KeepWarm
Renewing district heating

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

Development of Multi-level policy Plans – Action plans for retrofitting of District Heating Systems

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

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List of Abbreviations

AP	Action Plan
AT	Austria
CEE	Central and Eastern Europe
CF	Cohesion Fund
CoM	Covenant of Mayors for Climate and Energy
CHP	Cogeneration of Heat and Power
CRO	Croatia
CZ	Czech Republic
DH	District Heating
DHC	District Heating and Cooling
DHS	District Heating System
EC	European Commission
EE	Energy Efficiency
EED	Energy Efficiency Directive
EnMS	Energy Management System
EU	European Union
GHG	Greenhouse Gas
LV	Latvia
NECP	National Energy Climate Plan
NEEAP	National Energy Efficiency Action Plan
NG	natural gas
NGO	Non-Governmental Organisation
NREAP	National Renewable Energy Action Plan
RES	Renewable Energy Source(s)
SEAP	Sustainable Energy Action Plan
SECAP	Sustainable Energy and Climate Action Plan
SI	Slovenia
SRB	Serbia
UKR	Ukraine
WP	Work Package

Summary of the project

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

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

Project objectives

KeepWarm’s specific objectives are:

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

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

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

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

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

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

KeepWarm consortium partners

LOGO	PARTNER NAME	SHORT	COUNTRY
	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 Fortwirtschaft in 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
	Teplarenske Sdruzeni Ceske Republiky	TSCR	Czech Republic
	Biedriba Zemgales Regionala Energetikas Agentura	ZREA	Latvia
	Zavod Energetska agencija za Savinjsko, Šaleško in Koroško	KSSENA	Slovenia
	LLC KT-Energy Consulting	KT-Energy	Ukraine
	Institut za nuklearne nauke Vinča	VINCA	Serbia

Content

Executive summary

This document outlines the situation in the district heating (DH) sector in seven Central and Eastern European countries, including milestones and recommendations for actions required to enhance and promote processes of retrofitting, improving and developing district heating systems (DHS).

In order to decarbonise energy system in the shortest possible time (at least until 2050) it is essential to implement the practicable and available options now. It is important that the transition in the heating sector to energy efficiency and the use of renewable energy sources (RES) is systematically defined, so that the widest possible range of stakeholders is involved in a harmonised way. The main objective of this document is to support further uptake of district heating in Europe, in particular by making recommendations to national governments and local authorities on how to approach DHS retrofitting. The submitted plans aim to contribute to the improvement of a legal framework for systematic decarbonisation of DH 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 to 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 countries examined here are largely confronted with inefficient heating infrastructures and an inefficient building stock; the vast majority of heating systems are designed for high temperatures. Both the renovation, consolidation, efficiency improvement and expansion of existing DH systems and the construction of new ones must be addressed with appropriate measures. Most of these countries need to upgrade DH systems from first and second generation to third or even fourth generation systems. This can be implemented by installing new production units and an efficient heat distribution infrastructure, using renewables, improved heat metering and control and consumption-based billing, which has not yet been implemented in some of the countries studied. An important prerequisite for such an energy transition is also a highly efficient building stock that can use heat at lower temperature ranges.

The energy transition processes depend on the context of the country and the current situation. In general, countries studied have a fairly high share of district heating with much potential for improvement and expansion, that in connection with climate-neutral heat is necessary to quickly advance the heat transition, especially in densely populated areas. The provided national action plans for the renovation of DH systems require significant actions in the period from 2020 to 2030. It is important to create conditions under which DH sector can successfully contribute to energy system transformation and a more energy-efficient heat supply.

These national action plans consider the activation of national and local governments and communities (municipalities) as well as other stakeholders. Adequate regulation that enables local authorities to act in an appropriate, strategically defined direction should be ensured at national level, while local governments are responsible for planning, stakeholder coordination and implementation of heating infrastructure. The authorities

must introduce financial and other regulatory measures (e.g. in relation to price arrangements, subsidies, etc.) to ensure that DH is not disadvantaged compared to other means of heat supply.

Transparency in the price structure and level of prices is crucial, as without such transparency consumers may lose confidence in the district energy supply, which can have a negative impact with disconnections, rising prices, lack of satisfaction and a gradual deterioration of DHS.

This document has been developed by combining seven national action plans for DHS retrofitting, which have been developed in national contexts in consultation with the KeepWarm project partners and other interested stakeholders in all these countries. Specific targets and measures have been identified, most of which are missing in the existing national strategies and implementation programmes. The recommendations are divided into the following four groups: (1) Visions, strategies and plans for heating (and cooling), (2) Supporting measures and technical guidance, (3) Planning and regulation, and (4) Financing. The main conclusions that were identified during the preparation of the national Action Plans for the modernisation of the DHS within the KeepWarm project are presented in the following country-specific boxes.

Austria

Since the 1970s, district heating (DH) has become increasingly important in Austria. Since then, the use of DH has been steadily increasing. At present, 15% of the total heat demand is covered by DH. In addition, 26% of households use DH as their primary heating system. There are more than 2.400 DH systems, many of them not only in the cities but also in rural areas. The dominant fuel is biomass with a share of almost 50%. Furthermore, natural gas is a main fuel with a share of about 36%. The share of renewable energy sources (RES) has increased significantly over the last two decades. However, there is still a long way to go to achieve the government's goal of making DHS 100% renewable by 2040.

The main challenges for the improvement and decarbonisation of the DH systems are a decrease in heat demand due to energy improvements of the connected buildings, still too high temperatures in the grid, high investment costs for RES technologies, the lack of a national heating strategy and a lack of DH specific training, especially in small and medium sized utilities. Despite these mentioned challenges, the share of DH supply in Austria is increasing due to a positive public opinion about this sector.

However, in order to achieve the national targets, some paradigms need to be changed to fully exploit the potential of DH as a key player in the decarbonisation of the heating sector. In order to improve the targeted approach to exploit this potential, the country-specific Action Plan has formulated 20 key recommendations in the areas of strategic policy-making, technical guidance, planning and regulation, and financing, which highlight the need for long-term national and regional heating and cooling strategies combined with efficient heat mapping, emphasize the use of renewable heat (with a focus on biomass, green gasses and waste heat), the implementation of the special training programme for capacity building at national level, and the need for long-term stable and predictable funding for DHS retrofitting and increasing the share of renewable heat as a top priority.

Croatia

DH sector in the Republic of Croatia is considered to be a very important part of heating sector, especially in urban areas since it has a steady share of 15% in total heat consumption and provides heat energy to 11% of households. The most dominant fuel is natural gas where CHP plant take a main role in heat generation followed by very low share of all other fuels (i.e. renewable energy sources 0.4%). Main challenges in decarbonisation and improvement of current old and inefficient DHS networks are a constant decrease in heat demand due to energy renovations of connected buildings, lack of financial resources, high investment costs of RES technologies, unclear ownership structure between local authority units and DH companies, as well as lack of proper energy planning and legal framework which would support a proper development of the sector. Mentioned challenges and existing barriers such as current legislation resulted in very unfavourable position of DH sector in comparison to other heating options which has to be changed in order to transform the sector in a key player in the decarbonisation of urban areas, especially since the current situation do not contribute to the positive general public opinion about the sector.

Therefore, key recommendations given in this Action plan aim for systematic promotion of DH sector in terms of strategies and plans, technical guidance, planning and regulation, as well as financing. In total, 29 recommendations have been given, highlighting the necessity for setting clear long-term goals on local/regional and national level, conducting proper energy planning, utilising RES (focusing on solar and geothermal energy), increasing the energy efficiency in old heat distribution networks, as well as providing necessary funds for sustainable retrofits and increasing the attractiveness of DH sector.

Czech Republic

The Action Plan for the retrofitting of the DHS systems in the Czech Republic is a key document that defines problematic elements in the current situation of the heating market and proposes appropriate solutions that may contribute to its sustainability and to the improvement of the environment in the Czech Republic.

DHS operators generally face barriers to decarbonisation and modernisation due to heat price regulation, which reduces flexibility for operators and favours unregulated entities, thereby increasing customer interest in decoupling from DHS. DH has no longer a monopoly on the heating market, competition allows customers to use any available heating method, so that price regulation becomes less important. Another problem is that strategic documents only verbally support the development of the heating industry, the real economic environment is going in exactly the opposite direction and there is no real protection for DHS at legislative level. While under the Air Protection Act large sources have to buy GHG emission allowances and pay for the emission of classic pollutants, local production is not obliged to do so. One solution to this situation would be 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.

A major weakness of the DHS is the high proportion of fixed costs of heat production. In the vast majority of DH systems, there is a long-term downward trend in heat demand due to energy saving measures and investments in improving the thermal properties of buildings. If a part of customers switches to individual heating, the fixed costs are redistributed among the remaining customers and the price of heat rises, which leads to shut down and causes the system to fall

apart uncontrollably. The disintegration of the DH system would inevitably also lead to a reduction or cessation of cogeneration, reducing the capacity of ancillary services to electricity grids necessary for grid balancing. It is therefore necessary for the state to support the sustainability of DHS and cogeneration systems.

Latvia

District heating is the most widespread form of heating, supplying heat to about 80% of households, most public buildings and industrial facilities. The heat distribution service is provided by 72 licensed steam transmission and distribution companies. The total length of the heating networks is about 2000 km (about one third in the capital city of Riga), only 60 km of the network has been retrofitted by 2020. In 2018, thermal energy was generated in 633 boiler houses with an installed heat capacity of 2360 MW and 175 cogeneration (CHP) plants with an installed electrical capacity of 1270 MW - a total of 6998 GWh of thermal energy was delivered to consumers. In 2018, 61% of the thermal energy was generated from wood, while 38% of the thermal energy was obtained from natural gas (NG), which is the main fuel used in CHP plants. Most of the DHS was built more than 25 years ago and some networks are facing high losses. DH services such as heat generation, heat transmission and heat distribution and trading are regulated activities. The integration of solar thermal energy and surplus or waste heat from industrial or service processes is still at an early stage of development in Latvia, but individual pilot projects are already in operation (e.g. solar technologies in the city of Salaspils).

On the way to modernising the DHS there are many challenges that need to be overcome. For many DHS, increasing the energy efficiency of old DH systems and their modernisation remains the biggest challenge. An important task is the increased use of RES, in particular emission-free technologies (solar collectors, heat pumps) and modern technologies (such as heat storage, use of waste heat). In parallel, DHS should consider how to solve the decline in consumer demand due to a variety of factors (demographics, improved energy efficiency of buildings - end users) and how to attract new consumers, how to increase the social attractiveness of DHS solutions (currently - low price of NG does not allow to attract new consumers).

The main prerequisites for successful development of DHS are 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.

In NECP 2030 Latvia aims to increase the share of RES in heating (and cooling) by modernising the installed capacity of biomass plants/boilers, by increasing the capacity of installed heat (cold) pumps and by increasing the use of solar energy in heat generation. This (Latvian) Action Plan summarizes the main priority actions for the modernisation of DHS in Latvia according to NECP 2030 in terms of DH sector policy and strategic planning, legislation, supporting expertise and financing.

Serbia

The Serbian DH sector has developed an infrastructure supplying to 48% of urban households, with the possibility of expansion into densely populated areas and with plenty of room for

improvement. The national strategy documents recognize that heat production has the highest potential for increasing energy efficiency (EE) compared to all other energy activities. Given the high level of air pollution last year, when individual heating was identified as one of the causes, the connection of households to DHS was recommended by the authorities as one of the key solutions to avoid a similar situation in the future, this is the right time for a valid Action Plan (AP) to modernize DHS at all levels.

The main challenges for decarbonisation and improvement of DHS networks are the unfavourable position of the DH sector compared to other individual heating options due to inappropriate energy price parity (especially the relationship between electricity and fuel prices), lack of financial resources, high investment costs of RES technologies, a complex ownership structure between local authority units and DH companies, and the lack of adequate energy planning and a legal framework that would support appropriate development of the sector. AP provides guidance on how to address these challenges by improving the legal framework for the modernisation of the DH sector, introducing incentives for RES heat production and waste heat recovery and increasing the EE of DH systems (by renovating and replacing critical parts of the heat distribution, control and operation systems, and by providing ongoing and continuous training for DHS staff). At the same time, the measures taken must maintain and ensure profitability despite the reduction in the heat demand of energy-efficient buildings and in competition with other individual heating solutions.

Therefore, the main recommendations of in this (Serbian) Action Plan aim at a systematic promotion of the DH sector in terms of strategies and plans, technical guidance, planning and regulation and financing. A total of 23 recommendations were made, highlighting 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 EE of buildings and heat distribution systems, to introduce innovative technologies and modern systems for process monitoring and optimisation, to provide the necessary funds for sustainable retrofitting and to increase the attractiveness of the DH sector.

Slovenia

District heating (DH) accounts for 13% of the total heat supply in Slovenia and is therefore one of the important pillars for heat supply in general, but even much more important in a number of densely populated urban areas. Almost 87% of the total heat produced for the supply of DHS was generated in CHP units, mainly fired by fossil fuels (hard coal/lignite, natural gas). Only 17% of the primary energy products or sources for heat production in DHS come from renewable energy sources. Excess heat, geothermal energy and large heat pumps are clearly underused and contribute less than 2% to the total heat supply in DHS. However, in NECP, heating networks are considered an important element of the future energy system, which will play a key role in the decarbonisation of the heating sector especially by 4th generation DH systems.

The following drivers to an efficient and sustainable DHC service are considered most relevant: the coherent national policy and regulatory environment, direct or indirect subsidies and relevant energy taxation policies, integrative and coherent heat planning at municipal / urban level, alignment of interests through cooperation among key stakeholders, sound prices and the price competitiveness of DH supply service and a flexible heat generation that allows better cost-efficiencies.

More than 20 specific actions regarding DHS retrofitting have been recommended, wherein the

definition of clear vision, strategic framework and objectives for H&C sector has been recognised as the number one priority. Strategic and co-ordinated governance and financial structures are prerequisites to drive long-term actions across a number of national and local DH development programmes. The support to local authorities for developing a strategic approach to DH, to use relevant tools (e.g. for heat mapping) and to help with the procurement of funds is inevitable. The capacity-building programmes and awareness raising campaigns are needed to empower stakeholders to improve the positive role of DH in the processes of energy transition and climate policy-making. 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. An incentive framework that supports investments in carbon-neutral heat and targeted funding for the sustainable retrofitting of DH systems are required, while the development of new DH business models may be a supplement to these measures. The proper definition of taxation on fossil fuels for heating and interaction with GHG emissions trading should increase the attractiveness of efficient heating network solutions and stimulate more investments in renewable heat generation.

Ukraine

The DH sector is still one of the most important sources of heat supply in Ukraine, especially in densely populated urban areas, supplying about 40% of the population. Therefore, 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. The strategy should reflect existing policy priorities in the field of energy, climate and environment and be coordinated with the building renovation strategy and policy. The mapping of DH systems, the assessment of RES and the impacts and risks of climate change at local level should support the implementation of the strategy.

Natural gas remains the dominant fuel for the DH sector, while the use of biomass for heating purposes is increasing, but only accounts for about 8% of total energy consumption. To promote renewables in DH, additional support measures are needed, including 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.

Ongoing DH energy efficiency projects are aimed at balancing the currently reduced heat loads with existing heat generation and transport facilities, further centralising DH and modernising key technological equipment. The scale of investment in these activities throughout the country is to be significantly increased to ensure the medium and long-term reliability of the heat supply. 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.

Introduction

Why DH is important?

District heating (DH) is key to the vision for the future of heat in Europe, helping countries to use energy more efficiently, increase the opportunities for renewable and low-carbon heating and enable transition to smart energy systems. The decarbonisation of heating and cooling sectors is essential to achieve the ambitious climate and energy targets of the European Union. Renewable energy sources (RES) and energy efficiency (EE) are at the core of the EU priorities. Action plans on EE, RES and greenhouse gas (GHG) mitigation shall provide structured measures and instruments in support of energy and climate policies thus achieving targets at national and EU levels. These measures are covering technological, regulatory, financial and spatial planning/mapping aspects of DH sector, but the majority of analysed action plans only partially cover the true multifaceted nature of its development.

Modern solutions in district energy are increasingly climate resilient and low-carbon, allowing vast reductions of primary energy consumption for heating (and cooling) and the utilisation of excess and low-grade heat (e.g. waste heat from industry, power stations, waste incinerators, sewage treatment, data centres, etc.) and cold (cooling from water bodies). Energy losses can be treated as an environmental pollutant so it is even more important to increase the efficiency of heat production facilities and heat distribution systems. A number of important benefits provided by DH systems (e.g. storage of large amounts of energy at low cost, the integration and balancing of large shares of variable renewable power on electricity grids through thermal storage, cogeneration and heat pumps) make district energy a key measure for cities, regions and countries that aim to achieve 100% renewable energy or carbon neutral targets. DH can utilise energy sources that are difficult to use for individual buildings, such as unrefined biomass fuels, heat from waste incineration, heat from electricity generation in CHP plants and excess heat from industry or other activities. Therefore, district-heating expansion may be beneficial for economy and environment, besides it offers high level of comfort and enables collective green transition. In DH, heat supply for a large number of residents can be changed at once. Furthermore, DH has a number of non-economic advantages, which can mean that it is chosen over individual heating for an area, if the prices are similar.

Compared with competitive technologies, a new DH system is highly competitive with respect to heating price when compared to individual heating solutions, when DHS is established and there is sufficient energy demand density in a neighbourhood. Available technologies and costs will depend on local conditions, including the availability of RES such as sun, geothermal, and biomass. Analysis[1] show that the annual cost of DH is approx. 19% lower than an individual natural gas boiler and approximately 30% cheaper than an individual biomass boiler and an individual air-to-water heat pump.

District heating, particularly based on renewables, strongly depends on local conditions. Local authorities are uniquely positioned to advance district energy systems through their

[1] The competitiveness of district heating compared to individual heating, Green Energy Association, May 2018

roles as planners and regulators, facilitators of finance, role models and advocates, large consumers of energy, and providers of infrastructure and services. A strong political will, adequate planning, extensive training, high awareness levels, and a balanced mix of incentives and obligations are prerequisites to decarbonise heating sector. For this purpose, it is important to foster systemic changes, including

(1) a shift from gas distribution networks towards self-supply and local thermal networks, both based on the systematic use of locally available RES. DH networks should be the preferred option particularly in densely populated areas, decentralised solutions should be favoured where they are more cost-efficient (mainly in low-density areas) and sustainable;

(2) the optimisation of energy demand and supply, through energy storage (e.g. in case of energy surplus production from RES) and smart energy management systems (EnMS) at production, distribution, and consumption levels,

(3) a strong integration with the power sector enabled by the persistent diffusion of coupling points (e.g. heat pumps and thermal storage) together with the wide uptake of smart EnMS.

In order to use local sources, municipalities, energy utilities, and the industry must collaborate across sectors. Energy systems need to be more and more operated in such a way that actions are primarily taken at local and regional levels (at the most immediate level). Only actions that cannot be properly addressed locally/regionally are to be handled at a wider governmental level. While this is a macro-trend for the whole energy sector, the inherently local nature of heating and cooling supply means cities must play a leading role in developing and implementing strategies for their decarbonisation.

There are other important aspects of district energy, e.g. its strong **impact on local economy** by generation of jobs, from planning and construction to operation, and (besides competitive heating price, compared to individual heating) further cost savings which come from mitigating air pollution and the associated government expenses for health and productivity impacts. Due to economies of scale, far more effective pollution prevention (reduction of particle emissions, SOx and NOx) and control measures can be implemented in central DH production facilities than in individual boilers.

Technical and non-technical aspects

Many networks operate at high temperatures and are therefore not compatible with most of renewable heat sources, which can only be operated via low-temperature networks. Many networks are poorly insulated, resulting in significant heat losses. The high costs of insulation and retrofitting networks must be compensated with lower losses and opportunities to benefit from integrating RES.

The wide variety of renewables, including solar thermal, geothermal, bioenergy, ambient (water/air) energy sources and excess heat from industrial or commercial processes (e.g. data centres), complemented with electricity from RES, will enable planners, developers and operators to choose the most competitive and sustainable solutions in all European

regions. These technologies should be complementary, as diverse sources and components are needed to create a cost-effective, robust, and secure energy system. Thermal storage will play a particular role, allowing the optimal utilisation of a combination of different RES over a day or even a year, thereby significantly alleviating recurring problems associated with the intermittency of variable renewables. Smart EnMS, which enable the optimisation of production and operation, is expected to be widely adopted, both at centralised and decentralised levels.

There are a number of non-technical areas that are important to achieve the goal of sustainable and 100% renewable heating and cooling, such as (1) establishing consistent energy strategies with the aim of decarbonising the heating sector; (2) removing regulatory and market barriers, and simplifying procedures; (3) developing innovative financial models for large, medium, and small projects, all of which are quite capital intensive; (4) training technicians/experts and decision-makers from regional and local authorities to provide the technical background necessary to support sustainable projects, etc.[2]

Opportunities and barriers

The scale of the opportunity is potentially enormous. The economic opportunities of accelerating the uptake of heat networks include jobs in the construction sector to build the infrastructure and in energy supply services. DH also offers the opportunity to reduce energy costs for businesses and households, particularly in areas with high heat density and by using low-cost energy sources (e.g. excess heat).

Opportunities for efficient heat distribution include DH and thermal storage, and there is also significant potential to combine this with the recovery of excess heat from power generation, industrial processes and commercial activities. With the increasing need for decarbonisation of the heating sector by 2050, important questions also arise about the future of the gas grid and the related role of DH.

Great opportunities for improving and expanding heating networks require the involvement of all stakeholders, the creation of public-private partnerships, new ways of supplying heat, and, above all, long-term strategic planning to make the necessary public and private investments in infrastructure. A common view of policy-makers, citizens and stakeholders along the entire value chain on the main goals and pillars is needed to optimise efforts and resources.

Action (plan) is needed

Although many of the decisions and measures relating to district energy can and must be taken at local level, national (government) policies and action plans are also crucial. National policies enable the transfer of powers to the cities, support local coordination and performance, take into account the benefits of district energy in national building standards and certificates, and create a stable basis for the development of district energy.

In order to remove the obstacles and take advantage of the opportunities offered by the

[2] https://www.rhc-platform.org/content/uploads/2019/10/RHC-VISION-2050-WEB.pdf

DH, a concrete Action plan needs to be drawn up, setting out the tangible steps that governments in partnership with the wider public sector, business, industry, community representatives and other stakeholders, need to take to increase confidence in the public sector to drive projects forward, invest in the private sector and motive consumers to connect.

The role of key participants and stakeholders

The development of a sustainable DH systems depends on the cooperation of many stakeholders. Their impact in the process of DHS modernisation can be twofold - positive and/or negative. Differing expectations and values of the various stakeholders lead to fragmentation of the value chain, which increases costs and overall risk, the latter particularly due to the many complicated agreements that need to be made between them. The main stakeholder groups per participating country and their key roles are listed in *Annex 1*. Although these roles are not exhaustive, but mainly indicative, it can be concluded that proper and adequate involvement of stakeholders (especially key actors who make the decision to connect to a DHS, such as large building owners, developers and municipalities) and gradual, open communication between them is a prerequisite for success in DH.

Principles of Action plan creation and supporting processes within the KeepWarm project

There is an obvious need for structured plans to improve the energy efficiency of DHS and to phase out fossil fuel-based heating systems. This Action Plan is the document that provides an overview of actions needed to make district heating solutions more sustainable. It **defines concrete measures** that will support the transition and implementation of long-term environmental and energy-related strategies. This document is to be considered as a living document, particularly as ongoing actions provide results and experience that can be useful for future revisions of the plan (on a regular basis if possible).

This document is intended **to serve as a list of solutions/actions/activities** that will support the development of other (local or regional) action plans for heating and cooling. The data and proposed actions are intended for discussion with stakeholders at country expert meetings, initially in the framework of this project but also taken into account in the development of action plans for heating and cooling at different levels.

To encourage the implementation of the activities introduced by the action plans, it is essential to **ensure a diverse set of effective support instruments and tools**. The country review of the regulatory framework and barriers for retrofitting of DHS (provided by the KeepWarm project report D5.1[3]) gives an overview of financial and other support instruments that could improve the operation of DHS and/or its retrofitting and shows whether a specific support instrument is available in each country, together with comments on some existing obstacles or problems, links to information sources, etc.

[3] https://keepwarmeurope.eu/fileadmin/user_upload/Resources/Deliverables/GA_784966_D5_1_Regulatory_Framework.pdf

The preparation of this document has also been supported by expert meetings in the participating countries, which should involve as many relevant stakeholders as possible, including key stakeholders, such as DH companies and authorities at national and local level. These are considered to be among the most decisive when it comes to decision-making on policies and supporting instruments regarding strategic planning, development and implementation of pilot (demonstration) projects. The majority of DHS operators expect that the national DHC strategy and improved regulation in this regard will give DH the leading role in providing sustainable heat supply in urban, densely populated areas. In particular, local (municipal) authorities play a key role in facilitating the development of DHS by integrating its installation, maintenance needs and possible expansion into spatial development plans, while at the same time facilitating communication between the parties (stakeholders) involved. Care should be taken to strengthen relevant skills and increase knowledge among these decision-makers.

The national action plans being developed in the framework of this project are important to maximise the benefits from the partnership twinning actions of the project and discuss them at national Inspire events.

Basic data on district heating supply per countries

Austria

Since the 1970s DH is getting more and more important. The main expansion of DH since the 1980s has been related to biomass with the major uptake since 2000. In the period 2000 - 2015, the heat production from DHS increased by nearly 75%. Currently the heat production is 23.3 TWh (Figure AT1), which covers 15% of Austria's total heat demand. More than one half (54%) of DHS generated heat is based on renewables.

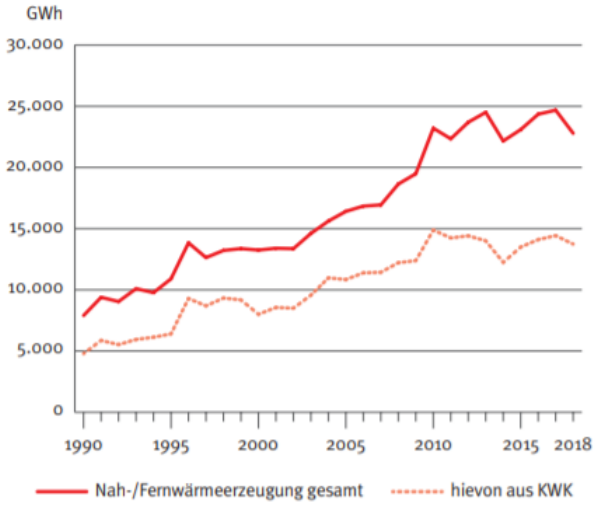

Figure AT1: Development of heat produced by DHS in Austria © FGW

The vast majority (77%) of newly built residential buildings constructed after year 2000 are connected to DH, which is not popular in cities only but also in smaller towns and villages. In total 26% of all apartments in Austria are currently heated with district heating and the trend is increasing. These are more than one million households in Austria (Figure AT2).

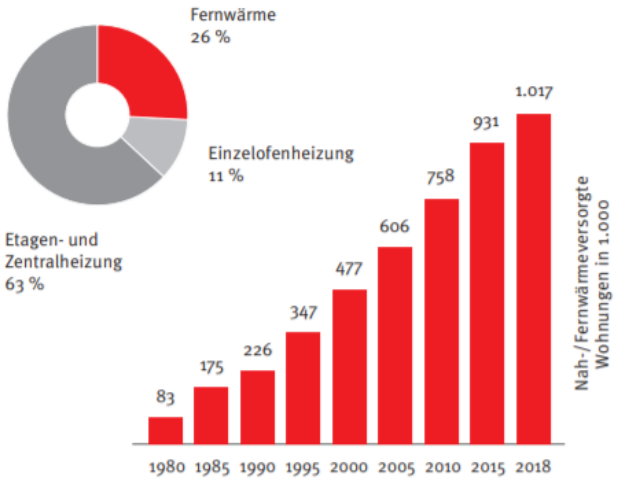

Figure AT2: Development of households heating with DHS in Austria © FGW

There are about 2.400 DHSs in Austria, 600 out of them are in Styria (Figure AT3).

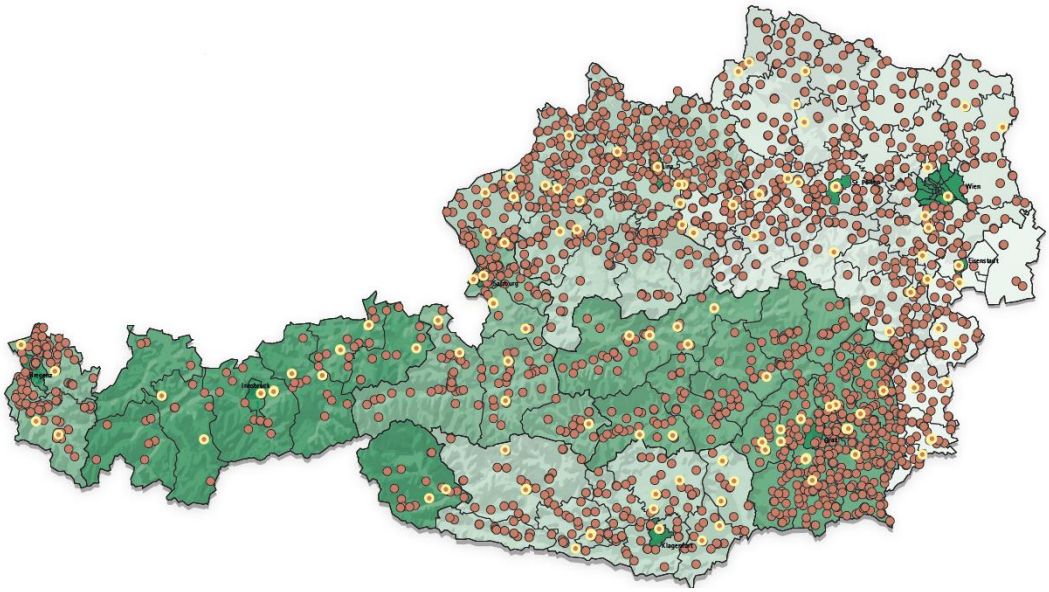

Figure AT3: Map of DHS and CHP in Austria. Yellow points are CHPs. © Austrian Biomass Association

Most DHSs are small size and fired with biomass. The fossil based (gas, oil, coal) DHSs can only be found in some larger cities, but in total they cover nearly one half of the total heat demand. There are also some geothermal heat plants and some waste incineration plants. Waste heat from industries has just a very little role so far. With 47% biomass is the most important fuel of DHS in Austria, followed by natural gas (36%), waste incineration (7%), oil (5%) and coal (5%) (Figure AT4).

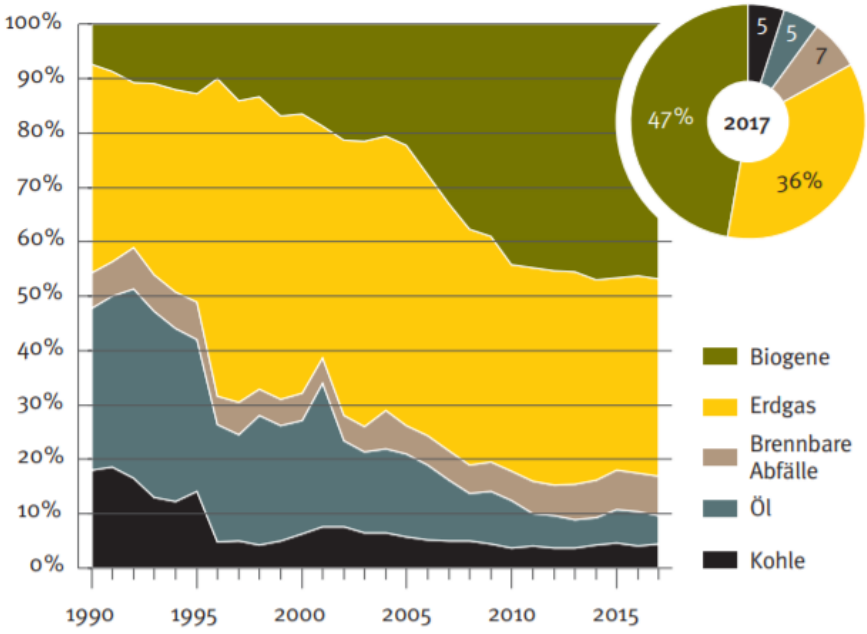

Figure AT4: Structure of the primary energy products for production of heat in CHP and boiler rooms in Austria © FGW

The heat supply companies operate a grid of approx. 5,500 km in length (2018). It is expected that the companies will continue to invest in further expansion of grid and the spatial consolidation of supply. With this length, Austria is ranked the fifth longest grid in Europe, but in terms of grid density, it is ranked even the third with 0.6 km grid length per 1000 inhabitants.

