity of DHS operators and owners, KeepWarm, in a second step, supported pilot systems to develop business plans (Annex 5 – Business model canvas) and attract investment as an efficient DHC system should be economically viable, providing stable and resilient supplies, high-quality services with medium to long-term adaptability at low CO_2 levels and affordable prices for the end-users. KeepWarm worked together with 29 pilot systems helping them to perform necessary assessments to maximise their economic, environmental and societal benefits.

First, a **feasibility study** for DHSs retrofitting was developed based on the local context. Within the feasibility study, following aspects were assessed:

- current state of DHS
- current technical state of resources and networks
- availability and potential for the use of renewable energy sources
- economic situation
- investment opportunities
- energy market, supply and demand

Based on findings at least three possible modernisation scenarios were evaluated, and a business model was developed for the most promising and suitable alternatives of DH

retrofit[15]. Business Model Canvas is a special tool for **Business model** development that is particularly well adapted to small and medium enterprises that set up their business models. Annex 5 is an abstract from this approach that was a guiding document for Business models development. Business models are then confidential. Therefore, the approach shows solely the main aspects which are required to be considered by operators.

Furthermore, in order to achieve investments, potential barriers were analysed (description, impact, possible solutions) and their influence on the process evaluated. The consortium developed a methodology for the calculation of the systems' energy efficiency, primary energy savings, increased share of renewable sources of heat and reduction of greenhouse gas emissions which was used to validate the project's impacts and the elaborated retrofitting approaches (Annex 6 – KeepWarm Impact Monitoring). KeepWarm has set itself seven Key Performance Indicators that make it easier to assess and monitor the project's impact. Three indicators focus on CO_2 and energy savings and as this can be difficult to monitor for a small-scale projects, we added our calculation model as well for KPI 1-3 in case this might be of any help for future projects or companies, as they are easily adaptable. Furthermore, such calculation method could also be considered as supporting tools by applying for external funds/grants when it comes to the realisation of modernisation projects. Nevertheless, such monitoring of primary energy savings, share of RES and greenhouse gas reduction can be applied by any DHS operator, as all those values are available for every DHS. There are no limits to DHS to use such calculations to prove their own performance increase.

Following the submission of proposals for new business models, KeepWarm provided further support to the DHSs to attract financial resources, in case that DHSs do not have sufficient amount of own financial resources, by identifying available financial mechanisms and assisting in the application process. Lessons learnt were consolidated in replicable schemes to enable stakeholders all over Europe to adapt the successful approach. The goal of KeepWarm is to go beyond the limited number of pilot systems. This is crucial for presenting best practices.

As a result of the business plans created and the support provided to the DHS pilot systems, **Replication models** have been developed to introduce retrofit patterns in (and beyond) KeepWarm countries. Throughout a short overview of applied KeepWarm approach, each model presents a different way of modernisation of certain aspects within DH sector such as implementation of new heat source, pipeline renovation projects, DH network expansion, small scale improvements, step-by-step approach and continuous investments in different measures which have been identified and created within KeepWarm project. Each model consists of short overview of performed activities and generated benefits, as well as given potential for replication. Project partners analysed pilot projects based on geographical characteristics, available resources, and country-specific information. Therefore, these models represent various ways of achieving decarbonisation in DH sector based on different technologies, financial and legislative constraints.

[15] KeepWarm •• DHS_Showroom of DHS pilot projects

Replication also raises the question, if the same (KeepWarm) approach can achieve the same outcomes since social, economic, political and other conditions might differ from the proposed models. In other words, DHSs which will intent to replicate the KeepWarm approach will "walk" the same path of the KeepWarm consortium, following the presented methodology and considering specific local/regional/national conditions, as well as other aspects. The eleven models presented in the Report on replication models[16] can serve as examples highlighting each one special feature at the core of the modernisation. It has to be emphasised that for a successful replication, original creators (KeepWarm consortium) should be included in the process in order to more carefully mirror the methods and procedures used within the project.

Within the KeepWarm project, the partners have developed a reliable and transferable methodology to boost the replication of exploitable results, namely modernisation of DHSs and integration of renewable energy sources (RES). The methodology starts by assessing the current state via questionnaires and direct contact with DHS, identifying the best approach through feasibility studies, process analysis and development of business plans. Then, the implementation can start establishing clear and effective training plans addressing the needs of DHS, getting in contact and collaborating with relevant stakeholders (and other DHSs) and finally, review of existing and proposals for future legislation regarding DH sector. The better each step is performed, the better the possible result for achieving investments – thus, DHS who decide to use the KeepWarm approach should take into consideration all aspects.

Austria

Since the 1970s DHS is getting more and more important. Since the 1980s biomass DHS were built and got more important. A major uptake was since 2000. From 2000 to 2015, the heat production from DHS increased by nearly 75 %. There are about 2,300 DHS in Austria. Mostly small scales biomass DHS. 600 are in Styria. Most of DHSs can follow main features of replication mode based on DHS Eibiswald.

Organize capacity-building programme	**Connecting Grids**
Building new boiler-house (biomass)	**Grid extension**
Applying for national environmental subsidy	**Heat Contracts**

Croatia

DHS has been active in major Croatian cities since 1970s and been playing an important role in the heating sector up to date. In total, 16 Croatian cities have DHS which are operated by 11 companies – in total, there are around 110 DHS of different size and type. Most of DHS use gas as the primary fuel, while almost all DHS use fossil fuel for either primary fuel or back up option. Most of DHSs can follow main features of replication mode based on DHS Zaprešić.

[16] KeepWarm •• Report on replication models

Organize capacity-building programme
Connection of public buildings
Applying for Innovation Funds
Solar energy integration
Connecting Grids
Heat Contracts

Czech Republic

The district heating is an important sector in the energy industry of the Czech Republic, providing heat needs to 1.7 million households and a significant share of industrial heat demand - 663 companies with a license for the production of thermal energy and 651 companies with a license for the distribution of thermal energy. Heat is produced mainly from fossil fuels. Most of DHSs can follow main features of replication mode based on DHS Brno.

Organise capacity-building programme
Increase resource efficiency
Applying for OP Funds
Biomass CHP integration
Modernisation of distribution network
Heat tariffs modifications

Latvia

In Latvia, consumers' heat supply is provided through centralised heat supply systems, local heat supply and individual heat supply. Fuelwood and natural gas are fuels, which are mainly used in the production of heat energy from boiler houses. It is essential that the share of local and renewable energy (fuel wood) increases each year, reducing the proportion of natural gas. Most of DHSs can follow main features of replication mode based on DHS Lielauce.

Biomass integration
Small-scale improvements
Automation of biomass supply
Modernisation of distribution network

Serbia

Most important fuel for household heating in Serbia is wood (34 %), while 25.1 % of households use heat from district heating (DH) systems (48.3 % of urban households), 20.1 % electricity, 10.5 % coal and 9.6 % natural gas. It should be noticed that electricity consumption is mostly by direct conversion to heat (via heaters and furnaces) and not for heat pumps or air condition units. Most of DHSs can follow main features of replication mode based on DHS Priboj.

Biomass (boilers) integration
Fuel (biomass) storage
Connecting boiler rooms
Bank loans
Modernisation of distribution network

Slovenia

Supply of heat is provided from 93 distribution systems by 55 heat suppliers in 64 Slovenian

municipalities. Heat distributors supplies 106,292 consumers and delivers 1,963.2 GWh of heat. The general opinion of the society about DHS is very positive due reliable and cost-effective supply, which among other things enables consumers to lower the costs of regular maintenance. Most of DHSs can follow main features of replication mode based on DHS Velenje.

Short-term pipeline renovation
Continuous pipeline renovation plans
Substations renovation
Fuel optimisation
Biomass (boilers) integration

Ukraine

Ukraine has well-developed district heating sector in terms of geographical coverage, but it is characterised by outdated equipment, low energy-efficiency, and declining number of customers. The total DH network length is about 21,000 km. Considering generation efficiency, this brings overall efficiency of district heating systems below 75 %. Most of DHSs can follow main features of replication mode based on DHS Bila Tserkva.

