DELIVERABLE D.T1.3.3

Summary report on the renewable heat potential assessment for the target regions

02/2020

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A.T1.3 Evaluation of potential for renewable heat

Issued by:	**Partner n° 2 - Partner REGEA**
Reviewed by:	**Partner n° 1 - Partner AMBIT**
Version date:	**28.02.2020**

Partners involved

Interreg CENTRAL EUROPE

Priority:	2. Cooperating on low-carbon strategies in CENTRAL EUROPE	
Specific objective:	2.2 To improve territorial based low-carbon energy planning strategies and policies supporting climate change mitigation	
Acronym:	**ENTRAIN**	
Title:	**Enhancing renewable heaT planning for improving the aiR quality of commuNities**	
Index number:	CE1526	
Lead Partner:	Ambiente Italia Ltd	
Duration:	01.04.2019	31.03.2022

Table of contents

LIST OF ABBREVIATIONS

Abbreviation	Explanation
DH	District heating
DHS	District heating system
EPEEF	Environmental Protection and Energy Efficiency Fund
ESIF	European Structural and Investment Funds
EU	European Union
OG	Official Gazette (hr. Narodne novine)
RES	Renewable energy sources
RSAG	Regional Advisory Stakeholder Group

1. Introduction

1.1. The ENTRAIN project

District heating (hereinafter: DH) is considered as the main option for efficient renewable heat supply for both urban and rural areas and thus as infrastructure enabling the transition to higher renewable energy sources (hereinafter: RES) share in energy generation and consumption. A further expansion of these networks is part of recent national and regional Climate and Energy Strategies, setting a focus on the extended use of biomass and enhanced integration of solar thermal and waste heat to improve air quality and foster more efficient use of biomass.

The outcome of the ENTRAIN project will lead to fossil fuels and CO_2 emission reduction, improvement of local air quality and socio-economic benefits for local communities through the growths of technical expertise and the start-up of investments and innovative financial tools. ENTRAIN's main objective is to promote structural cooperation between public authorities and key stakeholders at transnational level and to build-up skills and know-how for a systematic, holistic and efficient planning of small DH systems within five target regions (Austria, Croatia, Germany, Italy and Slovenia), based on renewable heat sources (solar, biomass, waste heat, heat pumps and geothermal).

As a part of the project, five Regional Stakeholders Advisory Groups (hereinafter: RSAG) involving 11 partners, 24 associated partners, and local actors will be set up and will be responsible for conducting five initial surveys and five local action plans. Acting as regional and transnational energy networks, they will be crucial for the implementation and achievement of ENTRAIN objectives, by involving local and regional authorities, DH utilities, energy and development agencies, and consumers. Heat planning guidelines and quality criteria will be made available, based on knowledge transfer from regions with advanced planning capacities and long term experience in renewable DH (Austria, Germany), also through an ambitious capacity building program with 25 training session. ENTRAIN will trigger the initiation of nine pilot local DH networks and nine heat planning studies, along with the development of three innovative local and regional financing schemes and the adaptation and adoption of the existing Austrian quality management system “QM Holzheizwerke” in at least three of the target regions.

ENTRAIN focuses on addressing challenges, which are common for the countries and regions participating in ENTRAIN, such as lack of energy planning skills and experiences of municipal and regional authorities, growing local air quality issues, land occupation of RES plants, need for increasing the use of waste heat to improve energy efficiency, as well as users’ acceptance of new energy plants. Therefore, transnational cooperation is needed to exchange best practices and models on how to tackle these challenges in different frameworks by adapting successful experiences to the local needs and conditions.

1.2. Scope of the deliverable

Heating and cooling in buildings and industry sector accounts for half of the energy consumption of the European Union (hereinafter: the EU), and a large part of the energy consumed is produced in fossil fuel plants. In order to make the heat supply climate-neutral, fossil fuels need to be replaced with RES (biomass, geothermal sources, solar energy, waste heat). These RES can be used

as a reliable source of heat and can be used by a wide range of users, from households to the commercial, public and industrial sectors. One of the main driving forces behind the increasing use of RES in the heating sector is an agreement made at the EU level seeking to reduce CO_2 emissions and increase RES share in final energy consumption. Using RES for heat production can help meet growing energy demand, improve energy efficiency and reduce emissions.

The analysis of heat supply and demand in the target region sets the foundation for further planning of the small local DHS. An initial evaluation of the current status and energy balance in the target region offers insight into the heat demand of the community and evaluates locally available RES as a potential solution for energy supply. When evaluating the potential of RES DH, different indicators of the target area were taken into account.

In the heat demand step, additional attention is given to the territorial aspect of the target area, i.e. climate of the area, urbanisation, industrial areas, which all provide an important element to consider when planning the DH system. Heat supply step provides an overview of the locally available renewable energy sources, each with a set of questions, which can help determine the potential for each in the target region. The final step of the evaluation combines the findings of the previous steps in order to reach a conclusion whether there is a potential for planning the local DH system. Although there may be sufficient heat demand and supply, without the involvement and support of the local community, successful implementation and future operation of the project cannot be guaranteed. ENTRAIN project puts a strong emphasis on the involvement and cooperation of the DH users and other relevant stakeholders and has established RSAGs in five target regions in order to grasp a better understanding of the current situation in each target region.

An evaluation of RES in the target area of the three counties was prepared using publicly available data. Before launching a RES-based project as an energy source, a comprehensive analysis of data and documents should be carried out, as well as a feasibility study with a cost-benefit analysis to determine the actual feasibility of the project.

2. Croatia

The renewable heat potential assessment included three Croatian counties: Krapina-Zagorje County, Zagreb County and Karlovac County, stretching through central Croatia and surrounding capital city, Zagreb, from northwest to southwest.

Figure 1 Target area of the ENTRAIN project in Croatia

These three counties constitute ENTRAIN target region in Croatia. All three counties included in the target region apply a regulatory, legislative and strategic framework developed at national and at the county level. Counties in their governmental scope and area carry out tasks of regional importance, which include, amongst others, tasks related to spatial and urban planning and adopting county development strategies.

A key prerequisite for successful implementation of RES projects in each target region is the existence of a supportive regulatory environment. In addition to the national legal and regulatory framework covering a number of laws and regulations governing the (heat) energy market, national strategic documents are equally relevant for these counties. National energy policies and objectives are prepared based on the Energy Development Strategy of the Republic of Croatia by 2020, and the regional and local energy strategies are adapted accordingly. Current Energy

Development strategy identifies biomass as an energy source of great potential, and the counties which are part of the targeted area are densely covered with forests and other land covers appropriate for cultivating short rotation coppice. In addition to the use of biomass, the Energy Development Strategy of the Republic of Croatia by 2020 encourages the use of solar energy for heat production. The Integrated National Energy and Climate Plan for the Republic of Croatia for the period between 2021 and 2030 provides an overview of the current energy system and situation in the area of energy and climate policy. The plan also proposes a number of measures relevant to the objectives of the ENTRAIN project, such as measures to encourage the development and maintenance of DHS and the use of RES for electricity and heat production. The main instruments for incentivising and financing the construction and development of heat systems using RES are the funds available from the Environmental Protection and Energy Efficiency Fund (hereinafter: EPEEF) and from the European Structural and Investment Funds (hereinafter: ESIF) allocated through the Operational Program Competitiveness and Cohesion 2014-2020.