In Austria DHSs are mainly owned and operated by private utilities, but decisions are done in close cooperation with the municipalities. Important players on DH market are also associations, like FGW, the Association of gas and district heating utilities. Furthermore, there are regional associations supporting mainly biomass DHS in rural areas. These regional associations are united in the Austrian Biomass Association and represent about 2,300 biomass DHSs. An important player in the development of new projects and the optimisation of existing ones is KPC – Austrians subsidy agency for district heating.

Croatia

Croatia has been developing DHSs since 1960s when a first heat distribution system was installed in the city of Zagreb. Since then, DHS has been playing an important role in the Croatian heating sector. There are around 110 DHSs of different size and type with the total installed capacity of 1 800 MW. Latest reports show that around 2 TWh were produced and distributed to end consumers. Total length of distribution systems is around 440 km which delivers heat to around 156 000 customers on a yearly basis. Typically, a DHS supplies heat from September to May, while domestic hot water and steam are delivered throughout the whole year.

Regarding statistical data, following table describe the trends since 2013. In 2018, public cogeneration plants recorded an increase of heat production (total production in 2018: 10.968 PJ) for 2.9% in comparison to 2017, as well as between 2013 and 2018 for 3.8%. Meanwhile, public heating plants (which are mostly part of DHS) recorded a downward trend (total production in 2018: 1.730 PJ) – a 2.3% decrease in comparison to 2017, and 8% decrease between 2013 and 2018. Regarding total heat production (including all heat production units), although a decrease in comparison to 2017 has been recorded, a change has remained positive in period between 2013 and 2018, -3.5% and 1.1% respectively.

As mentioned before, total length of heat distribution network is around 440 km which delivers heat from production units. Due to old and inefficient distribution network, the whole system achieves distribution losses which has been identified as a priority problem in Croatian energy sector. In 2018, distribution losses were measured at 1.69 PJ which is 10% higher than in 2017. In the whole observed period, distribution losses increased for 4.4%. When it comes to heat consumption, total value decreased in 2018 for 4.3% (24.93 PJ) in comparison to 2017 (27.58 PJ) due to increase of energy efficiency in industry, residential and service sectors. The overview of balance of heat can be seen in the Table HR1.

In 2018, DHSs had a share of 15% in total heat consumption in Croatia, while most of heat was delivered to household sector (60%). Around 11% of households are connected to around 110 DHSs. Besides of the household sector, DHSs deliver heat to industry (22%) and service sector (18%). These numbers remained steady with minor changes in last

several years, but it is expected that share for industry should be increased in the future.

Table HR1: Balance of heat in Croatian energy sector (Source: Energy in Croatia, 2018).

PJ	2013	2014	2015	2016	2017	2018
Production	25.256	23.289	25.347	25.7	27.583	26.615
Heat pumps	0.628	0.519	0.623	0.66	0.667	0.631
Public cogeneration plants	9.117	8.014	8.833	9.095	10.658	10.968
Public heating plants	2.621	2.113	2.273	2.316	1.772	1.73
Industrial cogeneration plants	10.077	10.003	9.611	9.492	10.159	8.888
Industrial heating plants	2.813	2.64	4.007	4.137	4.326	4.397
Distribution losses	1.364	1.415	1.588	1.478	1.534	1.689
Total consumption	23.892	21.874	23.759	24.213	26.049	24.926
Total energy sector	5.327	5.048	6.94	6.019	6.97	7.157
Final consumption	18.566	16.826	16.819	18.195	19.079	17.77
Industry	10.339	9.975	9.621	10.768	11.743	10.829
Households	6.412	5.307	5.63	5.651	5.567	5.302
Services	1.629	1.322	1.392	1.581	1.534	1.392
Agriculture	0.186	0.222	0.175	0.195	0.235	0.247

Regarding fuel used in DHS sector, the most dominant fuel is natural gas which is used in the cogeneration plants in DHS Zagreb and in all other DHSs except in city of Ogulin and Topusko. Apart from natural gas which takes around 85.7%, fuel oil and extra light fuel oil contributes with small shares, 6.3% and 7.6% respectively. There is no significant production from renewable energy sources (0.4%) which is one of the main focuses in development of DHS market in Croatia.

Each part of heating sector, especially in DHSs are regulated by Croatian Energy Regulatory Agency (Croatian: HERA) which controls and regulate necessary activities such as production, distribution and supply and sell of heating energy. A company must obtain relevant permits from HERA in order to participate in the DHS market. In 2018, there was 25 valid permits for heat production, 9 valid permits for heat distribution, 21 valid permits for heat supply and 36 valid permits for participating in heat market (buying/selling). According to HERA, 7 energy company have obtained all mentioned permits, while other companies participate with several of those activities.

In total, 11 companies were active in 16 cities and supplied heat to customers. The most dominant energy company in DHS sector is HEP Toplinarstvo which in 2018 had 91.5% share of total delivered heat, while the remaining share is divided among 10 other DH companies (Figure HR1). Also, HEP Toplinarstvo owns around 70% of total installed production units, Gradska toplana in Karlovac (17%), Tehnostan (7%) while other companies own less than 1%. An overview in terms of total delivered heat can be seen in Figure HR1.

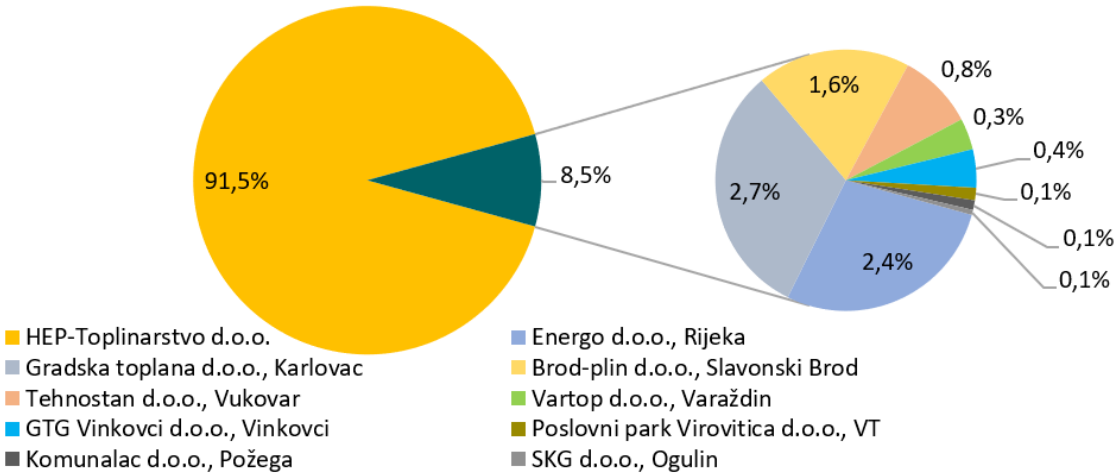

Figure HR1: Share of total delivered heat in DHS sector

Production of heat

Each producer of heat energy has to obtain a permit for performing activity of heat production, especially if installed capacity is more than 2 MW. Also, if energy company produces heat via cogeneration plants, uses waste energy or renewable energy sources, these activities have to be in line with relevant regulations which define environmental protection and waste management. In those cases, company can acquire the status of protected producer of energy.

Distribution of heat

Each local self-governmental unit which own a heat distribution network has to enable permanent supply of heat on their territory. These activities are agreed upon by signing contracts between distributors and local self-governmental unit (concession for distribution of heat and revitalisation/expansion). A concession is given to energy company on a period of at least 20 years (maximum 30 years). An energy company has to pay a financial fee agreed in the concession to a local self-governmental unit and ensure proper functionality of a distribution network in line with sustainable development and transparency acts. A point between the producer of heat and the distributor is a calculated measurement point.

Heat supply

A company which deals with the supply of heat can be registered for this activity if it purchases heating energy from a valid producer of heat and if it has an agreement with a valid distributor of heat which distributes heat in a certain DHS. This enables supplying companies to sell heat to end customers. Suppliers of heat can obtain permits as well if they purchase amount of energy input for heat production in closed heating system (small DHS) and if they sell heat energy to end customers.

The use of excess or waste heat from industrial or service processes in Croatia is in premature phase, while one of the likely most attractive heat sources are geothermal, particularly in regions where geological conditions enable successful and safe exploitation of heat from the ground and solar energy which is already on the agenda in HEP

Toplinarstvo and their pilot cities in KeepWarm project – Samobor, Zaprešić and the city of Velika Gorica. Currently one DHS with geothermal energy operates in Croatia, while the city of Zagreb has been investigating its geothermal potential for usage in DHS. Regarding biomass, there is a municipality owned biomass DHS in Pokupsko, including production units which is CHP plant and distribution network.

Czech Republic

According to the Czech Statistical Office Energo 2015 Survey, district heating systems (DHS) had highest 40,3% share among types of households heating in the Czech Republic, supplying approx. 1,734 mio households (Figure CZ1). Natural gas (NG) had second highest share of 35% (approx. 1,504 mio households in total) and the third option was electric heating with 9,7% share (approx. 0,418 mio households).

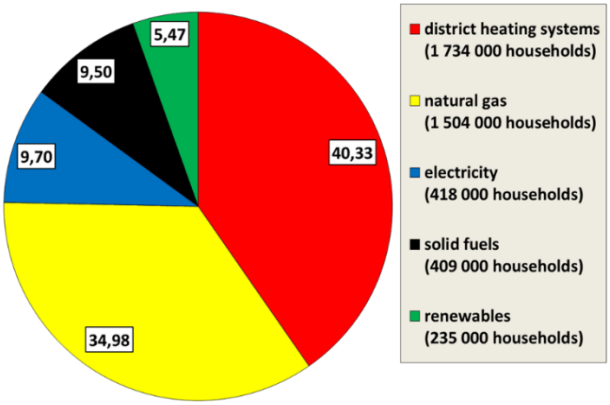

Figure CZ1: Share of the main types of household heating in the CZ (source: Czech Statistical Office, 2015)

Hard coal and lignite still account for more than a half (57.7%) of the heat supplied in DHS in 2019. However, the share of coal in both heat supply and the amount of heat produced are gradually decreasing. NG had the second highest share of 25,4% in 2019, followed by renewables with 8,1%.

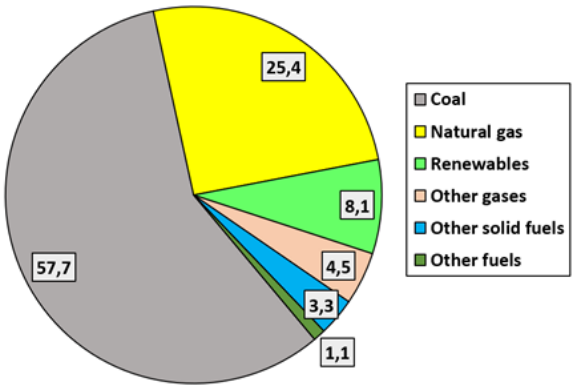

Figure CZ2: Structure of the heat supply in district heating systems in 2019 (source: Energy Regulatory Office)

Between 2017 and 2019, there was a decrease of heat supply by 3.5% (6,000 TJ).

However, the decrease in total heat supply between 2017 and 2019 accounted almost 7,000 TJ. The share of heat generated from NG is also slightly increasing (by 3.5%). However, compared to the heat supply of 2017 and 2019, this was a decrease of 975 TJ. In this period the share of heat from biomass and biogas has grown by almost 14.5% (increase by 414 TJ). This category of main fuels was the only one to see an increase in the amount of heat supplied.

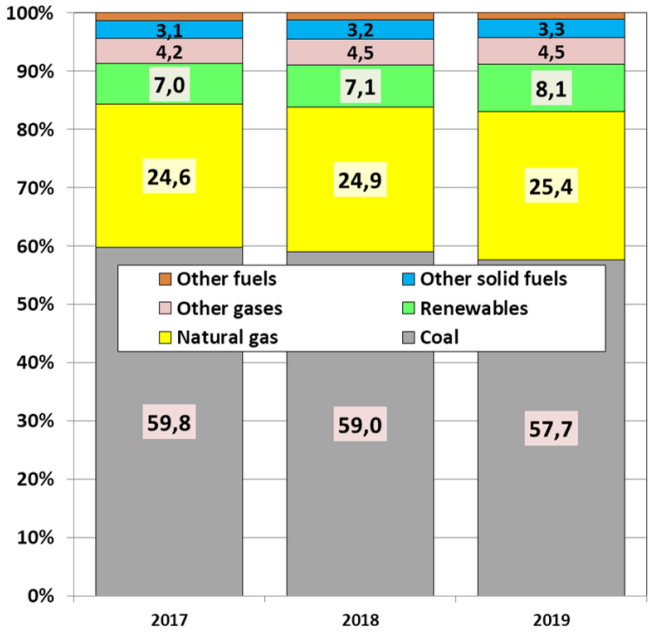

Figure CZ3: Structure of the heat supply in DHS between 2017 and 2019 (source: Energy Regulatory Office)

Utilisation of other gases (waste gases from industry, mining activities, etc.) increased by 7.1% (drop in supply by 36 TJ) and the share of other solid fuels (waste incineration plants, WEEE and cement plants) by 4.2% (drop of supply by 103 TJ).

Other fuels recorded the drop of 308 TJ (19,2%), see Table CZ1. This was mainly due to a significant decrease in the use of fuel oils to less than a third of the original production of 2017 compared to 2019, i.e. from 329 TJ to 96 TJ.

Table CZ1: Structure of the heat supply in DHS between 2017 and 2019 (source: Energy Regulatory Office)

Fuel	Heat supply in TJ			
	2017	*2018*	*2019*	*2019-2017*
Coal	56 014	52 221	50 025	-5 989
Natural gas	23 012	22 077	22 038	-974
Renewables	6 586	6 291	7 000	414
Other gases	3 974	4 026	3 938	-36
Other solid fuels	2 926	2 873	2 822	-103
Other fuels	1 221	1 063	913	-307
Total	**93 733**	**88 551**	**86 736**	**-6 997**

There is the gradual trend in replacement of inefficient steam distribution systems with high heat losses by modern hot water distribution systems from pre-insulated pipes. At present, this exchange is intensive especially in Brno and České Budějovice. In Prague it was basically completed in 2018. Statistics of the Energy Regulatory Office show a gradual decrease in the length of steam and hot-water pipelines, which is related to the modernisation of district heating systems. Despite ongoing refurbishment in 2018, there were still almost 1,400 km of steam distribution systems in the Czech Republic (Table CZ2).

Table CZ2: Development of the length of heat distribution (according to licenses for heat production and distribution) in km of the route in the Czech Republic in 2014-2018 (source: Energy Regulatory Office)

Heating media	Pipeline route length (in km)				
	2014	*2015*	*2016*	*2017*	*2018*
Steam	1 470,6	1 452,2	1 425,7	1 419,3	1 385,9
Warm water	3 509,1	3 439,8	3 449,1	3 442,4	3 460,4
Hot water	2 732,8	2 602,5	2 633,2	2 641,8	2 648,2
Total	7 712,5	7 494,5	7 508,0	7 503,6	7 494,5

The business in the production and distribution of thermal energy with the exception of heat production for one building of one customer is possible under the Energy Act only on the basis of a license issued by the Energy Regulatory Office. At the beginning of 2019, 661 licenses for thermal energy production and 649 licenses for thermal energy distribution were valid. In addition, 574 companies had a license for "non-licensed thermal energy generation and distribution, which is realized from thermal energy sources with an installed capacity of one source above 50 kW". Overall, at the beginning of 2019, more than 1,100 entities were involved in the production and distribution of thermal energy (Table CZ3).

Table CZ3: Number of valid licenses for the period 2010-2018 by type of business activity for the Czech Republic in 2010-2018 (source: Energy Regulatory Office)

	Number of valid licenses								
	2010	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Heat production	627	619	627	656	672	669	673	666	661
Heat distribution	675	663	653	653	663	654	658	654	649

Latvia

Considering winter climatic conditions, heating is an important part of the residents' life quality in Latvia. District heating (DH) is the most appropriate and convenient type of housing heating in cities and other densely populated areas. Heat supply within certain administrative territory shall be organised by local governments in accordance with the autonomous function specified in the law thereof. DH is the most common form of heating in Latvia and provides heat to around 80% of households, most public buildings and industrial plants. In 2017, the final consumption of heat accounted to 7034 GWh, with the following main shares: wood logs 35%, DH 30% and electricity 14% (Figure LV1, left). The

main sector of heat consumption is household with 62% (Figure LV1, right).

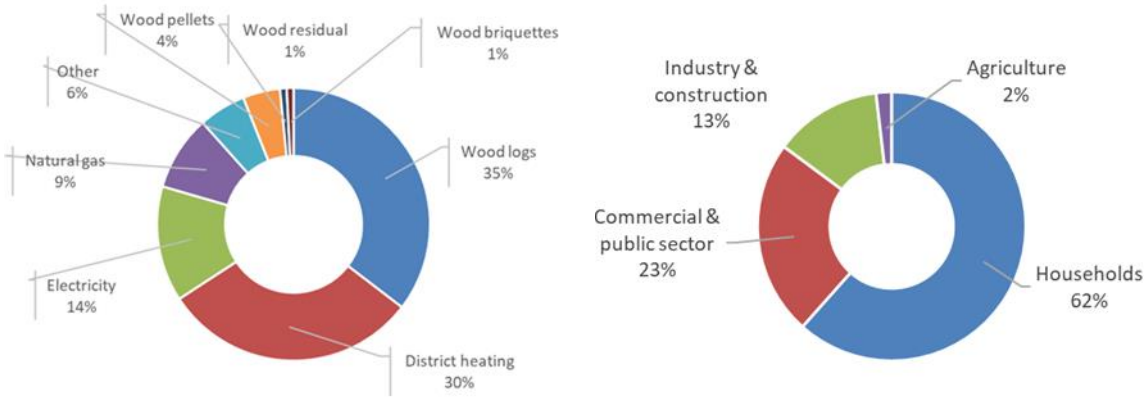

Figure LV1: Share of energy resources in total consumption (left); Main sectors of heat energy consumers (right) (SOURCE: Ministry of Economics).

In 2018, the thermal energy was produced in 633 boiler houses with an installed thermal power of 2360 MW and 175 cogeneration plants with an installed electric capacity of 1270 MW – in total 6998 GWh heat energy was supplied to consumers. In 2018, a total of 8247 GWh of thermal energy was produced in Latvia, including in CHP plants - 5892 GWh. The main fuels were wood and natural gas (NG). In 2018, 61,2% of the thermal energy was produced from wood, while 37,6% of the thermal energy was produced from natural gas. In total, the primary energy of fuels consumed in boiler houses accounted to 10924 TJ (wood chips - 6492 TJ, NG - 3431 TJ, wood logs - 633 TJ). Natural gas is used as the main fuel in cogeneration (CHP) plants. In 2018, 77,2% of electricity and 58,5% of heat was produced by CHP using NG. Total consumed fuel in CHP plants accounted to 46402 TJ of primary energy (NG - 30097 TJ, woodchips - 12577 TJ, biogas 3298 TJ), (Figure LV2). The consumption of biofuels (mostly produced on farms) is increasing significantly, e.g. between 2017 and 2018 it almost doubled.

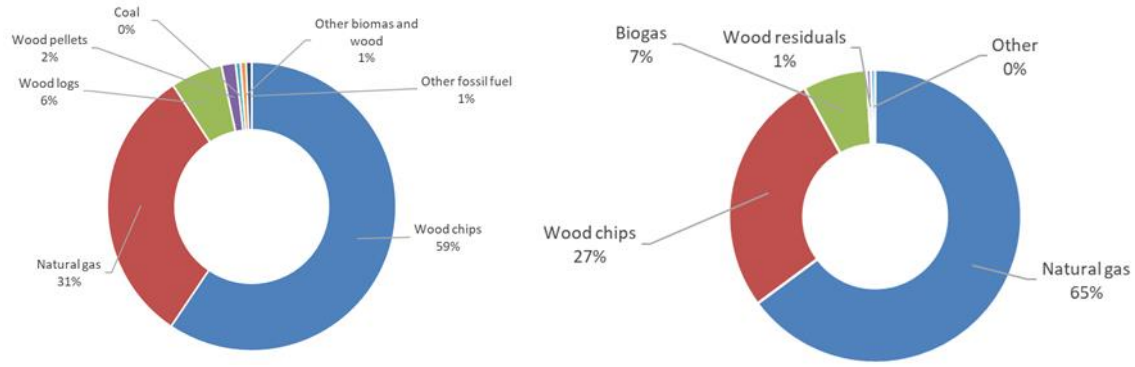

Figure LV2: Consumed fuel type in boiler houses (left) and cogeneration plants (right) in Latvia, 2018 (source: Ministry of Economics)

In 2018, the average annual losses at distribution are estimated at 11.8% of the produced heat and were 2% lower than 2017. Compared with sectoral consumption, the amount of

losses is quite low, but still there is room for improvements. The majority of DHSs was built more than 25 years ago, some networks are facing with high losses (e.g. 14% in Jekabpils city and 16% in Daugavpils city).

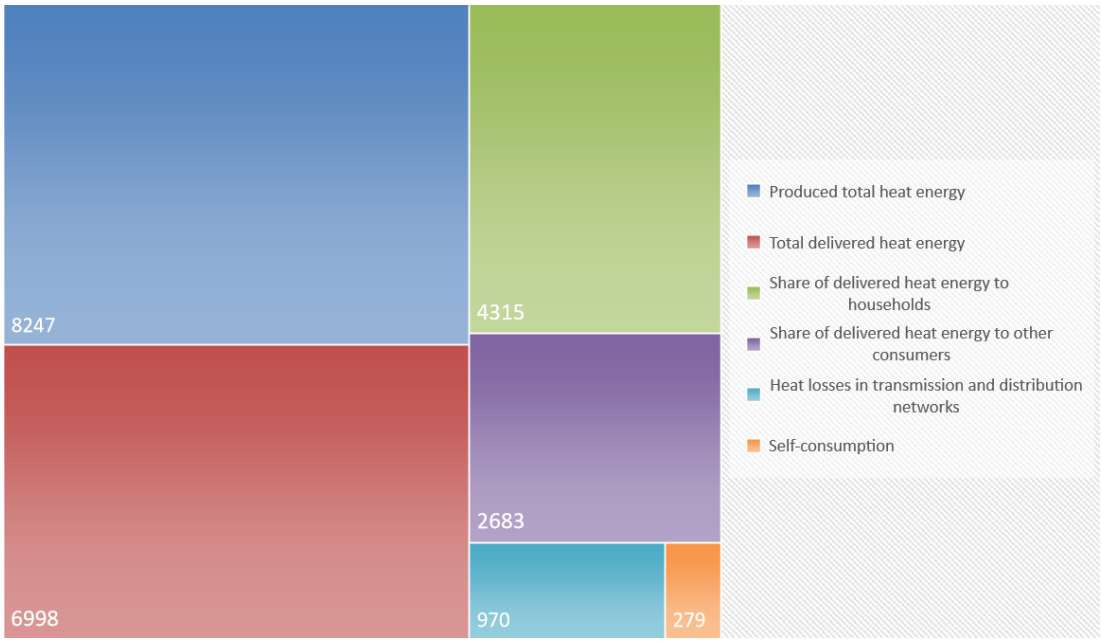

Figure LV3: Heat energy balance with basic data on produced and distributed heat, 2018 (source: Central Statistical Bureau of Latvia)

The service of heat distribution is carried out by 72 licensed steam transmission and distribution operators. The total length of heat networks is about 2000 km (about one third in the capital city Riga), only 60 km of network has been retrofitted until 2020. The vast majority of heat distribution systems is of the 2nd generation which is using hot water as heat carrier.

The excess or waste heat from industrial or service processes in Latvia is not being utilised mainly due to the fact that industrial processing plants are usually located outside the city and far apart from DH networks. In 2015, there was estimated (in the analysis on DHS planning provided by Ekodoma) that about 10% of excess heat from industries (located close to energy consumers) can be exploited in DHS.

The solar thermal sector is not developed. In September 2019, there was the first (and by now the only one) solar collector park which is feeding heat to municipal DHS installed by “Salaspils Siltums” in Salaspils city. The cost of the facility exceeded EUR 7 million (funded by company and EU funds) and consists of 1720 solar collectors (21 672 m^2) with an estimated annual heat generation capacity of 12 GWh. This pilot project serves as good example to be replicated by other DH systems.

DH services such as production of heat, transmission and distribution of heat and trading of heat are regulated activities. The heat supply service is re-regulated if the total annual amount of the heat supply exceeds 5000 MWh. On the other hand, small DHSs are not regulated in order to avoid imposing additional administrative burdens. Currently, heating

services are provided by around 240 companies, the regulated services represent around 93% of the total volume of the heating market, most of them are producers of heat as well. The Public Utilities Commission (PUC) or the Regulator determines heat supply final tariffs, currently it regulates 58 heating suppliers/merchants in different cities/parts of Latvia.

Serbia

Nearly 75% of households rely on their individual heating arrangements, while approximately 25% of households use heat from district heating (DH) systems[4]. The most important fuel for individual household heating in Serbia is still wood (34%), used practically exclusively in individual households, while 20.1% of households use electricity, 10.5% coal and 9.6% natural gas. Energy sources for household heating are presented on Figure SRB1.

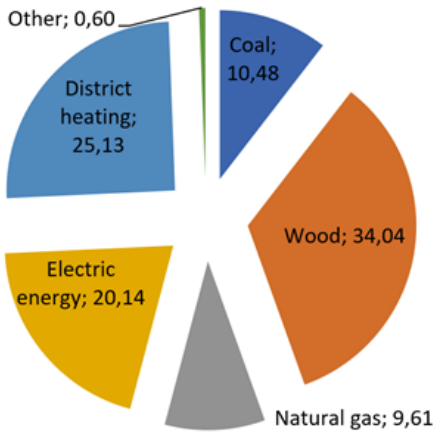

Figure SRB1: Energy sources for heating households in Serbia.

When focusing only on urban areas, heat from DHS is supplied to 48% of households. The total heating space area (heat delivered by DHS) in 2017 was 43.5 mio m^2, with 81% share of residential consumers (according to tariff groups).

The total installed heat capacity of the DH systems is 5821 MW, with a total annual heat production of around 6.9 TWh, generated by production plants on 255 locations and supplied to customers by 58 public companies. The average age of the heat production plants is around 28 years. Primary energy sources for heat production in DH plants are natural gas (NG, 77.7%), heavy oil (13.5%) and coal (8.8%). In the last 5 years the consumption of NG has gradually increased annually by around 5%, whereas consequently the share of heavy oil decreased. In the last few years, a trend of increased use of biomass in DH systems is noted particularly in Western Serbia.

The heat distribution network is 2354 km long with an average age of nearly 23 years. It has been constantly upgraded as well as extended, in the last 5 years the average annual extension was around 300 km. More than 24 thousand heat exchange stations (substations) with an average age of around 14 years is installed in DH systems. The average heat losses in the distribution system are estimated at 12 - 16%.

The largest DH system is in the capital city of Belgrade. It represents almost one half (49%) of

[4] Report on the operation of the district heating system in the Republic of Serbia for 2017, Business Association "Heating Plants of Serbia", October 2017

the total national installed heat generation capacity in DHS, supplying heat to 49% of city households representing 51% of total heating area. The length of the Belgrade DH distribution network distribution is about one third (31%) of the total length of all DH distribution networks in Serbia.

The legislative framework in regard to the overall operation of DH systems in Serbia is regulated by the Law on Energy. The government adopts the methodology of forming the prices of heat supply to final customers. In accordance with the Regulation on the establishment of the methodology for determining the price of supplying the end customer with heat energy, the entity/company performing the energy-related activity of heat supply determines the price of heat for final customers, which must be approved by the local self-government unit. All other aspects of DHS, including planning, choice of the type of DHS entity performing production, distribution and supply of heat (e.g. public company, public-private partnership, concession), the relationship between customers and DHS entity, are passed on to local self-government unit (municipalities) to decide and regulate. The local self-government units are also responsible for prescribing incentive measures and conditions for acquiring the status of a preferential heat producer.

Stable economic operation is heavy challenge for the vast majority of DH systems. The maintenance (including replacement of major equipment and modernisation) is often subsidized by municipalities, this often applies also for capital new investments. For all that, 20 DH systems (out of 58) have declared financial loss in 2018. Two other factors strongly influence the economics of the DHS operation, namely the state energy pricing policy and the prevailing heat billing method. The state energy pricing policy favours lower prices of both heat and electricity comparing to other energy sources, which is a result of social considerations rather than economic ones. The low price of heat, on one hand, hinders efforts of the DHSs to modernize, and on the other hand, the low price of electricity leads to the situation that many households use electricity for their heating purposes which is both highly inefficient and blocks DH operators to increase the number of consumers. The billing method is based on the size of heated space, what prevents most of consumers to be motivated for realisation of any energy saving measures.

The use of renewable energy sources (RES) and integration of CHP production facilities in DH systems is gradually increasing but not statistically important yet. The annual consumption of wood chips in DH systems is has reached 7.7 mio tones. Technical potential for utilisation of solar energy is large, particularly in the south-eastern part of the country. The annual duration of solar radiation is between 1500 and 2200 hours, while the annual average value of radiation is ranging from 1200 kWh/m^2 (in the N-W) to 1550 kWh/m^2 (S-E). Preliminary steps for exploitation of solar heat have been taken in connection with pilot DHSs which also supply hot water to their customers. Geothermal energy is currently used solely in small scale individual household heating systems, apart from an application in the DHS of City of Šabac, where the heat pump with 300 kW nominal heat power has been installed for the city in-door pool heating purposes.

The focus regarding the use of excess or waste heat for DH purposes is currently set on the possibility of using waste heat from thermal power plants. There have been two solutions implemented: one with Nikola Tesla TPP (thermal power plant), supplying waste heat to DHS

of the town Obrenovac (12.500 consumers, heated area of 837 thousand m^2) and the other with TPP Kostolac "A" & "B" which supplies waste heat to the DHS of cities of Požarevac and Kostolac (around 600 TJ of heat is annually distributed to 8.300 households, 770 public and commercial objects and 4 industrial buildings). Similar solutions are being considered for other cities in Serbia, e.g. in Belgrade.

Slovenia

The DH sector remains one of the most important pillars for heat supply in Slovenia, particularly in densely populated urban areas. In general, DH represents 13% of the total heat supply in Slovenia. The share of DH ("daljinska toplota") in space heating for household consumers amounts to 9%, the highest shares belong to wood logs (53%, "les polena"), extra light heating oil (13%, "ELKO") and natural gas (12%, "ZP"), Figure SI1.

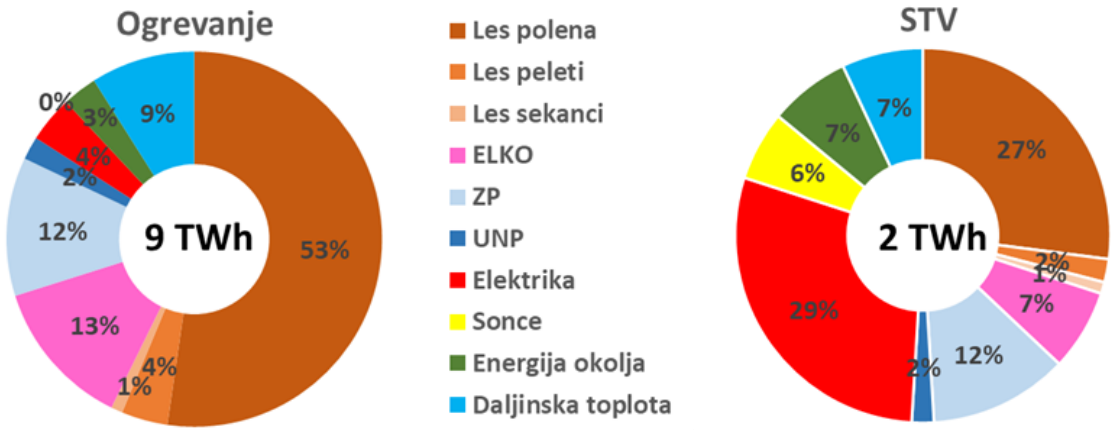

Figure SI1: Sources of space heating (left, "ogrevanje") and preparation of sanitary hot water (right, "STV") in Slovenia

The downward trend of the several past years (2012-2016) in the number of consumers of heat connected to district heating systems (DHS) has turned around in the last period; in 2017 it increased by 5.4%. In that year the heat supply was provided by 93 distribution systems from 55 heat suppliers in 64 Slovene municipalities. Consumption from DH systems increased by 2.3% compared to 2016, and by 6.7% compared to 2015. At the same time 940 GWh of electricity were produced in co-generation of heat and power (CHP), whereas the share of heat from CHP accounted for 86.8% of all generated heat. The primary energy source of heat production remains coal (56% in 2017), followed by natural gas (26.5%). While heat from renewable energy sources reaches almost 13% (Figure SI2).