Replacement of outdated equipment
Pipeline renovation
Development of bankable solutions
Biomass (boilers and CHP) integration
Step-by-step modernisation
Identification of available financing

3.3. Facilitating DH retrofits

Local working groups have been set up in order to boost energy transition towards low carbon heating, to support KeepWarm pilot DHSs, to discuss best options with different stakeholders and further possible adaptations of business models. The goal of the local working groups was to include all relevant stakeholders, which can be identified through the stakeholder analysis, to provide input for business plan development and feedback on future retrofitting plans as well as on barrier removal for DHS. The specific topics and focus of the conducted meetings were defined based on the needs of each DHS operator/owner and related stakeholder. The local working groups were responsible for the implementation and monitoring of the DHS retrofits. KeepWarm partners were mainly in the position of facilitator, discussion leader and triggering reflections and provided support in planned actions.

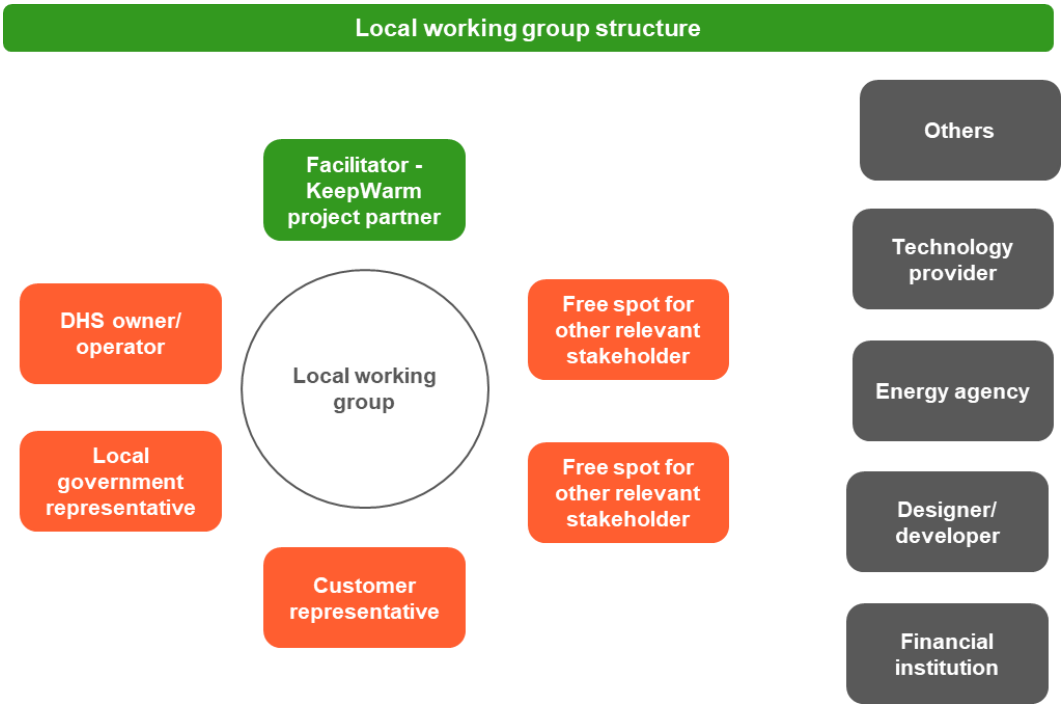


Figure 7: Local working group structure

The working groups brought together at least one representatives of DHS operators/owners, local government and end consumers (and possible other key stakeholders if needed). Members of this group mainly discuss and considered:

- choices in the optimal financial approach and business model (combination of public and private capital, financing schemes like on-bill financing and similar)
- application for potential grants (for example, EU structural funds through the Integrated Territorial Investment mechanism, and others)
- negotiations with customers (joint meetings with project partners as facilitators)
- specific technical issues (in addition to the ones analysed in Feasibility studies and Business Models)
- legal issues (e.g. unclear ownership/responsibilities of heating substations)
- exchange with twins – and including lessons learnt
- conclusions for future retrofit steps
- recommendations for the national action plans for district heating modernisation to eliminate barriers for retrofitting projects.

After identification of the current state and barriers which hinder successful investments in DHSs, the KeepWarm national partners provided tailor-made assistance to remove the barriers. The assistance is divided into five specific groups

- technical support
- financial support
- potential grant support
- legal support
- negotiation support

An overview of activities achieved through the collaboration between project partners, DHSs representatives and other stakeholders is available on KeepWarm website[17].

Another support mechanism in the KeepWarm project was a **Twinning and Ambassador Programme**. The purpose of this programme was to facilitate replication of the entire KeepWarm approach by pairing local stakeholders with peers in other countries to generate cooperation and synergies across the region and to learn from each other's experience. By allowing DHSs to exchange feedback with each other on draft documents, each DHS was better equipped to revise their retrofit plans benefitting greatly from the twins outside perspectives.

In the next step KeepWarm partners conducted **Inspire Events** where participating DHS owners/operators, DH associations and agencies reached out relevant stakeholders, local, regional and national authorities to attract interest for the project's results and stimulate motivation for policy improvements. Participants had the opportunity to network, discuss approaches to overcoming obstacles, and share experience with the retrofit process from successful DHSs.

In all participating countries, it was confirmed that the cooperation and support of individual stakeholders within the working groups is a necessary step to reach a consensus on the implementation of investment projects in the process of DHS modernisation.

[17] KeepWarm •• D4.3 Report on Support provided to DHS

4. Critical risks and mitigation actions

CRITICAL RISKS INFLUENCING A SUCCESSFUL MODERNISATION PROCESS OF DH SECTOR (*L(low), M(medium), H(high)*)								
TECHNICAL RISKS	AT	HR	CZ	LV	SI	SRB	UKR	**MITIGATION ACTIONS / MEASURES**
Low prices for oil and gas that reduce economic interest to invest in DHS modernisation	M	M	M	M	L[18]	M	M	Present DHS retrofitting as a long-term investment. Oil and gas prices likely to fluctuate and policy changes very likely to favour energy efficient DHS and increase in RES. It is necessary to **focus on long-term sustainability**, including assessment of wider benefits (i.e. socio-economic and environmental).
Decrease in heat demand due to thermal insulation of houses and thus limited interest in investing in DHS	M	L	L	M	L[19]	M	M	Retrofitting buildings towards passive house standard likely to take until 2050 and beyond, especially in Central/East Europe. Thus, **investment into DHS makes economic sense already now.** Investing in DH can be supported by the benefit of reduced peak demand and the possibility of decreasing temperatures (and therefore losses) and serving more customers.
POLITICAL RISKS								**MITIGATION ACTIONS / MEASURES**
Unfavourable national regulations and policies		M	M	L	H[20]		M	It is likely that in most countries national policies tend towards stronger energy efficiency standards and higher use of RES and provide support for these projects. The project promotes the use

[18] Short-term risk. The direction is clear (renewables, reduction of losses, low/no environmental impact).
[19] More positive than negative impacts. Positive: Motivation for actions aiming at reduction of losses, decrease of energy costs, flexibility, development of new/innovative services. Negative: lower income means less resources for investments (others sources need to be ensured)
[20] EU directions are clear. Goals are demanding and need immediate actions. Priorities are not defined. Systematic support and approach have not been established yet, it is expected in 5 years. Policies are defined and clear, but implementation does not follow. National taxation system is based on fossil fuels as dominant budget funding source.

								of RES in the DH sector, thus **reducing costs for the private investor and the public.**
Energy reforms have not been focused on DHS. Risk of continued disregard of DHS and in favour of other topics, e.g. wind, solar,..	L	L	M	L	M[21]	H	M	It is necessary to **integrate DHS modernisation into energy plans**. Participate in the legislative process and promote the integration of DHS into national strategies, regional and local plans. Show policy makers the benefits of DHS.
Heat tariffs for consumers in some Central and East European countries under government subsidy and utility plants owned by government. This leads to low competitiveness of DHS, and thus lack of incentive to modernise.		M	L	L			L	Given inefficiency of current systems, modernisation is unavoidable. The **heat price** per TJ consumed **can be reduced** considerably **due to energy efficiency measures**.
FINANCIAL RISKS								**MITIGATION ACTIONS / MEASURES**
Expected investments are not realised due to the problem with obtaining national financial support	L	L	L	M	L[22]		H	Very close **interaction with national DHS associations and potential investors to ensure modernisation project is coherent with national processes** and that support will be granted.
Many DHS operators are municipally owned, which limits the potential to attract private capital into DHS modernisation projects		L	M	H	M	H	M	It is necessary to **explore public-private partnership opportunities** for DHS modernisation projects.
RISKS OCCURRING DUE TO COV-2								**MITIGATION ACTIONS / MEASURES**
DHS operators are likely to have problems with default payments and will significantly reduce heat sales in the next months / years. As a result, larger investments are postponed	L	L	L	L	L	L	M	Continue to **identify supporting schemes and support them in the application process**. Regular exchange on activities and support schemes in each country in order to share best practice examples on how to support DHS operators to achieve

