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 Ozalj

City of Ozalj (Croatia)
District heating for the city of Ozalj

WP 4 – Task 4.4 and 4.5 / D 4.4

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CoolHeating website: www.coolheating.eu

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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 to meet the heat demand for the city of Ozalj.

2 General description of the current situation and concept

Currently, there is no district heating system in Ozalj so all the heat is supplied individually, at dwelling level. Regarding energy sources that are used for heating in households, biomass covers the largest share, followed by fuel oil. The reason for such a high share of biomass is the high amount of biomass available locally and no existing gas network in the city. Also, a fair number of citizens own a part of surrounding forests and therefore only encounter costs for transferring biomass to their home.

The main problem is that most of individual furnaces currently being used are old and therefore result in high environmental impact. Public buildings mainly use fuel oil (91 %), while the rest is covered by electricity. Furthermore, electricity is used in the majority of households for the preparation of domestic hot water. The survey carried out in Ozalj showed that the building stock is rather old and inefficient, reflecting the current state of buildings in Croatia. Therefore, specific heat demands of households are relatively high.

The technical concept for Ozalj includes two different combinations of biomass boiler and flat plate solar collectors for baseload. The first combination uses solar collectors to cover a minor part of the heat demand, mainly during summer. The second one uses solar collectors in combination with a seasonal thermal storage. Every combination has an additional fuel oil peak load boiler for covering the peak load. During summer, domestic hot water is being produced in the system.

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 91% of the buildings in Ozalj are households, about 35% have outer wall insulation and 34% have insulation on the rooftop. 84% of the buildings have a central heating system.

About 71% are heating with logwood, 14% with fuel oil and 6% with logwood and fuel oil. About 24% are producing their domestic hot water with electricity, 36% with logwood and 15% with logwood and electricity. 66% of the households have no cooling needs.

4 Heating/cooling demand for the concept and initial situation

Two district heating scenarios have been developed for the city of Ozalj, as described in more details in the next paragraphs. The idea was to cover the heat demand of all public buildings in the area and as much as possible households and service sector buildings.

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

A heat demand mapping was performed for the city of Ozalj by using the data gathered from the survey. This also included mapping of the existing buildings and providing them with their specific categories. There were two DH grid scenarios developed. The central scenario includes only the city centre and the industrial zone of the city, while the expanded scenario includes the whole mapped area of the city, south of the river, since the concentration of buildings north of the river is significantly lower. Most of the buildings in the analysed area are private houses, but there are also 10 public buildings, 8 apartment buildings and the industrial zone.

Results of the survey carried out in Ozalj show that most of the buildings already have a centralized heating system and therefore would not require additional investment when connecting to a district heating system. The needed flow temperature of the buildings is up to 80°C. Figure 1 provides the aggregated 100x100m heat demand map of the city. This provides valuable information since it shows the areas with highest heat demands, being most suited for connecting to a district heating system. This was the basis for the choice of scenarios.

