Market uptake of small modular renewable district heating and cooling grids for communities

Project No: 691679

Heating/cooling demand and technical concept for district heating/cooling in Šabac

City of Šabac - Serbia

Plan to implement biomass boilers for district heating in Šabac

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CoolHeating website: www.coolheating.eu

Contents

1 Introduction

The heating and cooling demand in Europe accounts for around half of the EU's final energy consumption. Renewable energy policies often mainly focus on the electricity market, whereas policies for renewable heating and cooling are usually much weaker and less discussed in the overall energy debate. Therefore, it is important to support and promote renewable heating and cooling concepts, the core aim of the CoolHeating project.

The objective of the CoolHeating project, funded by the EU's Horizon2020 programme, is to support the implementation of "small modular renewable heating and cooling grids" for communities in South-Eastern Europe. This is achieved through knowledge transfer and mutual activities of partners in countries where renewable district heating and cooling examples exist (Austria, Denmark, Germany) and in countries which have less development (Croatia, Slovenia, Macedonia, Serbia, Bosnia-Herzegovina). Core activities, besides techno-economical assessments, include measures to stimulate the interest of communities and citizens to set-up renewable district heating systems as well as the capacity building on financing and business models. The outcome is the initiation of new small renewable district heating and cooling grids in five target communities up to the investment stage. These lighthouse projects will have a long-term impact on the development of "small modular renewable heating and cooling grids" at the national levels in the target countries.

For each of the CoolHeating target municipalities one or two potential projects are identified in which small modular renewable heating and cooling grids could be implemented. The current report describes the technical concept for implementation of biomass boilers for the district heating grid in Šabac.

2 General description of the current situation and concept

Šabac is one of 58 cities in Serbia where a district heating system exist. This system is managed by the Public Utility Company "Toplana-Šabac", whose founder is the city of Šabac. In the mid-1980s, two city heating plants - "Trkalište" and "Benska Bara" were built. All existing local boiler rooms have been reconstructed and converted into heating substations. Since the heating season 2016/17 for the heat production in the DH in Šabac, only natural gas is used.

Three boilers with a capacity of 3 x 14 MW, type BKGV 175 (manufacturer TPK "Zagreb") with burners Monarch (manufacturer Weishaupt) for the combustion of natural gas (and alternatively fuel oil) were installed in the "Trkalište" heating plant. After the reconstruction in 2013th, 600 kW/unit recuperators were installed in the flue tract of each boiler. The efficiency of boiler units after the installation of the recuperators has increased to 94%.

The "Benska Bara" heating plant was reconstructed in 2003/4. New boilers with a capacity of 3 x 8.2 MW, UT-H 8200 (LOOS) with burners Monarch (Weishaupt) for combustion of natural gas and alternatively fuel oil were built in. The efficiency of boiler units amounts 91%.

The smallest heat source is the "Stari grad" boiler house, which was reconstructed in 2011 when two condensing boilers with a capacity of 2 x 0.29 MW type WTC - GB 300 (Weishaupt) were installed.

Table 1 shows the number of heat substations that are connected to the district heating network. The district heating system is indirect, and the basic components of the heat substations are the primary part with a combined control valve, a heat meter and a plate heat exchanger, and a secondary part with a frequency controlled circulating pump. The operation of the heat substation is managed by local controllers, type ECL 310 Danfoss and XF 5000 Phoenix BB (Herz).

Table 1: Number of heating substations in the DH grid of Šabac

	"Trkalište"	"Benska Bara"	"Stari grad"	Sum:
Multifamily apartment building	164	51	-	215
Office buildings	52	12	2	66
One-family houses	83	16	-	99
Total:	299	79	2	380

PUC "Toplana-Šabac" heats more than 7,500 households (374,000 m^2) and more than 500 commercial buildings (99,000 m^2). The total length of the heating network is 22,917 m. The average consumption of natural gas is 7 million m^3/year.