[21] There is a lot of untapped potential of DH development. Energy strategies and action plans do not address extensive benefits of DH appropriately; particularly the integrative role of DHS has been often overlooked.
[22] DHS project normally realized, but with significant delay (1-2 or even more years).

indefinitely. Financial resources in utilities are temporarily allocated for the maintenance of key operational activities.								investments in economically strained times. **Incorporate measures targeting DHS operation** under the emergency situations (occupational health and safety, procurement, communication with customers, etc.).
Realisation of investments/ retrofit will be impacted from several sides: banks and financial institutions are also affected so they process only urgent issues, the low economic activity puts down prices of fuels and CO2 emissions, so bankability of projects has also been changed. Uncertainty about financial schemes. Political support might be temporary withdrawn, due to CoV-2 outbreak. Investments will slow down.	M	M	H	M	L[23]	H	H	Close **cooperation with authorities** (for subsidies) and banks (for loans). Include withdrawal of investments in further project management planning, e.g. material investments instead of/in addition to financial ones. Provide **additional sensitivity analysis** or similar for projects with lower Internal Rate of Return (IRR).
Restrictions on holding physical meetings and negotiations with stakeholders can slow down the implementation of modernisation activities. The integration of strategies into national action plans may be limited.	L	L	M	L	L	M	L	Opinion exchange through other channels (mails, phone calls, …) Support partners to **prepare for the new types of communication activities** (software, hardware, etc.).
Activities aiming at the development and advice for SECAPs, LEC, etc. will need to be reorganised and rescheduled according to the new circumstances. This might cost more time and other resources.		L	M	L	L	M	L	Limited influence on activities, will be replaced through **digital communication**

Table 4: Critical risks and mitigation actions

[23] The economy recovery plan following Covid-19 pandemic may have positive impact on acceleration of transition to RES. Some processes are expected to be simplified in terms of administrative burden and procedures. This is also an opportunity to realise a systemic change towards clean technologies, related investments can be initiated and stimulated through EU and governments policies and support.

In the energy sector, there have been gradual changes in the fuel base and technologies over the last two decades. A decrease in the use of solid and liquid fuels (coal and heating oils) can be observed, while the use of natural gas (for individual heat production and smaller cogeneration sources) and renewable energy sources is increasing. There are realistic assumptions that these trends will continue. Most participating countries perceive the risk of reduced interest in investing in DH modernisation as medium, mainly due to falling natural gas prices.

There was also a significant reduction in heat consumption, due to the rationalisation of production, distribution and especially heat consumption. Although the potential for heat savings on the consumption side has not yet been exhausted, the downward trend has already slowed markedly. The outlook for heat demand reflects, on the one hand, the projected economic growth in both the services and industrial sectors, household growth and, on the other hand, the continuing trend of energy savings, which should offset the upward pressure on heat demand. The risk of reduced interest in investing in DH is therefore perceived as medium or even low.

The objectives of European environmental policy are clear. The general objectives of national and territorial energy policies proclaim support for the maintenance and development of district heating. The specified measures in the form of setting primary legislation and implementing regulations represent the basis for the application of energy and environmental effects of district heating. With a view to creating an appropriate economic and legislative environment for the further development of district heating, specific support measures should be implemented as soon as possible. Political risks are perceived as medium or high (except AT and LV).

District heating modernisation projects are widely implemented with the contribution of subsidies from the European Union. However, project participants consider the risk of private capital entering these projects to be medium to high, as DHSs are mostly fully owned by municipalities.

District heating operators do not expect to reduce heat production or postpone planned investments due to CoV-2. DH operators admit that delays can occur in the area of political support.

5. Lessons learned, impacts and recommendations

5.1. Why to support district heating?

The European district heating industry has a clear responsibility to provide 120 million customers with their most fundamental energy needs. District heating is a key element for sustainable heating in Europe, contributing to more efficient use of energy, providing an opportunity for the integration of renewable and low-emission sources and enabling the transition to a smart energy system. District heating is a perspective technology providing of heating in densely populated urban areas. It is an attractive and comfortable way of supplying heat and hot water for private, public, industrial and commercial customers. The modernised district heating system can be fully competitive with respect to the price of heat compared to individual sources and, in addition, a more environmentally friendly way of heating.

5.2. What is the current state of DH technologies in Central and Eastern Europe?

Simply alarming, requiring immediate upgrades. The following challenges of district heating systems need to be addressed:

- High dependence on fossil fuels
- Low heat production efficiency and sustainability
- High heat production costs
- High transmission losses
- Obsolete technology used, poor maintenance
- Oversized network coverage
- Lack of heat production and utilisation control (technical rigidity)
- Lack of experts in the field of energy efficient technologies and renewable energy sources
- Lack of investments

5.3. Supporting the integration of retrofitting DHSs in strategies and plans

To support the individual national strategies, the project partners created **action plans**[24] for the retrofitting of the DH sectors, pointing out areas which are not sufficiently addressed in these strategies. These action plans developed in cooperation with stakeholders aim to contribute to the improvement of a legal framework for systematic decarbonisation of DH

[24] KeepWarm •• Action plans for retrofitting of District Heating Systems

networks, the introduction of incentives for heat production from RES and to increase the energy efficiency of these systems. At the same time considerations are being made as how to maintain and secure economic viability despite the declining heat demand of connected buildings and the competition from other individual heating solutions for households.

The assessment of the existing national strategies and plans in the seven pilot countries of the KeepWarm project[25] shows that many improvements are required to strengthen these strategies, to ensure that they not only meet EU legislative requirements, but also provide strong support for DHC systems to play a visible role as a highly energy-efficient and cost-effective way of moving towards a decarbonised and sustainable heat supply.

The EU "winter legislative package" does not indicate the direction for the development of the individual sectors, but sets the framework for the MSs to lead the energy sector towards the 2030 targets. It introduces increased demanding commitments for DHC systems which need to be clearly reflected and supported at national level (e.g. NECP) and even more specifically addressed with a number of concrete goals and initiatives at local level (e.g. in SECAP).

The main themes of the related directives, which are crucial for the formulation of policies on the use of RES or EE in the DHC sector, have been selected for the three main areas where the EU is setting the direction of national legislation: energy efficiency, use of renewable energy and energy efficient buildings. In the following three sections, the articles of the Directives with direct strong DHC implications are presented to guide and support each of the stakeholders systematically through the integrity assessment of the relevant policy regulations, particularly those set at national level. Policy development in non-EU countries is also influenced by bilateral cooperation and the use of EU experience during the policy development process.

5.4. Impact of the KeepWarm project

The impact of the project is reflected in the use of project results and their exploitation routes. These key exploitable results have commercial and/or societal significance.

The KeepWarm project has defined three main indicators, which contributed to the validation of the project's impact – Primary energy savings, Increased share of renewables and Reduction of greenhouse gas emissions.

Baseline for the expected improvements was the Feasibility Studies and the related Business Plans including funding. Since the individual DHS approaches were not completely implemented by the end of the project, KeepWarm multiplied the expected outcome with the average lifetime of such an improvement/ installation.

In **Austria**, three pilot projects (DHS Eibiswald, DHS Ligist and DHS Möderbrugg) generally

[25] KeepWarm •• DHS recommendations for strategy or plan integration

opted for renewal of existing boiler rooms, as well as for grid expansion which would allow connection of new customers. For those three investments, in a 25-years lifespan, the estimated Primary Energy savings (PES) will be 54 GWh while RES increase 229 GWh and therefore CO_2 reduction 58,850 t.

In **Croatia**, three pilot projects generally opted out for integration of large-scale solar thermal fields, as well as for connection of disconnected boiler rooms in order to achieve greater solar fraction which would decarbonize heating sector within the Zagreb County. For those three investments, in a 25-years lifespan, the estimated Primary Energy savings (PES) will be 78.5 GWh while RES increase 123.7 GWh and therefore CO_2 reduction 50,325 t.

In the **Czech Republic**, three pilot projects undergo major pipeline reconstruction and change of heat source to more sustainable technologies. Two projects (DHS Písek and DHS České Budějovice) are expected to be fully implemented in 2021, while activities in DHS Brno are planned to finish in 2024. For those three investments, in a 25-years lifespan, the estimated Primary Energy savings (PES) will be 11,395 GWh while RES increase 6,782.5 GWh and therefore CO_2 reduction 3,363,875 t.