Population density of Krapina-Zagorje and Zagreb county is similar and amounts to 108,1 and 103,8 inhabitants/km^2, which surpasses the national average of 75,7 inhabitants/km^2. On the other hand, the population density of Karlovac county is 35,5 inhabitants/km^2, which is half the national average.

Data on the surface area of public and commercial buildings in each county relate to buildings owned by the county and it was collected using the Energy Efficiency Action Plans for each country and Energy Management Information System. Data for the residential buildings and households is not publicly available at the county level, so it was collected through various sources, such as the Croatian Bureau of Statistics and strategic documents.

Below is a summary of the building stock in the three counties and the heat demand for each building category.

Table 1 Building stock and the heat demand for each category of the building

Building stock category of the ENTRAIN target area	Area	Heat demand, kWh/m^2	Annual heat demand, MWh
Residential buildings	22.084.000	160	3.533.440
Commercial buildings	5.675.752	175	993.257
Public buildings	2.143.820	167	358.018
TOTAL	**29.903.572**		**4.884.714**

Comparison of the data on the use of energy sources in the households and public sector shows that biomass is the predominant energy source in households with a 68.2% share, while in the public sector it is natural gas with a share of 56.4%, which can be observed in the figure below.

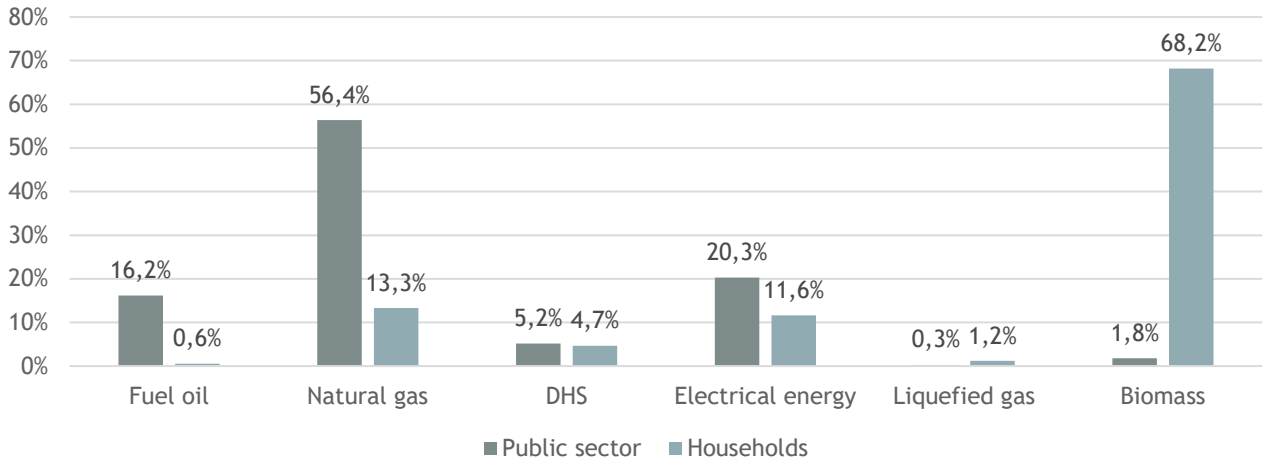

Figure 2 Comparison of energy sources used in the public sector and households in Karlovac, Krapina-Zagorje and Zagreb county

In the area of three counties included in the ENTRAIN target area, just under 60 local entrepreneurial zones are located close to urban areas. This vicinity of the entrepreneurial zones may be an advantage in the case there are industrial facilities producing waste heat in these areas, which can be exploited in the populated areas outside the entrepreneurial zone. In addition to the entrepreneurial zones, wood processing facilities are also operating in the counties, some of which have their own boiler rooms and use biomass to supply heat. Given the lack of information on the capacity of boilers and industrial plants, waste heat was not further analysed as a potential energy source.

HEAT SUPPLY

When evaluating the RES potential for heat production, the territorial aspects of the area (land cover type, nearby industrial facilities, possible natural barriers), as well as the quantity, energy potential and availability of each energy source were taken into account.

Biomass

The CORINE Land Cover tool was used to determine the territorial aspect of the area, as well as the area of each cover category, the technical potential of forest biomass and biomass from short rotation coppice.

The figure below provides a graphical overview of the land cover type in each county.