[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

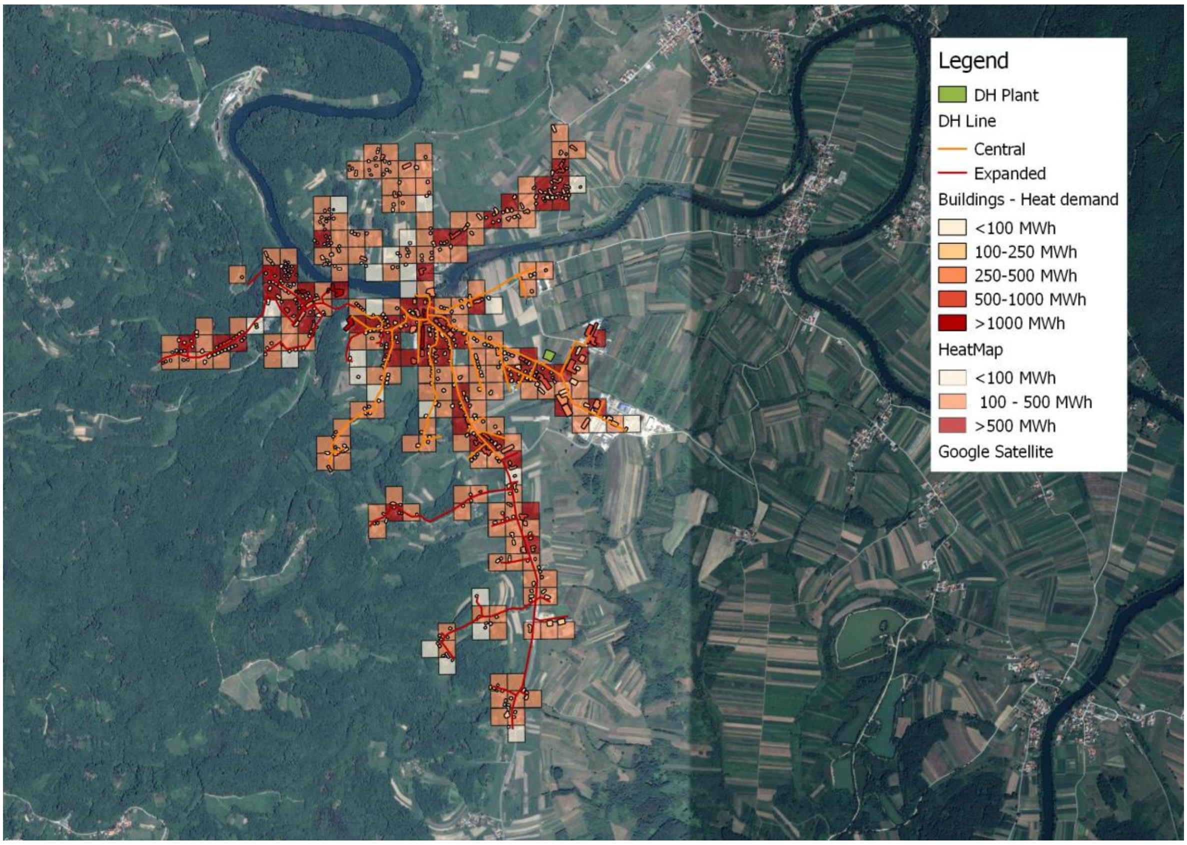

Figure 1: Aggregated 100x100m heat demand map of the city of Ozalj

4.2 Assessment of heating/cooling demand

Based on the results of the survey (Puksec et al. 2016[2]) and the size of the analysed city, it is expected that the overall connection rate could be up to 80% in both scenarios. Therefore, the heat demand of the potentially connected buildings in the central scenario could be 41,755 MWh, while in the extended scenario it is 66,413 MWh.

The heat demand was analysed by performing the heat demand mapping with data from the survey. Buildings were divided into 8 categories and assigned specific consumptions for every category. Specific consumptions represented average values received from the survey for each category. The annual load line of the heat demand in the city of Ozalj is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** for the central scenario and Figure 3 for the expanded scenario.

The focus of both scenarios is on heating since the cooling demands are significantly lower than the heating demands. Only about 34% of the buildings in Ozalj have cooling needs. The annual load line considers also the summer load for domestic hot water production. The usage of night setback by the consumers was also considered at the load line.