In **Latvia**, pilot project DHS Jekabpils has focused on a replacement of biomass boiler and replacement of gas boiler (for summer loads), while pilot DHS Bene is planning to switch from buying in biogas energy to production of own from biomass produced heat energy. The third pilot project DHS Lielauce will undergo installation of automated wood chip feeder, a pipeline renovation and installation of frequency changer for heat pumps. The first pilot project, which has started implementation phase, is DHS Jekabpils. Two projects have been postponed due to administrative territorial reform until end of 2021(DHS Lielauce) and 2024 (DHS Bene). For those three investments, in a 25-years lifespan, the estimated Primary Energy savings (PES) will be 49.73 GWh while RES increase 167 GWh with no reduction in CO_2.

In **Serbia**, four pilot projects opted out for biomass boilers in combination with appropriate fuel storage, connection of boiler rooms into a single heat network. One investment has already been started (DHS Priboj), while others (DHS Bajina Bašta, DHS Nova Varoš and DHS Šabac) are delayed. For those investments, in a 25-years lifespan, the estimated Primary Energy savings (PES) will be negligible while RES increase 167 GWh and therefore CO_2 reduction 576,477 t.

In **Slovenia**, two pilot projects (DHS Ptuj and DHS Slovenj Gradec) will combine pipeline renovation and biomass integration, alongside with a grid expansion (DHS Ptuj) and installation of heat storage (DHS Slovenj Gradec) through EU funding. Investments are expected to start in spring 2021. Last pilot project (DHS Velenje) already finished with activities of pipeline and substations renovation. For those investments, in a 25-years lifespan, the estimated Primary Energy savings (PES) will be 39.94 GWh while RES increase 500 GWh and therefor CO_2 reduction 97,475 t.

In **Ukraine**, all four pilot projects have begun. DHS Bila Tserkva plans to renovate pipeline and boilers with the aim of centralisation of heat production until 2024, while DHS

Khmelnytskyi focuses on biomass boiler integration, replacement of burners and centralisation of heat production by replacing pipeline until 2024. DHS Ternopil undergoes tendering processes for new biomass boiler which should be implemented by 2024, while DHS Zhytomyr has proceeded with major renovation of both heat production and distribution parts of DH system until 2025. For those investments, in a 25-years lifespan, the estimated Primary Energy savings (PES) will be 1,512 GWh while RES increase 3,442 GWh and therefor CO_2 reduction 1,093,600 t.

The following diagram shows the short, medium and long-term impacts of the project results.

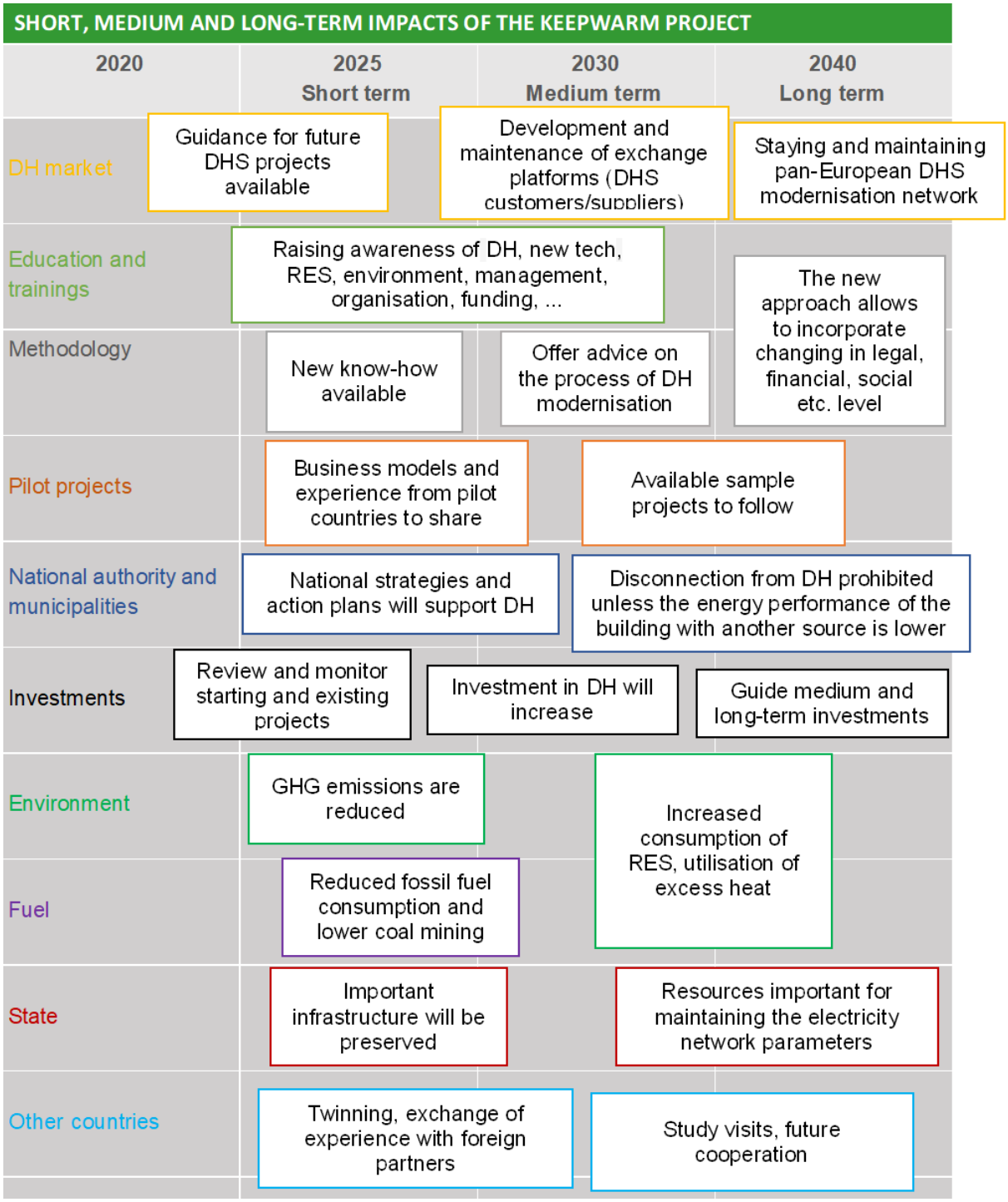


Figure 8: Impacts of the KeepWarm project

5.5. Specific recommendations for the transition to greener and more efficient district heating

Every pilot or regular DH system should be analysed according to its own specifics of efficiency and the most appropriate choice of RES. KeepWarm suggests the adoption of a sustainable roadmap for the technical assessment and implementation: First, energy efficiency gains of the current network shall be exploited, e.g. retrofitting of internal heat distribution systems (grid or distribution efficiency). When most or all (economically viable) efficiency gains are obtained, an improved energy source is recommended. Heat re-use (for instance excess heat from industry) should be looked at, while considering in parallel the replacement of fossil fuels with renewable energy sources, e.g. use of local renewable (particularly biomass, geothermal and solar-thermal). Waste-to-energy options can follow as well as deploying smart heat distribution and control management systems.

Having understood the diverse opportunities for each sustainable energy component as a source for district heating, it is possible to realise their distinct advantages over traditional fossil fuels. Since any option of efficiency, RES and excess heat can offer an alternative in most cases, it then becomes a question of choosing the most feasible combination.

- **Reflect on the current and future needs of the DH company** to see which of these renewable energy sources and excess heat options have the technical capacity and resource supply-availability to match the local heating demand in the long-run.
- If a DHS is one of the older networks (steam), **first prioritise modernising DH boilers, insulating pipes and reducing other losses** to make the system as efficient and low carbon as possible. Even so, retrofitting DHS is the ideal moment to simultaneously implement additional measures, there might not be sufficient resources available to do so. In any case, applying the efficiency first principal will ensure that the DHS is fully prepared to integrate the highest possible share of sustainable energy sources thereafter.
- **Make a gradual switch to RES and/or excess heat sources**. **Avoid a needless swap from one fossil fuel to another such as from coal to gas. As Europe has confirmed its ambition to be climate neutral by 2050,** natural gas is likely not a “bridge technology” for DH anymore that pays off investments in time.
- **Analyse the full potential of all local and regional renewable resources** at your disposal, be it biomass fuel supplies, solar irradiance, geothermal temperature gradients, heat pump sources or nearby industrial/commercial excess heat facilities.
- **Build Heat Synergy Regions** meaning urban and rural areas, which combine their renewable energy potentials and excess heat sources beyond their political boarders in order to optimise and create the most sustainable and low-carbon infrastructure.
- Be aware that there is **no need to rely just on a single energy source** – most of these alternative energies work excellently in combination. Thus map out (literally and figuratively) the RES and excess heat possibilities available across the region

in order to identify the most economic and synergetic combination of sustainable energy options for matching the regional DH demand.