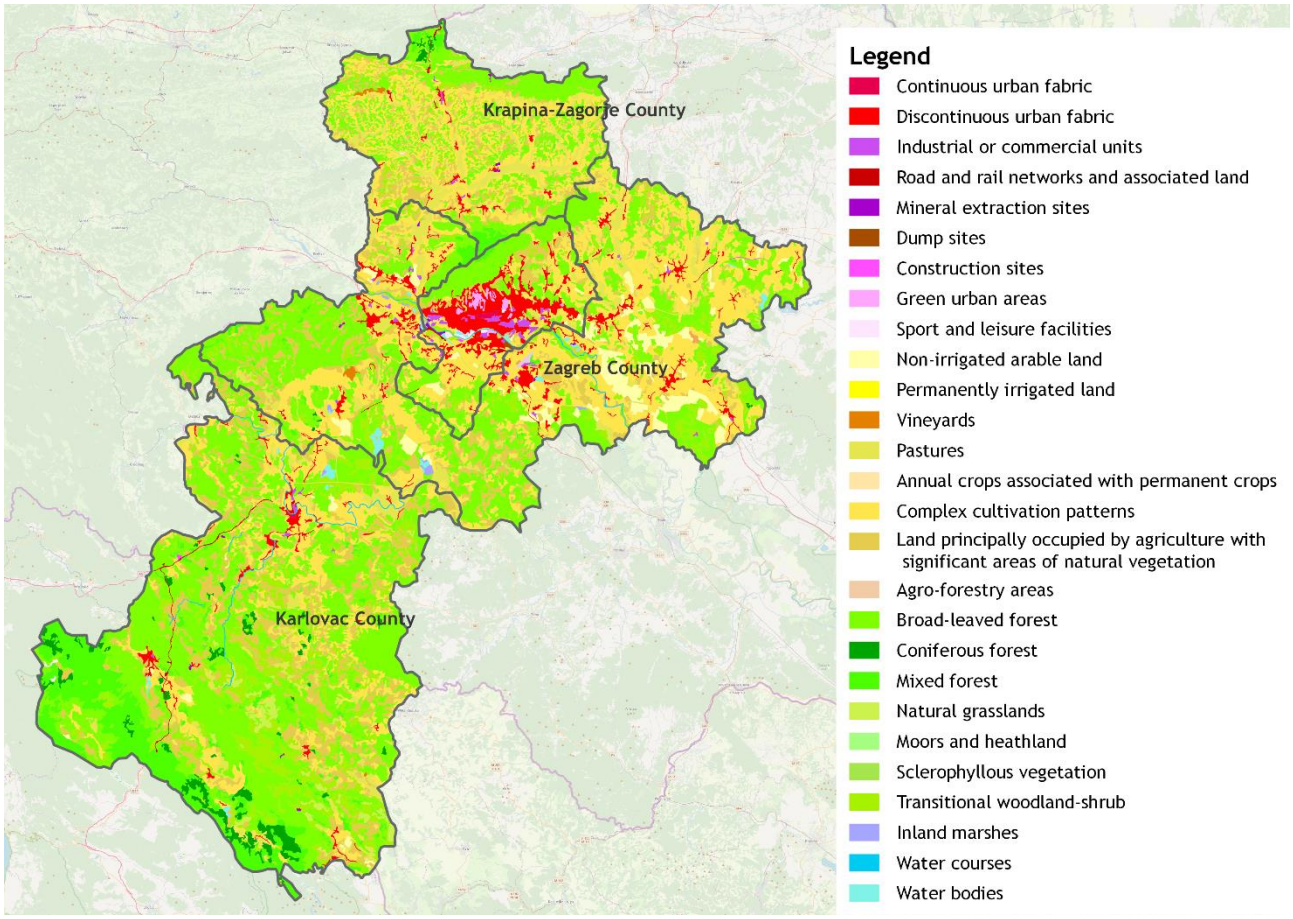

Figure 3 Land cover type in the ENTRAIN target area in Croatia

The table below shows an evaluation of the technical energy potential of biomass in the Croatian target area covered by the ENTRAIN project.

Table 2 Biomass energy potential in the Croatian target area of ENTRAIN

Item	Unit	Karlovac County	Krapina - Zagorje County	Zagreb County	Total
Woody biomass					
Available forest biomass	m^3/god	282.630	64.926	199.586	547.142
Technical energy potential	**PJ**	**1,83**	**0,42**	**1,29**	**3,55**
Short rotation coppice					
Surface area of the land cover suitable for planting Short rotation coppice	ha	5.318,21	1.467,42	3.272,92	10.058,54
Technical potential of short rotation coppice biomass	t	21.272,8	5.869,7	13.091,7	40.234,2
Technical energy potential	**PJ**	**0,26**	**0,07**	**0,16**	**0,49**
Total technical energy potential of biomass	**PJ**	**2,09**	**0,49**	**1,45**	**4,04**

According to theoretical preliminary estimates, forest biomass and short rotation coppice biomass can fulfil about one-third of the heat demand in this area. However, to kick off a RES DH project, a number of other parameters such as available technology, the market price of other energy sources, the cost-effectiveness of RES in relation to other energy sources, market incentives, etc. are also required to be considered.

Solar energy

Solar DH is not widely represented in Croatia since solar energy is mostly used to generate electricity and for hot water preparation. In cases where solar energy is used as a part of the heating system, it contributes up to 20% to the total heat supply, and with the addition of seasonal storage, the share of solar thermal energy can increase up to 50%. Ideal complementary technologies for heat production with solar collectors are cogeneration plants.

According to the Corine Land Cover methodology, the Industrial and/or Commercial Units category covers areas where the installation of solar collectors and other energy production and distribution facilities is possible. Taking into account such definition, the figure below is a visual overview of the geographical location of the urban areas relative to the areas covered by industrial units in order to identify the proximity of the potential area where the solar DHS could be built and the areas that would use heat.

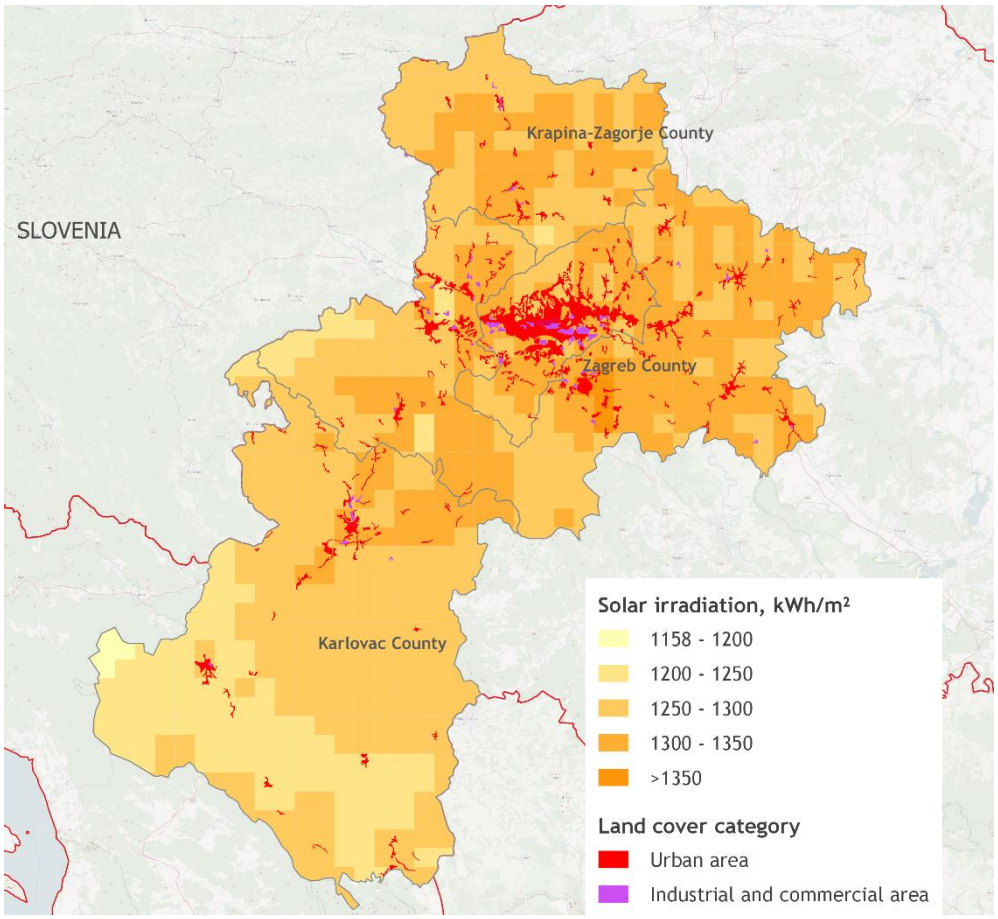

Figure 4 Urban and industrial areas of the ENTRAIN target area in Croatia with the solar irradiation of the area

The distribution of annual solar irradiation is similar in all three counties and ranges between 1.200 and 1.350 kWh/m^2. Based on the existing publicly available irradiation data in this area,

there is potential for the installation of solar thermal systems. However, to determine exact solar energy potential in this area, additional data and analysis are needed.