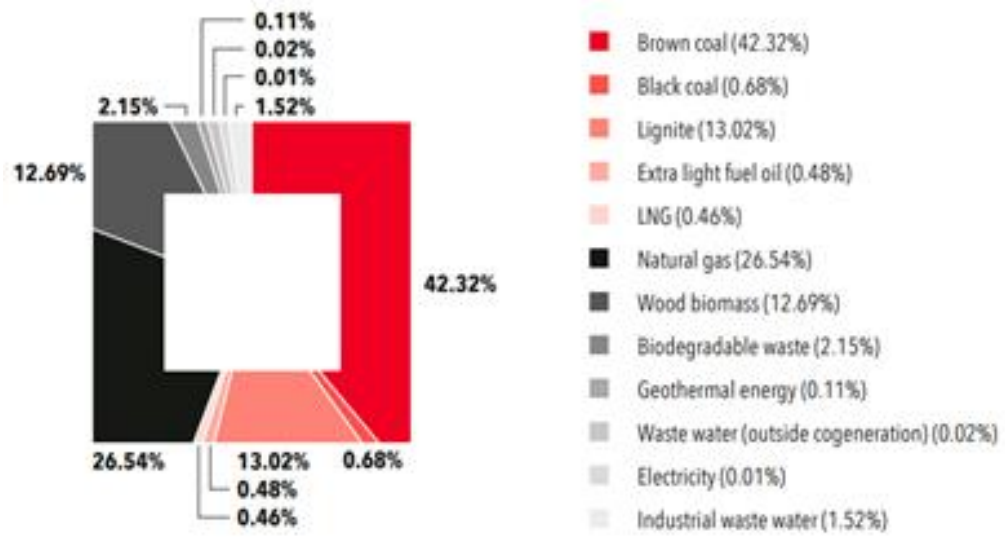

Figure SI2: Structure of the primary energy products for heat generation in DH, 2017 (source: Slovene Energy Agency)

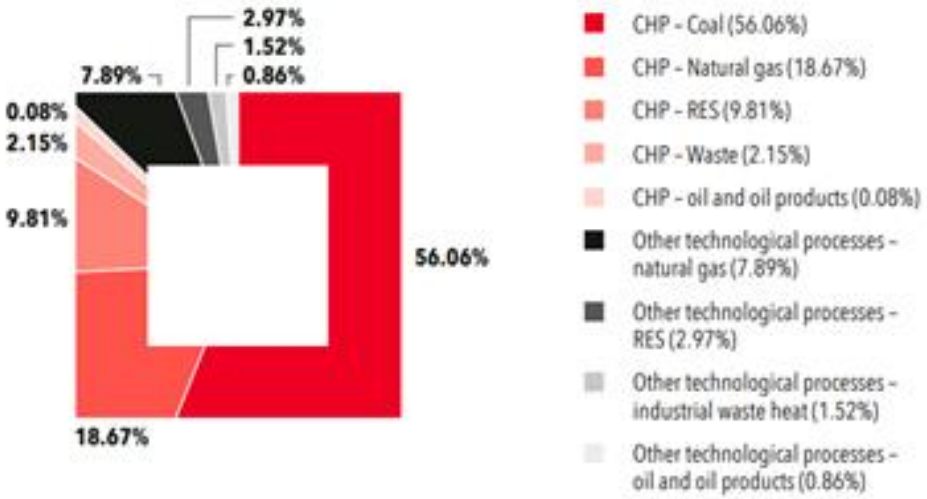

Figure SI3: Structure of the primary energy products for production of heat in CHP and boiler rooms, 2017 (source: Slovene energy Agency)

Almost 87% of all produced heat for the supply of distribution systems was produced in CHP units, while the remaining share comes from other processes of heat production, e.g. wood biomass boilers, gas, heat from geothermal wells, waste heat from industrial processes. Shares of primary energy sources used for the supply of DHS in relation to the technology are shown in Figure SI3.

In 2017, the average annual losses at distribution are estimated at 14.9% of the heat produced and were 0.4% higher than in 2016. Compared to sectoral consumption, the amount of losses exceeds the consumption of industrial consumers and accounts for more than half of the consumption of commercial (business) and other consumers. The amount of heat, generated and distributed in DH systems, the heat consumption per customer group and the heat distribution losses in 2017 are shown in Figure SI4.

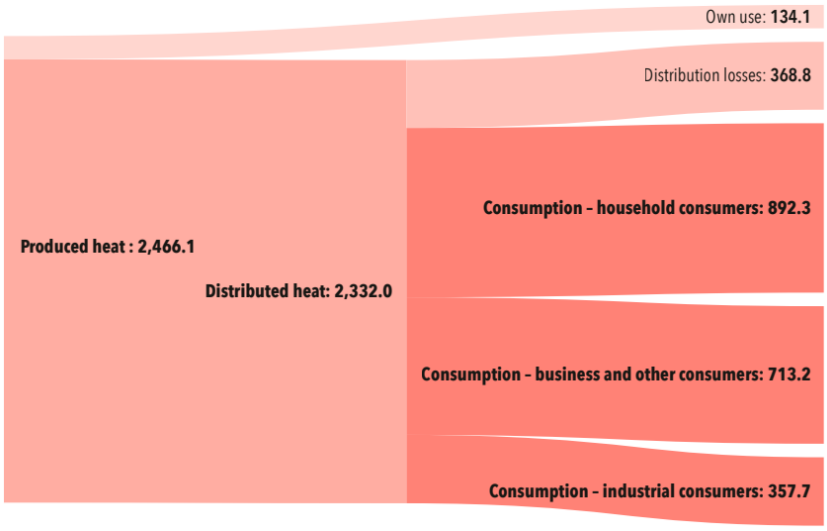

Figure SI4: Basic data on produced and distributed heat (in GWh) for consumers of heat connected to the distribution systems in 2017 (source: Slovene Energy Agency)

The service of heat distribution was in 2017 carried out by 93 distribution systems; their total length was 893 kilometres. The activity of heat distribution can be performed as an optional local public utility service (service of general economic interest) or as market distribution. The first option is obligatory if distributor supplies or intends to supply more than 100 household customers or when the permanent and uninterrupted supply of heat is in the public interest due to the provision of public needs. The distribution systems, where the activity was carried out as an optional local public utility service, supplied 89.3% of all consumers, and the share of delivered heat was 93.6%.

With respect to the temperature regime of the operations of the individual system, the systems are warm-water, hot-water and steam distribution systems. Warm-water and hot-water networks cover almost 99% of the total distribution systems.

On the basis of the Services of General Economic Interest Act and the Energy Act, municipalities make the decisions on heat distribution. The heat distributor defines the technical requirements that must be considered for the design, construction, maintenance and other works on the distribution system, heat stations and internal heat facilities. System operating instructions regulate the operation and method of managing the DHS, technical and other conditions for its safe operation, conditions and procedures on how to connect to the DHS and other issues related to heat supply, including the rights and obligations of customers.

On the basis of the Energy Act the Energy Agency is obliged to regulate the price of heat for district heating. Regulation is carried out in accordance with the Act on the methodology for district heating pricing. The Energy Agency is monitoring and analysing changes in starting prices of heat due to modification of eligible costs, and also supervises the method for heat calculation and publishing of heat tariffs.

The use of excess or waste heat from industrial or service processes in Slovenia is still in a premature phase, but the volume of waste heat utilisation is increasing and is foreseen to become one of the key heat sources in the future. One of the likely most attractive heat

sources is geothermal, particularly in regions where geological conditions enable successful and safe exploitation of heat from the ground. Their potential is currently being investigated and a map of corresponding areas with high potential drawn up. Currently only one DHS with geothermal energy operates in Slovenia. There is also limited biogas potential, mainly as fuel for CHP plants. Biogas is mostly produced on farms or at municipal waste (water) treatment plants/centres. The solar thermal sector is not (yet) high on the agenda among sectors to be developed or supported in Slovenia.

The efficiency of DHC systems according to EED and Energy Act is being analysed by Energy Agency, which makes these results public on https://www.agen-rs.si/izvajalci/toplota/ucinkoviti-distribucijski-sistemi.

Ukraine

The DH sector remains one of the most important sources for heat supply in Ukraine, particularly in densely populated urban areas. The share of citizens served by DH is approx. 40%, making it one of the largest DH markets in Europe. As a rule, DH systems are managed by municipal district heating 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.

Natural gas (NG) still remains the dominant fuel in DH sector, while the use of biomass for heating is growing but accounts for only about 8% of total energy consumption. Ongoing DH energy efficiency projects aim to balance current reduced heat loads with existing heat generation and transportation facilities, further centralise DH and upgrade major technological equipment. The scale of investment in these activities throughout the country is planned to be significantly increased thus ensuring mid- and long-term reliability of heat energy supply.

The extensive measures have been introduced to support DHS and to minimize NG usage, e.g. tariffs for NG used for heating in buildings were raised to economically reasoned prices. State Energy Efficiency Programme has been established to introduce cheap loans for population to purchase energy saving equipment and materials. Local budgets have received a subsidy for energy saving measures to reduce consumption of NG in heating systems and for measures of NG replacement with alternative energy sources. Often local municipalities also subsidize operational activities of their DH companies', while considerable investments into modernisation projects are executed with the active participation of international financial institutions.

Tariffs for heat energy in Ukraine are torn between the need to cover all expenses of DH operations and the capacity of clients, particularly individual households, to sustain the prices. Overall, general financial conditions of Ukrainian DH companies are often complicated. Many companies have significant debts to Naftogaz – the state natural gas supply company. Hence, local municipalities often subsidise their DHS companies, while international financial institutions continue to be the important investors in DHS renovations, subject to guarantees from municipalities and the state.

At the same time, DHS companies remain the actual monopolies on heat supply at major

urban settlements. Limited competition results in sector's inefficiencies and prevents new players (and investment) from entering the sector. Introduction of heat market in the country based on the competitive access to the heat transportation grid shall provide significant impetus for DHS development and modernisation in Ukraine.

Human resources and organisational capacities of the DH sector ought to be improved as well. On-going and coming introduction of modern heat generation and transportation equipment requires a new level of professionalism and skills from key DHS personnel, supported by regular trainings and education. The staff shall be appropriately paid and motivated to be able to execute energy efficiency and renewable energy projects in the district heating sector.

The successful transition toward efficient DH in Ukraine requires smart modernisation of DHS facilities supported by significant investment, competition and capacity development. A number of ongoing DHS modernisation projects demonstrate the feasibility of DHS reform with the effective support from the EU and International Financial Institutions.

Key challenges of DHS retrofitting and development

Austria

The main challenges in decarbonisation and improvement of DHS networks:

(1) Reduction of the heating load as a result of better insulation and gradual improvement of energy efficiency of the connected buildings;

(2) Lower network temperatures to enable more renewable energy sources to be integrated in the system and allowing a more efficient operation;

(3) How to ensure profitability also with decreasing heat demand of connected buildings;

(4) High investment costs for renewable energy sources is (currently) a risk in comparison with (cheap) fossil options;

(5) Lack of the national heating strategy;

(6) Uncertain business succession is often an issue for smaller DH systems;

(7) Permanent development of new technologies requires continuous education at increased levels, thus ensuring the competence of staff.

The concerns on reduction of losses in distribution, increase of the number of consumers and implementation of supportive actions for sustainable development are included in the above challenges which are strongly interconnected. As the development of a sustainable and competitive DH system depends on the cooperation of many stakeholders, coordinated actions are needed at various levels. Proper and timely involvement of stakeholders (particularly the key ones which make the decision to connect to a DHS, such as large-scale building owners, real estate developers and municipalities), their clear roles, relationships and communication among them is the prerequisite for success. By retrofitting and expanding heating networks, the decarbonisation of the heat supply can be achieved, but DH must remain competitive. A corresponding financial or price policy mechanisms (e.g. based on CO_2 pricing of fossil fuels) have to be established in order to steer the heat supply sector development.

In Austria, the following key success factors, which have been demonstrated as drivers to a high quality, efficient and sustainable DHS service, are considered the most relevant:

- The coherent national policy and regulatory environment which provides stable ground and incentives for the development of DHS systems (e.g. by setting ambitious CO_2 targets, establishing specific fiscal measures promoting the use of renewable energy, etc.).
- In addition to the national policy, regional policy on federal state level is a key success factor in the development of DHS systems (e.g. by additionally subsidising investments, easy building permit procedures; Designation of priority areas for DHS).

- Direct or indirect subsidies (e.g. investment grants, support schemes to CHP and RES, access to competitive debt funding, fossil fuel taxes...) and/or dedicated financial instruments supported by the long-term Cost-Benefit-Analysis approach can enhance (price) competitiveness of DH. Relevant tax incentives (increased taxes on electricity and fossil fuels) are essential to promote EE and support the energy transition.
- Coherent heat supply planning, supported by the promotion of DHS as part of municipal energy supply and climate strategy, where heat planning is integrated in their urban development projects (e.g. undertaking a long-term cost-benefit analysis for heat planning, establishing DH zones or specific environmental requirements for buildings, promoting compact and mixed-use new districts, etc.). Furthermore, energy spatial planning is very important for operators of local heating networks. With the knowledge of the heat demand, the network expansion can be planned efficiently.
- Integration of renewable energy sources, the use of various waste heat and cold sources as well as the development of new application areas outside the classic heating season. District heating also has the potential to contribute to load balancing to cope with peak production of wind and solar energy (power-to-heat). Sector coupling is a future change of DHS.
- Alignment of interests through cooperation and efficient communication between the national (public authorities, regulating bodies) and local actors (municipal authorities, DHS company, final users), all aiming at good quality service and a sustainable and cost-efficient heat and cold supply.
- Competitive DHS prices comparing to the alternative energy solutions available in the market. This price competitiveness can be enhanced through an optimised system design, through competitive procedures for the market or by using different heat sources available.
- A flexible production that allows better cost-efficiencies (mainly through a dynamic optimisation of the supply) can be achieved through a diversified and complementary energy mix, the use of CHP and enhanced management practices, connecting the electricity and heating markets.
- A strong national boiler industry and numerous research institutions are improving the quality of DHS constantly. This ensures the competitiveness in comparison to other technologies.

Croatia

The main challenges in decarbonisation and improvement of DHS networks:

(1) Better insulation of the connected buildings due to energy efficiency measures reduces the heating load;

(2) How to ensure profitability also with decreasing heat demand of connected buildings;

(3) Lower network temperatures to enable more renewable energy sources to be

integrated in the system;

(4) Negative financial statement (yearly losses) and lack of financial resources are hindering capital investments

(5) High investment costs for renewable energy sources puts these technologies in unfavourable position in comparison to fossil fuel technologies

(6) Dealing with uncertainty regarding the availability and cost of natural gas after the liberalisation of gas market in Croatia;

(7) Lack of a legal framework for systematic decarbonisation of DH networks (on local/regional/national level);

(8) Permanent development of new technologies requires continuous education at increased levels, thus ensuring the competence of staff.

The concerns on reduction of losses in distribution, increase of the number of consumers and implementation of supportive actions for sustainable development are included in the above challenges which are strongly interconnected. As the development of a sustainable and competitive DH system depends on the cooperation of many stakeholders, coordinated actions are needed at various levels. Proper and timely involvement of stakeholders (particularly the key ones which make the decision to connect to a DHS, such as large-scale building owners, real estate developers and municipalities), their clear roles, relationships and communication among them is the prerequisite for success. By retrofitting and expanding heating networks, the decarbonisation of the heat supply can be achieved, but DH must remain competitive. A corresponding financial or price policy mechanisms (e.g. based on CO_2 pricing of fossil fuels) have to be established in order to steer the heat supply sector development.

Furthermore, one of the main challenges of DHS is to raise awareness about advantages of DHS for both new and existing end-users. This can be mainly done by setting appropriate (competitive) prices of heat produced in DHSs which will allow further development of the sector.

In Croatia, the following key success factors, which have been demonstrated as drivers to a high quality, efficient and sustainable DHC service, are considered the most relevant:

- The coherent national policy and regulatory environment which provides stable ground and incentives for the development of DHC systems (e.g. by setting ambitious CO_2 targets, establishing specific fiscal measures promoting the use of renewable energy, etc.).
- Additionally, to the national policy, local and regional policy is a key success factor in the development of DHS systems (e.g. by additionally subsidising investments, easy building permit procedures; Designation of priority areas for DHS).
- Direct or indirect subsidies (e.g. investment grants, support schemes to CHP and RES, access to competitive debt funding, fossil fuel taxes...) and/or dedicated financial instruments supported by the long-term Cost-Benefit-Analysis approach can enhance (price) competitiveness of DH. Relevant tax incentives (increased taxes on electricity and fossil fuels) are essential to promote EE and support the

energy transition.

- Coherent heat supply planning, supported by the promotion of DHC as part of municipal energy supply and climate strategy, where heat planning is integrated in their urban development projects (e.g. undertaking a long-term cost-benefit analysis for heat planning, establishing DH zones or specific environmental requirements for buildings, promoting compact and mixed-use new districts, etc.). Furthermore, energy spatial planning is very important for operators of local heating networks. With the knowledge of the heat demand, the network expansion can be planned efficiently.
- Integration of renewable energy sources with the aim of sector coupling which is the future of DHS. This is a crucial factor due to e.g. existing and future buildings' renovation code which obliges all buildings to have a certain share of renewable energy used for heating. Without this, all DHSs which do not fulfil this requirement will be very uncompetitive on the heat market.
- Support of usage of alternative energy sources which can secure status of privileged producer of energy – CHP, renewable energy
- Alignment of interests through cooperation and efficient communication between the national (public authorities, regulating bodies) and local actors (municipal authorities, DHC company, final users), all aiming at good quality service and a sustainable and cost-efficient heat and cold supply.
- Competitive DHC prices comparing to the alternative energy solutions available in the market. This price competitiveness can be enhanced through an optimised system design, through competitive procedures for the market or by allowing competition between different heat/cold supply solutions.
- A flexible production that allows better cost-efficiencies (mainly through a dynamic optimisation of the supply) can be achieved through a diversified and complementary energy mix, the use of CHP and enhanced management practices, connecting the electricity and heating markets.
- Transparency of the prices, comparison at national level through benchmarking and clear visibility of future prices have a positive impact on a client's choice of DHC. Transparency is a necessity to gain the trust of all stakeholders and consumers in particular.
- Cooperation between industry, research institutions and energy agencies which can constantly increase the competitiveness of DH sector in comparison to other technologies.

Czech Republic

The main challenges in decarbonisation and improvement of DHS networks:

(1) Heat price regulation

(2) Competitive environment in the heat market;

(3) Economic discrimination of district heating industry;

(4) The vulnerability of DH systems and the consequences of their uncontrolled disintegration.

Heat price regulation

Heat prices are regulated by the Energy Regulatory Office in the form of so-called factual price regulation according to the provisions of Section 6 of Act No. 526/1990 Coll., on prices, as amended, which consists in setting certain conditions for calculating and negotiating heat energy prices. These conditions are specified in the price decisions of the Energy Regulatory Office and are binding for all thermal energy suppliers. Currently it is the Price Decision of the Energy Regulatory Office No. 2/2013, which was amended several times.

In the case of material regulation, only economically justifiable costs, reasonable profit and value added tax can be reflected in the heat price in accordance with the price decision. The price of thermal energy in the calendar year is calculated in the same way for the offtake points at the same delivery level, and each calculation can contain only the relevant economically justifiable costs and reasonable profit.

Competitive environment in the heat market

In the early 1990s, the district heating industry was considered to belong to the category of so-called natural monopolies requiring regulation. However, the situation on the heat market has changed radically since the introduction of the factual regulation of the price of thermal energy. Thanks to general gasification in the 1990s, natural gas is now available in virtually all cities and larger municipalities in the Czech Republic. At the same time, the technology of gas boilers and their automation significantly improved. Literally revolutionized heat pumps, which today thanks to significant technical improvements and at the same time cheaper represent another important competition for district heating. At present, virtually all district heating customers have the option of switching to and using this option.

Although a building permit is required to change the heating method, in which the air protection authority issues a binding opinion and the builder has to prove by an energy report that the use of heat from the district heating system is not economically acceptable for him. Given the almost universal extension of district heating substitutes and its virtually non-existent legislative protection in the Building Act and other related regulations, it is necessary to assume that district heating is principally in competition with other heating methods.

District heating companies are thus in a very difficult position, on the one hand exposed to competition, which is not subject to any regulation or information obligations, and on the other hand subject to factual regulation of the price of thermal energy, which creates both administrative burden and limits. The issues of unfair competition from the part of services of the so-called shared economy against the standard business regulated by the state, which has been widely discussed today, have been a reality in the heating sector for almost a decade. The use of deceptive business practices by boilers and heat pump sellers is a daily practice. While the state protects consumers and prosecutes unfair commercial

practices in many other areas, consumer protection is virtually nil in the heat market. Many customers are therefore convinced of individual heat production, which is actually economically disadvantageous for them.

Economic discrimination of district heating industry

Starting with the State Energy Policy, the strategic documents verbally support the development of the heating industry, but the real economic environment is in the exact opposite direction. While large sources have to buy greenhouse gas emission allowances, local production is not obliged to do so, and natural gas boilers do not even pay a symbolic tax under the Public Budget Stabilisation Act. Heating plants also pay for emissions of classic pollutants under the Air Protection Act, while local heat production is not subject to this obligation either.

A solution to this situation would be to increase the taxation of fossil fuels used for local heating (outside installations covered by the Emissions Trading Scheme) to a level comparable to the burden that heating plants included in the Emissions Trading Scheme have to pay. This is also envisaged by the State Energy Policy, one of the main objectives of which is (Chapter 5.4): “D.1 To maintain as long as possible an economically sustainable range of heat supply systems in terms of their competitiveness and to ensure a comparison of the economic conditions of centralized and decentralized heat sources for the payment of emissions and other externalities (carbon tax, allowances, emissions).”

In reality, however, the requirement to ensure the comparison of economic conditions of centralized and decentralized heat sources in the coverage of emissions and other externalities has not yet been met. Although the government has dealt with this issue several times, most recently in January 2017, it only required an analysis of the possible introduction of the tax by 31 December 2018. According to available information, another postponement occurred in September 2019.

Reducing the VAT rate on heat from 15 to 10% with effect from 1 January 2020 may partially offset the social impact of the increase in heat prices due to the additional cost of purchasing emission allowances, but will not fundamentally solve the competitive position of heating plants over local heating. External entities operating a boiler house can also reach the rate of heat VAT under certain conditions if, for example, they are leased and have a heat supply contract (not for the simple operation of a boiler house). This entails certain additional obligations, including the obligation to measure the amount of heat produced, but these are not major obstacles.

The vulnerability of DH systems and the consequences of their uncontrolled disintegration

The key vulnerability of district heating systems is the high proportion of fixed heat production costs, which cannot be reduced proportionally with decreasing heat consumption. This problem is particularly significant in the case of coal-fired heating plants with extensive heating networks. Investment in heating networks has a very long lifetime (up to 50 years), which in fact does not allow heating plants to respond flexibly to a rapid reduction in heat consumption. In the vast majority of DHSs, there is a long-term downward trend in heat demand due to cost-saving measures by customers and investment in

improving the thermal properties of building envelopes. Only in the case of larger conurbations with significant housing construction is this trend partially moderated by the addition of new housing construction and other buildings.

In a given DHS, if some customers switch to individual heating, the fixed costs will be reallocated to the remaining customers and the price of heat will increase. This may then motivate other customers to disconnect and the system will start to disintegrate uncontrollably. This process, sometimes also referred to as the "death spiral", is relatively fast, and experience shows that it can essentially destroy the heat supply system in about 4 years. In the end, the rest of the system is usually totally inefficient and economically uncompetitive and there is no choice but to decentralize it, usually using public funds. As a result, the original central source is usually divided into smaller block boiler rooms, usually natural gas.

In the event of a breakdown of the DHS, emissions of pollutants are usually shifted to lower emission heights in close proximity to the housing development. The result is a worsening of the air pollution load, which already exceeds the limits for the protection of the health of the population in many urban agglomerations. There is also a shift of carbon dioxide emissions from installations included in the Emission trading scheme outside EU ETS. However, for greenhouse gas emissions from installations outside the Emissions Trading Scheme, from 2020 onwards, the Czech Republic will have a binding trajectory to reduce them by 14% by 2030 compared to 2005 levels. If the targets will not be met, the Czech Republic will have to buy emission allocations from countries that will meet their targets. Given how ambitious the targets for reducing emissions after 2020 are set for all EU Member States, it is appropriate to expect a high price for emission allocations. Of course, shifting carbon dioxide emissions from heating plants covered by the Emissions Trading Scheme will significantly undermine efforts to reduce them in sectors outside the Emissions Trading Scheme.

The breakdown of DHS also necessarily leads to a reduction or cessation of cogeneration. The result would be not only a reduction in the supply of ancillary services for electricity grids necessary for balancing the grid, which will face the closure of a significant proportion of smaller flexible coal blocks, but also the emergence of grid problems that are directly dependent on decentralized electricity generation in some areas.

Latvia

The main challenges in decarbonisation and improvement of DHS networks:

(1) increase of energy efficiency of old DH systems and their modernisation;

(2) up-to-date technologies (heat accumulation, use of waste heat), including use of RES, in particular non-emissions (solar collectors, heat pumps) technologies;

(3) consumer demand falls due to a variety of factors (demography, improved energy efficiency of final consumers);

(4) consumer attraction and engagement issues, the increase of social attractiveness of DHS solutions (currently – low price of natural gas does not allow to attract new consumers);

(5) development of the services sectors associated with DHS;

(6) insulation of the connected buildings to reduce the heating load;

(7) permanent development of new technologies requires continuous education at increased levels, thus ensuring the competence of staff;

(8) non-existing district cooling;

(9) competition of heating providers after end of administrative territorial reform in 2021 (unification of neighbouring municipalities in order to reduce number of municipalities in Latvia from 119 to 39 is expected to affect also municipal DH companies).

The concerns on retrofitting of outdated, old heating systems (boilers older than 15 years), increase of the number of consumers and implementation of supportive actions for sustainable development are included in the above challenges which are strongly interconnected. As the development of a sustainable and competitive DH system depends on the cooperation of many stakeholders, coordinated actions are needed at various levels.

Proper and timely involvement of stakeholders (particularly the key ones which make the decision to connect to a DHS, such as large-scale building owners, real estate developers and municipalities), their clear roles, relationships and communication among them is the prerequisite for success.

By retrofitting and expanding heating networks, the decarbonisation of the heat supply can be achieved, but DH must remain competitive.

In Latvia, the most relevant key success factors, which have been demonstrated as drivers to a high quality, efficient and sustainable DHC service, are the following:

- The adequate national policy and regulatory environment which provides stable ground and incentives for the development of DHC systems.
- Direct or indirect subsidies (e.g. investment grants, support schemes to CHP and RES, access to competitive debt funding, fossil fuel taxes...) and/or dedicated financial instruments, availability for beneficial loans.
- Coherent urban municipal (local) heat supply planning, supported by the promotion of DHC as part of municipal energy supply and climate strategy, where heat planning is integrated in their urban development projects.
- Alignment of interests through cooperation and efficient communication between the national (public authorities, regulating bodies) and local actors (municipal authorities, DHC company, final users), all aiming at good quality service and a sustainable and cost-efficient heat supply.
- Competitive DHC prices comparing to the alternative energy solutions available in the market. This price competitiveness can be enhanced through an optimised system design, through competitive procedures for the market or by allowing competition between different heat/cold supply solutions.
- A flexible production that allows better cost-efficiencies (mainly through a dynamic

optimisation of the supply) can be achieved through a diversified and complementary energy mix, the use of CHP and enhanced management practices, connecting the electricity and heating markets.

- Transparency of the prices, comparison at national level through benchmarking and clear visibility of future prices have a positive impact on a client's choice of DHC.

Serbia

The main challenges in decarbonisation and improvement of DHS networks:

(1) Predominance of fossil fuels;

(2) Significantly high age of the DH systems;

(3) The charge of delivered heat per unit area of heated space prevails;

(4) Operation in conditions of unfavourable energy price parity;

(5) Deficiency of skilled professional staff;

(6) Duality of the service of production, distribution and supply of thermal energy.

Predominance of fossil fuels

Practically only fossil fuels are used in DH plants for heat production, gas being the predominant fuel with a share of around 77%, followed by heavy oil (mazut) with over 13% and coal with nearly 10%.

Significantly high age of the DH systems

The average age of DH heat plants exceeds 28 years, of the distribution networks 23 years and heat transfer stations 14 years:

- The present problems of the **production system**, considering the previous data, are the technological obsolescence of the most important elements of the system, low degree of automation, insufficient energy efficiency, emission of pollutants from plants that use fuel oil and coal.
- Present problems of **distribution systems** are large losses due to dilapidated pipelines, poor and/or damaged thermal insulation, hydraulically unbalanced network. The share of heat losses in some cases reaches 30%, the average value is 14% (calculated for the relative share of each loss in the total length of the distribution network).
- The indirect system of **heat transfer stations** is mostly used. In some DH systems distribution is such that no heat exchangers are used - direct system, so the main circulation pumps are also used for circulation through buildings and households.
- Local **systems of regulation**, control and monitoring of processes prevail, but they are mostly outdated and insufficient.

However, the high share of natural gas in DHS heat production implies also the use of highly efficient boilers with good process automation.

The charge of delivered heat per unit area of heated space prevails

Although the relevant Ministry of Energy has passed a *Decree on determining the methodology for determining the price of supplying the end customer with thermal energy* (OG RS, No. 63/2015), DH systems generally (with a few exceptions) charge per unit area of housing or business space. Sustainable switching to billing by heat consumption is one of the key challenges. The burden of modernisation of DHS with the liberalisation of the fuel market, in this case, is borne by the owners of apartments of the lowest thermal class (buildings without thermal insulation or poorly insulated) which leads to problems of service billing and a dramatic increase in the demand for disconnection from the DHS. Fixed costs, in this case, are redistributed to the remaining customers of heat energy and the price of the heating service rises. Higher prices demotivate the remaining customers, etc., so that DH becomes unattractive to customers, and cannot provide efficient operation and current business. The only way to overcome this problem is to raise the energy efficiency of buildings, before or together with the introduction of billing with consumption by subsidising works on thermal - insulation and/or thermal - regulation.

Operation in conditions of unfavourable energy price parity

They operate in conditions of unfavourable energy price parity, and above all the ratio of electricity and fuel prices. Namely, electricity in Serbia is produced from domestic energy sources - coal and hydro energy. For both, only the ore rent in the amount of 3% is paid, so electricity, unencumbered by the CO_2 emissions tax, has a low price. On the other hand, SDGs largely use imported gas and fuel oil as energy sources, so the price of SDG heating is formed based on the price of these energy sources. In that way, the end customer who pays for heating services even outside the heating season is in a less favourable position than the one who uses cheap electricity only in the heating season. Also, the use of heat pumps for heating buildings is becoming more and more attractive, so this option is more preferable to building investors than DHS.

Deficiency of skilled professional staff

The migration of skilled labour force is a problem in all sectors of the economy, even here. Therefore, the expertise of staff and organisational capacity in the DH sector should be improved. The introduction of modern equipment for heat production and transfer requires a new level of professionalism and skills of key DHS staff with the support of regular training and education. Staff must also be financially motivated to implement energy efficiency and renewable energy projects in the district heating sector.

Duality of the service of production, distribution and supply of thermal energy

According to the Law on Communal Activities (Official Gazette of RS, no. 88/2011 and 104/2016), heating is a **communal service** (the activity of general interest), and according to the Law on Energy, (Official Gazette of RS, No. 145/2014 and 95/2018 - other law) is an **energy activity**. Local self-government units, LSGU, establish public companies (PEs) and entrust them with the service of heating the population. PEs build and maintain the infrastructure from their revenues, by charging for the heating service. Therefore, the competent bodies of LSGU, have the final decision on the method of determining the price

and approve / or not the price of heat energy proposed by the DHS. Private sector participation in the provision of heating services is limited. This creates some problems in the inclusion of alternative heat producers, which could affect the market and possibly focus more quickly on renewable energy sources. One solution can be offered by public-private partnerships (PPPs), which is allowed by law. On the other hand, commodification and privatisation (at least in part) of the communal sector, including heating, if not carefully regulated can lead to an increase of service prices - similarly as under (3) above.