- **Accelerate the development of new and larger networks by supporting small-scale and micro DH systems**, assisting and cooperating with diverse, local groups like energy cooperative to allow the DHC market to grow.
- **Enable new DH systems faster** by using the pre-feasibility software THERMOS to identify cost-optimal networks.
- **Establish a local coordinating working group** to support for DHS development across a range of national to local programmes and in partnership with as much stakeholders as possible.

This publication summarised the results of the analysis of the baseline conditions and stakeholders of each participating country, the barriers that district heating sector has to face, opportunities for improvement in the modernisation process, critical risks, their impacts and possible solutions to mitigate or eliminate them.

Dedicated national DHC strategies supported by improved **regulation should assign DH the leading role it deserves in supplying sustainable heat in urban areas**. Particularly, local authorities play a major role in facilitating the development of DHS by integrating them into **spatial development plans** and mediating communication between stakeholders from a broader societal perspective. Relevant skills and knowledge among decision-makers should be strengthened in order to adequately promote and raise awareness on DH (co-)benefits.

From the technical point of view DH systems have one of the distinct advantages that other heating solutions do not have - the possibility to integrate different (local) energy sources, especially RES and excess heat. Due to the large-scale and long-term investments, it is necessary to **develop targeted financial mechanisms and business models**, which will support stable development of the DHS. Public and EU funding is inevitable to accelerate renovations.

The sustainability and replicability of the modernisation and improved operation of existing district heating is fostered by **applying the KeepWarm methodology**. Furthermore, the ***KeepWarm Learning Centre*** is offering supporting tools to engage stakeholders and facilitate the implementation and monitoring process. The publication ***Development of multi-level policy plans*** is just one highlight for public authorities to access a full set of specific recommendations for the integration of district heating and cooling in national, regional and local planning. Moreover, KeepWarm aims to accelerate the cost-effective and energy efficient retrofitting of existing, inefficient district heating networks by demonstrating the impact and change in almost one hundred DHS across CEE in a ***virtual showroom***. Knowledge, best practises and experience from these use cases are now available for the benefit of the entire stakeholder community in the field of DHS.

6. Conclusions

Sustainability and replicability of the modernisation and improved operation of existing district heating is fostered by KeepWarm methodology and supporting analytical tools targeted at related stakeholders in charge of the systems. KeepWarm aims to accelerate the cost effective and energy efficient retrofitting of existing inefficient district heating networks by demonstrating the impact through the interactions and exchanges between all stakeholders throughout Europe. Knowledge, best practises and experience from the use cases were shared through a large stakeholder community in the field.

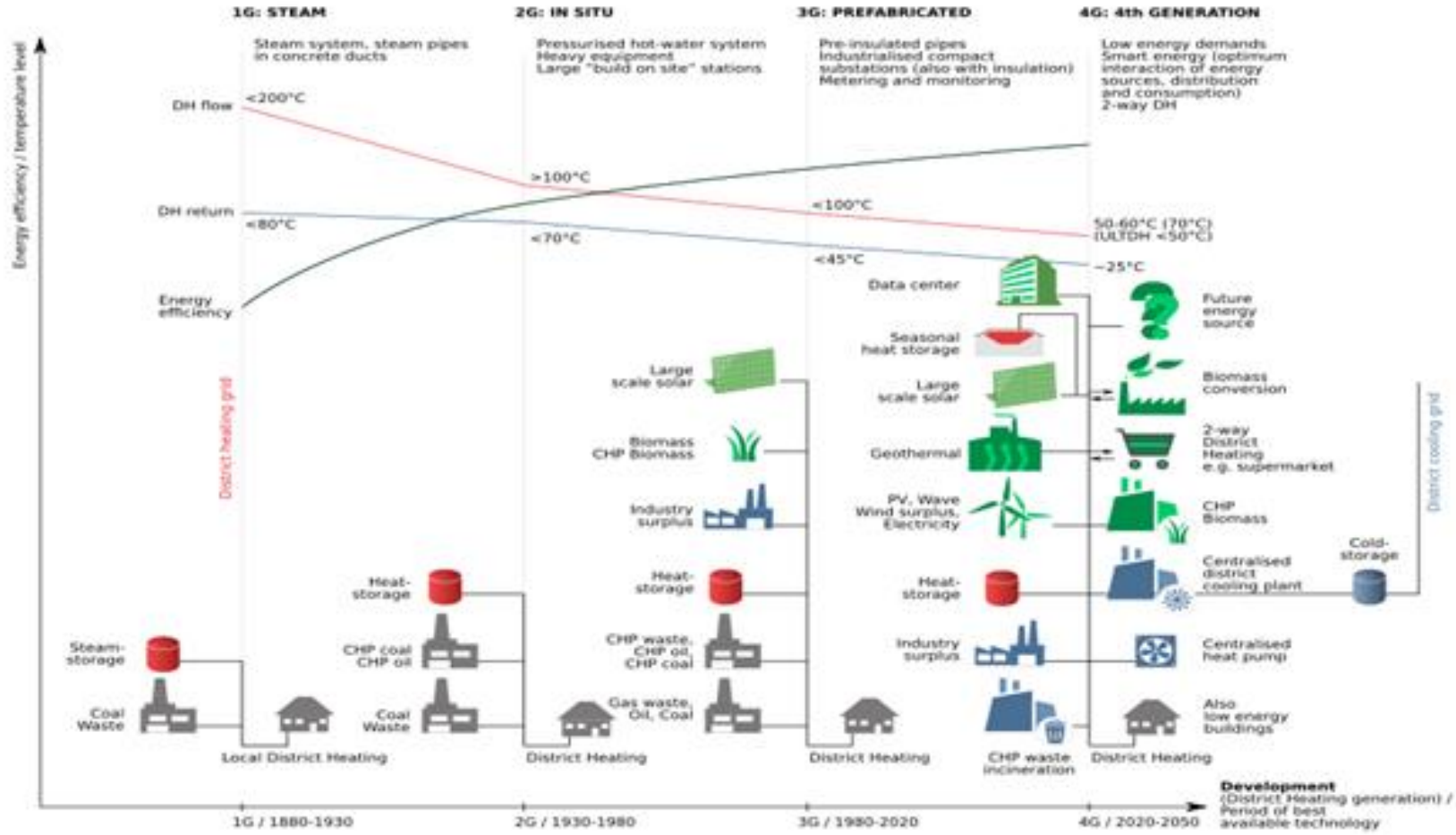
In this paper, we have summarised the results of analyses of the baseline conditions and stakeholders of each participating country, the barriers that district heating sector has to face, opportunities for improvement in the modernisation process, critical risks, their impacts and possible solutions to mitigate or eliminate them.

The national DHC strategy and improved related regulation shall assign DH the leading role in supplying sustainable heat in urban areas. Particularly local, municipal authorities play a major role in facilitating the development of DHS by integrating them into spatial development plans while at the same time they need to mediate communication between stakeholders. A care should be taken to strengthen relevant skills and raise knowledge among decision makers. Promoting and raising awareness of DH benefits is crucial for sustainable community development.

From the technical point of view DH system has one of the distinct advantages that other heating solutions do not have - the possibility to integrate different (local) energy sources, especially RES and excess heat. Due to the large-scale and long-term investments, it is necessary to develop targeted financial mechanisms and business models which will support stable development of the DHS. Public and EU funding is inevitable to accelerate renovations.

The intention of KeepWarm is to continue its activities even after the end of the project and thus ensure the replicability of the proposed solutions for the modernisation of the district heating system across Europe. Prepared promotional activities and materials are aimed at addressing other heating companies that need to streamline and decarbonise their operations, and offer best proven practices and assistance in the modernisation process.