Geothermal energy

Exploitation permits for geothermal energy in the area covered by the ENTRAIN project are issued for the Ivanić and Sveta Nedelja fields located in Zagreb County, while the exploration permits for the use of thermal energy were issued to the Zagreb geothermal field. In addition to these geothermal fields, the geothermal field in Karlovac with a water temperature of 140 °C is a potential field to be used for electricity production as well as for the use in the existing DHS. The new Hydrocarbon Exploration and Exploitation Act (OG 52/18, 52/19), which encompasses geothermal water exploitation fields and exploration areas, simplifies the process of issuing permits for the exploration and exploitation of geothermal energy, which will enable faster and easier acquisition of necessary permits. Evaluation of publicly available data shows that there is a potential for exploitation of geothermal energy for heating and cooling in the three counties, however, to determine accurate exploitation potential for small DH networks in this area would require detailed analysis.

Possibilities of using RES for DH projects

When planning and starting to implement RES DH projects, it is extremely important to conduct thorough analysis of the cost-effectiveness of the investment, taking into account all the necessary parameters (technology, prices of other energy products, market incentives for heat production from RES, distance of the production facility and supply area, heat losses...), as well as its long-term sustainability. For effective and successful implementation of such projects, it is necessary to carefully plan activities and costs and invest sufficient time in the preparation of project documentation.

Adopting a regulatory and legal framework that will address the difficulty of investing in such systems would allow investors a simpler and faster start-up process, which would result in reduced administrative difficulties and potentially more investment projects. Despite the currently competitive prices of fossil fuels and natural gas, a modern DHS that is also more environmentally friendly can, in the long run, have lower heating costs for the end-user.

An obstacle in the construction of DH for solar collectors, geothermal energy and heat pumps is the low representation of such systems in Croatia and potential consumers are unable to see the practical application and benefits of these systems and thus do not want to risk such investments. Continuing to encourage the installation of such systems and providing grants to future users, as well as educating them on the possibilities of the RES heating systems, will reduce the investment risk for users, making them more willing to participate in such projects.

3. Germany

The goal of this *Renewable heat potential assessment for the target region Neckar-Alb (D.T1.3.2)* is an assessment of the status quo of heat demands and renewable heat potentials in the region. Together with the *Guidelines for the simplified evaluation of the potential for renewable heat (D.T1.3.1)*, possible starting points for project development can be found and a first assessment of the feasibility can be done.

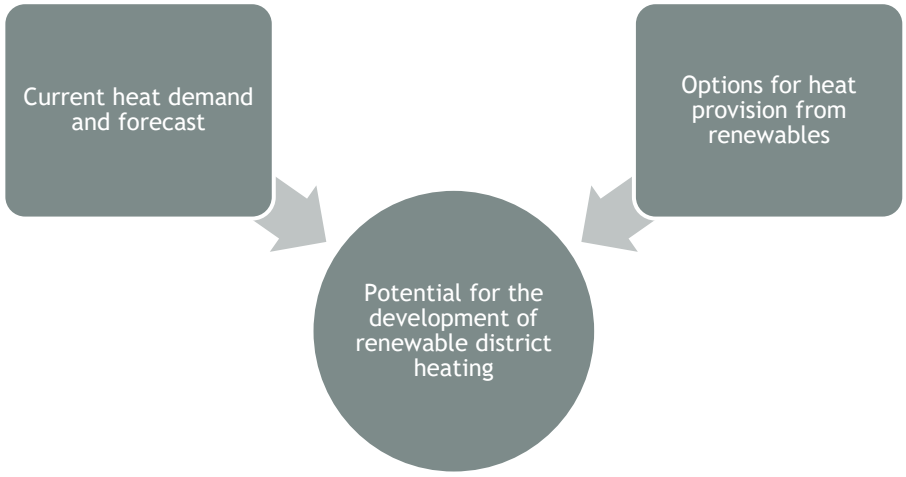

Figure 5 Steps to determine the potential for the development of renewable DHS

A set of indicators has been defined to assess both the state of heat demand and RES heat supply potentials in the federal state of Baden-Württemberg with a focus on the Neckar-Alb region with its three administrative districts (Tübingen, Reutlingen and Zollernalbkreis). On the demand side, population density and settlement structure, climatic conditions, heat demand and forecasted development, as well as the present heat supply (technologies and energy carriers), are evaluated. The potential for heat supply is assessed based on different RES and conversion technologies: Wood energy (estimation of regionally available biomass), solar thermal energy, geothermal energy (direct use or in combination with heat pumps) and waste heat (direct use or in combination with heat pumps).

RESULTS AND CONCLUSION

The assessed RES and conversion technologies are all available on the market. Especially wood and solar thermal energy are already in use, mostly on a household scale. Especially for new buildings, heat pumps are often used to harness environmental heat sources (e.g. near-surface geothermal energy). However, a more centralised heat production with distribution through a DH grid allows much higher efficiencies.

Heat demand and present heat supply infrastructure

The heat demand of buildings heavily relies on the type of the building (single family home or multiple dwelling) and the age of the building (efficiency requirements based on the year of construction). A successive reduction of the heat demand in the building sector due to modernization and the addition of new buildings fulfilling high efficiency requirements is restrained through rebound effects: While the specific heat demand [kWh/(m2*a)] is declining, the living space per capita steadily increases. Therefore, the total heat demand per capita

diminishes only slightly. An estimation based on data from the Reutlingen and Zollernalb districts leads to an assumed heat consumption of 9,5 TWh in the Neckar-Alb region per year. By the year 2050, this is projected to decline by 20 % to 7,5 TWh/a. The current heat supply relies heavily on fossil fuels (75 % on average). In the Neckar-Alb region, 63 % of the municipalities are connected to the natural gas grid. In off-grid towns and villages, oil-fired systems are the predominant source of heating, complemented mostly by biomass. Based on the present data, municipalities, where no competing grid bounded infrastructure is established can be identified. Those represent an interesting entry point for the development of renewable DH. The estimated heat demand can be met with combined use of different renewable resources:

Wood energy

- Forests in Baden-Württemberg show a record high of wood reserves; in total, the annual wood growth exceeds the use.
- Fuel wood potential from sustainable forestry is available for three times as much use as today (14.000 TJ or 3,9 TWh per year).
- Based on the regionally available fuel wood potential, the installed capacity of wood-fired heat (or heat and power) stations could be tripled.
- Synergies with climate friendly timber use as a building material, regional value creation as well as forest management measures can be reached.