Conclusions

Considering the 6 above mentioned major issues and considering the DH system as a whole, the DH network operators in Serbia are facing the following challenges regarding decarbonisation and their revitalisation and modernisation:

a) Creation of a comprehensive and coherent **national policy and regulatory environment** which provides stable ground and incentives for the development of DHS systems (e.g. by establishing direct and indirect subsidies, setting ambitious CO_2 targets, establishing specific fiscal measures promoting the use of renewable energy, sustainable regulation of dual heating activity, etc.);

b) Improvement of the **energy efficiency of the connected buildings** to reduce the heating load (not considered by KeepWarm Project);

c) Replacement of **quite old equipment** with new and more efficient one;

d) Rehabilitation and replacement of **critical sections of heat distribution systems**;

e) Introduction and use of **new technological solutions for DH sub-systems**, such as heat exchange stations, frequency regulated circulation pumps, lower temperatures of hot water, heat storage, more flexible DHS operation time including night shifts, etc;

f) Integration of **more renewable energy sources** in the system;

g) Integration of **industrial waste heat sources** in the system;

h) Implementation of **modern process regulation**, control and monitoring systems, both heat production and heat distribution;

i) Achieving **adequate energy source** mix to ensure reliable delivery of heat to consumers in light of the uncertainty regarding the availability and cost of imported fuels such as gas and oil;

j) Maintaining and **securing profitability** despite the decreasing heat demand of connected buildings and the competition from other individual household heating solutions;

k) Improvement of **a legal framework** for systematic decarbonisation of DH networks and the introduction of incentives for heat production from RES;

l) Modification and adjustment of **state pricing policy** so that social considerations are not as dominant as presently is the case (for DHS most important is the parity of prices between heat on one side and electricity and used fuels on the other);

m) Permanent and **continuous education** of the DHS staff, thus ensuring their competence to apply new technologies and operation methods.

These challenges are strongly interconnected and to be properly addressed it is essential that cooperation and coordination of many stakeholders and at many levels is present. By retrofitting and expanding heating networks, the decarbonisation of the heat supply can be achieved, but DH must remain competitive. Corresponding financial or price policy mechanisms (e.g. based on CO_2 pricing of fossil fuels) have to be established to steer the heat supply sector development.

In Serbia, the following key success factors, which have been demonstrated as drivers to high quality, efficient and sustainable DHS service, are considered the most relevant:

- The coherent national policy and regulatory environment which provides stable ground and incentives for the development of DH systems (e.g. by setting ambitious CO_2 targets, establishing specific fiscal measures promoting the use of renewable energy, proper parity of fuel prices and energy sources, etc.).
- Direct or indirect subsidies (e.g. investment grants, support schemes for heat production using RES, access to competitive debt funding, fossil fuel taxes...) and/or dedicated financial instruments can enhance the competitiveness of DHS. Relevant tax incentives (increased taxes on electricity and fossil fuels) are essential to promote EE and support the energy transition.
- Coherent urban municipal (local) heat supply planning, supported by the promotion of DHS as part of municipal energy supply and climate strategy, where heat planning is integrated into their urban development projects.
- Alignment of interests through cooperation and efficient communication between the national (public authorities, regulating bodies) and local actors (municipal authorities, DH company, final users), all aiming at good quality service and sustainable and cost-efficient heat and cold supply.
- Competitive DH prices compared to the alternative energy solutions available in the market. This price competitiveness can be enhanced through optimized system design, through competitive procedures for the market or by allowing competition between different heat/cold supply solutions.
- A flexible production that allows better cost-efficiencies (mainly through dynamic optimisation of the supply) can be achieved through a diversified and complementary energy mix.
- Transparency of the prices, comparison at the national level through benchmarking and clear visibility of future prices have a positive impact on a client's choice of DH systems. Transparency is a necessity to gain the trust of all stakeholders and consumers in particular.

Slovenia

The main challenges in decarbonisation and improvement of DHS networks are the following:

(1) Better insulation of the connected buildings reduces the heating load;

(2) Lower network temperatures to enable more renewable energy sources to be

integrated in the system;

(3) How to ensure profitability and economic stability also with decreasing heat demand of connected buildings;

(4) Dealing with uncertainty regarding the availability and cost of climate-neutral gas (syngas);

(5) Lack of a legal framework and strategies for systematic decarbonisation of DH networks;

(6) Permanent development of new technologies requires continuous education at increased levels, thus ensuring the competence of staff.

The concerns on reduction of losses in distribution, increase of the number of consumers and implementation of supportive actions for sustainable development are included in the above challenges which are strongly interconnected. As the development of a sustainable and competitive DH system depends on the cooperation of many stakeholders, coordinated actions are needed at various levels. Proper and timely involvement of stakeholders (particularly the key ones which make the decision to connect to a DHS, such as large-scale building owners, real estate developers and municipalities), their clear roles, relationships and communication among them is the prerequisite for success. By retrofitting and expanding heating networks, the decarbonisation of the heat supply can be achieved, but DH must remain competitive. A corresponding financial or price policy mechanisms (e.g. based on CO2 pricing of fossil fuels) have to be established in order to steer the heat supply sector development.

In Slovenia, the following key success factors, which have been demonstrated as drivers to a high quality, efficient and sustainable DHC service, are considered the most relevant:

- The coherent national policy and regulatory environment which provides stable ground and incentives for the development of DHC systems (e.g. by setting ambitious CO2 targets, establishing specific fiscal measures promoting the use of renewable energy, etc.).
- Direct or indirect subsidies (e.g. investment grants, support schemes to CHP and RES, access to competitive debt funding, fossil fuel taxes...) and/or dedicated financial instruments supported by the long-term Cost-Benefit-Analysis approach can enhance (price) competitiveness of DH. Relevant tax incentives (increased taxes on electricity and fossil fuels) are essential to promote EE and support the energy transition.
- Coherent urban municipal (local) heat supply planning, supported by the promotion of DHC as part of municipal energy supply and climate strategy, where heat planning is integrated in their urban development projects (e.g. undertaking a long-term cost-benefit analysis for heat planning, establishing DH zones or specific environmental requirements for buildings, promoting compact and mixed-use new districts, etc.).
- Alignment of interests through cooperation and efficient regular communication between the national (public authorities, regulating bodies) and local actors

(municipal authorities, DHC company, final users), all aiming at good quality service and a sustainable and cost-efficient heat and cold supply.

- Competitive DHC prices comparing to the alternative energy solutions available in the market. This price competitiveness can be enhanced through an optimized system design, through competitive procedures for the market or by allowing competition between different heat/cold supply solutions.
- A flexible production that allows better cost-efficiencies (mainly through a dynamic optimisation of the supply) can be achieved through a diversified and complementary energy mix, the use of CHP and enhanced management practices, connecting the electricity and heating markets.
- Transparency of the prices and their composition, comparison at national level through benchmarking and clear visibility of future prices have a positive impact on a client's choice of DHC. This is vital for gaining the trust of all stakeholders and consumers in particular.

Ukraine

In general, DH network operators are facing the following challenges in decarbonisation and improvement of their networks:

(1) reduced heat energy demand due to energy efficiency improvements in buildings, disconnections, and climate change impact on average ambient air temperatures during the heating season;

(2) significant debts levels and lack of financial resources for capital expenditures;

(3) human resources deficit due to labour migration and permanent development of new technologies requiring new skills and continuous education.

As the development of a sustainable and competitive DH system depends on the cooperation of many stakeholders, coordinated actions are needed at various levels. Proper and timely involvement of stakeholders (particularly the key ones which make the decision to connect to a DHS, such as large-scale building owners, real estate developers and municipalities), their clear roles, relationships and communication among them is the prerequisite for success. By retrofitting and expanding heating networks, the decarbonisation of the heat supply can be achieved, but DH must remain competitive. A corresponding financial or price policy mechanisms (e.g. based on CO2 pricing of fossil fuels) have to be established in order to steer the heat supply sector development.

In Ukraine, the following key success factors, which have been demonstrated as drivers to a high quality, efficient and sustainable DHC service, are considered the most relevant:

- Support from international financial institutions and other donors in providing financing resources and technical assistance;
- Direct or indirect subsidies (e.g. investment grants, support schemes to RES, access to competitive debt funding);
- Leadership at the local level among the city councils and management of DHS

operators in developing modernisation projects and attracting financial resources;

Detailed information on DHS modernisation barriers for DHS modernisation and potential mitigation actions is presented in the table below.

Barriers	Mitigation actions
Technological barriers	
Limited capacity for the power grid connection for the implementation of combined heat and power projects.	Evaluation of own electricity consumption needs and selection of potential grid connection points for the assessment of feasibility of combined heat and power projects implementation.
Lack of sufficient territory and street infrastructure limitations for the organisation of biomass supply and storage.	Evaluation of biomass capacities construction at the sites with less restrained urban conditions. Studying the experience of other enterprises on biomass supply organisation under the similar urban development conditions.
Limited access to technologies and equipment, which would ensure efficient combustion of locally available renewable fuel, in particular straw, for heat energy generation.	Biomass boilers market studies and learning from the experience of other district heating companies. Cooperation with scientific institutions on optimisation of combustion process for local renewable biofuels.
Need to ensure compliance with air quality standards for the exhaust gases from biomass installations.	Inclusion of air quality requirements to the terms of references for project design documentation development and tender documentation. Conducting periodic monitoring of air quality control on emission sources with the involvement of accredited laboratory.
Capacity barriers	
Lack of sufficient expertise in setting up and servicing of equipment, which is being installed within the modernisation projects (e.g., set up of substations, operation of cogeneration units and biomass, boilers, heat pumps, etc.).	Attracting the representatives of equipment suppliers for training of the personnel at the stage of commissioning works. Attracting of independent experts for training of the personnel. Site visits to the operational facilities of other district heating companies for experience exchange. Conducting regular trainings and courses to increase capacity of the personnel. Ensuring a competitive level of salary for the workers of the DH enterprises.
Organisational barriers	
Complexity of organising stable biomass supply chain and reliable biomass logistic system for heat energy generation.	Evaluation of potential biomass supply sources and concluding preliminary agreements at early stages of biomass projects development.
Lack of transparent and competitive market for biomass (fuel) supply.	Support and advocacy of legislative and regulatory initiatives aimed at launching competitive biomass market.
Lack of dedicated structural units responsible for the preparation, development and supervision of	Creation of project implementation units with the support of international financial institutions.

Barriers	Mitigation actions
investment projects.	
Administrative barriers	
Large number of approvals within the project development process with the involvement of local state authorities (e.g. granting local guaranties for loans), regional authorities (e.g. attraction of funds from State Fund of Regional Development), and national authorities (e.g. approvals from the Ministry of Finance to attract funds from international financial institutions) with long and complicated procedures.	Dissemination of guidance and procedures on project development process, as well as conducting additional consultations and trainings.
Lack of long-term development strategies for DH systems both on local and national levels.	Participation in the development of local and national development strategies for district heating sector.
Economic barriers	
High volatility of biomass prices during the heating season and in medium-term perspective.	Support and advocacy of legislative and regulatory initiatives aimed at launching competitive biomass market.
Limited availability of own financial resources for the implementation of investment projects.	Development of public-private partnerships and attraction of private investors, in particular, in renewable energy projects.
Financial barriers	
Complicated access to financial resources due to the levels of heat energy tariffs, which are not sufficient to ensure cash flow required to cover operational expenses and debt servicing.	Changes of the regulatory base for heat energy tariffs establishment, in particular: (1) automatic correction of heat energy tariffs in case of changes in regulated prices of natural gas and electricity, as well as changes in minimal wages level, etc.; (2) possibility to include competitive salary levels in heat energy tariffs. Subsidies from the local budget to support operational expenses of the DH enterprises.
Significant debts for natural gas supplied by Naftogaz of Ukraine.	Debt restructuring and development of mechanism for future debt repayment.
Specific requirements of existing financing programs, in particular, with respect to minimal project size or use of innovative technologies for in demonstration projects.	Consultations with international financial organisations and other parties that could provide financing resources at early stages of project development and selection of modernisation measures, which would be in line with relevant eligibility conditions.

Assessment of impact

Austria

Increase of RES

In order to achieve the national targets of RES use, Austria has set the specific goals for the DH sector in accordance with the requirements of Article 24 of the revised Directive (EU) 2018/2001 on the promotion of the use of RES. These goals are defined in NECP and are set at 1% annual increase in the share of RES and excess heat and cold in district heating and cooling systems.

CO_2 emissions reduction

Pursuant to the binding GHG emission reduction regulation for Member States, Austria is obliged to reduce its GHG emissions in sectors outside ETS by at least 36% (till 2030, relative to the 2005 level). An important impact on sectoral GHG reduction is expected because of heat consumption reduction as a result of the building stock renovation and switching from fossil heating systems to renewables and highly efficient DH. In total, it is expected that CO_2 emissions can be reduced by 37.5% in this sector by 2030. The total reduction is expected to be 3 million tons of CO_2 equivalent. Two million of this reduction will be reached by replacing oil boilers with renewables and efficient DH.

However, the new government has announced in its government program that the NECP goals will be further tightened with the goal of climate neutrality by 2040.

Increase energy efficiency in the heat sector

According to Austria's NECP the goal is to increase the share of buildings using efficient DH for heating, hot water preparation and cooling, possibly in combination with a more flexible heating supply through buffer tanks or component activation. To achieve this goal, further investments into DHS infrastructure are planned.

Croatia

Increase of RES

According to the National Energy and Climate Plan (NECP), indicative targets by 2030 has been set for gross direct consumption of energy for heating and cooling. It is estimated that the share in 2020 will be 33.3%, while the goal for 2030 is 36.6% - with an annual increase of 0.3% from 2020 to 2030. However, goals are more ambitious in DHS sector where the Directive on the promotion of the use of energy from RES requires 1% of annual increase of renewables in the period 2021-2025; the increase in the period 2026-2030 will be compared to the share in 2020 and expressed as a share of final consumption in accordance to the prescribed methodology. This requirement shall be directly fulfilled if the heat production in cogeneration (CHP) is more than 60%. The estimated CHP share in Croatian DHS sector is 79% by which Croatia fulfils the requirement.

CO_2 emissions reduction

The Republic of Croatia ratified the Paris Agreement in May 2017 and shares the common EU goal which is the reduction of GHG emissions by at least 40% by 2030 compared to 1990 emissions. This goal is divided into two units – GHG emissions that are obligated parties of the ETS sector and those which are not (non-ETS sectors) such as households, services, road transport. In order to meet the requirements, Croatia has set the following targets (figures compared to the 2005 level): (a) in the ETS sector - at least 43%; (b) in non-ETS sector - at least 7%.

An important aspect of CO_2 emissions reduction is the increase in energy efficiency in DH sector. Several measures are already being implemented in the period until 2020 as part of State Aid Programme for increasing the efficiency of DHSs, and under the Operational Programme "Competitiveness and Cohesion 2014-2020", Priority Axis 4 "Promoting energy efficiency and renewable energy sources", specific objective 4c3 "Increasing the efficiency of heating system" through the mechanism of Integrated Territorial Investments. The expected effects are a reduction in losses in distribution systems by relative 4% at the national level by the end of 2023 and primary energy savings of 1 PJ over the same period. Beyond 2020, these savings will be relevant as it is expected that the reduction in losses in DHS sector will continue in the period until 2030 with the assistance of ESI funds.

Apart from direct reduction in DH sector, as a result of reduction of fossil fuel used and increase of energy efficiency in production and distribution systems, it should be mentioned that an important impact on sectoral GHG reduction is expected due to increase of energy efficiency in building stock. According to NECP Croatia, annual rate of renovation in the building stock will be increased from the current 0.7% to 3% in 2030 (the targeted average renovation rate for the period until 2030 is 1.6%).

Potential for the application of high-efficiency cogeneration and efficient district heating and cooling

Indicators of potential for use of high-efficiency CHP and efficient DHC are taken from the document "Programme for use of efficiency potential in heating and cooling for the period 2016-2030"[5] of November 2015, which was prepared for the Ministry of Economy (now the Ministry of Environment and Energy) in accordance with Directive 2012/27/EC, Art. 14, para.1. The established overall (theoretical) potential for high-efficiency CHP plants has been observed through two scenarios (conservative, optimistic), which differed in shares of future consumers coupled to DH systems with high-efficiency cogeneration. The conservative scenario was based on the share of DH consumers following the existing trend, whereas the optimistic scenario was based on assumptions of positive changes in the national economy. Key indicators for both scenarios are presented in the table below (Table HR2).

[5] https://ec.europa.eu/energy/sites/ener/files/documents/croatia_report_eed_art_141update_en.pdf

Table HR2: Key indicators for conservative and optimistic scenarios

Scenarios >>>		conservative	optimistic
Total heat demand (theoretical heat demand for 2030)	GJ	18,312,866	29,982,128
	MWh	5,086,907	8,328,369
Required heating capacity (theoretical)	MWth	3,178	5,262
Share of DHS consumers	%	30.1	55.0
Equivalent heat demand	GJ	5,506,528	16,625,599
	MWh	1,529,591	4,618,222
Equivalent thermal capacity	MWth	956	2,903
Potentially produced electricity	GJ	8,653,115	26,125,941
	MWh	2,403,643	7,257,206

Czech Republic

Increase of RES

National Energy and Climate Plan of the Czech Republic (NECP) sets specific targets for three main sectors: electricity, transport and heating & cooling (H&C), the expected dynamics of the RES share in these sectors until 2030 is shown in Figure CZ4.

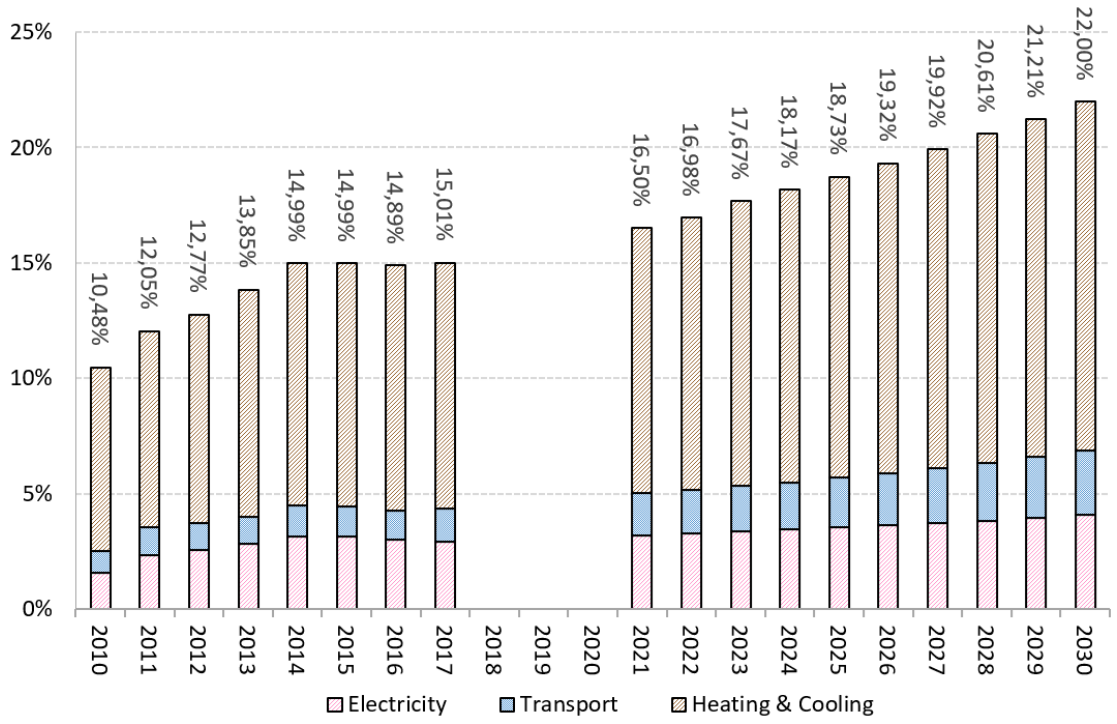

Figure CZ4: Estimation of the share of RES by 2030 divided into major individual sectors in 2010-2030 (source: NECP, January 2020)

NECP presumes the highest share of RES by 2030 in the H&C sector. As seen from the Table CZ4, an important share is expected to be covered by DHS, mainly supplying heat from biomass plants or waste to energy utilities.

Table CZ4: Estimated increase in RES utilisation in the H&C sector by 2030 (source:

NECP supporting documents, January 2020)

Heat source	Unit	Households (individual)	DHS
biomass – heat production	(TJ)	12 764,2	7 307,7
solar thermal	(TJ)	434,9	122,6
heat pumps	(TJ)	3 813,8	1 634,5
biogas (new plants) – heat production	(TJ)	N/A	344
biogas (currently used for electricity production) converted into biogas production (fed into gas infrastructure)	(TJ)	N/A	– 3 192
Waste-to-Energy plants – heat production	(TJ)	x	3 766,8
Geothermal heat	(TJ)	N/A	1 584
Sub-Total	(TJ)	17 013	11 567
Biomethane used in final consumption for heat production (via gas infrastructure)	(TJ)		8 834,2
Total increase in RES utilisation in H&C sector	(TJ)		37 414,2

CO_2 emissions reduction potential

Pursuant to the amended Act No 383/2012 Coll, investments leading to the reduction of GHG emissions, deployment of RES and increase of energy efficiency shall be supported through the Modernisation Fund (MF). The Act also provides for a certain share of the MF for investments in modernisation, diversification and decarbonisation of the power and heat sector, which are to be carried out by so-called electricity producers within the meaning of Article 3 of Directive 2003/87/EC and that these investments are to be given preference. The following main investment priorities can be identified:

- RES and energy accumulation in the heat sector: the expected support could reach up to CZK 11 billion, based on an assumed aid intensity of 50%. The estimated GHG savings amount to more than 2,1 million tCO_2 per year. A typical project could be the fuel switch from lignite/coal to biomass (boilers). Waste-to-energy projects are also considered a very promising way to reduce dependence on fossil fuels in DH sector (replacing existing lignite/coal boilers with waste-to-energy or SRF/RDF boilers). Energy storage is one of the inherent advantages of DH systems. Projects of this type involve the accumulation and storage of thermal or electrical energy which supports integration of RES into energy systems.
- Fuel switch from lignite/coal to natural gas (NG): the expected support could reach up to CZK 3,2 billion, based on assumed 50% aid intensity and the estimated GHG emission savings annually amount to more than 0,9 million tCO_2. The partial switch from lignite/coal to NG is an essential step towards a low-carbon transition as renewables are not sufficient and not feasible in all cases to replace coal. A typical project is based on the replacement of a lignite/coal boiler with a new NG boiler.
- DH networks and waste heat treatment: the support of CZK 8,4 billion is requested at an assumed average aid intensity of 50%. The estimated annual GHG savings amount to more than 0,2 million tCO_2. The steam DH networks urgently need to be refurbished, especially as this will reduce heat losses and facilitate fuel switch to RES.

Table CZ5: Estimation of the GHGs reduction potential in DHS (source: ADH CR database, January 2020)

Project types	Investments [mio CZK]	Estimated annual GHG reduction [mio tCO_2]
Renewable energy sources and energy storage	21,418	2,1
Fuel-switch from lignite / hard coal to NG	6,452	0,92
District heating networks and waste heat treatment	16,737	0,21
Total	44,607	3,23

Latvia

Increase of RES

Latvia already had a high share of RES in 2016-2017 (the third largest in the EU) and its further significant increase is burdensome. The share of RES in electricity and heating and cooling sectors is over 50%. The indicative share of renewable energy in the production of heating and cooling energy is 57,59% by 2030 (in 2017 it was 54,58%). In order to achieve the national RES targets - the share of energy produced from RES should reach 50% in gross final energy consumption by 2030[6] - specific targets for the DH sector (in accordance with the requirements of Article 24 of the revised EU Directive 2018/2001 on the promotion of the use of RES) have been set in the NECP and are defined at an annual increase of 0,55% in the share of RES in DH systems.

Latvia plans to increase the share of RES in heating and cooling supply by modernising and upgrading the installed capacity of biomass DH plants/boilers, by increasing the capacity of installed heat (and cold) pumps and by increasing the use of solar energy in heat generation.

CO_2 emissions reduction

Under the mandatory GHG emission reduction regulation / scheme for Member States, Latvia is obliged to reduce its GHG emissions in sectors outside the ETS by at least 13% (by 2030, compared to 2005 levels). The GHG reduction target for the energy sector (outside ETS) by 2030 is a 23% reduction in GHG emissions, where the main effect to be achieved through fuel substitution (natural gas to biomass) and increased integration of solar thermal in DH systems.

A significant impact on the sectoral GHG reduction is expected due to the reduction of energy consumption for heating as a result of building refurbishments and additionally by retrofitting the DH infrastructure. There are no specific targets or estimates on the impact of these renovations on emissions.

[6] National Energy and Climate plan 2030 of Latvia

Serbia

Increase of RES

The National Action Plan for the Use of Renewable Energy Sources (2013) predicts that the share of RES in total gross final energy consumption will increase from 21,2% in 2011 to 27,0% in 2020. In order to achieve this goal, the use of RES at the national level is to increase by 621 ktoe. Looking only at the H&C sector, the use of RES should increase from 1059 ktoe in 2009 to 1167 ktoe in 2020, which corresponds to an increase of 10,2% (108 ktoe). Plans for RES use in this sector amount to 149 ktoe, exceeding the target by 41 ktoe. One-third of the plan (49 ktoe) is to be implemented with new CHP units, one third (50 ktoe) with biomass in individual household heating, 16% (25 ktoe) with biomass in DHS, and the rest with biogas, geothermal and solar energy (no indication whether in DHS or for individual household heating). It should be noted, however, that these goals and plans are not mandatory.

Under the framework of the KeepWarm project, four DHS have been considered to build new wood-chips boilers with a total capacity of 27 MW (2x3 MW in Bajina Bašta, 1x3 MW in Nova Varoš, 1x8 MW in Priboj and 1x10 MW in Šabac). Table SRB1 summarizes the change in the amounts of various fuels considering the present state and the state after implementation of all four chosen cases (scenarios). It can be seen that the cumulative effect of the implementation of all four scenarios would lead to the substitution of around two-thirds of gas and practically all of oil and coal in these four DHS with wood chips, resulting in an overall increase of RES by 97,1 TWh. This amount represents approximately 87 toe and is even greater than the envisaged amount in the National Action Plan for the whole DHS sector. Considering the whole H&C sector in Serbia, the implementation of these four scenarios would potentially reach about 80,5% of the target set by the National Action Plan and even more than 14% of the total national target (621 ktoe - for all sectors).

Table SRB1: Use of various fuels, presently and after implementation of scenarios.

Type of fuel	Units	Present state	After scenario implementation	Difference
Gas	MWh	66036	24559	- 41477
Oil (mazut)	MWh	46632	709	- 45923
Coal	MWh	5081	0	- 5081
Wood pellets	MWh	1113	1113	/
Wood chips	MWh	/	97117	+ 97117
Total RES (wood)	MWh	1113	98229	+ 97117

The choice of biomass (as RES) to replace the fossil fuels currently used in the selected four DH systems has been made taking into account that this requires less investment than the installation of solar collectors or the use of geothermal energy and because biomass represents the greatest RES potential in Serbia (about 60% of the total RES potential, about one third is already used at present), as shown in Figure SRB3.

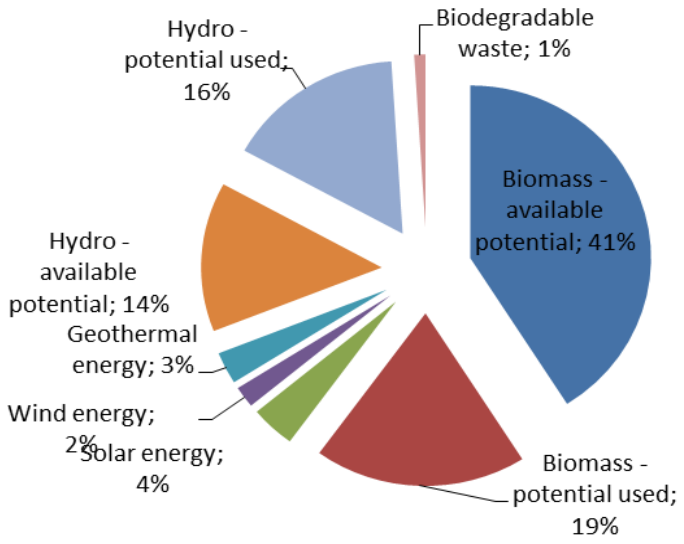

Figure SRB3: Renewable energy sources in Serbia

CO_2 emissions reduction

The Republic of Serbia has been engaged in the United Nations Framework Convention on Climate Change (UNFCCC) since 2001 and the Kyoto Protocol (Protocol) since 2008. As a non-Annex, I country (a developing country) it is required to report regularly on emissions, mitigation measures and adaptation in national communications and biennially updated reports.

Preparation of the National Climate Change Strategy, with an action plan, is in the initial phase and will provide a clear framework of activities in the fight against climate change during the period 2020 and 2030, as well as the framework for 2050. The draft of the Law on Climate Change is submitted for a public hearing. Two important novelties proposals may be highlighted at present. Firstly, this Law will enable the government to define limitations on GHG emissions (level of GHG emissions relative to a certain year), and secondly, plants emitting GHG will be obliged to obtain permits to operate.

The total GHG emissions in Serbia are in the order of 69000 Gg CO_2eq (without removals by sinks in forestry which are in the order of 18000 Gg CO_2eq). The energy sector contributes around 80% to overall GHG emissions. The GHG emissions from fuel combustion for energy production (a subsector of the energy sector which is most important for present analysis) amount to around 38 000 Gg CO_2eq. The CO_2 alone represents practically 99% of all GHG emissions.

If the modernisation of the four abovementioned DH systems will be fully implemented, the replacement of fossil fuels with biomass would result in annual savings in GHG emissions of 25,1 Gg CO_2eq (25079 tCO_2). Compared to the total GHG emissions of the whole DHS sector in Serbia (estimated in the Report for 2018 by the Association of DHSs in Serbia in the order of 1730 Gg CO_2eq) this represents 1,44% (compared to the total GHG emissions on the country level this represents around 0,066%).

There are no set goals or limitations regarding GHG emissions at the national level at present in Serbia, let alone for the DHS sector. Considering that these proposed modernisations of four

DHS have been well accepted by all stakeholders (most importantly by local government and DHS operators), it may be stipulated that even one third of all plants presently using fossil fuel may be substituted by new biomass boilers in the next 2 – 5 years. The main drivers supporting such scenario are: significant financial benefits (halving fuel costs if fossil fuels are substituted by biomass), replacement of critically old boilers is highly overdue anyway, global warming issues, and expected ban of the use of heavy oil in Serbia (around 12 - 14% of all heat produced in DHS). This would result in further cuts in GHG emissions in the order of 5500 Gg CO_2 eq.

A significant impact on the sectoral GHG reduction is expected due to the reduction in heat consumption resulting from the renovation of the building stock and additionally from the retrofitting of the DH infrastructure (focus on distribution networks) and the modernisation of the hardware and software of the control and monitoring systems. It is difficult to estimate the impact of these measures, but given the fact that the building stock in the cities is old and poorly insulated, it can be determined that between a quarter and a third of the heat can be saved, resulting in GHG emission savings in the order of 4500 - 5500 Gg CO_2eq.

The above may seem too optimistic, but this is not the case considering that the **National Sustainable Development Strategy** (Official Gazette of the Republic of Serbia, No. 57/2008) states that the reduction of heating energy consumption has the greatest potential for increasing energy efficiency (more than 50%) through improvements in building insulation and reducing electricity consumption for domestic heating.

Slovenia

Increase of RES

In order to achieve the national RES use targets, Slovenia has set the specific goals for the DH sector in accordance with the requirements of Article 24 of the revised Directive (EU) 2018/2001 on the promotion of the use of RES. These goals are defined in the NECP and are set at an annual increase of 1% in the share of RES and excess heat and cold in district heating and cooling systems.

CO_2 emissions reduction

Pursuant to the binding GHG emission reduction regulation for Member States, Slovenia is required to reduce its GHG emissions in sectors outside the ETS by at least 15% (by 2030, compared to 2005 levels). The GHG reduction target for the energy sector outside ETS by 2030 indicates a 34% reduction in GHG emissions, with the main impact coming from the gradual phasing out of the use of domestic and imported coal for energy production. It is expected that by 2023 at the latest, all black and brown coal will be replaced by natural gas or another less polluting source, leading to a significant reduction of CO_2 emissions in the DH sector.

A significant impact on the sectoral GHG reduction is expected due to the reduction in heat consumption resulting from the renovation of the building stock and additionally from the retrofitting of the DH infrastructure (including heat generation facilities). If the buildings refurbishment follows the advanced NEPN scenario, energy consumption in the DH sector

(assuming the same buildings are connected to the DHS; without extensions) is expected to decrease by 16% (compared to 2017) by 2030 (see Figure SI5). No specific targets have been given or estimates made for reducing losses in DH distribution networks.