[2] 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

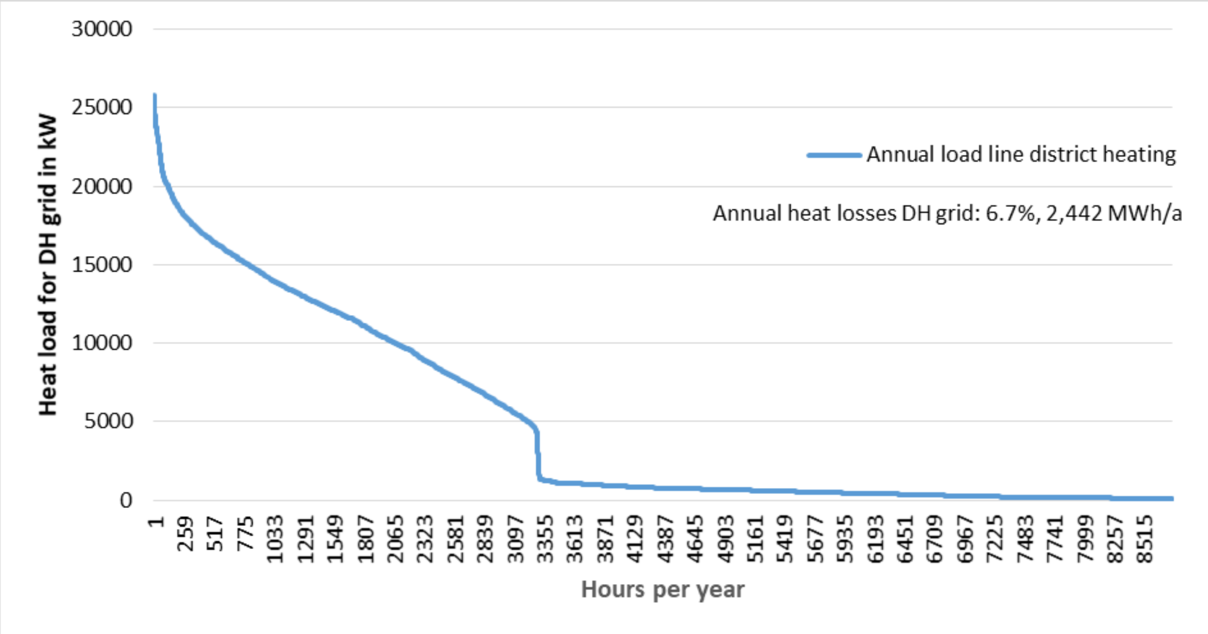

Figure 2: Annual load line for the district heating system in the central scenario, at 80% connection rate

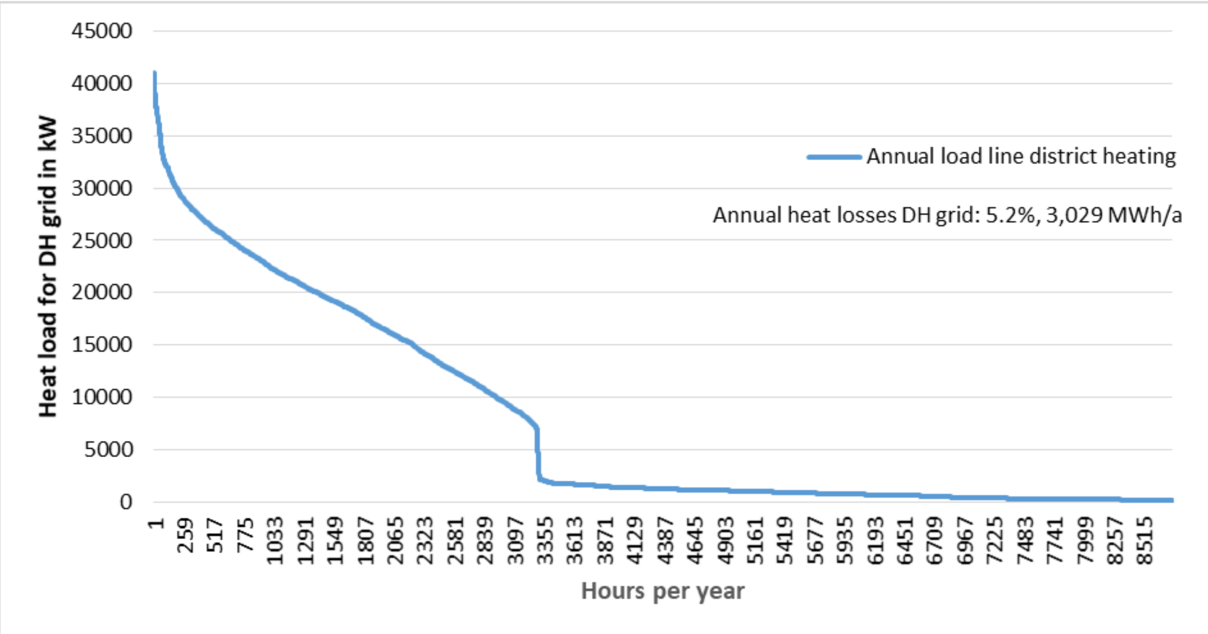

Figure 3: Annual load line for the district heating system in the expanded scenario, at 80% connection rate

5 Technical concepts for heat/cold generation

Various renewable energy sources could be used to supply heat in the city of Ozalj, but the forest biomass has by far the highest potential. It covers more than 50% of the land in the surrounding areas of the city and is already used as a fuel for the individual stoves. Forest residues are particularly interesting since this waste is currently just being left in the forest to decompose.