Solar thermal

- In order to cover 15 % of the region's district heating demand with solar thermal energy, 800.000 m² (80 ha) of land area or 400.000 m² collector area are required.
- For higher coverage, further systems with larger collector areas and seasonal heat storage are required.
- It is difficult to estimate a realistically usable land potential, as in Germany every open space is usually overplanned and different interest groups claim the available areas.
- Various municipalities in the Neckar-Alb region have a high potential for the implementation of large-scale solar thermal systems on old landfill sites.

Geothermal

- Near-surface (< 400 m depth):
    - Potentials depend on available areas and/or drilling depths.
    - Responsibilities are bundled at the Federal State Office for Geology Resources and Mining (LGRB) that offers comprehensive information.
    - Regulatory restrictions in the Tübingen district due to sensitive geological conditions.
- Deep geothermal energy (1.000 – 3.000 m depth):
    - Risky and cost-intensive project development.
    - Favourable conditions with thermal springs in the Reutlingen district (Bad Urach), recent developments to exploit hot aquifers.

Waste heat

- Direct use (e.g. industrial waste heat)
    - Industrial waste heat can cover ca. 9 – 15 % of total energy consumption within the industry sector (estimation for Baden-Württemberg).
    - Pilot-scale developments to utilize waste heat of a cement plant in the Zollernalb district.
    - Further potential from regional biogas plants.
- Indirect use (focus wastewater heat)
    - Municipal sewers offer a stable (low temperature) heat supply.
    - The theoretical potential of 50,5 GWh/a from wastewater heat.
    - Power usage of heat pumps has to be taken into account.
    - Initial consultations have already been carried out in four municipalities (response rather low).

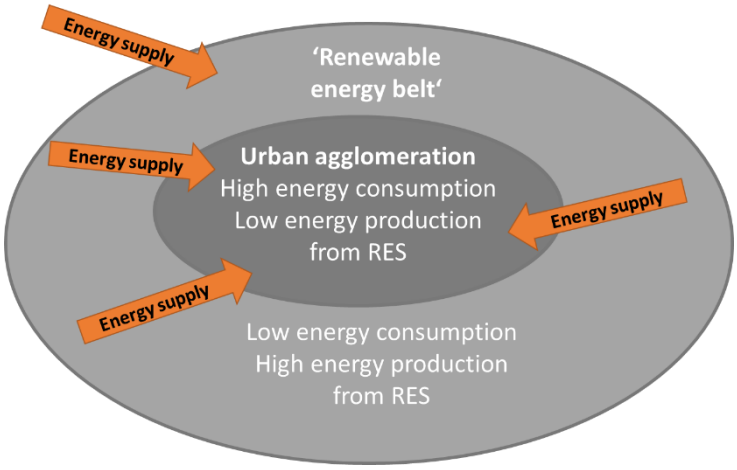

Figure 6 Connection between urban agglomeration and rural areas rich in RES

The Neckar-Alb region has both urban and rural areas that show differences in renewable heat potential. While the available land space, e.g. for the use of solar thermal energy is lower in urban agglomerations, 'energy imports' from rural areas can compensate this shortage. In total, a heat supply based in regionally available and renewable sources increases value creation and independence from fossil energy sources.

4. Italy

The main source of information to run this preliminary assessment of DH heat potential demand in Friuli Venezia Giulia is the "Pan- European Thermal Atlas" developed within the H2020 "Heat Roadmap Europe Project (HRE4)" integrated with further data collected from the Regional Energy Plan of Friuli Venezia Giulia.

The estimate of available forest biomass for energy production feeds on a 2007 survey by AIEL – Italian Agroforestry Energy Association commissioned by the Regional Central Direction of agricultural, natural, forestry and mountain resources – Fire and Forest Management Service (Udine). Data from this survey is considered reliable and possibly on the rise with reference to the yearly available biomass as a consequence of improvements on the forest road network funded by the Region.

The potential of solar heat was assessed building on data collected from the solar atlas 'sunRiSE' (http://sunrise.rse-web.it/) and available online thanks to the RSE and PVGIS (https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html#MR).

As for the assessment of waste heat potential from industrial processes, the source is the waste heat cadastre developed by APE FVG within the Interreg Central Europe CE-HEAT project and available online at this link www.atlanteenergetico.fvg.it.

RESULTS AND CONCLUSION

Results of the analysis of the RES potential in the Autonomous Region of Friuli Venezia Giulia show that forest biomass is the most interesting energy source to foster the development and diffusion of small RES DH networks at the regional level.

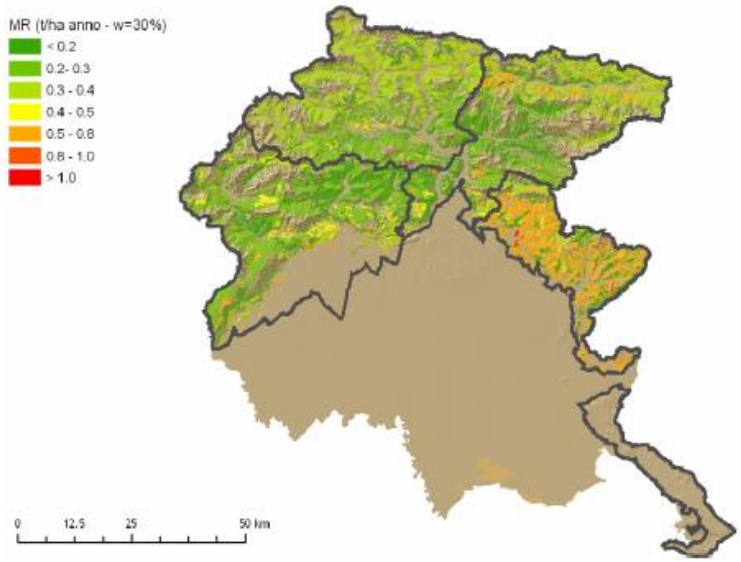

Figure 7 Distribution of available forest biomass in Friuli Venezia Giulia

93% of the regional forest area (covering little less than 3.000 km^2) is mainly found in the alpine and pre-alpine sectors of the provinces of Udine and Pordenone, more specifically in the so-called mountain communities (Comunità Montane) located in the west of Friuli, in the area of Gemona del Friuli, in the Carnia and Natisone valleys.

Wood waste resources from the total forest area amount potentially to nearly 72.600 tons yearly. Based on the extension and the conditions of the road system in the area, it is estimated that about 74% of those resources (equivalent to a little less than 54.000 tons/year or 2.230 TJ/year) are actually available for woodchip energy production.

There are both classes A woodchips, with low moisture contents therefore suitable for smaller plants, and class B which is suitable for medium to large-sized plants.

Overall, it is estimated that over 37.000 tons of class A and 16.700 tons of class B wood chips are obtainable from the regional mountain areas.