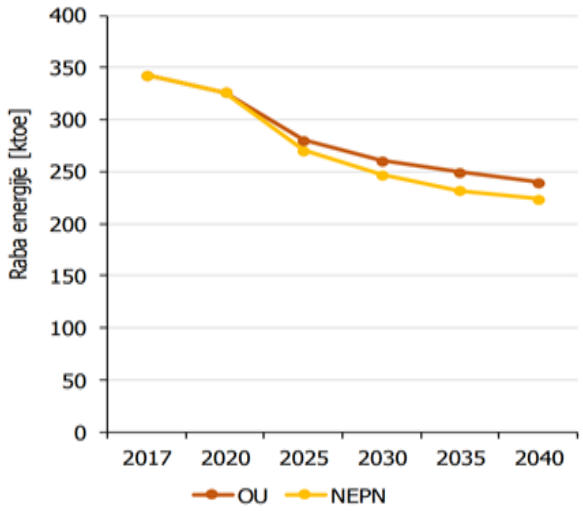

Figure SI5: The primary energy use in DH sector (scenarios: OU - with existing measures, NEPN - advanced measures). Source: NECP

Ukraine

The measures proposed in the Action Plan will contribute to the achievement of national and sectoral targets for energy efficiency, use of renewable energy and reduction of CO_2 emissions.

Energy efficiency

The concept of implementation of the state policy in the field of heat supply specifies the expected results of modernisation and improvement of energy efficiency of heat supply systems as the target 10% reduction of heat energy losses by 2035.

Increase of RES

In order to achieve the national RES utilisation targets, Ukraine has set an indicative target for the use of renewable energies in the DH sector. The goal is to achieve a 40% share of renewable energies by 2030.

CO_2 emissions reduction

There is no specific GHG emission reduction target for the DH sector. The NDC submitted to the UNFCCC Secretariat contains an economy-wide GHG emission reduction target to ensure that GHG emissions do not exceed 60% compared to 1990 levels.

Recommended actions aiming at DHS development and refurbishment

The main objective of this work is to define a set of actions in a format of Action Plan that fits in with broader national policy developments so that these actions can be taken forward in a coordinated way. The areas of recommendations for the majority of participating countries are structured as follows: (1) Visions, strategies and plans for heating (and cooling), (2) Supporting measures and technical guidance, (3) Planning and regulation and (4) Financing.

Austria

In Austria National Energy and Climate Plan (NECP) heating networks are considered an important element of the future energy system. In densely populated areas DHSs have proven to play a key role in the decarbonisation of the heating and cooling sector. But also in rural villages thousands of small biomass DH systems are very important for a renewable heat supply in rural areas. The most important role will be played by the 4th generation DHS, which is characterized by low operating temperatures, flexibility in operation, the possibility of combined heat and power generation (cogeneration), heat storage, integration with sectors of electricity generation, transport, and integration of RES and excess heat.

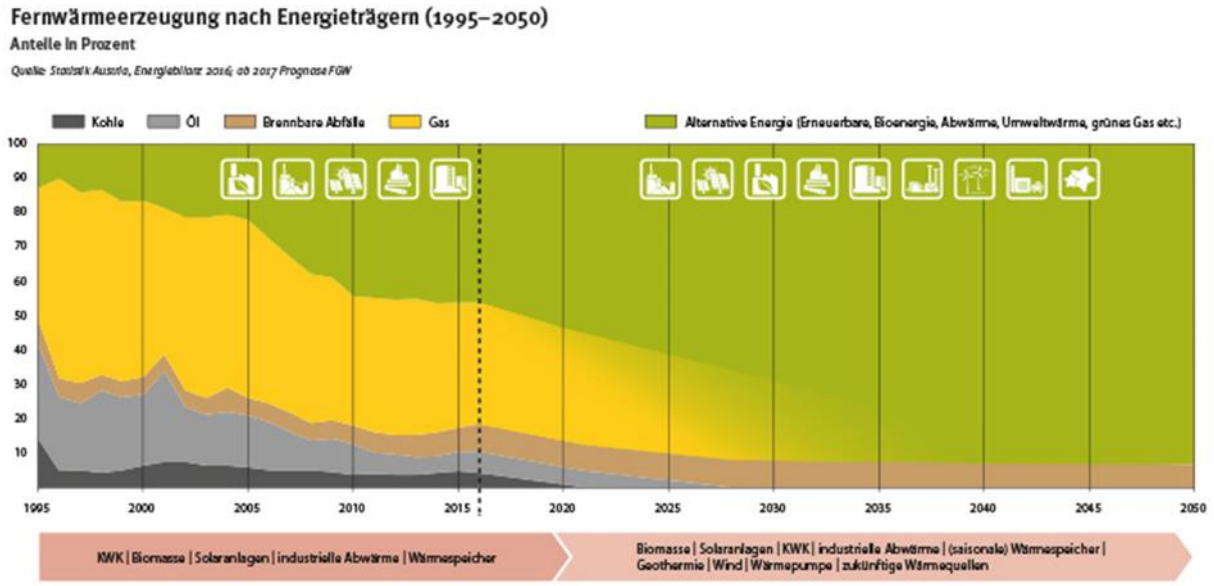

Figure AT5: Development of the primary energy sources for production of heat in DHS (CHP and boiler rooms) in Austria © FGW

According to the scenario, DHS energy sources will be almost 100% renewable by 2035. The structure of technologies and fuels in DHS follows the guidelines that lead to decarbonisation of the sector. The use of fossil fuels is decreases while the shares of RES and more efficient technologies - CHP and heat pumps - are increasing (Figure AT5). Gas will be less dominant and the remaining gas share will be covered by renewable “green” gas. Overall, DH will become more important in the heating sector. Although, the heat

demand of buildings will decrease due to energy efficiency improvements in renovation, the final energy demand of DH is expected to increase from 86 PJ at present to 98 PJ in 2030. All these trends indicate that all the challenges mentioned above need to be addressed in a systematic and thorough manner.

To meet energy and climate protection targets, DH facilities must become increasingly efficient, which is achieved through a mix of technologies such as better controls, insulation, heat recovery, provision of renewable energy such as biomass and waste heat. Each of these technologies has different benefits and it is clear that all will play a role in providing low carbon heat.

Strategic planning to support the introduction of DH was recognised as a top priority. However, the creation of new DHS and the development of existing ones is highly dependent on the political framework conditions. Hence, there is a need for a comprehensive national heat strategy. The strategy aims to reduce the heat demand in buildings and for production processes as well as to supply the heat required from renewable sources, with DH being a key source. Such a strategy must be comprehensive and include developments of energy requirements in the buildings sector, the electricity sector and developments in energy sources. In addition, concrete, district-specific medium to long-term planning is required in order to determine the future role of heating networks in relation to other types of heat supply and to provide investment security for heat suppliers. This basis should be developed in independent, structured and participatory processes. A local DH program must be embedded in a long-term strategy for heat supply, which in turn must be fed back into developments in energy transition at national level. Such a strategy must also include the development of an energy spatial planning which allows to give priority to specific energy sources in specific areas. The strategy and subsequent legislation should also provide, where technically and financially feasible, for compulsory connection to DH supply for new buildings and buildings replacing their heating systems.

The expansion of DH in connection with climate-neutral heat is necessary in order to quickly advance the heat transition, especially in densely populated urban areas. To reach Austria’s goal of being 100% carbon neutral in 2040, huge efforts are necessary to replace more than 600,000 oil and even more natural gas boilers. DH is a key element in urban areas and in villages in rural areas. In urban areas it is necessary to dense the grid and replace fossil based individual heating. In rural areas, densification of the grids of existing DHS is also necessary. In addition, there is a need of new small-scale DHSs. The goal till 2030 should be to build 500 new DH systems which will use RES, with the total heat power of around 500 MW.

Furthermore, in order to maintain and develop existing DH systems and to build new ones, it is necessary to support the future development of renewable DHS. Therefore, the national subsidy scheme for DH must be maintained and adapted in some aspects. It is essential to continue supporting the construction of new DH systems in rural areas. In addition, optimisations of energy efficiency must be supported more strongly. It is also necessary to subsidise consultancy and further training for DHS operators. The subsidy scheme must be simplified from a procedural point of view.

CHP is very important in Austria DH systems and will probably continue to play a role in the medium and long term, as newly installed biomass CHP plants offer advantages in CO_2 reduction. However, there is still a huge potential for retrofitting and upgrade of DHS with a small-scale biomass CHP plant (<500 kWel). There must be strategic governance and financial structures in place to drive long-term action. The current system, with reasonable tariffs, but very little budget, is not effective because operators have to wait years for implementation due to limited subsidies. Due to the large-scale and long-term investments, it is necessary to develop targeted financing mechanisms and business models that support a stable development of the DHS. Public and EU funding is inevitably crucial to accelerate renovations.

Beside these direct subsidies, government investment loans could boost the development of renewable DHS. Due to the high and long-term investments, these loans foster the creation of new investments. Furthermore, tax incentives for renewable DHS would take development to a new level. As an alternative or supplement to traditional investment support, an VAT exemption for renewable DH could be introduced for DHS customers. This would strengthen the position of renewable DH compared to other fossil options.

Decarbonisation of DH also means its expansion, which undoubtedly requires customer acceptance. Although surveys show that DH is already the most popular form of heating in Austria, much remains to be done to promote and publicize the benefits of DH for sustainable community development. Promotion campaigns and marketing activities are essential for the DH sector, as they help to inform the public and help them make the right decisions.

(1) Visions, strategies and plans for heating (and cooling)

No.	Action	Timing	Responsible stakeholder
1.1	Relevant national authorities (ministries) in collaboration with different stakeholders elaborating a clear heat strategy for Austria (*Where do we want to go?*), where a pathway for heating is set strategies and an Action plan elaborated (*How do we get there?*) for Heating and Cooling. At least period till 2040 shall be covered. With the goal of 100% carbon free heating and cooling till 2040. For each measure or action, it is important to set the responsible body, the timing (start-end, major milestones), the cost estimation and financing/source as well as the indicators for monitoring.	2020-2021	Ministry of climate action, environment, energy, mobility, innovation and technology (BMK)
1.2	Relevant regional authorities (federal states) in collaboration with different stakeholders elaborating a clear heat strategy for Austria (*Where do we want to go?*), where a pathway for heating is set strategies and an Action plan elaborated (*How do we get there?*) for Heating and Cooling. The federal state of Styria elaborated a strategy till 2030. With the goal of increasing the efficiency of DHSs in Styria, increasing the share of renewables and the utilisation of excess heat. An Action plan how to handle these goals has to be elaborated.	2020-2021	Federal State of Styria, Department 15 – Energy, housing and technology
1.3	Relevant national authorities (ministries) in collaboration with the DH industry and other stakeholders to establish a clear vision (*Where do we want to go?*), set strategies and elaborate Action plan (*How do we get there?*) for District Heating and Cooling. At least period till 2040 shall be covered to comply with Austria heat strategy.	2020-2021	BMK

No.	Action	Timing	Responsible stakeholder
	For each measure or action, it is important to set the responsible body, the timing (start-end, major milestones), the cost estimation and financing/source as well as the indicators for monitoring.		
1.4	Provision of Heat mapping is one of the short-term plans which will allow local authorities to identify the source of both heat supply and demand and identifying if the circumstances are appropriate for potential DH projects (construction, extension, refurbishment). It is expected that heat maps will contribute effectively to local decisions on heat networks and at the same time support national strategies and targets. The existing heat maps will be expanded by GIS data of each DHS and their grid. This action will allow a detailed energy spatial planning on national, regional level and on municipalities	2021-2025	BMK, Federal states, Municipalities
1.5	Considerable potential for heat generation can be expected on the basis of renewable energies. It is recommended to build at least 500 new renewable DHS in urban as well as in rural areas of Austria till 2030. Therefore, relevant economic and legislation framework has to be set.	2020-2030	BMK, Municipalities, DH operators
1.6	In addition to renewable energies, the possible use of industrial/commercial waste heat should be examined in a structured manner and further promoted. The establishment of a (national) waste heat register is recommended.	2021-2023	BMK
1.7	Relevant national authorities will foster sector coupling. The CHP potential of DH will be forced through a long-term CHP and DH strategy. The creation of renewable CHP plants will be supported by the elaboration of a renewable energy expansion law. This will cover feed-in tariffs for renewable CHP. DHS will upgrade will CHP units.	2020-2021	BMK, Ministry of finance (BMF)

(2) Supporting measures and technical guidance

No.	Action	Timing	Responsible stakeholder
2.1	Adaption of the OIB 6 directive about energy saving and thermal insulation. The CO2 emission factor of the directive for DH will be reduced to a realistic value. This considers the increased share of renewables in DH in recent years and brings advantages against fossil options with high CO2 emissions.	2020-2022	Federal states, Institute for construction technology
2.2	Equalisation of grid law in district heating networks with other grid-bound energy sources such as electricity and gas. This will promote the efficient expansion of district heating grids and increase the coverage area.	2021-2022	BMK, DH associations
2.3	Ban of the installation of new fossil oil boilers and gas boilers in new buildings and planning of a phase-out of existing fossil boilers in existing buildings.	2021-2035	BMK
2.4	To investigate the potential for integration of large-scale excess heat recovery, biomass or ambient heat - in conjunction with DH. To develop the support programme for implementation of the most viable applications	2020-2022	BMK, Austrian Biomass Association, Federal States
2.5	Capacity-building (trainings and education) and awareness raising campaigns increase capacities of various stakeholders – from DH operators, municipalities to associations, local legal experts and manufacturers – to learn from each other.	2020-2030	DH Associations, Biomass Association, Chamber for commerce,

No.	Action	Timing	Responsible stakeholder
			Chamber for forestry and agriculture, Federal states
2.6	Awareness raising through promotional campaigns in order to attract the general public and trigger policy-making plans favourable to DH.	2020-2030	BMK, Federal and regional Energy Agencies, DH Associations, Biomass Association, Chamber of commerce, Federal states

(3) Tax adjustments

No.	Action	Timing	Responsible stakeholder
3.1	The national authorities need to give tax incentives for district heating to foster the conversion of fossil individual heaters. A VAT exemption on grid connection costs and on heat prices of renewable DH gives and advantage against fossil options. Furthermore, prices of renewable DHS are attractive for potential customers.	2021-2024	BMK, BMF
3.3	Tax exemptions and tax-free allowances on investments support the further development, building and optimisation of DHS.	2021-2030	BMK, BMF
3.3	The proper definition/setting of a CO2 tax on fossil fuels for individual heating would make heating solutions based on heating oil and natural gas boilers considerably less attractive and would thereby increase the attractiveness of heating network solutions. Taxes for fossil fuels in DH also need to be examined, aiming at appropriate price signalling which will stimulate more investments in renewable heat generation. The interaction with GHG emissions trading, which larger DH producers are subject to, must be also considered.	2023-2025	BMK, BMF

(4) Financing

No.	Action	Timing	Responsible stakeholder
4.1	Provide necessary funding for the sustainable retrofitting of DH systems aiming at increased efficiency and competitiveness (optimisation of operation, expansion of networks), increasing the use of RES and excess heat, promotion of CHP in DH systems; sectoral integration (e.g. by energy storage, “power2heat” and micro-grids).	2020-2022 (2030)	BMK, BMF, Environmental subsidy in Austria office (KPC), EU (Rural Development plan)
4.2	Co-financing programme (financial incentives) for investments in new DH using wood biomass systems and micro-systems, as well as the expansion of existing DH systems and the construction of new boiler rooms containing wood biomass boilers or solar systems as a source for existing DH.	2020-2030	BMK, BMF, Environmental subsidy in Austria office (KPC), EU (Rural Development plan)

No.	Action	Timing	Responsible stakeholder
4.3	Introduction of government grants to finance renewable energy projects. Investments in renewable DH are very high. With government supported loans at a fixed rate and some repayment-free years investments in renewable DH will be more easily funded.	2021-2030	BMK, BMF, Environmental subsidy in Austria (KPC)
4.4	Adaptions in the existing funding system makes simplifies the process and fosters the creation of new systems, as well as the optimisation of existing ones. Smaller optimisations and extensions will be funded unbureaucratic. Planned projects in rural areas get more easy funding criteria as well as an increased local renewable bonus. To increase the capacity of operators also training courses will be subsidised.	2021-2030	BMK, BMF, Environmental subsidy in Austria office (KPC)

Croatia

In the National Energy and Climate Plan (NECP) heating networks are considered as an important element of the future energy system. In densely populated areas, DHS have proven to play a key role in the decarbonisation of the heating and cooling sector. The most important role will play the 4th generation DH systems, characterized by low operating temperatures, flexibility of operation, the possibility of cogeneration of heat and electricity, storage of heat, integration with sectors of electricity generation, transport, as well as integration of RES and excess heat.

In order to meet the energy and climate protection targets, DH installations will increasingly need to be more efficient, achieved through a mixture of technologies such as better controls, insulation, heat recovery, delivering renewables such as geothermal and solar and, as we decarbonise the electricity grid, electric heating such as heat pumps. Each of these technologies has different advantages and all will have a role in delivering low carbon heat.

Strategic planning as support to uptake of DH has been recognised as top one of the top priorities. Creation of the refurbishment and development programme in heat supply depends heavily on developments in the electricity sector and the development of energy requirements in the building sector due to future renovation strategy (increase of energy efficiency). In addition, the concrete, district-specific mid- to long-term planning is required in order to determine the future role of the heating networks in conjunction with other types of heat supply and to create investment security for the heat suppliers. A local district heating program must be embedded in a long-term strategy for heat supply, which in turn must be fed back with the developments in the energy transition at the national (and EU) level.

The expansion of DH in connection with climate-neutral heat is necessary in order to quickly advance the heat transition, especially in the densely populated urban areas. CHP is core of Croatian DH sector and is likely to continue to have a role in both the short and medium term with benefits of newly installed gas CHP plant in reducing CO2, however, decarbonisation efforts require that DH systems will need to source a much higher proportion of heat from more low carbon sources such as solar energy, excess (industrial) heat, heat pumps and biomass. The expansion of heating (and other district energy)

networks is necessarily a process that the respective stakeholders must control. Without active management and support from the public authorities, the necessary investment security for long-term investments in the network infrastructure is at risk.

DH in Croatia is to a large extent based on cogeneration of heat and power (CHP) fired by natural gas as presented above. The funding conditions for high-efficient cogeneration are among the most important factors when making investment decisions for DH. So far, the funding conditions for CHP have been significantly more attractive than for other climate-neutral heat generation options, hence a design of (CHP) subsidising policy needs to be reconsidered, aiming at the integration of renewable energies and waste heat in the heating market. There must be strategic governance and financial structures to drive long-term action. 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. Apart from CHP, other technologies have to be included as well with special focus on geothermal and solar energy.

Leveraged investment in district energy projects shall involve supporting cities to identify funding opportunities and the business models to bring projects to market. Investments demonstrate agreement between city governments, investors and consumers, with directly attributable benefits, including GHG emission reductions, improved air quality, green jobs and improved access to sustainable energy. A number of funding streams which can ensure initial development funding for public and private sector resource efficiency, including specific DH support have to be provided.

Decarbonisation of DH means also its expansion which undoubtfully requires customer acceptance. Much remains to be done in promoting and raising awareness of DH benefits for sustainable community development. This shall help overcome the lack of good practices and positive examples which hinder motivation of consumers to connect to DH as an alternative. Promotion campaigns and marketing activities are essential for the DH sector, helping to inform the public and make the right decisions.

A list of existing legal framework in the Republic of Croatia is given below:

- Act on the thermal energy market
- General Terms and Conditions of Thermal Energy Supply
- General Terms and Conditions of Thermal Energy Delivery
- Network Rules of Thermal Energy Distribution
- Rules on the method of cost allocation and billing for thermal energy delivered
- Decree on the amount and method of payment of a concession fee for heat distribution and a concession fee for the construction of heat distribution energy facilities
- Methodology for determining tariff item amounts for thermal energy production
- Methodology for determining tariff item amounts for thermal energy distribution
- Energy Act
- Tariff system for electricity generation from renewable energy resources and

cogeneration

- Decree on incentive fee for electricity generation from renewable energy resources and cogeneration
- Rules governing the use of renewable energy resources and cogeneration
- Renewable Energy Sources and High-Efficiency Cogeneration Act
- Environmental Protection and Energy Efficiency Fund Act
- Energy Sector and Investment Monitoring Centre Act
- Energy Efficiency Act
- Decree on contracting and implementation of public sector energy service
- Rules of systematic public sector energy management

Also, measures relevant for heating sector (not all measures are applicable in DH sector) are derived from existing legislation and presented in the table below. These measures are important to be reconsidered in a process of creating proposals for change of legislation regarding promotion of DH sector in the Republic of Croatia

Name of the measure	Document / Legislation	Description
Feed-in tariffs and a system of premiums to support the use of renewable energy sources in electricity generation and for highly efficient cogeneration	Act on RES and COE (OG Nos. 100/15, 123/16, 131/17, 111/18)	The main mechanism for the development of renewable energy sources has so far been supportive pricing. It is expected that this system of stimulation will continue in the forthcoming period for 500 kW plants. The Act on Renewable Energy Sources and Highly Efficient Cogeneration introduced an incentive scheme through premiums.
Promoting the use of renewable energy sources and energy efficiency through the Croatian Bank for Reconstruction and Development (CBRD)	Plan for Air Protection, Ozone Layer Protection and Climate Change Mitigation in the Republic of Croatia (OG No. 139/13)	The objective of the loan programme for environmental protection, energy efficiency and renewable energy projects is the realisation of investment projects aimed at environmental protection, improving energy efficiency and promoting the use of renewable energy sources. Loans are intended for investment in land, buildings, equipment and devices. The final loan beneficiaries may be units of local and regional self-government, utility companies, companies, small businesses and other legal entities.
Promoting the use of renewable energy sources and energy efficiency through the funds of the Environmental Protection and Energy Efficiency Fund	Plan for Air Protection, Ozone Layer Protection and Climate Change Mitigation in the Republic of Croatia for the period 2013-2017 (OG No. 139/13)	Funds for financing are secured from the dedicated revenues of the Fund paid by environmental polluters, which include fees for carbon dioxide emissions, fees for burdening the environment with waste, environmental user fees and special environmental fees for motor vehicles. Renewable energy projects for which the Environmental Protection and Energy Efficiency Fund grants funds include solar energy, wind energy, biomass, energy from small hydropower plants and geothermal energy.

Name of the measure	Document / Legislation	Description
Use of biogas for electricity and heat generation.	Plan for Air Protection, Ozone Layer Protection and Climate Change Mitigation in the Republic of Croatia for the period 2013-2017 (OG No. 139/13)	The measure is associated with measure "Feed-in tariffs and premium system for the support of the use of renewable energy sources in electricity generation and for highly efficient cogeneration".
Reconstruction and renovation of hot water pipelines and steam pipelines	Heat energy distribution	Aging and damaged hot water and steam pipelines result in high losses of energy. Investments in the forthcoming period are secured by utility companies and through ESI Funds within the OPCC in the amount of EUR 80 million. This measure is planned to be implemented in the next period (2021 – 2030) in NECP.

(1) Visions, strategies and plans for heating (and cooling)

No.	Action	Timing	Responsible stakeholder
1.1	Relevant national authorities (ministries) in collaboration with the DH industry and other stakeholders to establish a clear vision, set strategies and elaborate Action plan for Heating and Cooling. At least period till 2030 shall be covered, if possible, with the view until 2050. For each measure or action, it is important to set the responsible body, the timing (start-end, major milestones), the cost estimation and financing/source as well as the indicators for monitoring.	2020	Ministry of Economy and Sustainable Development (MESD)[7], HEP Toplinarstvo (DHS owners), Energy Agencies
1.2	Authorities (at national and local level) to support goals by setting targets for a public sector estate (covering a wide range of organisations at national and regional level) being connected to a DH systems (e.g. by 2030) where there are public buildings located in areas practically and commercially viable for DH. This will depend on a number of factors including heat density in an area, vicinity of fuel sources particularly where renewable energy is an option and the comparative costs of heating. Refurbishment and maintenance of DH systems and networks has high impact on long-term competitiveness of DH. The review should also highlight where public buildings can provide key anchor loads to catalyse implementation of heat networks.	2020-2021	MESD, Ministry of Regional Development and EU Funds (MRRFEU), Municipalities / Cities
1.3	Provision of Heating (and Cooling) maps is one of the short-term plans which will allow local authorities to identify the source of both heat (and cooling) supply and demand and identifying if the circumstances are appropriate for potential DH projects (construction, extension, refurbishment). It is expected that heat maps will contribute effectively to local decisions on heat networks and at the same time supporting national strategies and targets. This action will be a part of (national) Heating and Cooling Strategy support programme which is intended to support local authorities in	2020-2022	MESD

[7] The new Ministry was created in the recent mandate of the Croatian Government.

No.	Action	Timing	Responsible stakeholder
	developing DH strategies and heat planning. (Remark: This action was included in the NEEAP8 and the draft NECP9.)		
1.4	Considerable potential for heat generation can be expected on the basis of (shallow) geothermal energy. It is recommended to explore this potential in more detail (if not explored) and to use it as soon as the relevant economic framework is in place.	2020-2022 (2025)	MESD
1.5	According to Analysis of heating sector and utilisation of geothermal potential in Urban Agglomeration Zagreb[10], develop a long-term strategy of integration of geothermal energy in heat production of DH sector in the Urban Agglomeration Zagreb.	2020-2025	MESD, City of Zagreb, Zagreb County
1.6	Long-term heat storage is a key element for the decarbonisation of heating networks, hence detailed examination of the site conditions to build thermal storage facilities has to be carried out at the municipal/city level.	2021-2022	MESD, HEP Toplinarstvo
1.7	In addition to renewable energies, the possible use of industrial waste/excess heat should be examined in a structured manner and further promoted. The establishment of a (national) waste heat register is recommended.	2021-2022	MESD, MRRFEU, Energy agencies
1.8	Establish a clear strategy for integration of heat prosumers in collaboration with DH industry in order to start developing this technological concept where remote (RES) systems such as solar thermal fields can produce renewable energy and feed it in heat distribution network. (Remarks: Pilot sites need to be identified and relevant demonstration projects have to be selected and implemented.)	2020-2022	MESD

(2) Supporting measures and technical guidance

No.	Action	Timing	Responsible stakeholder
2.1	Establishing the body which co-ordinates support for DH development across a number of national and local programmes and develops a DH strategy programme for local authorities to help accelerate the growth of heat networks. The coordination body shall have the following roles: (1) Strategic planning, (2) Knowledge and best practice sharing (technical, financial, project development aspects), (3) Identification of collaborative opportunities, (4) Leading the Heat mapping initiative, (5) Identification of funding opportunities and financial support, (6) Technical advice and support. Remarks: (1) This body can be part of or related to the s.c. Committee for inter-sectoral coordination for policy and measures for mitigation of and adaptation to climate change, which is proposed (by draft NECP) to be established. (2) Progress in developing DH infrastructure can be expected if dedicated (loan) funds are formed to drive the sector going forward. See Funding)	2020-2021	MESD
2.2	Establish a national support programme (at governmental level) for local authorities to develop a strategic approach to DH and supporting use of the relevant tools (e.g. heat mapping). This can include creation of permanent expert team or service supporting DH	2021-2022	MESD

[8] https://ec.europa.eu/energy/sites/ener/files/hr_neeap_2017_en.pdf

[9] https://mzoe.gov.hr/UserDocsImages/UPRAVA%20ZA%20ENERGETIKU/Strategije,%20planovi%20i%20programi/hr%20necp/Integrated%20National%20Energy%20and%20Climate%20Plan%20for%20the%20Republic%20of_Croatia.pdf

[10] https://www.zagreb.hr/UserDocsImages/gu%20za%20strategijsko%20planiranje/ANALIZA%20SEKTORA%20TOPLINARSTVA-UAZ-Studija.pdf (in Croatian)

No.	Action	Timing	Responsible stakeholder
	development and co-ordinating exchange and sharing of good practice for a period of 5 years, reflecting the long development cycles of district heating projects and their implementation in practise.		
2.3	In the existing large centralized heating systems, a large source of losses is the deteriorated distribution network, and this measure foresees the continuation of the replacement of deteriorated steel hot water pipes and steam lines with new pre-insulated pipes and a technological shift towards the fourth generation of district heating. In smaller systems with their own boiler room, it is necessary to allow for the reconstruction of boiler rooms, by replacing them with high-efficiency cogeneration systems, systems using heat pumps or by technologies which use RES. The measure also envisages the development of new heating and cooling systems, which use high efficiency cogeneration or renewable energy sources. In view of the provisions of Directive 2018/2002 on energy efficiency, and in particular with the introduction of the obligation of individual measurement at the level of the end-user, district heating systems have become systems with variable heat demand, which requires the introduction of advanced metering systems as an additional step towards the integration of different energy systems and increasing overall energy efficiency. (Remark: this measure is included in NECP).	2021-2030	MESD, HEP Toplinarstvo
2.4	Investigate the potential for connecting smaller DHS (if exist on a local level – cities) into a single DHS if analyses show positive techno-economic indicators. This measure should contribute to sustainable development of DH sector in terms of reduction of fossil fuel usage and boost of renewable energy usage potential.	2020-2021	Energy Agencies, Research Institutions
2.5	The individual use of renewable energy at the very locations of its transformation or direct use (building) brings with it several potential technical, economic and logistical problems such as vacancy, usability and transportation. The distribution of heat through centralized systems enables the exploitation of various sources, the production of energy in suitable locations, and a sufficiently high energy flux density to satisfy densely populated urban areas. Therefore, a potential for integration of smaller DHS using RES in rural areas should be investigated in order to develop a strategy for development of DH sector in rural areas.	2020-2022	MESD, MRRFEU
2.6	To investigate the potential for integration of large-scale heat pump applications, excess heat recovery, geothermal or solar energy – in conjunction with DH. To develop the support programme for implementation of most viable applications.	2020-2021	MESD
2.7	Provision of standardised legal and contractual document templates for DH projects can take advantage of replication of good practises.	2021	MESD, HERA
2.8	In order to achieve high level of customer acceptance which is prerequisite for further development and expansion of DH, the improving of legal framework is required to protect consumer interests and to increase transparency.	2020-2022	MESD, HERA
2.9	A modular support (complementary market incentive) program is proposed, in which the different parts of a heating network (heat generators, heat storage, heat pipes, house heat transfer stations) or measures at customer facilities can be supported independently	2021-2023	

No.	Action	Timing	Responsible stakeholder
	of each other. It would be based on the provision of a network transformation plan, which must justify the reason and significance of measures.		
2.10	Capacity-building (trainings and education) and awareness raising campaigns bring together various stakeholders – from city officials to real estate developers, local legal experts and business owners – to learn from each other.	2020-2030	MESD, Energy Agencies, Research Institutions
2.11	Awareness raising through promotional campaigns in order to attract the general public and trigger policy-making plans favourable to DH.	2020-2030	MESD, REGEA

(3) Planning and regulation

No.	Action	Timing	Responsible stakeholder
3.1	The national authorities need to create guidance on both national and local aspects of planning for district heating. Local authorities should designate areas based on heat maps where district heating would be the presumption for new developments or refurbishments. These local heat planning processes should be used to examine the potential for expanding the heating networks and converting the heating networks to renewable energies. Development plans should consider the benefit of allocating and co-locating heat supply and demand, and should support heat networks where they are possible, particularly if they implement low carbon solutions through renewables.	2021-2022	MESD, Municipalities / Cities
3.2	The national authorities shall establish support to the municipalities in heat planning in various ways with central services, in particular by helping with the procurement of funds, guidelines for municipal heat planning, training and the creation of inter-municipal data, e.g. “heat maps”, “waste heat register” (industry and trade), possible areas for large open-space solar thermal systems, potential for geothermal energy, building and energy-related data.	2020-2030	MESD, Local/Regional authority units
3.3	To require producers of significant amounts of heat to investigate options for capture and use of their waste heat and to facilitate the supply of waste heat to a network where this is economically viable. This shall apply to all electricity generation and industrial plants, which need to be required to carry out a cost benefit analysis on heat use. DH networks will also need to carry out a cost benefit analysis where potential industrial heat sources are available.	2021-2030	MESD, MRRFEU
3.4	Trainings on district heating planning issues for planning practitioners and other stakeholders need to be organised.	2021-(2030)	MESD, Energy Agencies, Research Institutions
3.5	To cope with the space requirements that the conversion of the heat supply to renewable energy entails. This concerns the supply of biomass, open space solar heat, geothermal energy (underground surface resources), the access of large heat pumps to large heat sources as well as the expansion of renewable electricity generation for the operation of heat pumps.	2020-2022 (2030)	MESD, Ministry of Construction and Physical Planning (MCPP)

No.	Action	Timing	Responsible stakeholder
3.6	The proper definition/setting of a CO_2 tax on fossil fuels for individual heating would make heating solutions based on heating oil and natural gas boilers considerably less attractive and would increase the attractiveness of heating network solutions. Taxes for fossil fuels in DH also need to be examined, aiming at appropriate price signalling which will stimulate more investments in renewable heat generation. The interaction with GHG emissions trading, which larger DH producers are subject to, must be also considered.	2021-2022	MESD, Ministry of Finance

(4) Financing

No.	Action	Timing	Responsible stakeholder
4.1	The national (government) and local (municipal) authorities to support the development of new business models for refurbishment and expansion of heat networks.	2020-2022	MESD, MRRFEU
4.2	Provide necessary funding for the sustainable retrofitting of DH systems aiming at increase of efficiency and competitiveness (optimisation of operation, expansion of networks), increasing the use of RES and excess heat, promotion of CHP; sectoral integration (e.g. by energy storage and “power2heat”), etc.	2020-2022 (2030)	MESD
4.3	An incentive framework is needed that supports investments in climate-neutral heat, allowing adequate (quantitatively limited) support for the remaining heat generated by CHP that can’t be ensured by RES or waste heat in a short term. (*Remark: Related actions were included in the NEEAP.)*	2020-2030	MESD
4.4	Co-financing programme (financial incentives) for investments in new DH using RES and extension of support for modernisation of heat distribution networks.	2020-2030	MESD

Czech Republic

National Energy and Climate Plan (NECP) stipulates DHS as essential energy infrastructure for the efficient use of heat from renewable and secondary energy sources that cannot be obtained and used separately at the level of individual buildings (less valuable biomass, biogas from bio-waste, geothermal energy, waste heat from industrial processes, etc.). The use of locally available heat sources contributes to the decentralisation of energy, reduces dependence on imports of fossil fuels and strengthens the local economy.