The other, very interesting source is solar irradiation. This part of Croatia has high average annual values of solar irradiation, with global horizontal irradiation of more than 1,200 kWh/m^2/a. Therefore, solar energy already represents an important energy source and its potential should be further exploited.

Taking into account the above mentioned specifics, the most welcome technology for district heating production in the city of Ozalj would be based on biomass and solar thermal technologies. The business model which could be implemented is to buy wood from the citizens, that way lowering their heating bills. This should be taken into account since a significant number of citizens owns a part of the forest and currently have very low heating costs, using their woods as an energy source in the individual furnaces. On the other hand, since this is the rural part of Croatia, there is enough land available for the construction of solar thermal panels and a seasonal storage.

The technical concept for Ozalj includes two different combinations of biomass boiler and flat plate solar collectors for baseload. The first combination only uses solar collectors to cover a minor part of the heat demand, mainly during summer (up to 10% of the heat demand). The second one uses solar collectors in combination with a seasonal thermal storage, therefore allowing it to cover a higher share of heat demand (up to 30%). Every combination has an additional fuel oil peak load boiler for covering the peak load. As mentioned earlier, the connection rate for all the scenarios is 80%. During summer, domestic hot water is being produced in the system. All the sources, except from the fuel oil, are locally available, increasing the sustainability of the proposed concept.

5.1 District heating / cooling grid

Two different scenarios for district heating implementation (central and expanded scenario) are shown in Figure 4. However, it is not realistic to expect that all the buildings will be connected in the first stage. Therefore, the connection rate of 80% has been taken.

The needed length of distribution pipes in the central scenario is 8,798 m (pipeline), while in the expanded scenario it is 16,586 m. This is the trench length, i.e. the length of the flow pipe. This includes the main district heating pipeline and the pipes to the consumers. The distance of each building from the main pipeline has been assumed with 5 m.