Annex 1 - Modernisation process in the district heating sector



Annex 2 – Training needs questionnaire

Training needs topic questionnaire

Name of the project partner:

Name of the DHS operator/City:

T1 Capacity development on technical concerns

Name of the topic	Give priority to the training topic (1 = lowest, 5 = highest priority)					Insert a few keywords on why you prioritised this topic so high/low
Assessment of energy losses in the district heating grid and determination of actions to improve grids and make them smart, remote metering systems, Metering standards	1	2	3	4	5	
Automatisation of boiler house/substation and heat storage optimization	1	2	3	4	5	
Optimising temperatures of supply/return pipes. Optimizing temperatures of supply/return pipes	1	2	3	4	5	
Optimisation of heat networks energy audits and surveillance	1	2	3	4	5	
Modelling of DHS after energy retrofitting of connected buildings (consumers) – Building retrofit reduced heat demand, so DHS often needs to be adjusted to new heat demand	1	2	3	4	5	
Technical evaluation and comparison of the municipal heating system development options, including a comparison of DHS with decentralised solutions in municipalities with reduced heat load density	1	2	3	4	5	
Identification of cost-effective approaches to optimize DHS	1	2	3	4	5	
Use of GIS-based tools (Heat demand assessment, DH network development, mapping of excess heat sources)	1	2	3	4	5	
Suggest other possible topics for training in your country						

T2 Capacity development on the utilisation of RES, waste and excess heat

Name of the topic	Give priority to the training topic (1 = lowest, 5 = highest priority)					Insert a few keywords on why you prioritised this topic so high/low
The inclusion of RES in DHS (solar thermal, biomass, geothermal, heat pumps, …)	1	2	3	4	5	
Sustainability of biomass supply (increasing capacity of plant operators and their fuel/biomass suppliers, estimation of biomass potential)	1	2	3	4	5	
The utilisation of waste heat in an urban environment and from industrial sites	1	2	3	4	5	
Feasibility analysis of switching from fossil fuel to renewable energy or waste heat sources and feasibility analysis of using different RES/waste heat	1	2	3	4	5	
Assessment of the biomass quality	1	2	3	4	5	

Suggest other possible topics for training in your country	1	2	3	4	5	

T3 Organisational capacity needed

Name of the topic	Give priority to the training topic (1 = lowest, 5 = highest priority)					Insert a few keywords on why you prioritised this topic so high/low
Identification of measures and processes for improving the organization management of DH&C networks (comprising energy generation, distribution and consumption)	1	2	3	4	5	
The increase of the organisational qualifications of boiler house operators	1	2	3	4	5	
Different possibilities to organise DH companies according to national law	1	2	3	4	5	
Suggest other possible topics for training in your country	1	2	3	4	5	

T4 Financial concerns

Name of the topic	Give priority to the training topic (1 = lowest, 5 = highest priority)					Insert a few keywords on why you prioritised this topic so high/low
Assessment of the economic and financial viability of using RES and waste heat in DHS plants	1	2	3	4	5	
Development of innovative financing mechanisms (on-bill, public-private, inclusion of consumers/citizens…)	1	2	3	4	5	
Tools for economic/financial viability analysis	1	2	3	4	5	
Financial support schemes and funding resources for DHS retrofits and decarbonisation	1	2	3	4	5	
Business plans development	1	2	3	4	5	
Suggest other possible topics for training in your country	1	2	3	4	5	

T5 Managerial concerns

Name of the topic	Give priority to the training topic (1 = lowest, 5 = highest priority)					Insert a few keywords on why you prioritised this topic so high/low
Identification of measures for increasing the attractiveness of DHS for end-consumers, in close interaction with end-consumers and public authorities	1	2	3	4	5	
Training on PR and user engagement towards new and existing consumers	1	2	3	4	5	
How to assess user behaviour	1	2	3	4	5	
Identification of options for individual billing in multi-apartment buildings equipped with building heat meters	1	2	3	4	5	

Increasing transparency of information about bill structure and available energy services to reduce heat consumption	1	2	3	4	5	
Contractual arrangements needed to ensure a smooth retrofit of the DH network	1	2	3	4	5	
Contractual arrangements needed to ensure a smooth biomass supply	1	2	3	4	5	
Suggest other possible topics for training in your country	1	2	3	4	5	

Questionnaire on the training preferences

Name of the project partner:

Name of the DHS operator/City:

PART A: Questions for DHS operators:

1. What is your preferred type of training?
    a. Lectures
    b. Workshops
    c. Webinars
    d. Software training
    e. Field trip
    f. Individual training (1 on 1 consultancy)
    g. Combination of above mentioned, which?
    h. Other
2. What type of training duration and slots would you prefer?

Example:

- 3 days full training with 8 hours slots
- 2 weeks training with 2 hours per day slots
- 1-day full training with 8 hours slot(s)
- Other…

3. Type of learning materials that you would prefer?
    a. Online material (lectures, presentations, exercises)
    b. Scripts
    c. Books
    d. Field trip
    e. Combination of above mentioned, which?
    f. Other

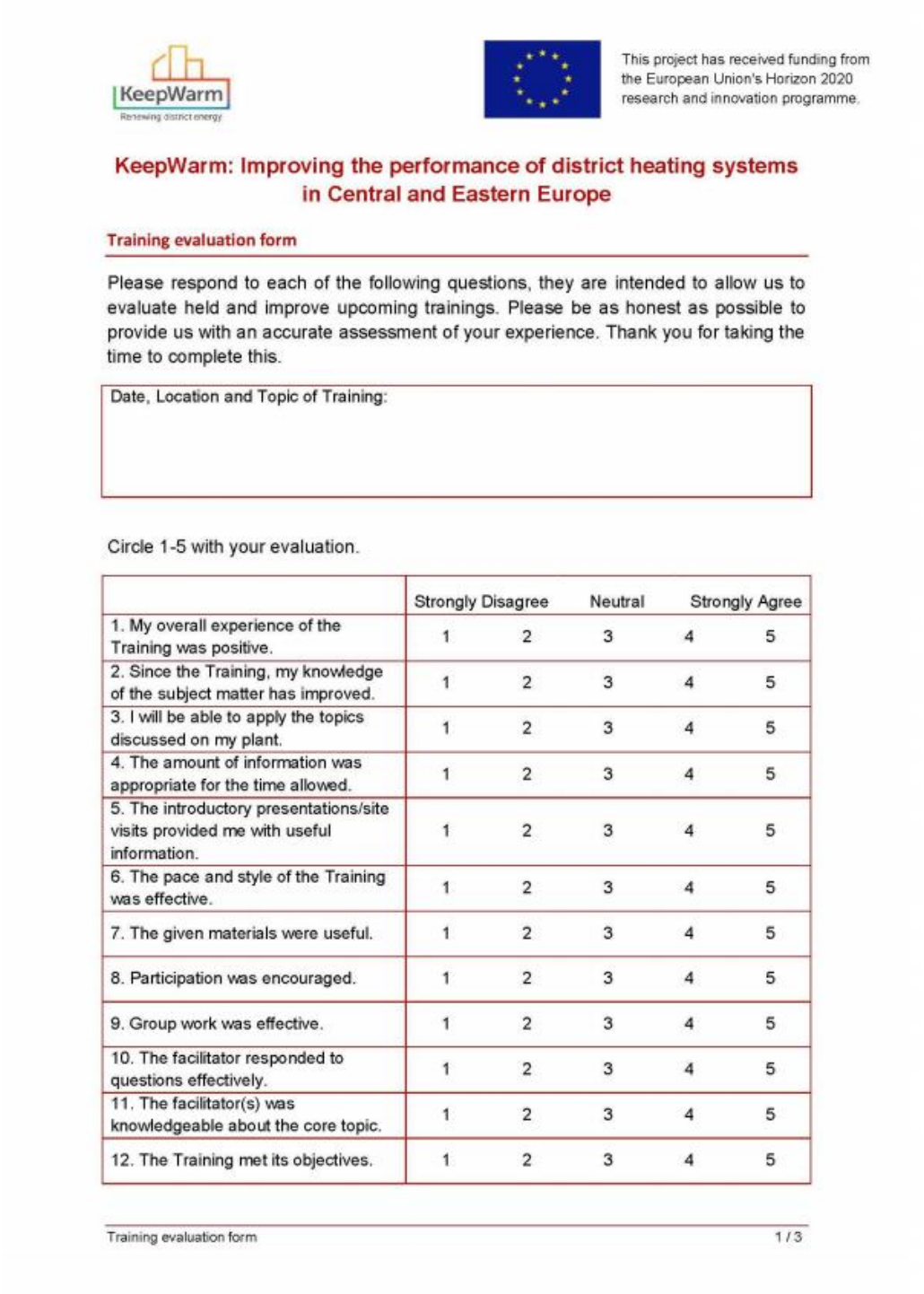
4. What type of personnel would you send to the training?
    a. Managers
    b. Financial officers
    c. Boiler operators
    d. Operation and maintenance workers
    e. Engineers
    f. IT officers
    g. Legal and personnel officers
    h. Combination of above mentioned, which?
    i. Others

5. Would you like to include any external stakeholders in the training?
    a. Local and/or regional public authorities
    b. Spatial development planners
    c. Development and/or energy agencies
    d. Potential investors/banks
    e. Real estate developers
    f. ESCO companies
    g. Others
6. Describe what would be for you the desired outcome of the training?