The county has a developed network of DH systems, which need to be progressively converted to use low-carbon energy sources, including waste heat, and efficient energy transmission to consumers, especially in urban agglomerations.

In particular, the increased RES use in existing heat supply systems will be crucial for achieving national 2030 targets. The Czech Republic therefore intends to support, in particular, the modernisation of existing heat supply systems to meet the requirements for efficient heat supply systems under the EED. However, there is also scope for creating new (particularly smaller) heat supply systems based on RES, for example using heat from biogas plants, which today mostly serve as electricity generation facilities, but generate a

considerable amount of heat produced from RES. The solution could be the conversion of existing biogas power plants to bio-methane plants and the use of bio-methane for CHP in place using heat.

The State Energy Policy (approved in 2015) sets the target of covering at least 20% of the supply of thermal energy from DHS by RES until 2040. The Figure CZ5 shows the expected development of the heat supplied by DHS and the share of RES (27% shall be reached until 2040). The graph explicitly expresses the contribution of biogas or bio-methane, which emphasizes that Czech Republic counts on a partial contribution of biogas within the DHS heat.

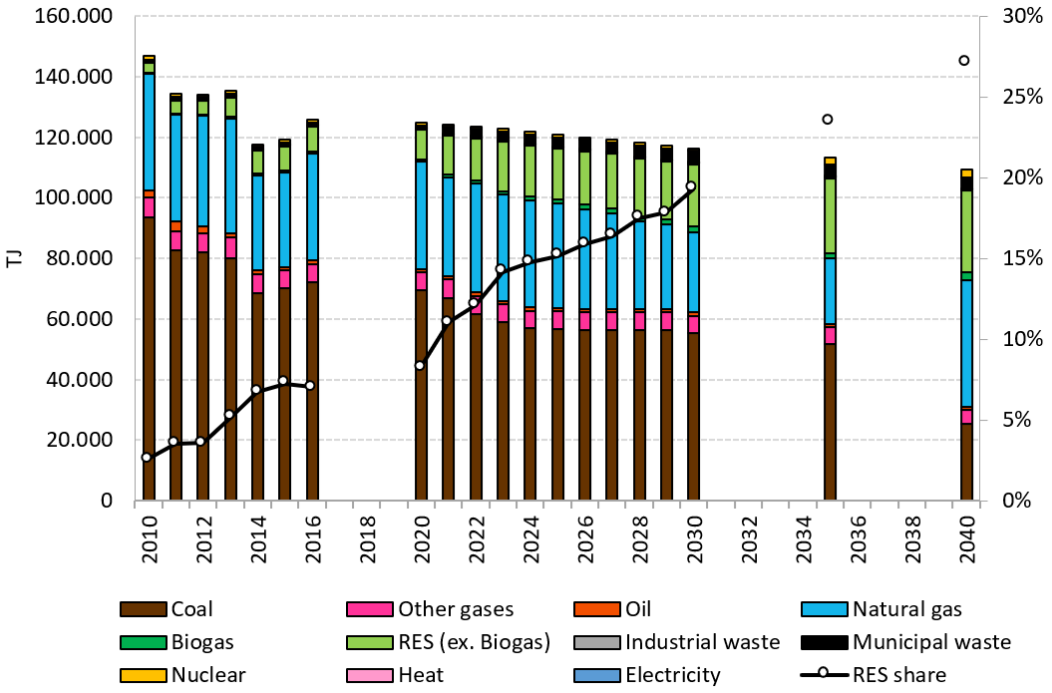

Figure CZ5: Energy mix for DH supply and share of RES in the period 2010-2040 (source: NECP, January 2020)

NECP stipulates that particular emphasis should be given to the Renewable Energy Community ('energy community'), which brings the economic, environmental and social benefits on a local and national scale. The participation of citizens and local authorities (e.g. municipalities) in energy community projects creates significant added value in terms of local acceptance of RES and access to private capital. Its development is accompanied by local investment, greater choice for consumers and increased citizen participation in energy transformation. Above all, the participation of citizens and local authorities in energy community is associated with the desirable increase in renewable energy production and the emphasis on energy savings. Energy community can thus become an important element for meeting the goals of the Czech Republic in some areas.

The measures listed below to support and develop the DHS have been derived from the NECP for the period 2021-2030.

(A) Supporting actions

No.	Action	Timing	Responsible stakeholder
A.1	Promotion of electricity from high-efficiency cogeneration The scope of support will continue to be determined for all cogeneration plants on fuel neutral basis. Aid for electricity from CHP will not be announced if other operating aid is declared for a given type of primary energy sources - for example, if operational support for electricity from RES and operational support for electricity from secondary energy sources is listed, then support for electricity from CHP will only be announced for non-RES. The plant will only receive one type of operating aid. The form of support will be applied to new electricity generating plants by an annual green bonus, divided into electricity generating plants, which will compete with the amount of the aid in the auction. For sources up to 1 MW, the support will be provided in the form of an annual green bonus officially set out in the ERO's price decision and for sources over 1 MW, support will be provided by auction competition in the form of an “auction bonus”. A new support period will be set for electricity generators from high-efficiency cogeneration for a lifetime (15 years).	after 2020	Ministry of industry and trade (MPO) /Energy Regulatory Office (ERO)
A.2	Support of heat from renewable energy sources The scope of the aid will be intended for the construction of new biogas, biomass and geothermal power plants and to compensate for the fuel costs of renewable energy compared to the fuel costs of non-RES in the case of biomass and geothermal energy. The form of support will be determined by an annual green bonus. The support period for the construction of new biogas plants, biomass and geothermal energy, will be fixed for the lifetime (20 years). The period of support in the case of so-called maintenance support (to keep plant in operation after expiration of the support) will be set at least 3 years from the announcement of the support in the Government Decision.	after 2020	MPO/Government
A.3	Support for electricity to keep the power plant in operation The aid is intended to offset the difference between the price of biomass and the price of solid fossil non-RES fuels for biomass-fired power plants or operating costs and the market price of electricity and heat for a high-efficiency CHP power plant, and power plant using secondary energy sources. The form of support will be determined by an hourly or annual green bonus. The support period will be set at least 3 years from the announcement of the support in a government order and further if the same market situation applies, i.e. operating costs and biomass price are higher than the market price of solid fossil non-RES fuels or market price of electricity and heat.	after 2020	MPO/Government
A.4	Support for heat to keep the heat production plant in operation For heat generating plants, the same principle and rules as for the above-mentioned electricity support for maintaining the plant in operation will apply. In the case of support for heat for maintaining the heat production plant in operation, this support will also apply to the co-incineration of RES and non-RES, i.e. the transition from support to electricity to support of heat. The form of support will be determined by the annual green bonus for this support.	after 2020	MPO/Energy Regulatory Office (ERO)
A.5	Auction bonus support This form of support stems from the State Aid Guidelines for the	after 2020	MPO/Energy Regulatory Office

No.	Action	Timing	Responsible stakeholder
	Environment and Energy for 2014 to 2020, which will very likely be used for the period 2021 to 2030 and responds to the revised RES Directive. In both EU regulations, there is an obligation to compete in auction from certain threshold (usually installed electricity output). Therefore, a mandatory auction bonus is introduced to support electricity from RES for generators with a capacity of over 1 MW (for wind turbines with an output of over 6 MW or 6 units) and for installations using cogeneration and secondary energy sources with an output of over 1 MW. In the case of electricity generating plants from RES, the so-called reference price is competing, in the case of CHP and secondary energy sources plants, the auction bonus directly competes. In the case of a CHP and secondary energy sources electricity generating plant, the electricity producer is thus granted a directly competitive annual auction bonus, and in the case of a RES electricity generating plant, the producer is provided with an auction hourly bonus set as the difference between the reference price and the hourly electricity market price.		(ERO)

(B) Tax adjustments

No.	Action	Timing	Responsible stakeholder
B.1	The proper definition/setting of a CO_2 tax on fossil fuels for individual heating would make heating solutions based on heating oil and natural gas boilers considerably less attractive and would increase the attractiveness of heating network solutions. Taxes for fossil fuels in DH also need to be examined, aiming at appropriate price signalling which will stimulate more investments in renewable heat generation. The interaction with GHG emissions trading, which larger DH producers are subject to, must be also considered.	2021-2022	MESD, Ministry of Finance (MFCR)

Latvia

In National Energy and Climate Plan (NECP) DH systems are considered as an important element of the present and future energy system. They have proven to play a key role in the decarbonisation of the heating and cooling sector. The overall objectives of the NECP regarding the development of the DHS by 2030 are as follows: DH systems should explore and implement the transition to RES based technologies (especially non-emission technologies), increased number of connections to DH networks, increased use of DH systems and centralized cooling systems, etc.

The main problems that need to be addressed and the situation improved in the coming years are: 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); outdated heat generation and supply infrastructure of existing DH systems; low shares of RES utilisation; densely populated areas without DHS; low rate of new connections to DHS; prejudice towards DHS (e.g. “costly, inefficient, obsolete heating mean”, etc.), non-existent DH cooling, etc.

According to the NECP target scenario, the total heat supplied by DHS in expected to be 4,7% lower in 2030 than in 2017. The target scenario envisages further replacement of NG

by solid biomass, with the aim of increasing the use of RES in thermal energy generation by about 58% by 2030. Compared to the baseline scenario, only the amount of heat energy from RES is increasing slightly in the target scenario. The Figure LV4 shows the heat supplied by DHS by different sectors - by 2030 it is expected to increase in the commercial and public sectors, but to remain at the same level in the sector of the largest consumers - households. Figure LV5 shows the use of RES until 2030.

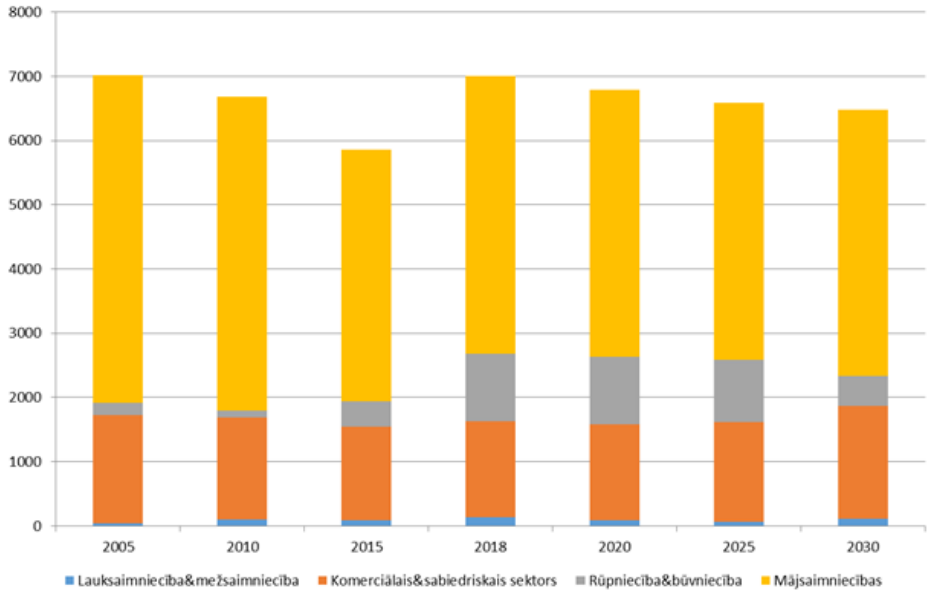

Figure LV4: Heat (in GWh) supplied by DHS per sectors (blue – Agriculture & Forestry; dark orange - Commercial & public sector; grey - Industry & Construction; light orange - Households), source: NECP Latvia

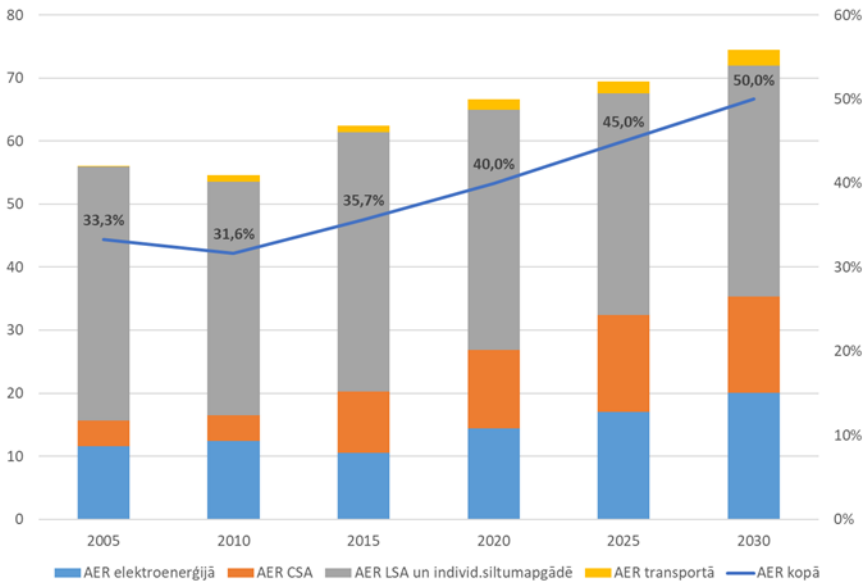

Figure LV5: The target scenario forecasts until 2030: the amount of RES (PJ, left axis), the share of RES in final energy consumption (right axis) (blue – RES in electricity; dark orange - RES in DH; grey – RES in local heating and individual heating; light orange – RES in transport)

Assessing the economically available potential of RES and the measures planned to promote the use of certain types of renewables (wind, solar, biomass, biogas), the share of RES in total final energy consumption in the target scenario is expected to be 50% by 2030.

As a result of the planned policies and measures, the share of heat produced from RES is expected to be 58% by 2030 (Figure LV6). To achieve this target, a significant share of natural gas will have to be replaced by biomass.

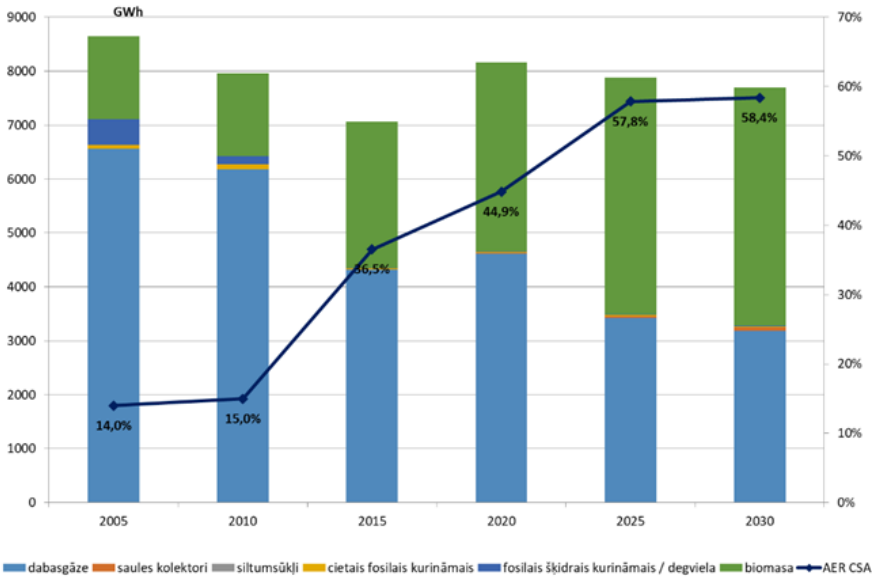

Figure LV6: The planned structure of the DH and the share of the RES in DH (left axis – GWh, right axis –%) (light blue – natural gas; dark orange – solar collectors; grey – heat pumps, light orange – solid fossil fuel, dark blue – fossil liquid fuel, green – biomass)

In order to achieve the abovementioned targets of LV NECP, the following main actions are recommended:

(1) Visions, strategies and plans for heating (and cooling)

No.	Action	Timing	Responsible stakeholder
1.1.	Implementation of the principle: energy efficiency first[11] – assessment of possibility to include in territory development planning documents: • an obligation to assess, before planning and investment decisions are taken, whether the measures envisaged are, in whole or in part, interchangeable with cost-effective, technically, economically and environmentally friendly alternative measures which equally effectively ensure that the objectives are achieved; • burden-effective alternatives include measures that make energy demand and energy supply more efficient, particularly through means such as cost-effective energy end-use savings, demand response initiatives and more efficient energy transformation, transmission and distribution;	2020-2030	Ministry of Economics (EM); Ministry of Environmental Protection and Regional Development (VARAM)

[11] Horizontal planned policies and implementing measures of LV NECP:H1

No.	Action	Timing	Responsible stakeholder
	• the obligation to include an assessment in the relevant development planning or policy planning document.		
1.2.	Review Energy Responsibilities Scheme to promote energy efficiency improvement measures among large energy suppliers and energy consumers[12]	2020-2030	EM
1.3.	Strengthening agreements on energy efficiency, the use of RES and the promotion of energy efficiency services and simultaneous support for the conclusion and implementation of agreements.[13]	2020-2030	EM
1.4.	To promote the use of RES and improve the energy efficiency in district heating. To adjust DH systems for provision of cooling the buildings.[14] Ensure elaboration of the necessary Regulations of the Cabinet of Ministers to ensure that the following activities are implemented: • improving the energy efficiency of DHS consumers evaluated, performed or scheduled together with investments in DHS infrastructure; • upgrading existing DHS capacities; • transition to electricity as a heating resource for DH where it is cost-effective and reasonable; • reconstruction of DH networks by reducing losses (in medium-sized cities where there is still potential); • adaptation of existing DHSs infrastructure for provisions of cooling in buildings; • building an efficient centralised cooling infrastructure, achieving GHG emissions savings compared to an alternative local cooling solution; • the introduction of a centralised cooling supply for the use of RES; • providing energy storage facilities for DHS companies.	2020-2030	EM

(2) Supporting measures and technical guidance

No.	Action	Timing	Responsible stakeholder
2.1.	Studies or surveys to be carried out to introduce efficient heating and to reduce emissions, considering the conditions for improving air quality, in order to[15]: • state and local government buildings identified in large cities, as well as residential buildings with individual heating facilities, assessed whether the building is technically and legally feasible and economically justified to be connected to the DHS; • assess the possibility for owners of such buildings or parts thereof (a legal person such as a State or local authority, an association of apartment owners, an operator) to review the applicable tax conditions; • developing guidelines for the economic justification of the connection to the DHS.	2025	EM, VARAM
2.2.	Where appropriate, develop an appropriate legislation to ensure, even after 2021, the transition to low temperature DH systems and	2021	EM

[12] Horizontal planned policies and implementing measures of LV NECP:H2
[13] Horizontal planned policies and implementing measures of LV NECP:H3
[14] Horizontal planned policies and implementing measures of LV NECP: Direction of action 2.2 (No. 1.4.).
[15] Horizontal planned policies and implementing measures of LV NECP: Direction of action 2.2 (No. 2.1., 2.2.)

No.	Action	Timing	Responsible stakeholder
	the integration of waste energy within the EU Structural Funds and other sources of funding.	-2022	
2.3.	To assess options for improving the heat supply market[16]: to elaborate the relevant financial mechanisms.	2024	EM

(3) Planning and regulation

No.	Action	Timing	Responsible stakeholder
3.1.	Legislation acts limiting use of fossil fuels, except where fossil fuels are used in a limited amount as an admixture or where such equipment is used as a backup for the maximum load or for equipment operated in the event of an emergency, as well as considering the need to comply with the regulatory enactments and conditions governing air quality.	31.12.2022	EM, VARAM
3.2.	The relevant legislation to be elaborated to ensure: the installation of non-emission technologies or biomass combustion plants (taking into account the need to comply with air quality legislation and conditions).	31.12.2030	EM

(4) Financing

At present it is not possible to determine a possible indicative share of the national budget, including co-financing for the implementation of the identified measures, as the conditions for the EU Structural Funds allocation for the period after 2021 have not yet been approved. According to recent announcements by the Ministry of Economic Affairs, DH companies will be able to receive subsidies in accordance with National Development Plan. A special Operational Programme "Use RES and Improvement of Energy Efficiency in Local and Individual Heating and Cooling" is expected to be available within the new EU funding period 2021-2027, the amount allocated for the improvement of heating systems is expected to be EUR 65 million.

Serbia

Many national strategic documents (energy sector development strategies and implementation and action plans at national, regional and local level) highlight the following aspects of district heating: modernisation and expansion of existing DH systems to increase energy efficiency in the generation, transport, distribution and use of heat, reduction of the share of liquid fuels and coal, and increased use of RES and CHP. The National Sustainable Development Strategy recognizes that heat generation has the highest potential increasing energy efficiency compared to all other energy activities. Unfortunately, no (quantitatively defined) targets are set or specific plans provided for the modernisation of the DH sector.

On the basis of the national Energy Sector Development Strategy[17], the following sectoral

[16] Horizontal planned policies and implementing measures of LV NECP: Direction of action 2.5 (No. 2.3.)
[17] 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)

(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 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.

The abovementioned strategy includes the indicative plan for investment in DHS heat generation and distribution, which is summarized in Table SRB2.

Table SRB2: Data on planned investments in the DHS sector

Field of investment	by 2020	by 2025	by 2030
Reconstruction, modernisation and construction of heat sources	90	50	75
Rehabilitation of distribution network	105	50	70
Rehabilitation of heating substations	45	30	35
Cumulative investment (mio EUR)	240	370	550

The document Decree on Establishment of Implementation Program of the Energy Sector Development Strategy of the Republic of Serbia for the Period to 2025 Year with Projections to 2030, specifies several major projects related to the use of waste heat (from thermal power plants), transition to RES, flue gas heat recovery, improvement of the control systems, new CHP plants, rehabilitation of the DHS network, new compact substations, etc.

The Strategy and the Program for the Implementation of the Strategy and all APs for EE envisage to further encourage and strengthen the energy management system, SEM, established by the Law on Efficient Use of Energy (Official Gazette of the Republic of Serbia, No. 25/13). All local self-government units with over 20 thousand inhabitants and all industrial plants that consume more than 2,5 ktoe/year, and among them 21 heating plants are liable for this system and as such are obliged to save 1% of primary energy, and to do so, through Annual Reports, inform the Ministry of Mining and Energy (MRE), as well as to prepare planning documents: Energy Efficiency Plans and Programs.

In the main national document regarding energy efficiency, the Third Action Plan for Energy Efficiency in the Republic of Serbia for the Period up to 2018, it is stressed that main reasons for low efficiency are outdated DHS distribution systems, heat plants and heat exchangers, and insufficient use of recycled heat. Thus, promoted are projects for reconstruction (rehabilitation) and modernisation of these systems (specifically stated 8 such projects). Additional measures for the support of DHS are stipulated: (1) Preparation

of heating and cooling strategy with support for local planning (heat maps, etc.), (2) Stabile financing of the CHP support scheme. Regarding the use of RES, the National renewable energy Action plan (NREAP) sets the following main activities (again without quantification) for the use of RES until 2020 and methods of their implementation: (1) Replacement of heating oil, coal and natural gas used for heating with biomass and other RES; (2) Introduction of DH systems based on the use of RES and CHP.

The introduction of measuring heat consumption of end-users and applying the tariff system according to the heat consumed is also one of the specified priority actions. In order to support the implementation of the above-mentioned activities, economic incentive measures and actions are stipulated, e.g. supporting instruments for heat generation from RES and highly efficient CHP, provision of guidelines for supporting the production of heat from RES at the local level, direct financial stimulations and corresponding taxation policies. It should be noted that the Ministry of Construction, Transport and Infrastructure has initiated the development of a Long-Term Strategy for Encouraging Investments in the Reconstruction of the National Fund of Buildings, which should be finalized by the end of October 2020.

However, nearly all plans and goals in these documents are defined only qualitatively and there is a lack of planning activities that could yield more precise goals and plans. There is a lack of local district heating programs which then could be embedded in the long-term strategy for heat supply.

Strategic planning to support the uptake of DH has been recognized as a top priority. This is especially important, also considering the extreme air pollution that is increasing in the last winter seasons. State and local government officials (notably the Minister of the Environment) have often stressed the need to connect individual users to DHS to reduce the pollution caused by inefficient individual furnaces fuelled by poor quality wood or coal. In addition, larger and professionally-maintained boiler plants with high stacks replace a large number of individual heating systems with low stacks and often poorly controlled combustion and pollutant emissions.

The creation of a refurbishment and development program in heat supply depends heavily on developments in other energy sectors such as the electricity sector and the development of energy requirements in the building sector. Local DH programs must be embedded in a long-term strategy for heat supply, which in turn must be fed back with the developments in the energy transition at the national level.

(1) Visions, strategies and plans for heating (and cooling)

#	Action	Timing	Responsible stakeholder
1.1	Formulation of a clear vision (where do we want to go?). This action implies setting up strategies and elaborated Action plans (How do we get there?) for Heating and Cooling. At least period till 2030 shall be covered, if possible with a view until 2050. For each measure or action, it is important to set the responsible body, the timing (start-end, major milestones), the cost estimation and financing/source as well as the indicators for monitoring.	2021	Ministry of Mining and Energy (MME), Ministry of Construction, Transport and Infrastructure (MCTI)

#	Action	Timing	Responsible stakeholder
	In preparation: MME has started drafting the Integrated Energy and Climate Plan of the RS (NEKP), which should cover the period from 2021 to 2030, including projections until 2050, to ensure compliance with long-term goals at the level of the European Union (EU). Part of this plan will also apply to SDG.		
1.2	Setting targets and road maps for upgrading insulation of the public sector buildings, as well as for incentive and support actions for individual and commercial housing owners. The public sector should include both the national, regional and local levels. Planning should consider a period of at least up to 2030. In preparation: in the coming period, MME plans, in addition to the EE Budget Fund, which subsidizes the public sector, to establish an ENERGY EFFICIENCY FUND as a separate institution. The work of this Fund will be directed towards both citizens and the public sector.	2020 - 2021	MME, MCTI, Municipalities
1.3	Creation of Heat maps. This action will be a part of a (national) Heating and Cooling Strategy support programme with the aim to support national strategies and targets and help local authorities (according to the recommended methodology) to identify the source of both heat supply and demand and identifying if the circumstances are appropriate for potential DH projects (construction, extension, refurbishment). It is necessary to pass a new Law on Thermal Energy or the Law on the Operation of District Heating Systems, which will enable the thermal energy market	2020-2022	MME, MCTI, Municipalities/ Local self-government units
1.4	Evaluation of (shallow) geothermal energy potential. This action will be a part of a (national) Heating and Cooling Strategy support programme to support national strategies and targets. The Law on Mining should be amended so that in the administrative sense, it is easier to use geothermal energy, especially in the case of its use with heat pumps. (Remark: Pilot sites need to be identified and relevant demonstration projects have to be selected and implemented.)	2020-2022	MME, MCTI, Municipalities /Local self-government units The University of Belgrade, Faculty of Mining and Geology, Institute of Geology
1.5	Selection and examination of long-term heat storage sites. Heat storage is one of the key elements for the decarbonisation of heating networks. This action should be carried out at the municipal level, but motivation and guidance should come from national bodies.	2021-2022	MME Municipalities /Local self-government units
1.6	Evaluation of industrial/commercial waste heat potential that may be used in DH, along with promotional, incentive and support measures for such usage. The establishment of a (national) waste heat register is recommended.	2021-2022	MME, MCTI, Municipalities /Local self-government units

(2) Supporting measures and technical guidance

#	Action	Timing	Responsible stakeholder
2.1	Establishment of a body which co-ordinates support for DH development.	2020-2021	MME, MCTI, Ministry of Environmental

#	Action	Timing	Responsible stakeholder
	The coordination body shall have the following roles: (1) Strategic planning, (2) Knowledge and best practice sharing (technical, financial, project development aspects), (3) Identification of collaborative opportunities, (4) Leading the Heat mapping initiative, (5) Identification of funding opportunities and financial support, (6) Technical advice and support.		Protection (MEP), Business Association of Heating Plants of Serbia-TOPS
2.2	Establishment of a national support programme at the national level for the development of the DH sector, with access to the Budget Fund for Energy Efficiency Improvement. The intention is to assist the local authorities to develop a strategic approach to DH and supporting the use of the relevant tools (e.g. heat mapping). This can include the creation of a permanent expert team or service supporting DH development and co-ordinating exchange and sharing of good practice for a period of 5 years, reflecting the long development cycles of district heating projects and their implementation in practice.	2021-2022	MME, MCTI, Business Association of Heating Plants of Serbia-TOPS, Public Investment Management Office (PIMO)
2.3	Evaluation of the potential for integration of large-scale heat pump applications in conjunction with DH. This action will be a part of a (national) Heating and Cooling Strategy support programme with the aim to support national strategies and targets. Analysis of possible full/partial exemption from network charges, as well as other specific incentive measures, should be incorporated.	2020-2021	MME, MCTI, Ministry of finance (MF)
2.4	Improvement of the legal framework related to the protection of consumer interests and transparency. The intention is to achieve a high level of customer acceptance which is a prerequisite for further development and expansion of DH.	2020-2022	MME, Energy Agency
2.5	Introduction of tax incentives for district heating to foster the conversion of fossil individual heaters. A VAT exemption on grid connection costs and heat prices of renewable DH gives an advantage against fossil options.	2021-2024	MME, MEP, MF, Energy Agency
2.6	Introduction of tax exemptions and tax-free allowances on investments to support further development, building and optimisation of DHS.	2021-2030	MME, MF, Energy Agency
2.7	Capacity-building (training and education) and awareness-raising campaigns. Apart from training and teaching specific groups and categories of individuals, the intention is to bring together various stakeholders – from city officials to real estate developers, local legal experts and business owners – to learn from each other.	2020-2030	MCTI, MME, Standing Conference of Towns and Municipalities, Business Association of Heating Plants of Serbia-TOPS
2.8	Awareness-raising through promotional campaigns. The main intention is to attract the general public and trigger policy-making plans favourable to DH.	2020-2030	MCTI, Energy Agency

(3) Planning and regulation

#	Action	Timing	Responsible stakeholder
3.1	Adoption of guidelines on national and local aspects of DH planning. Local authorities should designate areas based on heat maps where district heating would be the presumption for new developments or refurbishments. These local heat planning processes should be used to examine the potential for expanding the heating networks and converting the heating networks to renewable energies. Development plans should consider the benefit of allocating and co-locating heat supply and demand and should support heat networks where they are possible, particularly if they implement low carbon solutions through renewables.	2021-2022	MCTI, Municipalities, Energy Agency, Energy Management System (SEM)
3.2	Adoption of methods of support to the municipalities in heat planning. The main goal is to ensure the involvement of central services in various ways, in particular by helping with the procurement of funds, guidelines for municipal heat planning, training and the creation of inter-municipal data, e.g. “waste heat register” (industry and trade), possible areas for large open-space solar thermal systems, the potential for geothermal energy, building and energy-related data.	2020-2030	MCTI, MME, Municipalities
3.3	Ensuring that producers of significant amounts of heat regularly investigate options for capture and use of their waste heat and to facilitate the supply of waste heat to a network where this is economically viable. This shall apply to all electricity generation and industrial plants, which need to be required to carry out a cost-benefit analysis on heat use. DH networks will also need to carry out a cost-benefit analysis where potential industrial/commercial heat sources are available.	2021-2030	MCTI, Municipalities
3.4	Specific trainings on district heating planning issues for planning practitioners and various stakeholders. These trainings are significantly more advanced than before mentioned capacity-building efforts and awareness campaigns. This is especially in the case when targeted are planning practitioners in which case even certificates may be foreseen.	2021-(2030)	MCTI, MME, Business Association of Heating Plants of Serbia-TOPS
3.5	Introduction of carbon pricing in Serbia. This legislation should cover the whole energy sector but our interest is focused on the heating/cooling sector. The proper definition/setting of a CO2 tax on fossil fuels for individual heating would make heating solutions based on fossil fuels considerably less attractive and would thereby increase the attractiveness of renewables. If carbon taxes are specified for each sector separately, the heating/cooling sector should be in the privileged group.	2021-2022	MME, MEP, MF, Energy Agency

(4) Financing

#	Action	Timing	Responsible stakeholder
4.1	Support activities for the development of new business models for the delivery, refurbishment and financing of heat networks. One possible business model is ESCO, which can be developed as a not-for-profit Energy Service Company which can tackle fuel	2020-2022	MCTI), MME, MF, Towns and Municipalities/Local

#	Action	Timing	Responsible stakeholder
	poverty, cut carbon emissions and create new jobs. New models should be investigated such as modified ESCO models in which the DHS itself finances individual households in their activities to improve the energy efficiency of their buildings. Public-private partnership (PPP) arrangements should also be investigated. The implementation of public-private partnership, i.e. the ESCO mechanism, is regulated by the Law on Efficient Use of Energy from 2013. The amendments to the same law, whose adoption procedure is in progress, prescribe the form of the energy service contract.		authorities, DHS
4.2	Provision of necessary funding for the sustainable retrofitting of DH systems aiming at increased efficiency and competitiveness (optimisation of operation, expansion of networks, increasing the use of RES and excess heat, promotion of CHP in DH systems, etc.).	2020-2022 (2030)	MME, MCTI, Energy Agency, Public Investment Management Office, Ministry of European Integrations (MEI)
4.3	Securing incentive framework that supports investments in climate-neutral heat, allowing adequate (quantitatively limited) support for the remaining heat generated by CHP that can't be ensured by RES or waste heat in a short term, and other.	2020-2030	MCTI, Energy Agency, MEI
4.4	Establishing a co-financing programme (financial incentives) for investments in new DH using wood biomass (DHWB) systems and microsystems, as well as the expansion of existing DHWB systems and the construction of new boiler rooms containing wood biomass boilers or solar systems as a source for existing DH.	2020-2030	MME, MCTI, Public Investment Management Office

Slovenia

In Slovenia National Energy and Climate Plan (NECP), heating networks are considered an important element of the future energy system. In densely populated areas, DHS have proven that they play a key role in the decarbonisation of the heating and cooling sector. The most important role will be played by the 4th generation DH systems, which are characterized by low operating temperatures, flexible operation, the possibility of cogeneration of heat and electricity, heat storage, integration with sectors of electricity generation, transport and integration of RES and excess heat.