The demand for wood chips currently amounts to little less than 16.500 tons/year for 18 DH networks located in Carnia. These plants mainly run on class B wood chips (about 12.800 tons/year which is more than 70% of the total potential) that are produced, stocked and distributed by about 20 logistics platforms that could potentially be employed also in the western areas of the region.

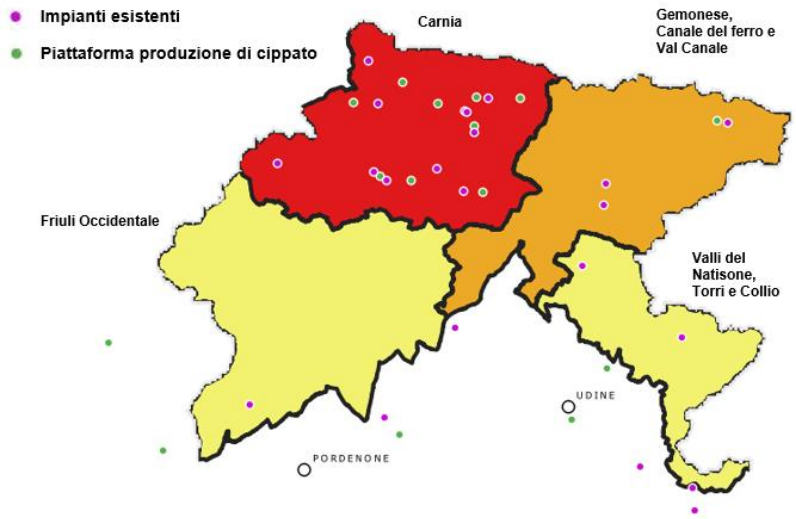

Figure 8 Distribution of existing DH networks and logistics platforms as of 2019

As for the production and distribution of class A wood chips, results show that the most interesting forest cover is located in areas which are off the gas grid. Nevertheless, these areas can count on a good quality road network and on the presence of several logistics platforms. These are mainly mountainous areas, sparsely urbanized, with cold winters and low population density that have low specific heat demand.

Diesel fuel and LPG are the most common heating fuels but wood biomass is also widely used for domestic heating mainly in small plants with manual loading or in combination with boilers and traditional plants. These systems are generally characterized by low efficiency both from an energy and environmental point of view especially in relation to dust emissions which can be quite high in case of poor or inadequate maintenance and therefore bad combustion.

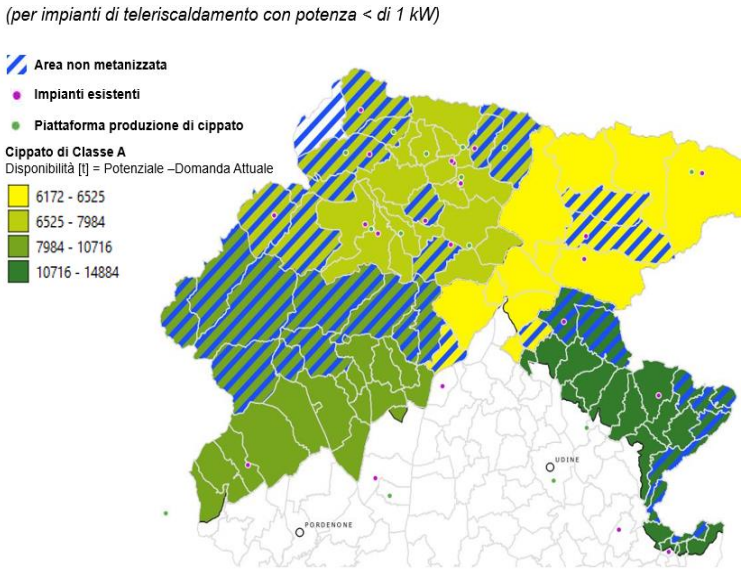

Figure 9 Most interesting areas for the diffusion of small DH networks

In these areas, all the operational requirements are met for the start-up and diffusion of "short energy chains" based on a local forest biomass supply system and aimed at small to medium scale heat production combined with small DH networks serving small urban areas or groups of buildings.

These systems, on one hand, are able to establish stable and profitable biomass supply opportunities for the local forestry sector and, on the other, to offer local communities an alternative to fossil fuels for their energy needs helping the protection and ecological-environmental requalification of the territory.

Combining energy, ecological, environmental and socio-economic aspects, the diffusion of these systems can provide a fundamental contribution to a general territorial enhancement through the achievement of multiple objectives such as:

- reduction of fossil fuel consumption and carbon dioxide emissions through profitable exploitation of local renewable materials;
- increase of generation and distribution efficiency and reduction of economic costs related to the procurement, management and maintenance of plants;
- protection and enhancement of natural resources (improvement of forest standards, defence of soil and water, benefits in terms of hydrogeological stability, conservation of ecosystems, etc.);
- containment of pollutant emissions (such as particulate matter in particular), which can also have a significant impact on local air quality.
- the stimulus to the economy and local employment through the growth of biomass supply and activities related to plant management and realization.

The energy and environmental value of small DHS fueled with wood biomass are also important for further integrations with other locally available renewable sources.

In this scenario, an integration with solar thermal energy is very interesting, given the almost unlimited availability of this resource and the average reduced surface area required for solar panel installation.

The integration with other renewable sources (geothermal or waste heat from industrial production) must be assessed on a case-by-case basis according to the location of the new DH network.

5. Poland

In Poland pilot territory covers the area of the city municipality of Płońsk, the rural municipality of Płońsk and neighbouring local administrations (including Nowe Miasto and Sochocin, whose representatives are part of the RSAG and who are potentially interested in RES use development). The biggest heat demand is associated with the first one, which has the highest number of inhabitants, which has over 22.000 inhabitants, the population density of 1.918,6 person/km^2, already existing biomass-fired CHP and citizens potentially interested in connecting to the district heating network and thus giving up individual boiler houses.