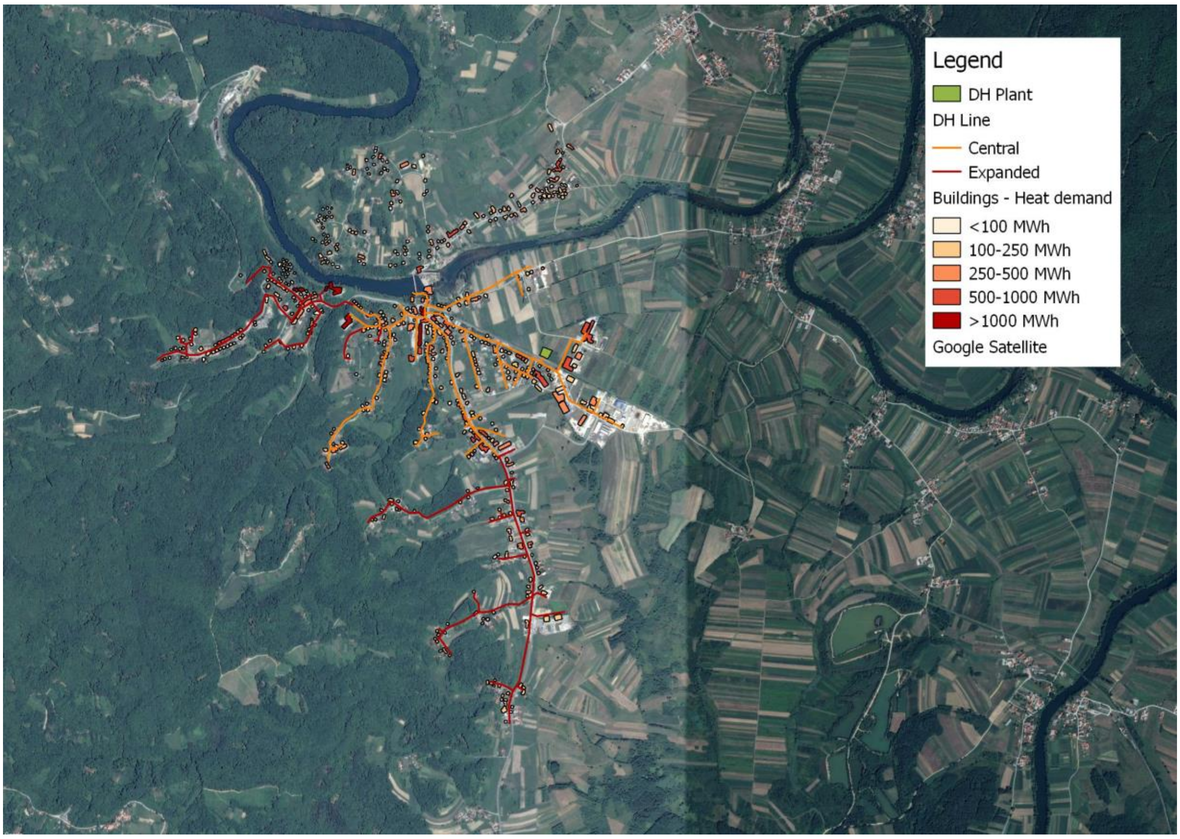

Figure 4: Two district heating scenarios for the city of Ozalj including the heat demand of each building in the city and the location of DH plant

The grid density of a DH grid is an important indicator for the economy of a system, as well as for the DH grid losses. The grid density is calculated with the annual heat consumption of the consumers, divided by the grid length. The calculated grid density for the central scenario is 4,594 kWh per meter pipeline and per year, while for the expanded scenario it is 3,873 kWh per meter pipeline and per year.

The annual heat losses for the DH grid in the central scenario were calculated with 6.7%, or 2,442 MWh/a, while in the expanded scenario they were calculated with 5.2 % or 3,029 MWh/a. The calculations were based on real DH grids data in Austria (calculation based on Malik 2012[3]), for the grid density shown above.

The overall heat demand which could be covered by a district heating system equals to 41,755 MWh/a in the central scenario and **66,413 MWh in the expanded scenario**. These figures include the grid losses.

The temperature level of the DH grid could be designed with 90°C flow and 65°C return flow. Within summer time the flow temperature must be at least 70°C to cover the domestic hot water production.

Using night setback (reduction of room temperature at night and heat up in the morning) by the consumers causes higher peak loads in the morning and could also cause very low loads at night. Therefore, it is assumed that all the consumers use the night setback. That's why the peak load of the grid is rather high. The thermal peak load of the DH grid was calculated at about 26 MW for the central scenario and 41.5 MW for the expanded scenario.

5.2 Heating / Cooling generation

Four scenarios have been considered for the technical heat generation concept for Ozalj, as shown in Table 1. In all scenarios, the baseload is covered by a biomass boiler, peak load by a fuel oil boiler, while flat plate solar collectors are used to cover the demand in the summer. However, Central Scenario 2 and Expanded Scenario 2 additionally use seasonal thermal storages in order to increase the production from solar collectors throughout the year. The scenarios have been calculated in the EnergyPRO software and the load lines have been taken directly from it.

Table 1. Scenarios for the technical concept for Ozalj

Scenario	**Production units**
Central Scenario 1	Wood chip boiler, fuel oil peak load boiler, flat plate solar collectors
Central Scenario 2	Wood chip boiler, fuel oil peak load boiler, flat plate solar collectors, seasonal thermal storage
Expanded Scenario 1	Wood chip boiler, fuel oil peak load boiler, flat plate solar collectors
Expanded Scenario 2	Wood chip boiler, fuel oil peak load boiler, flat plate solar collectors, seasonal thermal storage

The calculated load line of heat production units for every scenario is shown in Figure 5 to Figure 8.