The usual heating time is 16 h/day in the period from 5 am to 9 pm, except during the "ice day". "Ice days" are defined as days when the average daily temperatures are in the range from -3 °C to -18 °C. During the "ice day", the district heating system works 24 h/day. A possible number of "ice days" is 10 to 15 during January and February. The average number of operating hours of the heating plant is 3,000 h/year in the period from October 1st to April 30th. When daytime temperatures exceed 14°C the heating system interrupts operation. The lowest temperatures drop to -10°C (for example: January 2017) and the extremely low temperatures are down to -18°C.

Other important data are as following: 2,588 degree-days, 181 heating days, mean temperature in the heating period is 5.7°C. There is no central system for sanitary water heating nor central systems for space cooling in existing buildings. There is no heat consumption outside the heating season, so the installation of CHP plants at this moment is financially unsustainable.

It is important for the Municipality to bring renewable energy into the DH grid in Šabac. That's why the CoolHeating project gives the chance to calculate a sustainable usage of biomass for the DH grid. Three biomass boilers with 4.5 MW each could be installed. One at the existing main heating plant Trkalište and two at a new location.

3 Key results of the survey for heating/cooling demand in the target community

The key results of the survey (Puksec et al. 2016[1]) shows that 74% of the buildings in Šabac are households, 26% apartment buildings, about 28% have outer wall insulation and 26% have insulation on the rooftop. 44% of the buildings have a central heating system and 21% have a district heating system.

About 54% are heating with logwood, 17% with district heating, 16% electricity and 7% with natural gas. Most of the households are producing their domestic hot water with electricity. 79% of the households have no cooling needs.

[1] Pukšec T. et al. (2016) Survey on the energy consumption and attitudes towards renewable heating and cooling in the CoolHeating target communities. – University of Zagreb FSB; CoolHeating Report available at www.coolheating.eu

4 Heating/cooling demand for the concept and initial situation

4.1 Map: Potential buildings to be connected to the DH grid

Within this concept, biomass heating boilers should be implemented in the existing DH grid in Šabac. There might be some additional buildings that will connect to the DH grid, but this is not focus of this concept. That's why there is no map shown here to connect potential buildings.

4.2 Assessment of heating/cooling demand

The average heat production in the DH grid is about 62,000 MWh/year. The total number of households in Šabac is 21,000. Except the mentioned 7,500 households that are connected to district heating network, another 2,500 households are connected to a natural gas distribution network, while the remaining 11,000 households use individual boilers and other stoves. In those furnaces logwood is burned, but sometimes coal is burned as well.

Most of the buildings were built before 2012 when there were no strict regulations on the energy properties of buildings. For this reason, the heat consumption is extremely high. From the aspect of energy efficiency and the energy demand, there are small number of facilities in class C. Other buildings do not meet the minimum criteria and are found in classes D, E and F (Ministry of construction, 2012)[2]. The local Energy Policy promotes energy efficiency measures and the city administration have been considered a proposal to allow connection to the district heating grid only for facilities that meet the requirements of the minimum energy class "C", i.e. that the annual heat consumption is 75 kWh/m^2. Also, the city administration will continue to co-finance the improvement of the energy properties of existing buildings, and for newly constructed buildings the legislation regulates the maximum required annual energy consumption at level of 70 kWh/m^2 of heated space.

Based on the above, it can be concluded that regardless of the expected construction of new facilities and the possible increase of heat consumption in the future, there will be no increase in thermal capacity, even a decrease can be expected.

The heat production was analyzed from the year 2015 for the heating plants Trkalište and Benska Bara. An annual load line of the total heat production is shown in Figure 1. The load line shows the mean heat load within one day. There are about 2,900 operating hours per year and a peak load of about 50 MW (average per day).