Regarding heat demand in the city, it was assessed using HOT MAPS tools and individual consultations with the city of Płońsk, City Energy Utility and local stakeholders. Following numbers were extracted:

For the city municipality of Płońsk:

- Total heat demand: 230,91 GWh/yr
- Average heat density: 320,71 MWh/(ha*yr)
- Heat demand in the residential sector: 170,9 GWh/yr
- Average heat density in the residential sector: 237,36 MWh/(ha*yr)
- Heat demand in the non-residential sector: 60,01 GWh/yr
- Average heat density in non-residential sector: 83,35 MWh/(ha*yr)

For the city + rural municipality of Płońsk:

- Total heat demand: 259,49 GWh/yr
- Average heat density: 202,73 MWh/(ha*yr)
- Heat demand in the residential sector: 194,34 GWh/yr
- Average heat density in the residential sector: 151,83 MWh/(ha*yr)
- Heat demand in non-residential sector: 65,15 GWh/yr
- Average heat density in the non-residential sector: 50,9 MWh/(ha*yr)

Regarding RES heat supply potential, it is similar as in the whole Mazowsze Voivodeship. The biggest one is associated with biomass, biogas and solid waste of high calorific value. The significant potential is also connected with solar energy and wind energy, however, the latter one cannot be developed within the current legal framework (very much restricting the possibilities of locating new wind power plants). Geothermal and water potential is limited due to the local environmental, geographical and topographical conditions. Below there are some major numbers on RES potential for the City Municipality of Płońsk (main target area) and the city together with the surrounding rural municipality:

For the city municipality of Płońsk:

- Average excess heat power from wastewater treatment: 0 kW

- Wastewater treatment capacity: 0 person equivalent
- Potential from agricultural residues: 819,45 GWh/yr
- Potential from livestock effluents: 0 GWh/ year
- Average potential from forest residues: 0 MWh/(ha/yr)
- Potential from forest residue: 0 GWh/yr
- Potential from Waste: 0 GWh/yr
- Average wind speed at 50 m: ND
- Average solar radiation: 1.140,84 kWh/(m2*yr)
- Average heat conductivity: 0 W/mK
- Average solar thermal potential – rooftop: 200,17 MWh/(ha*yr)
- Total solar thermal potential – rooftop: 151,93 GWh/yr
- Average solar thermal potential – open field: 987,43 MWh/(ha*yr)
- Total solar thermal potential – open field: 549,01 GWh/y

For the city + rural municipality of Płońsk:

- Average excess heat power from wastewater treatment: 4.295,87 kW
- Wastewater treatment capacity: 66.660 Person equivalent
- Potential from agricultural residues: 1.638,89 GWh/yr
- Potential from livestock effluents: 0 GWh/ year
- Average potential from forest residues: 4 MWh/(ha/yr)
- Potential from forest residue: 3,15 GWh/yr
- Potential from Waste: 0 GWh/yr
- Average wind speed at 50 m: ND
- Average solar radiation: 1.140,98 kWh/(m^2*yr)
- Average heat conductivity: 0 W/mK
- Average solar thermal potential – rooftop: 133,45 MWh/(ha*yr)
- Total solar thermal potential – rooftop: 232,59 GWh/yr
- Average solar thermal potential – open field: 1.027,36 MWh/(ha*yr)
- Total solar thermal potential – open field: 12.604,72 GWh/yr

For further project activities, it was agreed to take into consideration City Municipality of Płońsk heat demand potential (the buildings are too distributed in the rural area to consider district

heating) and the City + Rural Municipality of Płońsk heat supply potential. Considering not only the numbers above but also local needs, already existing infrastructure, legal, environmental and social conditions, it was agreed to have a closer look at the following options that could be developed in the future:

- Further development of the biomass-fired CHP already existing in the city – increasing capacities and connecting new consumers to the grid; the plant is mostly operating on the wood chips;
- Further use of the biogas potential – there is already one biogas plant operating in the region and within the Płońsk Energy Cluster – it is selling electricity to the city but cannot make use of the excess heat, which is now released in the air. It is worth trying to find a use for the excess heat and provide it to the end-users;
- Making energy use of biodegradable municipal waste – new waste segregation system is implemented, which will allow for better separation of biodegradable and calorific waste. This could be used for energy generation, however, there is a problem (in the current legal framework) with making use of the solid by-product);
- Making use of solar energy: following activities are considered:
    - ✓ Building 3 PV farms and PV installation of approx. 9 MW; use of power to heat technology considered; investment value of 31 Mio PLN; implementation time till 2024
- Making use of the wind energy, provided the unfavourable legal frameworks change; the following activities are considered:
    - ✓ Building wind farm with the capacity of 3 MW; use of power to heat technology considered; investment value of 11,5 Mio PLN; implementation time till 2027.

6. Slovenia

The Lower Podravje region comprises 16 municipalities: Cirkulane, Destrnik, Dornava, Gorišnica, Hajdina, Jursinci, Kidricevo, Majšperk, Markovci, Podlehnik, Ptuj Municipality, Sveti Andraž in Slovenske gorice, Trnovska vas, Videm, Zavrč and Žetale.

The area of the Lower Podravje region, covering 647 km^2, is a relatively densely populated and mainly agricultural oriented area, which includes Haloze and parts of Slovenske gorice, and the plains along the Drava and its tributaries in the Ptuj field. In the north, the Lower Podravje region also covers the central-western part of Slovenske gorice and extends from Krčevina near Vurberk across the River Pesnica to the municipality of Sveti Andraž in Slovenske gorice.

ENERGY USE AND SUPPLY

Dwellings: Fuel oil consumption (30%) causes higher gas emissions than wood biomass consumption (40%). This is an individual use of this energy source, which means individual fireboxes, which are often poorly maintained, with technologically obsolete boilers, which results in low efficiency and high consumption of fuel oil. Some households switched to natural gas heating (14%), mainly in urban centres where no other energy sources can be used.

Public buildings: Public buildings are heated by heating oil, natural gas, district heating, common boiler rooms and LPG. Most buildings do not have solar collectors or heat pumps installed, and they heat all domestic hot water by central heating to non-renewable energy sources or electricity. Additional thermal insulation of the facades is only in 35% of buildings. Other buildings are without insulation facade. 68% of public office furniture is energy efficient. 66% of public buildings that are constantly heated during the heating season do not have thermostatic valves installed. Also, only occasionally heated buildings do not have thermostatic valves installed.

Industry and crafts: Fossil fuels are mostly used, with 79% of the energy consumed coming from natural gas and 19% from extra light heating oil. Average awareness of economic operators about RES and EE. Bigger companies with high energy consumption, like TALUM kodričevo, has designated energy managers. In smaller companies' energy management becomes more and more important.

Opportunities lay in increased biomass use in individual, public and industrial buildings. On the national level, the following incentives are available, which can be identified as investments opportunities:

- High national subsidies for renewable and high-efficiency DH systems,
- High feed-in tariff for small CHP project using RES,
- Good availability of RES: abundant forests, untapped potential of geothermal energy, the high solar energy potential.

The main barriers are low awareness of positive impacts of centralised small scale DH (especially higher efficiency and less pollution with hard particles) of the general population, problematic legislation for above 1 MW district heating networks, existing use of biomass or individual heating, low price of heating oil and natural gas.

Some additional barriers are given below:

- Slow administration and problematic obtaining of needed permits

- Few national examples of small RES driven DH projects and
- Low public awareness on the benefits of small RES driven DH projects.

USE OF RENEWABLES IN DHS

Biomass

The sector has developed quite well in the last 20 years. 12,8 % of this DHS heat comes from renewable energies. The use of biomass for energy is well developed in Slovenia.

Many households use biomass district heating, firewood, wood chips or wood pellets for heat supply. In total, about 56 % of Slovenian needed thermal heat for households come from biomass.