PART B: Questions for training organisers:

1. Who will be the lecturers providing training in your country? Describe the necessary qualifications.
2. How will you prefer to evaluate training efficiency?
    a. Signing sheet
    b. Anonymous questionnaire
    c. Combination of the above mentioned
    d. Other
3. What will be the necessary competences and knowledge necessary to participate in and understand planned training?
4. What will be expected learning outcomes of the planned training?
5. Provide a 10-row description of the planned training? After you receive responses on the topic and training preferences from the DHS operators.

Annex 3 - Training evaluation form



This project has received funding from the European Union's Horizon 2020 research and innovation programme.

KeepWarm: Improving the performance of district heating systems in Central and Eastern Europe

Training evaluation form

Please respond to each of the following questions, they are intended to allow us to evaluate held and improve upcoming trainings. Please be as honest as possible to provide us with an accurate assessment of your experience. Thank you for taking the time to complete this.

Date, Location and Topic of Training:

Circle 1-5 with your evaluation.

	Strongly Disagree		Neutral		Strongly Agree
1. My overall experience of the Training was positive.	1	2	3	4	5
2. Since the Training, my knowledge of the subject matter has improved.	1	2	3	4	5
3. I will be able to apply the topics discussed on my plant.	1	2	3	4	5
4. The amount of information was appropriate for the time allowed.	1	2	3	4	5
5. The introductory presentations/site visits provided me with useful information.	1	2	3	4	5
6. The pace and style of the Training was effective.	1	2	3	4	5
7. The given materials were useful.	1	2	3	4	5
8. Participation was encouraged.	1	2	3	4	5
9. Group work was effective.	1	2	3	4	5
10. The facilitator responded to questions effectively.	1	2	3	4	5
11. The facilitator(s) was knowledgeable about the core topic.	1	2	3	4	5
12. The Training met its objectives.	1	2	3	4	5

Training evaluation form 1 / 3

13. What were the major strengths of the Training? What did you find most useful?

14. What aspects of the Training could be improved and how?

15. Did anything strike you as interesting, new, provocative, or meaningful during the Training?

16. Can you identify one change that you will make in your practice, or one idea that you will put into practice, as a result of this Training?

17. What part of the Training format should be changed to improve discussion?

18. Any other comments?

Annex 4 - Long-term evaluation questionnaire

KeepWarm long-term evaluation questionnaire

Thank you for participating in our previous KeepWarm trainings (09.18-06.19). We would like to verify the impact of these trainings and the benefits for you with the following evaluation. Therefore, we kindly ask you for your feedback. The questionnaire consists of 20 multiple and single choice questions and can be answered in 5 minutes.

Reminder: Used training material is available on the KeepWarm website under the categories "Learning Centre" and "Country Pages" - partly in English and partly in the local language."

Please circle or highlight your answers.

1. In which of the following roles did you take part in the training?

a) DHS Owner

b) DHS Employee

c) Researcher

d) Investor

e) Other

2. Which of the following topics guided your training? (You may select multiple answers.)

a) Technical training

b) Organizational training

c) Managerial training

d) Financial training

e) RES/ Waste and excess heat

3. If you would go back in time, how would you describe the trainings organized by KeepWarm? (You may select multiple answers.)

a) Well-structured organization

b) Good learning atmosphere

c) Appropriate practical orientation / professional relevance

d) Good selection of participants/trainees

e) Useful content

f) None

4. If your answer is f) none, please elaborate it briefly.

5. To what extent did the trainings strengthen your expertise, use of methods and access to networks for the improvement of your DHS?

a) To a great extent

b) To some extent

c) To a very little extent

d) Not at all

6. To what extent do you consider the training materials and methods to be appropriate and suitable for the context of the trainings?

a) To a great extent

b) To some extent

c) To a very little extent

d) Not at all

7. If your answer is d) not at all, please elaborate it briefly.

8. How far would you consider the training content, materials and methods to be of value for your work?

a) To a great extent

b) To some extent

c) To a very little extent

d) Not at all

9. If your answer is d) not at all, please elaborate it briefly.

10. To what extent field trips and good practice examples have provided you with valuable insights and/or concrete solutions that could possibly be applied in your own work?

a) To a great extent

b) To some extent

c) To a very little extent

d) Not at all

11. If your answer is d) not at all, please elaborate it briefly.

12. Has the KeepWarm training encouraged you / your company to further explore and develop internal projects to improve the energy efficiency of your system, sustainable energy production, the organization and/or economic performance of your systems?

a) Yes

b) No

13. If yes, can you provide an example of a concrete improvement strategy/ idea that was inspired or specified through the training?

14. To what extent did the training impact the setup, mentality and future orientation of your company?

a) To a great extent

b) To some extent

c) To a very little extent

d) Not at all

15. If your answer is d) not at all, please elaborate it briefly.

16. To what extend did the trainings impact your professional network?

a) To a great extent

b) To some extent

c) To a very little extent

d) Not at all

17. Based on your training experiences, would you like to point out additional fields/ topics to be valuable for modernization of DHS?

18. Based on your training experiences, would you like to resume with the training activities after the KeepWarm project?

a) Yes

b) No

19. Did you participate in the Inspire Event organized by KeepWarm?

a) Yes

b) No

20. Would you describe the participation as inspiring for future projects for you/ within your company?

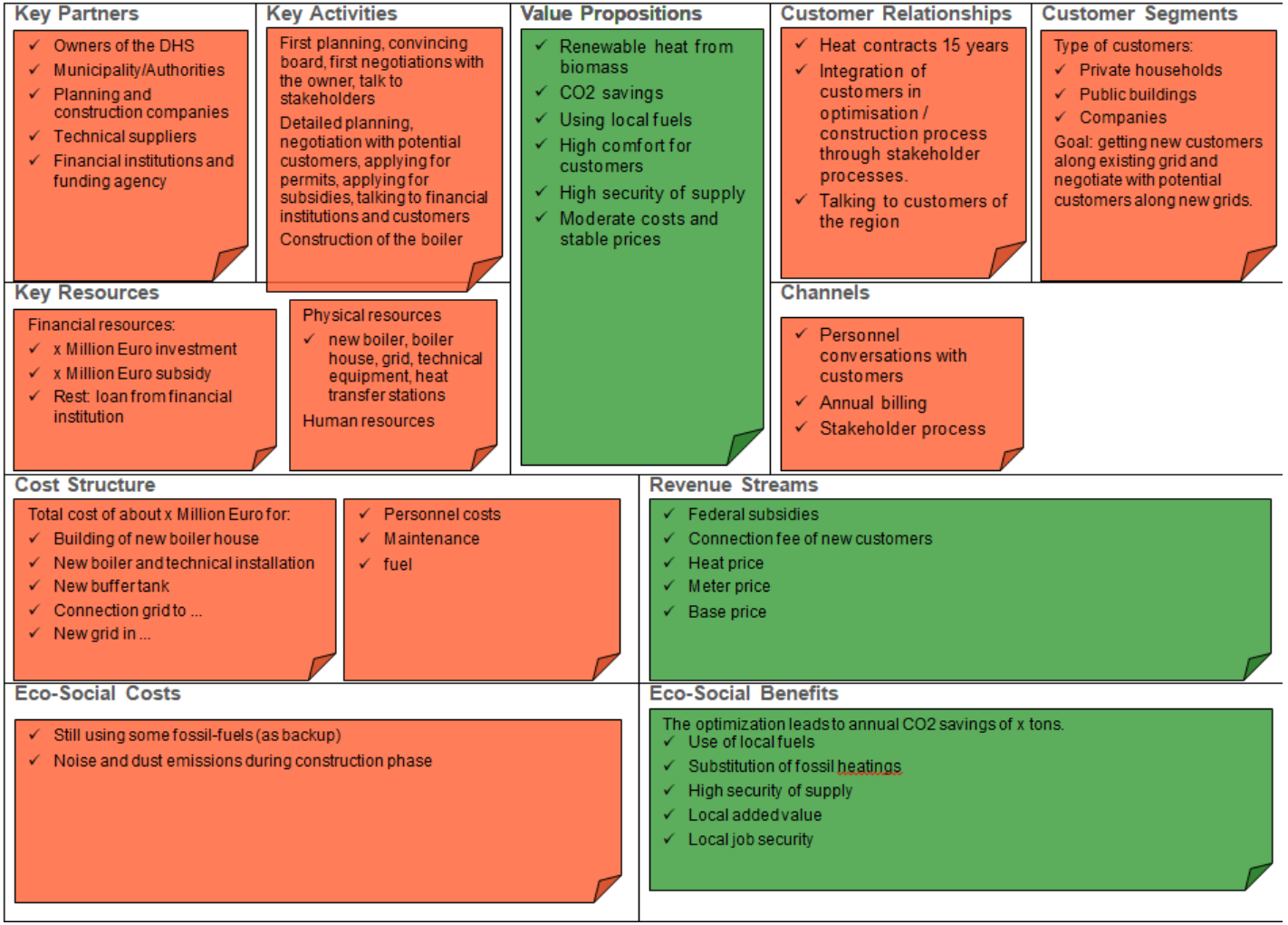
a) Yes, future ideas are growing.