[2] Ministry of Construction, transport and infrastructure Republic of Serbia - Rule book of energy certification of buildings (2012)
http://www.mgsi.gov.rs/sites/default/files/PRAVILNIK%20O%20USLOVIMA%20SADR%C5%BDINI%20I%20NA%C4%8CINU%20IZDAVANJA%20SERTIFIKATA%20O%20ENERGETSKIM%20SVOJSTVIMA%20ZGRADA.pdf

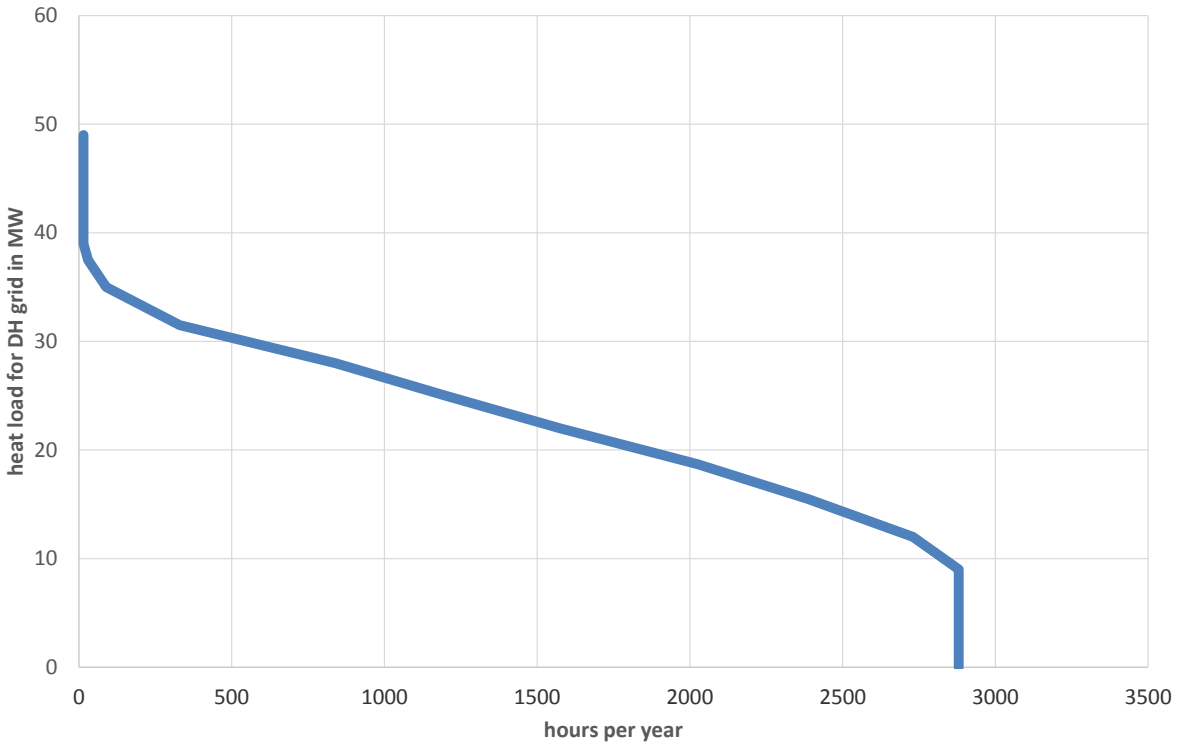

Figure 1: Annual load line of district heating grid Šabac

5 Technical concepts for heat/cold generation

The management of the new biomass plant could be left to the local heating company PUC "Toplana-Šabac", which could also be obliged to provide the logistics of biomass supply. There is a possibility that the construction of a biomass plant will be entrusted to a private partner (PPP model), but nevertheless heat distribution and heat supply would remain in the PUC "Toplana-Šabac". The locations of the main heating plant Trkalište and the possible new biomass plant are shown in Figure 2.