[3] A. Malik et. al. (2012) Was ist ein gutes Heizwerk? - Landesenergieverein Steiermark and qm heizwerke Datenbank; https://www.klimaaktiv.at/dam/jcr:9f6e7fe5-48b0-4cb1-a9d6-8a57dc908713/Was_ist_ein_gutes%20Heizwerk.pdf

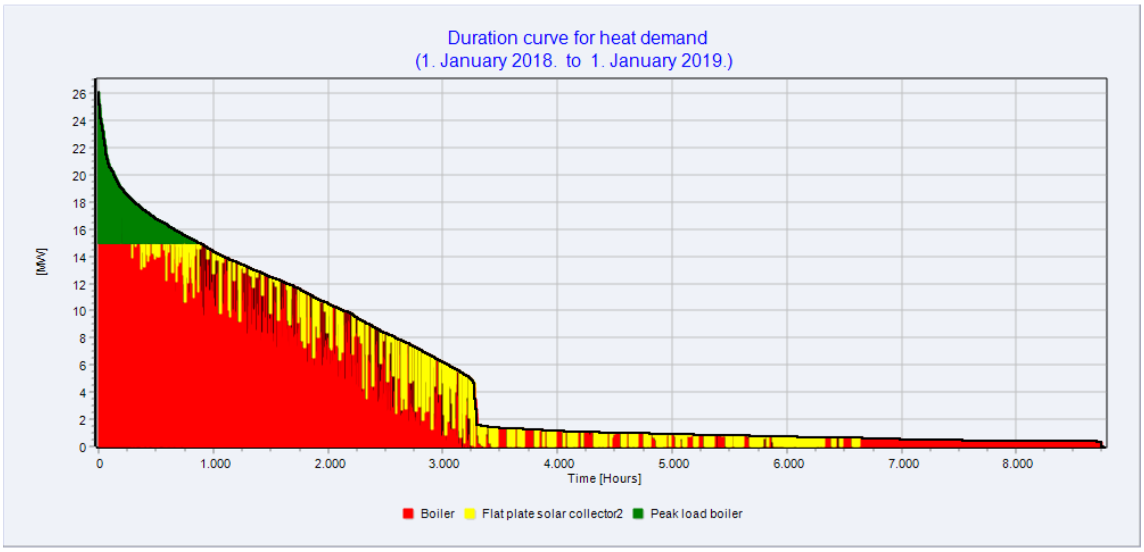

Figure 5: Annual load line of heat production units for Central Scenario 1 in Ozalj

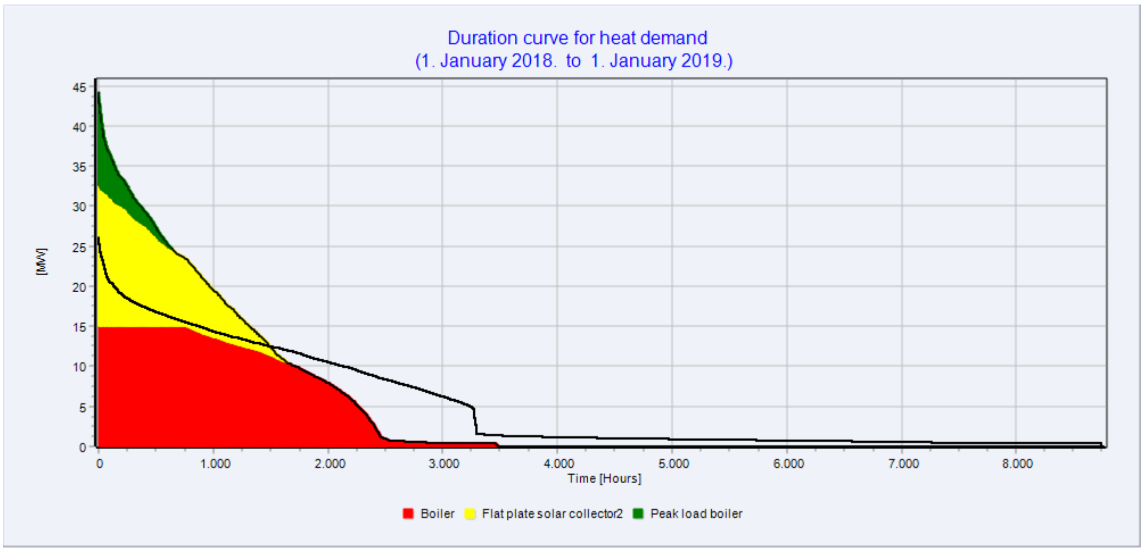

Figure 6: Annual load line of heat production units for Central Scenario 2 in Ozalj