b) Not yet, but we will use the network and the content of the events to develop new ideas

c) Not at all

Thank you very much for your time and effort!

Annex 5 - Business model canvas



Annex 6 – KeepWarm Impact Monitoring

The KeepWarm project has defined seven Indicators, which will contribute to the validation of the project's impact. The following section provides an overview of these indicators as well as a short explanation and the guidance on how the KeepWarm project will assess these impacts during and beyond the project lifetime.

Baseline for the expected improvements are the Feasibility Studies and the related Business Plans including funding. Since the individual DHS approaches will not be completely implemented by the end of the project, KeepWarm will multiply the expected outcome with 20 since this is the average lifetime of such an improvement/ installation.

Primary energy savings

This indicator has two sub-components:

1. improvements of the efficiency of the system in each target DHS
2. the combined primary energy savings triggered by the project in its pilot systems

In both cases, energy efficiency measures will occur in different areas: improvements to the plant or the grid, better organisational management or improved consumption by the end-consumer. The exact ratio of energy inputs versus heat consumption can only be measured by the end of the project and will depend on the measures to be taken (i.e. in the future business plans).

Needed Values for the calculation:

- Primary energy input baseline ($Energy_{base}$)
- Heat consumption baseline ($Consum_{base}$)
- Primary energy input after optimisation ($Energy_{final}$)
- Heat consumption after optimisation ($Consum_{final}$)

Calculate the total baseline and total final efficiency of the DHS:

$$efficiency_{base} = \frac{consum_{base}}{energy_{base}}$$

$$efficiency_{final} = \frac{consum_{final}}{energy_{final}}$$

Calculate a new adjusted baseline primary energy input, adjusted by the new final consumption and the baseline efficiency:

$$energy_{base-adjusted} = \frac{consum_{final}}{efficiency_{base}}$$

Subtract the final primary energy input from the new baseline primary energy input:

$$energy\ savings = energy_{base-adjusted} - energy_{final}$$

Example:

A DHS has a baseline primary energy input of 1800 GWh per year and 1260 GWh of heat have been delivered to customers*. During the project the DHS increased their number of customers. After the optimisation, the DHS has a final primary energy input of 2000 GWh and sells 1600 GWh of heat.*

$$efficiency_{base} = \frac{1260\ GWh}{1800\ GWh} = 70\ \%$$

$$efficiency_{final} = \frac{1600\ GWh}{2000\ GWh} = 80\ \%$$

$$energy_{base-adjusted} = \frac{1600\ GWh}{70\ \%} = 2285\ GWh$$

$$energy\ savings = 2285\ GWh - 2000\ GWh = 285\ GWh\ savings$$

Increased share of renewables

Based on the mentioned feasibility studies and business plans it is expected that the improvements/ new installations will allow some of the systems to switch heat generation at least partially to less CO_2 intensive options.

For this measure, KeepWarm uses the absolute increased amount of used RES from primary energy demand. However, a decreased primary consumption of RES through efficiency gains will be counted with 0.

Calculation:

$$RES\ increase = energy_{\ final\ from\ RES} - energy_{base\ from\ RES}$$

Example 1:

A DHS has a baseline primary energy input of 1800 GWh per year from gas. During the project, they install a biomass boiler. After the project the input is: 1500 GWh Gas and 300 GWh biomass.

$$RES\ increase\ = 300\ GWh - \ 0\ GWh\ = 300\ GWh\ increase$$

Increased RES share = 300GWh/1500GWh – 0GWh/1800GWh = + 20%

Example 2:

A DHS has a baseline primary energy input of 1800 GWh per year from gas and 200 GWh biomass. During the project, they install a bigger biomass boiler. After the project the input is: 1800 GWh Gas and 500 GWh biomass.

$$RES\ increase\ = 500\ GWh - \ 200\ GWh\ = 300\ GWh\ increase$$

Increased RES share = 500GWh/(1800+500)GWh – 200GWh/(1800+200)GWh = 21.7% - 10% = 11,7%

Example 3:

A DHS has a baseline primary energy input of 1800 GWh per year from biomass. During the project optimize and have efficiency gains. After the project, the input is 1500 GWh biomass.

$$RES\ increase\ = 1500\ GWh - \ 1800\ GWh\ = 0\ GWh\ increase$$

Increased RES share = 1500GWh/1500GWh – 1800GWh/1800GWh = 0%

Reduction of greenhouse gas emissions

GHG reduction is due to efficiency gains, switching from fossil fuels to RES or due to a switch from less intense fuels. This combination may lead to a 15-50% reduction of GHG emissions, which can be calculated from the expected primary energy savings and RES production that replaces heat generation using fossil fuels.

The conversion factors are based on sources according to IPCC[26].

Calculation:

There are two types of calculation of the greenhouse gas emissions depending of the change in primary energy demand:

The primary energy input stays constant or reduces because of efficiency gains or a switch to a less intense fuel: KeepWarm will subtract the final CO_2 emissions by the CO_2 emissions baseline.

$$CO2\ reduction\ = CO2\ emissions_{\ base} - \ CO2\ emissions_{final}$$

The primary energy input increases: KeepWarm will calculate adjusted baseline CO_2 emissions according to the new final primary energy input and calculate the CO_2 reduction

[26] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf

afterwards like it has been done in the first example 1.

$$CO2\ emissions_{\ base-adjusted} = energy_{\ final} \times Conversion\ factor_{base}$$

$$CO2\ reduction = CO2\ emissions_{\ base-adjusted} - CO2\ emissions_{final}$$

Example 1:

A DHS has a baseline primary energy input of 1800 GWh per year from gas. The baseline CO_2 emissions are about 95 500 tons. During the project, they install a biomass boiler. After the project the input is: 1500 GWh Gas and 300 GWh biomass. The final CO_2 emissions are about 79 500 tons.

$$CO2\ reduction = 95\ 500\ tons - 79\ 500\ tons = 16\ 000\ tons$$

Example 2:

A DHS has a baseline primary energy input of 1800 GWh per year from oil. The baseline CO_2 emissions are about 139 000 tons. During the project, they install a gas boiler and gain efficiency gains. After the project the input is: 1000 GWh Oil and 500 GWh gas. The final CO_2 emissions are about 104 000 tons.

$$CO2\ reduction = 139\ 000\ tons - 104\ 000\ tons = 35\ 000\ tons$$

Example 3:

A DHS has a baseline primary energy input of 1800 GWh per year from gas. The baseline CO_2 Emissions are about 95 500 tons. During the project, they install a biomass boiler and connect new customers. After the project the input is: 2000 GWh Gas and 300 GWh biomass. The final CO_2 emissions are about 106 200 tons.

$$CO2\ emissions_{\ base-adjusted} = 2300\ GWh_{final} \times 53.1_{conversion\ factor\ base\ (gas)} = 122\ 100\ tons$$

$$CO2\ reduction = 122\ 100\ tons - 106\ 200\ tons = 15\ 900\ tons$$