Figure 2: Location of "Trkalište" heating plant and the potential new biomass plant (Source: Geographic information system of City of Šabac)

The City Council of the City of Šabac has the authority to issue the necessary regulatory acts such as: Decree on the operation of the heating system, tariff system and heat prices, model of the contract between PUC and end consumers including the rights and obligations of the contracting parties and the duration of the contract as well as other legally prescribed documents. In accordance with the Law on Efficient Use of Energy, the city administration could decide on subsidizing the costs of equipment procurement or costs of heat production using renewable sources.

5.1 District heating / cooling grid

The planned plot for a new biomass heating plant could be located in the eastern industrial zone. There is direct access from the plot to the bypass road around Šabac and regional road Šabac-Belgrade or Šabac-Valjevo, so that the logistics of biomass supply is facilitated. The plant locations are shown in Figure 3. The existing district heating network and the heat substations are not planned to reconstruct.

Figure 3: Connection pipelines (Source: Geographic information system of City of Šabac)

The biomass heating plant could be connected with the main heating plant "Trkalište" with a connecting pipeline of diameter DN 350 (at least DN 250 for 9 MW load) in the length of 2,000 m. The pipeline could be constructed of pre-insulated steel pipes.

There might be the possibility to find a connection point that is closer to the biomass plant, so to have only a shorter connection pipeline. This need to be checked in detail.

The maximum flow temperature could be 110°C at low outside temperatures, e.g. -15°C. The return flow temperature could be 60°C in that case. There is no need to produce domestic hot water in summer time.

5.2 Heating / Cooling generation

Biomass boilers with a capacity of 3 x 4.5 MW could be installed at the district heating system. Those boilers are selected to cover the basic heat demand but gas boilers in "Trkalište" and "Benska Bara" heating plants will remain to work as peak demand boilers. It is envisaged that at least 60% of the required heat will provide by combustion of biomass, i.e. between 36,000 MWh/year to 45,000 MWh/year. According to the study on the availability of biomass, which was done by GIZ DKTI (2016)[3] for the needs of Šabac for this amount of heat there are sufficient wood biomass potential.

One 4.5 MW biomass boiler could be installed at the main heating plant Trkalište, the other two 4.5 MW biomass boilers at the new plant location. Figure 4 shows the annual load line for the DH grid with the heat production units. The result is that about 61% of the annual heat consumption of the DH grid could be covered with the 3 biomass boilers (**37,688 MWh/a produced heat**). These boilers could reach annual full load hours of about 2,792 h/a. This is nearly the full operating time of the grid. This means that the biomass boilers cover the base load of the load line. One thing to consider is that biomass boilers are not designed to start and stop like fossil fuel boilers, so they could not be switched off or on that easily. Normally,

[3] M. Malidžan, S. Vitorović (2016) - Agro-biomass and woody biomass potential and logistics study for the city of Šabac, GIZ DKTI, http://www.bioenergy-serbia.rs/images/documents/studies/Agro_biomass_and_woody_biomass_potential_and_logistics_study_Sabac_Final.pdf

boilers of this size do not have automatically ignitors to start the firing. That's why it is important to implement a buffer storage tank with about 200 m³ on the new plant location to lower the peaks and to balance the fluctuations of the heat demand and production. Otherwise there might be the possibility to use the DH grid as a buffer storage, but this needs to be analyzed in detail.

The three biomass boilers would have a fuel consumption of about 44,338 MWh/a with wood chips (e.g. with 35% water content), or another agro biomass (at estimated 85% annual efficiency of the boilers). The temperature level of maximum 110°C for the DH grid could be reached with the boilers.

The existing natural gas boilers could cover about 39% (24,285 MWh/a produced heat) of the annual heating needs. The natural gas consumption would be about 26,397 MWh/a at estimated 92% annual efficiency.