According to the NECP scenario, the energy consumption in DHS will be reduced by 28% between 2017 and 2030. Despite the encouragement of the connection of multi-family buildings and buildings of the service sector to the DH network, the significant reduction in energy consumption will be mainly due to the implementation of energy renovation of buildings. The structure of the technologies and fuels in DHS follows the guidelines that lead to the decarbonisation of the sector. The use of fossil fuels is decreasing, while the share of RES and more efficient technologies - CHP and heat pumps - are increasing (Figure SI6). All these trends and the long-term implications of solutions show that all the above challenges need to be addressed systematically and thoroughly.

In order to achieve the energy and climate protection targets, DH installations must become

increasingly efficient, which is achieved through a mixture of technologies such as better control, insulation, heat recovery, provision of renewable energy sources (such as geothermal, solar and biomass) and excess heat as we decarbonise the electricity grid, electric heating such as heat pumps. Each of these technologies has different advantages and it is clear that all will play a role in providing low carbon heat.

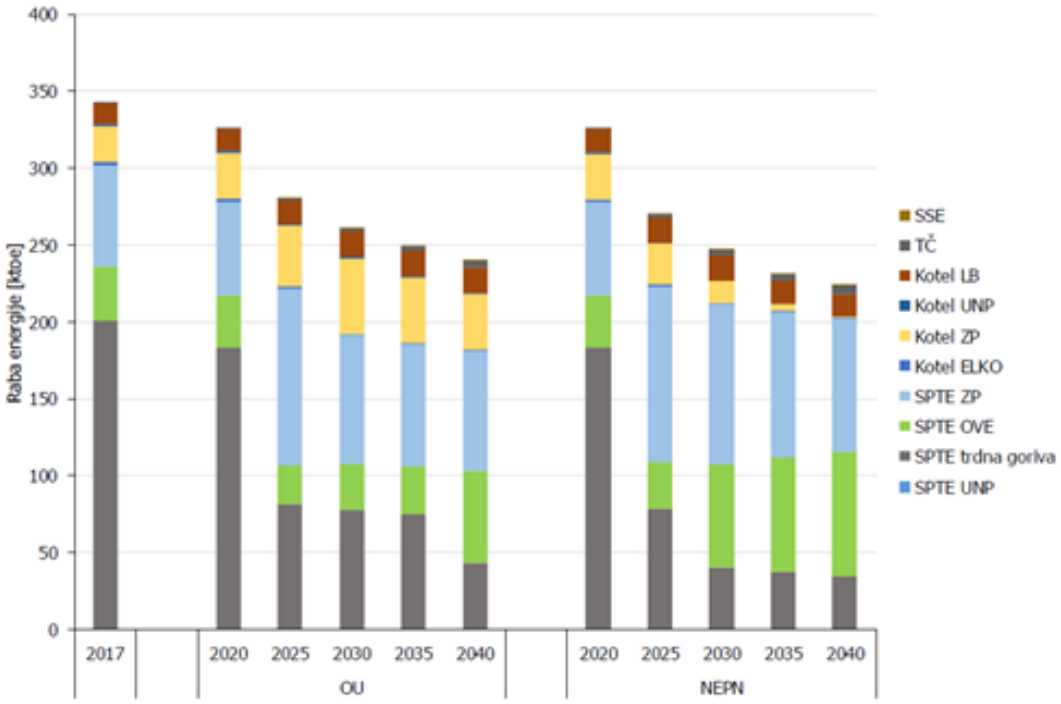

Figure SI6: Energy projection and structure of technologies and fuels for the DH – scenarios: OU (existing measures), NEPN (advanced measures) (source: NECP, February 2020)

Strategic planning to support the introduction of DH was recognised as a top priority. The creation of a refurbishment and development programme in the heat supply sector is strongly dependent on developments in the electricity sector and the evolution of energy requirements and demand in the building sector. In addition, concrete, district-specific medium to long-term planning is required to determine the future role of heating networks in conjunction with other types of heat supply and to provide investment security for heat suppliers. This basis should be developed in independent, structured and participatory processes in the municipalities that are supported by the energy industry. A local/regional district heating programme must be embedded in a long-term strategy for heat supply (e.g. within the framework of local energy concepts), which in turn must be fed back into developments in energy system transformation at national (and EU) level.

The expansion of DH in conjunction with climate-neutral heating is necessary in order to quickly advance the heat supply transition, especially in densely populated urban areas. Natural gas CHP is very common in Slovenian DH systems and is likely to continue to play a role in both the short and medium term, with the advantages of newly installed gas cogeneration plants in reducing CO_2 emissions. However, decarbonisation efforts require

that DH systems will need to obtain a much higher share of heat from more low carbon sources such as excess (industrial/commercial) heat, heat pumps and biomass. The refurbishment and expansion of heating networks (and other district energy networks) is necessarily a process that must be managed and controlled by the municipality concerned. Without active management and support by the municipality, the necessary investment security for long-term investments in the network infrastructure is at risk.

DH in Slovenia is largely based on cogeneration of heat and power (CHP), in particular fired by coal and natural gas. The financing conditions for cogeneration are one of the most important factors in investment decisions for DH. So far, the funding conditions for CHP have been significantly more attractive than for other climate-neutral heat generation options, so that the design of (CHP) funding (subsidising) policy must be reconsidered with the aim of energy efficiency and the integration of renewable energies and waste heat into the heat market. There must be strategic governance and financial structures in order to push forward long-term measures. Due to the extensive and long-term investments, it is necessary to develop targeted financing mechanisms and business models that support a stable development of DHS. Public and EU funding is inevitably crucial to accelerate renovations.

When investing in district energy projects, the aim is to help cities identify financing opportunities and business models for the market introduction of projects. Concrete investments demonstrate agreement between city governments, investors and consumers, with directly attributable benefits, including GHG emission reductions, improved air quality, green jobs and improved access to sustainable energy. A range of funding streams must be provided to ensure initial development financing for public and private sector resource efficiency, including specific support for DH sector.

Decarbonisation of DH means not only retrofitting and optimisation but also its expansion, which undoubtedly requires customer acceptance. There is still much to be done to promote and raise awareness of DH's benefits for sustainable community development. This should help to highlight good practices and positive examples and thus support consumer motivation to connect to DH as one of the alternatives or to create conditions for zoning (defining zones where connection to the DH is mandatory). Transparent promotion campaigns and marketing activities are essential for the DH sector and help to inform the public and make the right decisions.

(1) Visions, strategies and plans for heating (and cooling)

#	Action	Timing	Responsible stakeholder
1.1	Relevant national authorities (ministries) in collaboration with the DH industry and other stakeholders to establish a clear vision (*Where do we want to go?*), set strategies and elaborate Action plan (*How do we get there?*) for Heating and Cooling. At least period till 2030 shall be covered, if possible with a view until 2050. For each measure or action, it is important to set the responsible body, the timing (start-end, major milestones), the cost estimation and financing/source as well as the indicators for monitoring.	2020	Ministry of infrastructure (MzI)
1.2	Authorities (at national and local level) to support goals by setting	2020-	MzI,

#	Action	Timing	Responsible stakeholder
	targets for a public sector estate (covering a wide range of organisations at national and regional level) being connected to a DH system (e.g. by 2030) where there are public buildings located in areas practically and commercially viable for DH. This will depend on a number of factors including heat density in an area, vicinity of fuel sources particularly where renewable energy is an option and the comparative costs of heating. Refurbishment and maintenance of DH systems and networks has high impact on long-term competitiveness of DH. The review should also highlight where public buildings can provide key anchor loads to catalyse implementation of heat networks.	2021	Municipalities
1.3	Provision of Heat mapping is one of the short-term plans which will allow local authorities to identify the source of both heat supply and demand and identifying if the circumstances are appropriate for potential DH projects (construction, extension, refurbishment). It is expected that heat maps will contribute effectively to local decisions on heat networks and at the same time support national strategies and targets. This action will be a part of a (national) Heating and Cooling Strategy support programme which is intended to support local authorities in developing DH strategies and heat planning. (*Remark: This action was included in NEEAP and the draft NECP*.)	2020-2022	MzI
1.4	Considerable potential for heat generation can be expected on the basis of (shallow) geothermal energy. It is recommended to explore this potential in more detail and to use it as soon as the relevant economic framework is in place. (*Remark: Pilot sites need to be identified – presumably by municipalities - and relevant demonstration projects have to be selected and implemented*.)	2020-2022	MzI, Municipalities
1.5	Long-term heat storage is a key element for the decarbonisation of heating networks, hence detailed examination of the site conditions to build thermal storage facilities has to be carried out at the municipal level. *(Remark: Identification of pilot sites to be done by municipalities, followed by selection of demonstration projects at national level and further implementation.)*	2021-2022	MzI, Municipalities
1.6	In addition to renewable energies, the possible use of industrial/commercial waste heat should be examined in a structured manner and further promoted. The establishment of a (national) waste heat register is recommended.	2021-2022	MzI

(2) Supporting measures and technical guidance

#	Action	Timing	Responsible stakeholder
2.1	Establishing the body which co-ordinates support for DH development across a number of national and local programmes and develops a DH strategy programme for local authorities to help accelerate the growth of heat networks. The coordination body shall have the following roles: (1) Strategic planning, (2) Knowledge and best practice sharing (technical, financial, project development aspects), (3) Identification of collaborative opportunities, (4) Leading the Heat mapping initiative, (5) Identification of funding opportunities and financial support, (6) Technical advice (direction) and support. Remarks: (1) This body can be part of or related to the s.c. *Energy and climate council (this council is proposed by NECP).* (2) Progress in developing DH infrastructure can be expected if dedicated (loan) funds are formed to drive the sector going forward. See 4, Funding)	2020-2021	Energy Industry Chamber of Slovenia (EZS), MzI, Ministry of environment (MOP)

#	Action	Timing	Responsible stakeholder
2.2	Establish a national support programme for local authorities to develop a strategic approach to DH and supporting use of the relevant tools (e.g. heat mapping). This can include creation of a permanent expert team or service (e.g. at the interest DH association level) supporting DH development and co-ordinating exchange and sharing of good practice for a longer period (e.g. at least 5 years), reflecting the long development cycles of district heating projects and their implementation in practise.	2022-2023	MzI, EZS
2.3	In conjunction with DH development strategies and plans - to investigate the potential for integration of large-scale heat pump applications, excess heat recovery, geothermal or ambient heat or local (wooden) biomass. To develop the support programme for implementation of the most viable applications.	2020-2021	MzI
2.4	Provision of standardised legal and contractual document templates for DH projects (e.g. renovation, extension, technology upgrades) can take advantage of the replication of good practises.	2021	MzI
2.5	A modular support (complementary market incentive) program is proposed, in which the different parts of a heating network (heat generators, heat storage, heat pipes, house heat transfer stations) or measures at customer facilities can be supported independently of each other. It would be based on the provision of a network transformation plan, which must justify the reason and significance of measures and their contribution to transformation goals.	2021-2023	MzI, Government Office for Development and European Cohesion Policy (SVRK), Eco Fund
2.6	Capacity-building (trainings and education) and awareness raising campaigns bring together various stakeholders – from city officials and spatial planners to real estate developers, businesses (technology or service providers), investors and legal experts - all to exchange knowledge and learn from each other.	2020-2030	MzI, Local Energy Agencies
2.7	Raising awareness of the general public through promotional activities, helping to improve the image of DH and overcome negative stereotypes (e.g. “DH is outdated mean of heating”) in this regard, and improve the positive role of DH in the processes of energy and climate policy-making.	2020-2030	MzI, Local Energy Agencies

(3) Planning and regulation

#	Action	Timing	Responsible stakeholder
3.1	The national authorities need to create guidance on both national and local aspects of planning for district heating. Local authorities (municipalities) shall designate areas based on heat maps where district heating would be the presumption for heat supply, thus making the basis for new developments or refurbishments of DHS. Within the framework of this local heating planning, the potential for expanding the heating networks and converting the heating networks to renewable energies should be examined. Remark: Development plans should consider the benefit of allocating and co-locating heat supply and demand, and should support DH networks where they are possible, particularly if they implement low carbon solutions through renewables.	2021-2022	MzI, Municipalities
3.2	The national authorities shall establish support to the municipalities in heat planning in various ways with central services, in particular by helping with the procurement of funds, guidelines for municipal	2021-2023	MzI

#	Action	Timing	Responsible stakeholder
	heat planning, training and the creation of inter-municipal data, e.g. “waste heat register” (industry and trade), possible areas for large open-space solar thermal systems, potential for geothermal energy, building and energy-related data. This also includes a change in the concept of LEK (Local Energy Concept) preparation.		
3.3	To require producers of significant amounts of heat to investigate options for capture and use of their waste heat and to facilitate the supply of waste heat to a network where this is economically viable. This shall apply to all electricity generation and industrial plants, which need to be required to carry out a cost benefit analysis on heat use. DH networks will also need to carry out a cost benefit analysis where potential industrial/commercial heat sources are available.	2021-2030	MzI
3.4	Trainings on district heating planning issues for (spatial) planning practitioners and other stakeholders need to be organised.	2021-(2030)	MzI
3.5	To cope systematically with the space requirements that the conversion of the heat supply to renewable energy entails. This concerns e.g. open space solar heat, (shallow) geothermal energy, the access of large heat pumps to large heat sources as well as the expansion of renewable electricity generation for the operation of heat pumps, the supply of biomass.	2020-2022 (2030)	MOP, MzI
3.6	One of the main obstacle to the inadequate expansion of large heat pumps (in addition to the high temperature level of many DH networks) is the high electricity price for large heat pumps. Likewise, to discuss and conclude on the exemption from network charges, when large heat pumps are used in combination with heat storage and other heat generator networks.	2020-2021	MzI, Ministry of finance (MF)
3.7	The proper definition/setting of a CO_2 tax on fossil fuels for individual heating would make heating solutions based on heating oil and natural gas boilers considerably less attractive and would thereby increase the attractiveness of (efficient) heating network solutions. Taxes for fossil fuels in DH also need to be examined, aiming at appropriate price signalling which will stimulate more investments in renewable heat generation. The interaction with GHG emissions trading, which larger DH producers are subject to, must be also considered.	2021-2022	MOP, MF

(4) Financing

#	Action	Timing	Responsible stakeholder
4.1	The national (government) and local (municipal) authorities to support the development of new business models for the delivery, refurbishment and financing of heat networks. One possible business model is ESCO, which can be developed as a not-for-profit Energy Service Company which can tackle fuel poverty, cut carbon emissions and create new jobs.	2020-2022	MzI, MF, Municipalities
4.2	Provide necessary funding for the sustainable retrofitting of DH systems aiming at increased efficiency and competitiveness (optimisation of operation, expansion of networks), increasing the use of RES and excess heat, promotion of highly-efficient CHP in DH systems, sectoral integration (e.g. by energy storage and “power-to-heat”), etc.	2020-2022 (2030)	MzI, SVRK, MF
4.3	An incentive framework is needed that supports investments in	2020-	MzI, SVRK, Eco

#	Action	Timing	Responsible stakeholder
	carbon-neutral heat, allowing adequate (quantitatively limited) support for the remaining heat generated by highly-efficient CHP that can't be ensured by RES or waste heat in a short term.	2030	Fund
4.4	Co-financing programme (financial incentives) for investments in new DH using wood biomass (DHWB) systems and micro-systems, as well as the expansion and renovation of existing DHWB systems and the construction of new boiler rooms containing modern wood biomass boilers, solar systems or other RES as a source for existing DH.	2020-2030	MzI, SVRK, Eco Fund, MF

Ukraine

The Energy Strategy of Ukraine for the period till 2035 "Security, Energy Efficiency, Competitiveness" provides for increasing the efficiency of heat supply in existing DH networks and developing local heat supply systems based on the economically feasible potential of local fuels, supply logistics and regional and national energy infrastructure.

The main areas of energy efficiency improvements of the national economy include a number of measures related to DH:

- increase of energy efficiency in DHS by optimising power generation capacities and modernisation projects;
- reduction of energy losses in heat transport and distribution systems through technical modernisation and review of energy supply schemes, taking into account recent developments in decentralized energy supply, RES use and energy demand management;
- evaluation of the potential of DHS optimisation by switching to individual heating solutions in the regions and objects, where such option is economically feasible;
- implementation of measures allowing regulation of heat energy consumption by consumers (switch from central heating units to individual heating units, reconstruction of heating systems in buildings, installation of heat consumption controllers in buildings and individual apartments).

The main measures foreseen by the Energy Strategy to reduce energy consumption in DHSs include:

- optimisation of energy generation facilities with the focus on cogeneration capacities and increase of efficiency;
- potential switch from the least efficient sources to module boiler houses near buildings;
- replacement of pipelines with the installation of pre-insulated pipes and reduction of energy losses during heat energy transportation;
- modernisation of heating units;
- use of excess heat from technological processes at industrial enterprises;
- creation of market conditions for the open access of third parties to DHS;
- use of frequency converters for the pumping equipment;
- use of automatic controllers of heat consumption based on ambient air temperature at heating units;
- switching to individual heating options in the cities, where the current state conditions of DH lead to the increased cost and inefficient use of energy;

- implementation of energy demand management and energy services mechanism as alternatives for energy generation.

Besides, the Concept of State Policy Implementation in the area of heat supply defines expected results of heat supply system modernisation before 2035 as following:

- ensuring quality, reliable, safe and affordable district heat energy supply services and hot water supply services, as well as increased payment rate for the services provided;
- increase the share of alternative energy sources to 40% and strengthen energy independence of the country;
- reduce environmental pressure of heat supply system;
- attract foreign investments in the heat supply sector;
- ensure efficient operation of DHS operators and reduce debts for energy resource supply;
- reduce heat energy losses to 10%;
- implement energy saving measures and 100% consumption-based billing.

The goal of the Concept of state policy implementation in the area of climate change for the period till 2030 is to ensure the achievement of nationally determined contribution for 2030, which will not exceed 60% of emission level in baseline year 1990, as well as ensure National Determined Contribution (NDC) ambition increase, considering conditions of social and economic development of the country. Ukraine's second NDC is expected to be developed and submitted to the UNFCCC Secretariat in 2020. According to the presentation made within stakeholder consultation process, three different scenarios are being considered:

- Scenario 1 - baseline scenario foreseeing only partial implementation of already approved goals;
- Scenario 2 - reference scenario foreseeing full implementation of already approved goals;
- Scenario 3 – climate neutral economy scenario.

DHS development is considered within the scenario modelling using the assumptions on the following parameters:

- share of renewable energy in heat energy generation by DH systems ranging from 10% under the baseline scenario to 35% under reference and climate neutral economy scenarios in 2030; for 2050, the assumptions are 10% and 40% respectively;
- heat energy losses in DH systems with the value of 11% under the baseline scenario and less than 11% under reference and climate neutral economy scenarios for 2030; for 2050, the assumptions are 10% and less than 10% respectively;
- assumptions on the energy savings achieved due to thermal modernisation of residential and public buildings ranging from 15% under the baseline scenario to 50% under reference and climate neutral economy scenarios in 2030; for 2050, the assumptions are 20% and 75% respectively;
- assumptions on the use of solar power for heating and hot water production in both residential and public buildings (without references to DHSs); for baseline scenario the assumed values are between 0.5% and 5%, however for other two scenarios the assumed values are in the range of 10% - 35% for 2030 and 20-60% for 2050.

In 2020 the Government of Ukraine has adopted National Plan on Increasing the Number of Near-Zero Energy Buildings, which defines multiple measures to improve the regulatory base for energy efficiency improvements in buildings, attract investment in buildings renovation and

increasing the amount of renewable energy generation in buildings. For 2025, the National Plan sets a goal for reducing final energy consumption in residential sector by 24% and in public buildings by 16%.

National plan on energy and climate for the period 2021-2030 is expected to be approved in 2020 (according to the action plan on implementation of the Concept of state policy implementation in the area of climate change for the period till 2030).

On the local levels, the priorities of DHSs modernisation are defined in the regional socio-economic development and energy efficiency programs, as well as local sustainable energy and climate action plans prepared on a voluntary basis within the Covenant of Mayors for Energy and Climate initiative.

Therefore, DH system will continue to play an important role in energy supply in Ukraine during the next decades. The future developments of DH systems should take into consideration the following factors stemming from national policy priorities:

- potential **significant reduction of heat energy demand and heat load density** due to thermal insulation of residential and public buildings, growing renewable energy use in buildings, increased average temperatures during the heating period caused by climate change, as well as disconnection of some heat network segments, where DH is not economically feasible comparing to alternative solutions;
- need to **increase the efficiency of both heat energy generation and transportation** to be competitive with alternative heat energy supply solutions and meet state policy goals;
- need to **increase the share of renewable energy sources and waste heat** to benefit from lower costs of locally available energy source, increase competitiveness, reduce environmental and climate impact, and meet state policy goals;
- increased **demand for greater automation and demand control** tools to meet customers' needs and cope with changing climate conditions;
- **growing competitiveness** both from independent heat energy producers under expected heat market conditions and decentralized heat energy generation options.

To cope with the all mentioned challenges, state policy should address identified barriers and support DHSs operators in achieving energy and climate protection targets. DH installations will increasingly need to be more efficient by applying a mixture of technologies such as better controls, insulation, heat recovery, and using renewable energy sources (biomass, heat pumps, solar, etc.). Each of these technologies has different advantages and will have a role in delivering low carbon heat.

In addition, concrete, district-specific mid- to long-term planning is required in order to determine the future role of heating networks in conjunction with other types of heat supply and to create investment security for heat suppliers. This basis should be developed in independent, structured and participatory processes both at the national level and in the municipalities.

State authorities should also 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.

Raising awareness of DH benefits for sustainable community development should be an important component of public policy to help operators maintain their customer base and improve the motivation of consumers to connect to DH. Promotion campaigns and marketing activities are essential for the DH sector, helping to inform the public and make the right decisions.

(1) Visions, strategies and plans for heating (and cooling)

#	Action	Timing	Responsible stakeholder
1.1	**Approval of district heating development strategy for Ukraine and an action plan with specific measures** Relevant national authorities (Ministry of Communities and Territories Development, Ministry of Energy and Environmental Protection, State Energy Efficiency and Energy Saving Agency, etc.) in collaboration with the DH industry and other stakeholders to establish a clear vision and a strategy for the development of district heating in Ukraine, as well as an action plan with specific measures. The Strategy should reflect existing policy priorities in the area of energy, climate, and environment, as well as additional actions required for sustainable and efficient district heating systems development considering heat density in an area, energy sources availability, cost, and other factors. At least period till 2035 shall be covered, if possible with the view until 2050. For each measure in the Action Plan, it is important to set the responsible body, the timing (start-end, major milestones), the cost estimation and financing/source as well as the indicators for monitoring.	2020-2021	Ministry of Communities and Territories Development (MINREGION)
1.2	**Approval of buildings energy efficiency improvement strategy for Ukraine** The planning of the modernisation of the DH sector should be based on the understanding of future changes in heat energy demand and should be carried out in coordination with the state policy on buildings energy efficiency improvement. The strategy for improving the energy performance of buildings and the corresponding national action plan should set specific targets for the energy performance of buildings, including energy consumption for heating, based on the requirements of national building standards norms and plans for the renovation of buildings, as well as a timeline for achieving the targets and the relevant policy instruments to be used. Performance targets should be taken into account in the planning of DH development in order to avoid investments in stranded assets and additional expanses for their maintenance and operation.	2020-2021	MINREGION
1.3	**Division of responsibilities and powers between state and local authorities** Public authorities at national, regional and local level will review the distribution of responsibilities and powers in the management and development of the DH sector on the basis of extensive stakeholder consultation, taking into account the crucial role of DH for the energy security of local communities and the political responsibility of local authorities for the quality of heat supply services on the one hand, and the need to introduce general principles and strategies on the other side. The issues for stakeholder consultations could include the	2020-2022	MINREGION, National Commission for State Energy and Public Utilities Regulation, regional state administrations, City councils

#	Action	Timing	Responsible stakeholder
	distribution of powers in relation to the approval of investment programs and profit margins, heat energy tariffs, etc.		
1.4	**Support of district heating system modernisation in development planning documentation** State authorities at regional and local level to support the development of DH systems in line with the national strategy and Action Plan and incorporate relevant measures into regional and local development priorities, considering the crucial role of DHS for the energy security of cities (e.g. regional and local programs of socio-economic development, DH development schemes, municipal Sustainable Energy and Climate Action Plans).	2020-2021	Regional State Administrations, City councils
1.5	**Mapping of district heating systems** Local authorities, with the support of the Ministry of Communities and Territories Development to carry out DH mapping as part of the development of heat supply schemes, in order to identify the source of both heat supply and heat demand and to identify priority areas for DH development projects. It is expected that heat maps will effectively contribute to local decisions on heat networks while supporting national strategies and objectives. Such systems should be based on GIS platforms and contain detailed information on the DHS of cities.	2020-2022	MINREGION, regional state administrations, City councils
1.6	**Assessment of renewable energy potential for heat supply** Local authorities under the support of the State Energy Efficiency and Energy Saving Agency to conduct assessment of renewable energy sources that could be used in DH systems (e.g. biomass supply sources, geothermal and solar energy), including for combined heat and power generation. Potential for application of heat pumps in DH should be considered.	2020-2022	State Energy Efficiency and Energy Saving Agency, City councils
1.7	**Assessment of waste heat potential for heat supply** Local authorities under the support of the State Energy Efficiency and Energy Saving Agency to conduct assessment of waste heat energy sources that could be used in DH systems (e.g. industrial processes, CHPs, wastewater collection and treatment facilities, commercial buildings with large air-conditioning systems, etc.). Waste heat from the exhaust gases of existing DH boiler houses should be considered in the assessment.	2021-2024	State Energy Efficiency and Energy Saving Agency, City councils
1.8	**Assessment of the feasibility of constructing heat energy storage facilities** Local authorities under the support of the State Energy Efficiency and Energy Saving Agency to assess the technical and economic feasibility for the construction of heat storage facilities for local heating networks. In particular, in case of using CHP units and CHP power plants in the district heating systems and the possibility to optimize their operation under the electricity market rules in Ukraine.	2021-2024	State Energy Efficiency and Energy Saving Agency, City councils
1.9	**Consideration of climate change impacts and adaptation to climate change** To incorporate climate mitigation and adaptation aspects (reduced heat energy demand and heat load, impact on economic feasibility of operational activities of district heating companies and investment projects, increased need for demand driven heat energy generation control, mitigation measures and reduction of heat carrier losses for more efficient use of water resources, etc.) in the planning of DH development.	2021-2024	MINREGION, Ministry of Energy (MPE), Ministry of Ecology and Natural Resources (MENR), City councils

(2) Supporting measures and technical guidance

#	Action	Timing	Responsible stakeholder
2.1	**Strengthening institutional capacity of national state authorities** Strengthening the institutional capacity of state authorities for the coordination of DH modernisation process. Ministry of Communities and Territories Development to be responsible for the following roles: (1) Strategic planning, (2) Knowledge and best practice sharing (technical, financial, project development aspects), (3) Identification of collaborative opportunities, (4) Supporting the heat mapping initiative, (5) Identification of funding opportunities and financial support and accompanying the cooperation with international financial organisations, (6) Technical advice and support. State Energy Efficiency and Energy Saving Agency to be responsible for the supporting of DH modernisation initiatives targeting energy efficiency improvements, waste heat utilisation, and the use of renewable energy sources. Strengthening of institutional capacity will aim at reducing the risks related to lack of coordination of action under conditions of leadership change and reducing the impact of political factors on decision making process. Strengthening of institutional capacity could include clear formulation of the areas of responsibilities in the area of district heating in relevant organisational policies, human resource management, training, development of guidance documents and other materials, etc.	2020-2021	MINREGION, State Energy Efficiency and Energy Saving Agency
2.2	**Strengthening institutional capacity of local state authorities** Local state authorities will be responsible for the preparation of district heating development schemes and the support of relevant investment programs of the district heating companies. National state authorities will provide support to local authorities on the aspects related to district heating systems development, in particular with respect to securing finance, guidance on development planning and mapping of district heating systems, as well as collection and provision of information on renewable energy potential in the regions considering available supply chains, environmental and technical limitations.	2020-2022	MINREGION, State Energy Efficiency and Energy Saving Agency, City councils
2.3	**Basic requirements for modernisation projects** To develop benchmarking criteria for the energy efficiency and resource efficiency improvements, and renewable energy projects in DH (e.g. minimum efficiency of boilers and pumping equipment, heat losses, biomass sustainability, etc.)	2020-2021	MINREGION, State Energy Efficiency and Energy Saving Agency
2.4	**Increasing the attractiveness of district heating systems for final consumers** To improve customer acceptance of DH systems by strengthening legal framework on customers' rights protection, transparency of billing information, support of projects enhancing demand control and automation of DH services, public participation in decision-making process, and provision of additional energy services. The measures should also target the drawbacks of individual heating solutions (safety, impact on human health, environmental pollution, impact on heat networks efficiency, etc.).	2021-2024	MINREGION, State Energy Efficiency and Energy Saving Agency, City councils
2.5	**Capacity building and training** Capacity-building (trainings and education) and awareness raising campaigns bring together various stakeholders – from city officials to	2020-2035	MINREGION, State Energy Efficiency and

#	Action	Timing	Responsible stakeholder
	real estate developers, representatives of DH companies, local experts and business owners – to learn from each other. Priority areas of focus could include capacity building (e.g. training centre, advisory services) on the installation and setup of heating substations and systems targeting automatic regulation of heat consumption based on ambient air temperature and temperatures inside the building. Demonstration of successful case studies of using modern renewable energy technologies and waste heat technologies for the representatives of DH companies taking into account technology specifics and environmental requirements.		Energy Saving Agency
2.6	**Awareness raising activities** Awareness raising through promotional campaigns in order to attract the general public and trigger policy-making plans favourable to DH. Information campaigns on successful cases of district heating modernisation in Ukraine and worldwide with the focus on the impact on heating cost, quality and reliability of heat energy supply after modernisation. Supporting measures on installation of smart metering and control systems for individual consumers, as well as cost allocators for a just division of cost and ensuring ability to control heat energy consumption.	2020-2030	MINREGION, State Energy Efficiency and Energy Saving Agency, City councils
2.7	**Increased transparency of information on the operation of DH systems** To improve data transparency on the operation of DH systems, including information on efficiency, renewable energy use, carbon emission reductions, cost, etc. Data allowing tracking the achievement of key performance indicators are to be published in open data format. Openly available publication of district heating systems passports with the information on the structural aspects (e.g. share of heat generated from renewable energy sources, share of district heating system in heat supply), efficiency (e.g. specific fuel consumption for heat energy generation, energy losses during heat energy transportation, specific electricity consumption), reliability (e.g. share of deteriorated heat networks, number of accidents per year per km of networks), quality (e.g. correlation between fuel consumption and ambient air temperature, number of accidents), and environmental characteristics (e.g. specific emissions of main polluting substances and greenhouse gases) of DHS of a human settlement in the baseline year and targeted performance indicators after proposed modernisation measures. Support of automated monitoring and control systems with the possibility to collect and publish data on DH systems operation both from consumers and DHS operators.		MINREGION, City councils