Next picture shows installed district heating systems by energy source. Light green colour present CHP units where use renewable energy sources, dark green present pure renewable heating source.

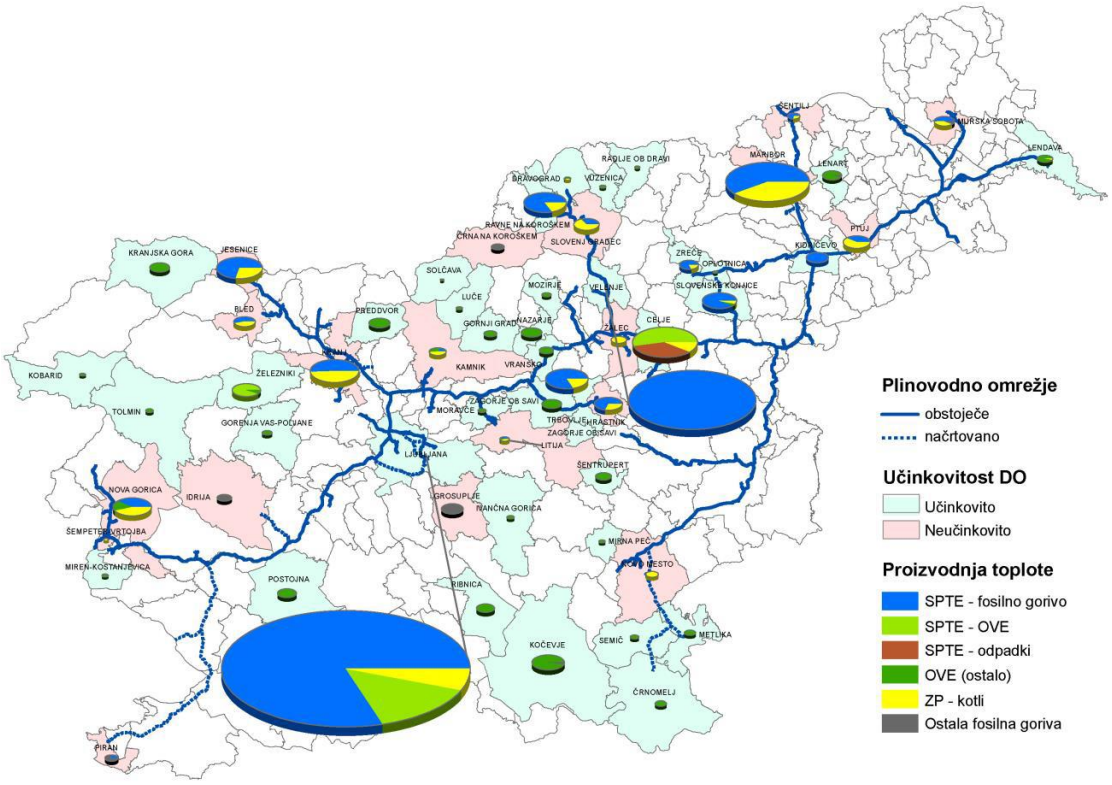

Figure 10 Map of DHS in Slovenia by heating source

Source: Podnebno ogledalo

The use of biofuels is very well accepted in society. Especially in rural areas and in smaller cities. In bigger cities, it sometimes has a negative image because of fine dust emissions. The political opinion on using biofuels is positive. Politicians decide on the awarding of subsidies. Politics also know that biofuels are needed for a transition of the national energy system to a renewable way.

Excess/waste heat

In 2017, consumption of heat was 2,34% higher than a year before. 55 heat suppliers in 64 Slovenian municipalities provided heat supply from 93 distribution systems. As much as 86,76% of the heat supply was produced by cogeneration of electricity and heat.

In Slovenia, only in the municipal waste incinerator in Municipality of Celje heat is produced from biodegradable waste, and in the area of former ironwork Ravne na Koroškem (SIJ Metal Ravne, d.o.o.) waste heat from industrial processes is used for heat distribution. Heat, produced from biodegradable waste covered 2,15%, and waste heat from industrial processes 1,5% of all generated heat for the supply of distribution systems.
The use of excess/waste heat is accepted in society. Although it is not that well known in society yet. The political opinion on using excess and waste heat is positive. Politicians decide on the awarding of subsidies. They know that it is necessary to use heat efficiently to reach climate and energy goals. Therefore, they understand the need to utilize excess/waste heat.

Solar-thermal energy

The sector is well developed; many houses have installed a solar system for hot water production. However, in recent year the development of this sector is stagnant.
In general, the use of solar thermal energy is well developed, in district heating systems it is only used in one project. Characteristics of the thermal solar plant as part of the DHS are:

- The maximum solar peak power of the system is up to 420 kW.
- »Low-Flow« principle was connected to the solar energy receivers.
- The desired amount of energy would require approx. 1.500 m^2 SSE, only 842,3 m^2 was realized.
- 100 m^3 storage tank.

In society, thermal solar projects are well accepted. Although after integration of the net metering system in the electric grid, the use of solar energy is much more focused on photovoltaics.

LEGAL FRAMEWORK AND SUBSIDIES

Emission limits

The emission limits are defined in national legislation by “Decree on the emission of substances into the atmosphere from small combustion plants” (Official Gazette No. 46/19) and “Decree on the emission of substances into the atmosphere from medium-sized combustion plants, gas turbines and stationary engines” (Official Gazette No. 17/18 and 59/18). The decree is also related to the European MCP-Directive (EU 2015/2193), which regulates the emission limits for medium combustion plants.

Table 3 Emission limits for various energy sources in Slovenia

Particle	Coal		Oil		Gas		Biomass	
	< 1 MW	1-50 MW	< 1 MW	1-50 MW	< 1 MW	1-50 MW	< 1 MW	1-50 MW
Dust mg/m^3	40	22	-	50	-	5	40	30
SO_2 mg/m^3	1.000	1.400	-	-	-	-	1.000	1.500
CO mg/m^3	500	160	150	80	100	80	500	225
NO_x mg/m^3	400	325	111-185	180	60 - 120	100	400	375

Subsidies

In Slovenia, there are subsidies for installing DHS, but only for plants using renewable fuels or utilization of technological heat. For the optimisation, there are subsidies for the investment cost (environmental subsidies) – subsidies for new and expansion of existing RES DHS and optimisation of existing DHS.

The subsidies are funded from different funds. Main funds are EU Funds (financial perspective 2014 - 2020) and national environmental fund “Eko Sklad”. The subsidy is between 20 and 55 %, depending on specified criteria.

Permissions

Building permit and plant operation permit are required. The Building Act is a matter of the respective national legislation and the execution of the operating license is based on the trade regulations. The approval procedure is carried out by the responsible national Energy Agency. Depending on the size and location of the district heating plant need other permits.