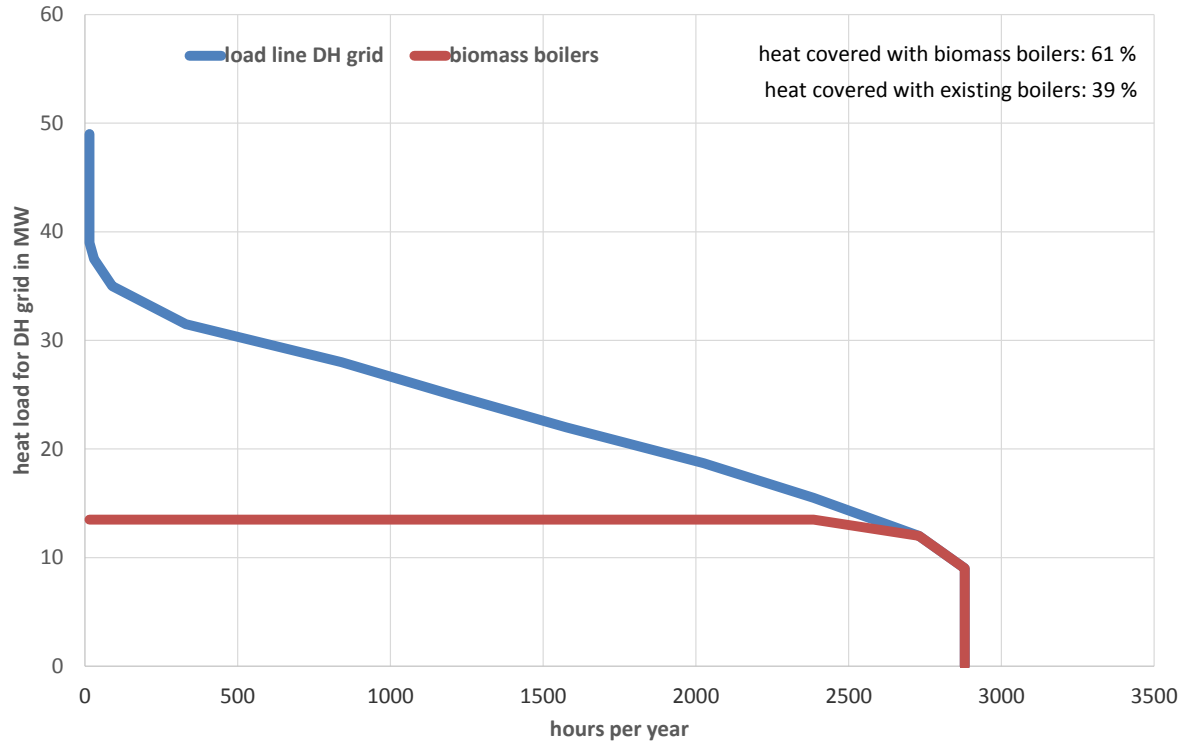

Figure 4: Annual load line for the DH grid and the heat production with the biomass boiler

The size of the plot, shown in Figure 3 and Figure 5 is about 240 m by 73 m. This plot seems to be large enough to build a heating plant for two 4.5 MW biomass boilers, plus space to handle the biomass (storage and logistics). It should be avoided to chip the biomass at the plant, because of dust, that might displease neighbors.

Figure 5: Possible biomass plant location in Šabac (source: Google Maps)

6 Summary of the technical concept

The concept for the implementation of renewable energy in the DH grid Šabac could plan three biomass boilers with 4.5 MW nominal capacity each. This could lead to about 61% coverage of the annual heat demand and supply the DH grid with **37,688 MWh/a** renewable energy. The rest could be covered with the existing natural gas boilers (39% annual coverage). The new biomass plant should be connected to the main heating plant Trkalište with a new DH pipeline with DN 350, or at least DN 250 for 9 MW thermal load. The fuel for the biomass boilers could be wood chips or local agro biomass. A buffer storage tank with 200 m³ at the new plant could improve the controlling behavior of the biomass boilers and decrease peak load.

In the next step, economic calculations will be made for these scenarios in order to facilitate the selection of the best concept in order to develop an individual business model. In the final step, a feasibility check will be made to present the potential project with most feasible technologies and business options to decision makers and investors.