(3) Planning and regulation

#	Action	Timing	Responsible stakeholder
3.1	**Preparation of DH development schemes** The national authorities need to create guidance on both national and local aspects of planning for district heating. DH development scheme is a document, which contain technical and economic justification for construction, reconstruction (extension, technical rehabilitation) and modernisation of facilities in district heating systems considering perspective development of a human settlement, as well as measures relate to ensuring energy efficiency,	2021-2024	MINREGION, Local councils

#	Action	Timing	Responsible stakeholder
	quality, safety, reliability and environmental performance during operation of district heating systems. Guidance documents should contain detailed structure of the DH development scheme and key requirements for the main sections. These schemes should be developed by local authorities in cooperation with DH companies. These local heat planning processes should be used to examine the potential for improving the efficiency of DH networks and their transition to renewable energies. DH development schemes should define zones for the use of heat supply options — districts of a human settlements, for which based on the results of cost benefit analysis a certain type a heat supply system is feasible (central district heating, decentralized solution, individual heating), and which is characterized by a certain level of heat load density. Besides, the schemes could foresee zones for priority or compulsory connection to district heating systems in case of new construction of large-scale reconstruction of buildings to increase the efficiency of DH operation and investment in modernisation.		
3.2	**Assess the feasibility of launching competitive heat energy market** Access the feasibility of legislative changes aimed at launching competitive heat energy market and access of third-party heat energy producers to DH networks. To develop and approve legal framework for the competitive DH market operation and free access to the DHS for independent heat energy producers. Development of heat energy market will eliminate market entry barriers, increase competitiveness and support the reduction of energy and carbon intensities of DH systems. At the same time, launching of heat energy market contains risks related to the stability of municipal enterprises operation and energy security of the cities.	2020-2022	MINREGION, State Energy Efficiency and Energy Saving Agency
3.3	**Launching electronic trading of biomass fuel** To develop and approve legal framework for electronic trading of biomass resources to ensure market transparency and competitive prices. The provisions of the legislation should ensure drivers for the supply and demand for biomass fuels, as well as biomass quality control provisions. The electronic trading of biomass will reduce biomass prices volatility and support the investment in biomass energy projects.	2020-2022	MINREGION, State Energy Efficiency and Energy Saving Agency
3.4	**Improving regulatory base for approving the level and structure of heat energy tariffs** To improve regulatory framework on DH tariffs structure and approval targeting such aspects as automatic adjustment of natural gas and electricity costs, possibility to increase personnel wages, and new tariff incentives for renewable heat.	2020-2022	MINREGION, National Commission for State Energy and Public Utilities Regulation
3.5	**Introducing state support system for district system development in cities** The national authorities shall establish support to the municipalities in heat planning in various ways, in particular by helping with the procurement of funds, guidelines for municipal heat planning, training, the creation of inter-municipal data, e.g. “waste heat register” (industry and trade), possible areas for large open-space solar thermal systems, potential for geothermal energy, building and energy-related data.	2020-2030	MINREGION
3.6	**Assessment of waste energy potential utilisation for large energy producers** To require producers of significant amounts of heat and electricity to	2022-2030	MINREGION

#	Action	Timing	Responsible stakeholder
	investigate options for capture and use of their waste heat and to facilitate the supply of waste heat to a network where this is economically viable. This shall apply to all electricity generation and industrial plants, which need to be required to carry out a cost benefit analysis on heat use. DH networks will also need to carry out a cost benefit analysis where potential industrial heat sources are available.		
3.7	**Reforming carbon taxation mechanism** To improve the legislative framework on carbon tax and strengthen its climate mitigation impact. The changes to be considered include exemptions from carbon tax for biomass fuel, increasing the level of carbon tax for fossil fuels and broadening the base for taxation by covering fossil fuel consumption by individual consumers, including natural gas consumption for individual heating. The interaction with GHG emissions trading, which larger DH producers are subject to, must be also considered.	2021-2024	MPE, MENR / Ministry of Finance (MOF)
3.8	**Construction norms and technological standards for district heating sector** Ensuring renewal of state construction norms, which are applied during district heating modernisation projects and/or impact the development of DHS in order to take into account the development of modern technologies and information about potential risks (e.g. norms on heat networks, environmental requirements, installation of individual heating systems, etc.). To introduce technological standards for DH sector for individual equipment and/or overall performance of DH operators with the minimum performance requirements for generation equipment and auxiliary equipment (grace period and gradual standards strengthening schedule could be provided).	2021-2024	MINREGION, MPE, MENR
3.9	**Improvement of public procurement procedures** Improvement of regulatory and legislative base for the organisation and execution of procurement process for the implementation of district heating modernisation projects in line with the requirements of the Law of Ukraine On Public Procurement, including the introduction of energy efficiency criteria and other non-financial criteria.	2021-2022	Ministry of Economic Development, Trade and Agriculture (ME), MINREGION
3.10	**Incentives for heat energy generation from renewable energy sources** Ensuring a stable incentive mechanism for fostering heat and power generation from renewable energy sources using the existing green tariff mechanism, incentivising renewable energy generation using auctions and quotas mechanisms, as well as development of new mechanisms for supporting heat energy generation from renewable sources (e.g. premium for heat energy from RES during a specified period of time). The use of RES requires larger capital investment and faces additional barriers (technical barriers, capacity barriers, etc.), however at the same time brings society benefits due to lower negative environmental impact and social benefits and thus requires state support measures.	2021-2022	MINREGION, MPE, MENR
3.11	**Environmental requirements for the use of biomass in heat supply systems** Reforming legislative and regulatory base for the introduction of environmental requirements for the use of biomass for heat energy generation, in particular with respect to: (1) sustainability criteria for biomass and (2) air emissions limits for small and medium biomass	2021-2022	MPE, MENR, State Energy Efficiency and Energy Saving Agency

#	Action	Timing	Responsible stakeholder
	installations and measures to avoid violation of air quality standards near residential and public buildings.		

(4) Financing

#	Action	Timing	Responsible stakeholder
4.1	**State support program for DH modernisation projects** To develop a state support program for the implementation of DH modernisation projects and define relevant financing sources, including a defined minimum share of funds from the State Fund for Regional Development and Energy Efficiency Modernisation Fund that should be directed to DH modernisation projects and/or establishment of a dedicated state fund with defined funding sources. The tools used by the program could include direct finance and partial reimbursement of interest rates or loans. The funding should target sustainable retrofitting of DH systems aiming at increase of efficiency and competitiveness (optimisation of operation, expansion of networks), increasing the use of RES and excess heat, promotion of CHP in DH systems. The focus should be on the modernisation measures that demonstrate medium of low cost-efficiency (based on the analysis of net present value of cash flows, internal rate of return and discounted payback period indicators) and could not be financed from other available sources but important to ensure energy security and sustainability of DH development (e.g. replacement of pipelines with the installation of pre-insulated pipes) and allows to significantly improve the overall efficiency of district heating systems (e.g. centralisation of DH sub-systems or separate sections of the grid).	2020-2021	MINREGION, State Energy Efficiency and Energy Saving Agency, MOF
4.2	**Support of DHS modernisation by local authorities** Support of district heating modernisation projects implementation using funds from local budgets to reduce the financial burden on final consumers.	2020-2030	City councils
4.3	**Debt management strategy for district heating system operators** To develop and execute debt management strategy for DH operators to deal with accumulated debts for natural gas supply during the previous years	2020-2024	MINREGION, MOF
4.4	**Supporting the development of new business-models for district heating systems** The national (government) and local (municipal) authorities to support the development of new business models for the delivery, refurbishment and financing of heat networks. Possible business models to consider include establishment of ESCO, ensuring access of independent producers to the grid of district heating systems, public-private partnership models, extending the scope of services by covering emergency and maintenance servicing of distribution networks within the buildings and apartments, substation servicing and maintenance, conducting energy audits, renewal of hot water supply, participation in electricity market, etc. Definition of the scope of additional services, pricing mechanisms, as well as development of relevant cooperation procedures for different parties, typical agreement forms and other required documents. One of the priority measures could be new business-models for servicing and modernisation of distribution networks within multi-apartment buildings, as their conditions impact financial feasibility of other	2020-2024	MINREGION, Local councils

#	Action	Timing	Responsible stakeholder
	modernisation measures in district heating systems.		
4.5	**Support energy efficient renovation in residential and public buildings** To continue support of energy efficiency improvements in residential buildings via warm loans program and State Energy Efficiency Fund and other instruments. The coordination between the measures targeting energy efficiency improvements in buildings and planning DH systems development should be ensured, including the possibility of development low-temperature DH sub-networks. An important aspect of energy efficiency measures in buildings would be rehabilitation, replacement and balancing of heat energy and hot water distribution networks within multi-apartment buildings, as their conditions impact financial feasibility of other modernisation measures in district heating systems. Assess international experience and possibilities of involving private companies in buildings renovation state support programs to mitigate capacity barriers (technical, legal, financial, etc.). At the same time, include measures on capacity buildings for household owners' associations on topics related energy efficiency projects in buildings sector.	2020-2030	MINREGION, State Energy Efficiency and Energy Saving Agency
4.6	**Cooperation with international financial organisation and other partners** To continue cooperation with international development institutions, technical assistance programs, development agencies and other donors to secure financing sources for DH modernisation. Ensuring attractive financing conditions due to low interest rates, extended crediting period, and soft collateral requirements. Mitigation of regulatory and capacity barriers related to cooperation with international financial organisation, including project approval.	2020-2030	MINREGION, MOF
4.7	**Mitigation measures for potential delays in payments in case of emergency situations** Development of mitigation measures for the potential non-payments for the heating services stemming from emergency situations, including COVID-19 pandemic.	2020	MINREGION

Conclusions and further steps

Between 2020 and 2030 the energy transition should focus on the refurbishment, optimisation and extension of existing and establishment of new district heating (DH) systems and investments in energy efficiency measures across the energy value chain. As DH plays a crucial role in securing energy needs of many citizens in examined countries, improving the efficiency and sustainability of DH systems operation has to be addressed in a systematic manner. This document contains proposal for the following key directions:

- Heating visions, strategies and plans: measures to enhance the role of district heating modernisation priorities in national, regional and local development planning process;
- Supporting measures and technical guidance: measures and actions to strengthen institutional capacity of state authorities, technical, organisational and financial capacity of DH operators, as well as legal framework improvement and awareness rising;
- Planning and regulation: measures to address legal and regulatory barriers for DH modernisation projects, as well as create additional incentives for improving energy efficiency and use of renewable energy sources;
- Financing: measures to assist DH operators in attracting financial resources for DH modernisation projects and provision of targeted financial support.

The proposals presented in this document are expected to serve as a basis for further stakeholder consultation activities regarding development of energy systems in examined countries, in particular district heating sector modernisation and adoption of relevant state support measures. It is important that municipalities and national authorities carefully assess the potentials in their areas for district energy solutions; other activities under the KeepWarm project relate also to supporting activities regarding comprehensive assessments (CA) according to the EED's Art. 14 (Task 5.4).

Annex 1: Key stakeholders and actors in DH

Austria

Group of stakeholders / actors	Role in process of DHS retrofit and development
Owners and operators of DHS	POSITIVE: All owners work together. Efficiency gains, high security of supply. / NEGATIVE: Discouraged by high investment costs.
Suppliers of RES	POSITIVE: Long term secure supply of RES. Stable fuel/energy prices on a long term. / NEGATIVE: Afraid of lower fuel demand after DHS optimisation.
Technology suppliers	POSITIVE: Generating local added value and secure jobs. Work with local suppliers.
Suppliers of fossil fuels	POSITIVE: Have no impact as there is no demand for fossil fuels.
Customers, end-users and customer organisations	POSITIVE: Consumers require high (improved) security of supply, which puts efficient DH ahead of other heating means.
Local governments, policy-makers and municipal authorities	POSITIVE: Very supportive to DHS and their customers.
Regulatory and energy agencies	POSITIVE: Important for consulting.
Spatial planning offices, technical planning authorities	POSITIVE: Crucial for good planning. Assist in utilisation of local resources.
Financial institutions, banks	POSITIVE: Provide loans for investments (as part of their regular business).
Central government, policy-makers and state authorities	POSITIVE: Enforce legislation which is aiming at reduced emissions. Provide effective subsidies. / NEGATIVE: Stimulating CO2 taxation not yet elaborated.
Environmental NGOs	POSITIVE: Demand the reduction of emissions. / NEGATIVE: Oppose the use of biomass for heating.
Academic sphere, scientific and research community	POSITIVE: Technical/expert assistance in DHS optimisation and development.
Media and social platforms	POSITIVE: An important channel to help rising positive image of DH. / NEGATIVE: Opponents of using RES have uneven space in media.

Croatia

Group of stakeholders / actors	Role in process of DHS retrofit and development
Owners and operators of DHS	POSITIVE: Positive examples of practice are being applied through conversation and cooperation with other DHS operators.
Suppliers of RES	POSITIVE: High interest in cooperation. / NEGATIVE: A small number of suppliers on the market.
Technology suppliers	POSITIVE: Good knowledge and presentation of the latest technologies that can be implemented in DHS.
Suppliers of fossil fuels	POSITIVE: Safe and timely delivery of fossil fuels (for DHS boilers). / NEGATIVE: Unstable fuel prices.
Customers, end-users and customer organisations	POSITIVE: In communication with end-users, valuable information is provided, which helps developing new DH services. / NEGATIVE: Sometimes, the expectations and demands of end-users cannot be met due to the market situation.
Local governments, policy-makers and municipal authorities	NEGATIVE: Low interest in DHS.
Regulatory and energy agencies	POSITIVE: Recognize and consider the opinion of the DHS. Cooperative with DHSs. Solid level of knowledge. / NEGATIVE: Slow reactions to market changes and sometimes

Group of stakeholders / actors	Role in process of DHS retrofit and development
	misleading directions.
Spatial planning offices, technical planning authorities	POSITIVE: Good cooperation in the process of obtaining a permit (for reconstruction, operation…). / NEGATIVE: Poor accuracy (or absence) of installation maps/plans of do not ensure reliable foundation for planning of reconstruction and modernisation.
Financial institutions, banks	POSITIVE: Cooperative in project financing.
Private investors	POSITIVE: Good response in terms of connecting new buildings or facilities to DHS.
Central government, policy-makers and state authorities	POSITIVE: Defining a national policy that allows the expansion of heat services and enables possibilities of co-financing specific projects. / NEGATIVE: Slow response in case of preparation and implementation of projects for which co-financing is possible.
State regulatory office	POSITIVE: Timely adoption of all necessary acts, which regulate the heating services. / NEGATIVE: Poor consideration of the DHS operators' positions.
State financial authorities	POSITIVE: Great support in project financing.
Academic sphere, scientific and research community	POSITIVE: High level of cooperation on development and research projects.
Media and social platforms	POSITIVE: Inform public on success stories. A great opportunity to improve cooperation and an enormous room for progress. / NEGATIVE: Mostly negative end-consumer stories are being published. Lack of interest in transmitting news about completed projects, as well as positive stories from end-consumers.

Czech Republic

Group of stakeholders / actors	Role in process of DHS retrofit and development
Owners and operators of DHS	POSITIVE: DHSs are interested in investing and operating equipment that is efficient, modern and environmentally friendly, retaining existing customers or acquiring new ones. / NEGATIVE: Inactivity of DHSs with obsolete equipment or installations, which do not have enough funds to upgrade.
Suppliers of RES	POSITIVE: The number of RES suppliers is growing. Increased demand for RES by DHS. / NEGATIVE: The volume of biomass is limited; its price is expected to rise. There is limited space for solar thermal fields. Exploitation of geothermal energy is still associated with high costs.
Suppliers of excess heat	POSITIVE: Good opportunities for the use of surplus heat from industry. Possibilities for excess heat supply are being analysed by stakeholders. / NEGATIVE: Lack of coordination among stakeholders. Related projects are typically very complex from organisational point of view.
Technology suppliers	POSITIVE: Follow global trends and keep high level of knowledge. / NEGATIVE: The latest technologies are hardly affordable due to high prices. Lack of experts.
Suppliers of fossil fuels	POSITIVE: There are restrictions set for coal mining. Fuel prices are rising. / NEGATIVE: The price of coal is still lower than other fuels. Easy access to fossil fuels due to large number of fossil sources.
Customers, end-users and customer organisations	POSITIVE: Customers have a high awareness of individual technologies and environmental impact, they support the use of RES. / NEGATIVE: Customers are focused on price, followed by service and comfort.
Local governments, policy-makers and municipal authorities	POSITIVE: Municipalities are often the owners of DHS and are interested in enabling heating services at affordable prices. Seeking for environment friendly technologies. / NEGATIVE: Inefficient cooperation with DHSs.
Regulatory and energy agencies	POSITIVE: Cooperative with DHSs. Elaborate various expert analyses, concepts, projects. Stand up for modernisation of the DH sector. / NEGATIVE: High consultancy costs.
Spatial planning offices, technical planning authorities	POSITIVE: Readiness to cooperate with DHSs in finding solutions.
Financial institutions, banks	POSITIVE: Financial institutions appraise the DH sector, promote modernisation and create acceptable offers for DHSs. / NEGATIVE: Available funds (e.g. subsidies) remain

Group of stakeholders / actors	Role in process of DHS retrofit and development
	only partly used.
Private investors	POSITIVE: Ability to invest. / NEGATIVE: Primarily focused on immediate profit. They may have unrealistic demands.
Central government, policy-makers and state authorities	POSITIVE: Make the effort to maintain regulatory support for the development of DH systems. / NEGATIVE: Ambiguous rules and legislation, lengthy approval processes.
State regulatory office	POSITIVE: Regulatory authority has positive attitude towards the interest of final consumers. / NEGATIVE: Poor consideration of the DHS sector economy. Insufficient stimulation of CHP and RES usage.
State financial authorities	POSITIVE: Supporting the modernisation of the DH system, e.g. by reducing taxation of heat. / NEGATIVE: They should be more supportive of maximum drawing of subsidies.
Environmental NGOs	POSITIVE: Strive for awareness raising about the climate change and protection of environment. / NEGATIVE: Often prone to uncompromising positions and strict attitudes e.g. to environmental protection or energy related issues.
Academic sphere, scientific and research community	POSITIVE: Knowledge transfer and advisory support. / NEGATIVE: Theoretical approach does not always evolve into robust, practical solutions. Lack of actual, operational experience.
General public	POSITIVE: DH is gaining favour if associated with environmental protection. / NEGATIVE: Conservative attitude towards DHS.
Media and social platforms	POSITIVE: Share positive image about the status and importance of the DH sector. / NEGATIVE: Powerful tool to create unfavourable public opinion, damage the reputation of DHS operators or exaggerate individual cases.

Latvia

Group of stakeholders / actors	Role in process of DHS retrofit and development
Owners and operators of DHS	POSITIVE: In general willingness to modernise DHS. Participation in DH association, which gives motivation for modernisation, possibilities to see best examples/practices in modernisation, thus having up-to-date information on developments in the DH sector. / NEGATIVE: Future insecurity in case of municipal DHS, because of ongoing administrative reforms. Lack of finance due to restrictions imposed by the Ministry of Finance to limit loans for municipalities.
Suppliers of RES	POSITIVE: Stable biomass supply. / NEGATIVE: Fluctuation in biomass prices, depending also on weather conditions.
Technology suppliers	POSITIVE: Provider of support and information (to DHS). / NEGATIVE: Often too expensive technologies (implementation in DHS is economically questionable).
Suppliers of fossil fuels	POSITIVE: Stable fuel supply, important particularly for NG fired CHP plants. / NEGATIVE: Fuel price fluctuations.
Customers, end-users and customer organisations	POSITIVE: Interest in energy efficiency measures in order to decrease own heating costs. / NEGATIVE: Insufficient resources to invest or cover the costs.
Local governments, policy-makers and municipal authorities	POSITIVE: Interested in energy efficiency measures in order to decrease maintenance costs of buildings, including heating expenses. / NEGATIVE: Limited ability to invest and weak attraction of funding.
Financial institutions, banks	POSITIVE: Commercial banks offer targeted loans. / NEGATIVE: Interest rates are too high (thus making loans unattractive).
Private investors	POSITIVE: Willing to cooperate. / NEGATIVE: Want to have profit – therefore their services are expensive for DHS.
Central government, policy-makers and state authorities	POSITIVE: Supportive in implementation of EU and national binding acts and policy documents.
State regulatory office	POSITIVE: Supportive. / NEGATIVE: Excessively strict rules for setting up new DHS heating tariffs, which does not allow to partially cover the costs of DHS improvements.
State financial authorities	NEGATIVE: Imposed restrictions for municipalities to take out the loans hinder projects of

Group of stakeholders / actors	Role in process of DHS retrofit and development
	DH systems which are (co-) financed by municipal capital.
Environmental NGOs	POSITIVE: Active sectoral organisations (e.g. Association of heating companies) have strong voice and ability to participate in a dialogue with the Government.
Academic sphere, scientific and research community	POSITIVE: Capability (having knowledge) and willingness to participate in development / optimisation / modernisation projects.
General public	POSITIVE: Interested in implementation of EE measures. / NEGATIVE: Cost reduction is highly valued, other benefits of DH are not in focus.

Serbia

Group of stakeholders / actors	Role in process of DHS retrofit and development
Owners and operators of DHS	POSITIVE: Understanding the need for modernisation and providing security and energy independence. Resolved land ownership issues. / NEGATIVE: Lack of funding.
Suppliers of RES	POSITIVE: Promotion of RES and adequate price policy. / NEGATIVE: Underdeveloped market.
Technology suppliers	POSITIVE: Transfer of new technology trends to DH systems. / NEGATIVE: Very limited number of domestic suppliers. Lack of competition and service support.
Suppliers of fossil fuels	POSITIVE: Stable fuel supply. / NEGATIVE: Large variations in prices, unfavourable payment terms, and a monopolistic position.
Customers, end-users and customer organisations	POSITIVE: Demand for increasing the quality of heating systems. / NEGATIVE: Lower prices are demanded. Insufficient financial resources for initial (connection) expenses.
Local governments, policy-makers and municipal authorities	POSITIVE: Understand the need of modernisation and providing security and energy independence. / NEGATIVE: Lack of funding.
Spatial planning offices, technical planning authorities	POSITIVE: Ensure harmonisation of planning acts of all utility/infrastructure companies. / NEGATIVE: Lack of promptness and consistency in planning acts create problems in the development of DHS.
Financial institutions, banks	POSITIVE: Readiness for financial support. / NEGATIVE: Project financing is not applicable, particularly due to absence of guarantee funds and unfavourable credit conditions.
Central government, policy-makers and state authorities	POSITIVE: Many strategic documents favour DH as a key area for increasing the energy efficiency at various levels. / NEGATIVE: Action plans and measures are not effectively implemented.
Environmental NGOs	POSITIVE: Launching initiatives and debates. Raising awareness of environmental protection and climate change. / NEGATIVE: Negative campaigns of particular interest groups. Criticism in media without clear arguments and competences.
Academic sphere, scientific and research community	POSITIVE: One of the main promotors of new technologies, implementation of EE measures and exploitation of RES.
General public	POSITIVE: Demand for clean environment. Launching initiatives and debates, targeting sustainable energy and climate issues.
Media and social platforms	POSITIVE: Enable positive influence on the general public. / NEGATIVE: Deficient or biased reporting, often as a result of incompetent journalists.

Slovenia

Group of stakeholders / actors	Role in process of DHS retrofit and development
Owners and operators of DHS	POSITIVE: Seeking for advanced and efficient technologies. High interest in reduction of losses. Willing to cooperate and exchange good practices and experiences with other DHS. / NEGATIVE: Primary focus on sustainability and convenience, but energy costs are mainly of prime importance for customer's decisions on heating alternatives. Monopolistic position of DHS operator (no room for competition as the owner of the network is normally also responsible for heat delivery).

Group of stakeholders / actors	Role in process of DHS retrofit and development
Suppliers of RES	POSITIVE: Stimulation of the local economy and the creation of employment opportunities. / NEGATIVE: Underdeveloped market with low number of suppliers.
Suppliers of excess heat	POSITIVE: In principle, a low-cost heating source. Availability throughout the country. / NEGATIVE: No adapted (heat) market models on the supply side. Image of unreliable heat source (possible interruption due to termination of business).
Technology suppliers	POSITIVE: Support the increase of DHS flexibility (in terms of the generation and distribution of heat, but also in the integration with other energy sectors) / NEGATIVE: Innovative character of the solutions may be riskier and more expensive to exploit. Besides there is lack of funding for research and development in efficient and low-carbon heating technologies.
Suppliers of fossil fuels	POSITIVE: Stable fuel supply (NG, coal). / NEGATIVE: Maintaining competitive prices against other fuels or heat sources.
Customers, end-users and customer organisations	POSITIVE: Customers are prepared to contribute to energy savings, environmental/climate protection and sustainability, however this mostly concerns efficiency measures that also lead to cost savings. / NEGATIVE: In the case of dwellings, the end user does not make the decision to connect to a DHS, but this was usually decided in the construction phase (e.g. by municipality).
Local governments, policy-makers and municipal authorities	POSITIVE: Normally in collaboration with the municipality, developer or housing company makes the decision to connect buildings to the DHS, sometimes municipality obligates the connection to the DH by municipal building regulations. Municipalities are major driving force behind the demand for DH. Have a critical role to play in promoting, convening, providing early development capital and potentially investing long term in DHS. / NEGATIVE: DH related benefits of CO2 (GHG) reduction and particulate matters' (air quality) emissions, and decrease of primary energy (in comparison to e.g. individual gas fired or biomass boilers) are not valued financially. This means that public involvement may be necessary for the deployment, modernisation and long-term development of DHS.
Regulatory and energy agencies	POSITIVE: Help to evaluate and promote benefits of DH compared to other means of heating. / NEGATIVE: Not proactive.
Spatial planning offices, technical planning authorities	POSITIVE: High impact on promotion of DH in areas with high heat demand density. / NEGATIVE: Spatial and development plans are often not communicated to DHS operators/suppliers so the commitment of all involved parties is not assured.
Financial institutions, banks	POSITIVE: Targeted loans stimulate renovation of DH substations and connection to DHS. Can help to find innovative solutions to make sure good projects can be financed. / NEGATIVE: Absence of funding programmes adapted to DH projects. Larger total financing risk due to involvement of more stakeholders, which raises interest rates and shortens amortisation periods for loans.
Private investors	POSITIVE: New real estate development projects have an important effect on the financial returns of a DH. / NEGATIVE: Investments are particularly risky for private companies, e.g. in case of economic crisis which may halt construction projects.
Central government, policy-makers and state authorities	POSITIVE: Developing long-term state energy and climate policies which favour DH. / NEGATIVE: Insufficient resources (human, knowledge) hinder preparation of the national Heating and Cooling Strategy and related action plan.
State regulatory office	NEGATIVE: The eligible costs of a distributor or a regulated heat producer are not sufficient to support ambitious renovation plans.
Environmental NGOs	POSITIVE: By following the work of the Government and participating in the decision-making processes, the sustainable development, climate change and energy related issues become more transparent. / NEGATIVE: Achieving of reasonable trade-off can be very difficult.
Academic sphere, scientific and research community	POSITIVE: Involved in research (e.g. H2020) projects, paving implementation of new technologies in demonstration projects. / NEGATIVE: Lack of project-implementation oriented cooperation with DH systems.
General public	POSITIVE: Demand to reach targets on EE, increase of RES and reduction of GHG/PM emissions. / NEGATIVE: Difficult to change the way of thinking / attitude. Can be easily misled (e.g. by media, influencers).
Media and social platforms	POSITIVE: Some media have very competent journalists, enabling fair informing the public. Targeted communication of DH related content. / NEGATIVE: Unattractive topic for the majority of audiences. Good (positive) stories only seldom find place in media.

Ukraine

Group of stakeholders / actors	Role in process of DHS retrofit and development
Owners and operators of DHS	POSITIVE: Interested in renovation of DHSs and increased capacity of their employees. / NEGATIVE: Monopoly within a particular city, which limits the access of private companies to DHS modernisation projects.
Suppliers of RES	POSITIVE: Suppliers of biomass provide resources for the development of DH, foreseeing biomass use for heat energy generation. / NEGATIVE: High and volatile prices of biomass during a heating season. Poor biomass quality. Fuel supply not reliable. No possibility to conclude long-term fuel purchase agreements with secured prices and supply volumes. Non-transparent market conditions.
Suppliers of excess heat	POSITIVE: Relatively affordable energy source that could be integrated into DHSs. / NEGATIVE: Technical difficulty to get the heat into DH system. Lack of incentives/support instruments to cooperate with DHSs.
Technology suppliers	POSITIVE: Provision of modern and efficient technologies. Timely implementation of contracted projects. Availability of suppliers for different technologies is leading to market competition and price optimisation. Transfer of expertise and increase of capacity of DHS employees through trainings and consultations. / NEGATIVE: Lack of reliable and publicly available data on suppliers and their products/services. Absence of long-term warranty of the installed equipment.
Suppliers of fossil fuels	POSITIVE: Stable and reliable supply of NG under regulated prices. / NEGATIVE: Supports the increase of NG prices to market levels and enforces strict contractual arrangements due to monopoly on regulated gas market.
Customers, end-users and customer organisations	POSITIVE: Attractive when co-financing of energy efficiency projects within the multi-apartment buildings exists. control over the quality of works/services; participation in public hearings regarding heat energy tariffs establishment and DHS investment programs. / NEGATIVE: Delays in payments for the consumed heat. Disconnection from the DHSs and switch to alternative heat supply options (e.g. individual natural gas or electric boilers, etc.).
Local governments, policy-makers and municipal authorities	POSITIVE: Municipalities provide operational and financial support (subsidies, funds for municipal/regional EE programmes, guarantees, etc.) to owners and operators of DHSs. Contribute to political support at the national level. / NEGATIVE: Political influences and conflicts potentially blocking DH strategies and modernisation projects. Weak communication with other stakeholders.
Regulatory and energy agencies	POSITIVE: In support of project development process. Assist to attract financial resources. / NEGATIVE: Insufficient level of expertise and capacities to provide effective support.
Spatial planning offices, technical planning authorities	POSITIVE: Familiarity with technical issues. Keeping control over the quality of technical documentation/works. / NEGATIVE: Municipal zoning requirements for the compulsory connection to DHSs not evolved. Causing delays in provision of needed documents.
Private investors	POSITIVE: Provide additional financial sources and capacities. Mainly in support of RES use projects. / NEGATIVE: Reduced control over municipal DHS assets.
Central government, policy-makers and state authorities	POSITIVE: Provision of state guarantees for attracting financial support and ensuring effective cooperation with international financial institutions (e.g. World Bank, EBRD, EIB, etc.). Development and enforcement of national policies and instruments (e.g. tariff systems), which support DH. / NEGATIVE: National strategy on the development of DH sector is not available. Long legislative procedures. Low priority of DH in the political agenda.
State regulatory office	POSITIVE: Provision of timely regulatory information, guidelines and consultations. Organisation and execution of stakeholders' consultation processes. / NEGATIVE: Heat tariffs do not allow sufficient investments in modernisation and operational expenses (e g. to employ highly qualified staff and ensure reliable service of existing infrastructure) since they are regulated at inadequate levels. Delays in heat tariff adjustments (e.g. after increasing other fuel prices or costs).
State financial authorities	POSITIVE: Provide targeted financial resources for DH modernisation and energy efficiency improvements in buildings. /

Group of stakeholders / actors	Role in process of DHS retrofit and development
	NEGATIVE: Administrative procedures are complicated.
Environmental NGOs	POSITIVE: Follow the environmental impact of DHSs operation. Participate in public consultations during environmental impact assessment procedures for large-scale DH projects. Awareness rising activities on the importance of EE, energy savings and reduction of emissions. / NEGATIVE: Misuse of public consultation mechanisms (e.g. public hearings) for blocking potential DH projects due to political or other reasons.
Academic sphere, scientific and research community	POSITIVE: Provide high level of expertise in the optimisation of DHS operation. / NEGATIVE: Lack of effective (e.g. project based) cooperation with DHSs.
General public	POSITIVE: Participation in public consultations with DHSs operators. / NEGATIVE: Sometimes, nonconstructive interference in (public) discussions on energy/climate strategies (thus hindering new projects).
Media and social platforms	POSITIVE: Quick dissemination of information. Effective communication with customers and other audiences, inter alia, through social media. / NEGATIVE: Occasionally excessive critics (especially regarding prices of executed works) which tend to be generalised.