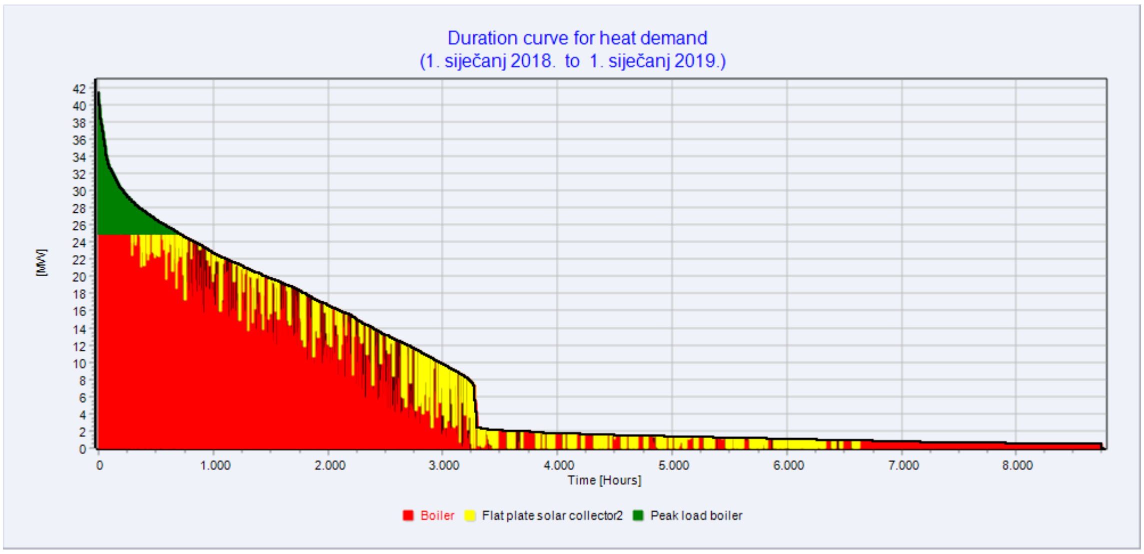

Figure 7: Annual load line of heat production units for Expanded Scenario 1 in Ozalj

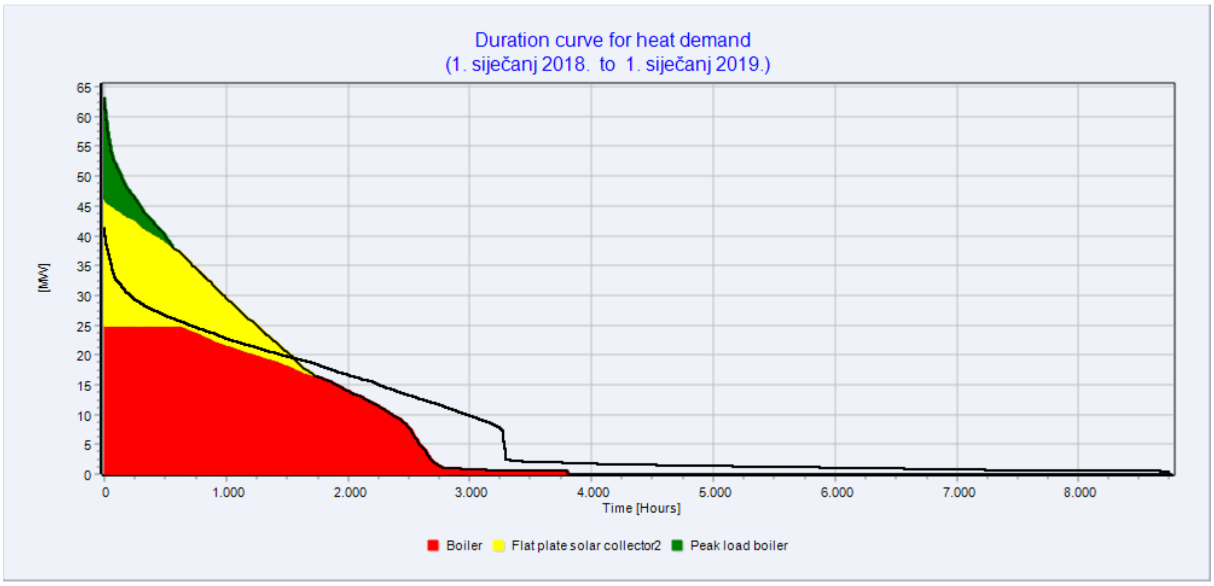

Figure 8: Annual load line of heat production units for Expanded Scenario 2 in Ozalj

The calculation details for heat production units are shown in Table 2 to

Table 5.

Table 2: Calculation details for heat production units in Central Scenario 1

Central Scenario 1	Installed capacity	Produced heat in MWh/a	Needed fuel energy in MWh/a	Annual efficiency in %	Share of total heat for DH in %	Operating hours per year
Biomass boiler	15 MW	38,039.25	44,752.06	85%	86.5	7,274
Fuel oil peak load boiler	26 MW	2,200.35	2,750.43	80%	5	807
Flat plate solar collectors	8,000 m^2	3,756.36	-	-	8.5	2,801

Table 3: Calculation details for heat production units in Central Scenario 2

Central Scenario 2	Installed capacity	Produced heat in MWh/a	Needed fuel energy in MWh/a	Annual efficiency in %	Share of total heat for DH in %	Operating hours per year
Biomass boiler	15 MW	28,890.46	33,988.78	85%	65.6	3,482
Fuel oil peak load boiler	26 MW	1,863.08	2,328.85	80%	4.4	635
Flat plate solar collectors	25,000 m^2	13,242.41	-	-	30	1,652
Seasonal thermal storage	1,390 MWh	-	-	-	-	-

Table 4: Calculation details for heat production units in Expanded Scenario 1

Expanded Scenario 1	Installed capacity	Produced heat in MWh/a	Needed fuel energy in MWh/a	Annual efficiency in %	Share of total heat for DH in %	Operating hours per year
Biomass boiler	25 MW	60,909.86	71,658.66	85%	88.1	7,273
Fuel oil peak load boiler	42 MW	2,604.24	3,255.30	80%	3.8	654
Flat plate solar collectors	12,000 m^2	5,611.81	-	-	8.1	2,801

Table 5: Calculation details for heat production units in Expanded Scenario 2

Expanded Scenario 2	Installed capacity	Produced heat in MWh/a	Needed fuel energy in MWh/a	Annual efficiency in %	Share of total heat for DH in %	Operating hours per year
Biomass boiler	25 MW	49,993.97	58,816.44	85%	72.3	3,811
Fuel oil peak load boiler	42 MW	2,334	2,917.5	80%	3.4	563
Flat plate solar collectors	30,000 m^2	16,797.94	-	-	24.3	1,732
Seasonal thermal storage	1,854 MWh	-	-	-	-	-

When there is no seasonal thermal storage, solar collectors cover about 8.1 to 8.5% of the demand, but when the seasonal storage unit is implemented in the calculation, solar collectors cover between 24.3 and 30% of the heat demand. In all the scenarios, biomass boilers cover the highest share since they serve as baseload units. However, it is significantly reduced in cases of seasonal thermal storage implementation due to the increased share of solar collectors. Storage capacities were 30,000 m^3 (1,390 MWh) for Central Scenario 2 and 40,000 m^3 (1,854 MWh) for Expanded Scenario 2.

Additionally, a short-term buffer storage tank with about 300 m^3 could be installed to lower peaks and to balance fluctuations of loads, especially caused by night setback. One of the installed biomass boilers should be smaller (e.g. 2 MW) to cover the summer load.

6 Summary of the technical concept

The technical concept shows the heat supply for the city of Ozalj. The grid density is quite high, that would lead to a more economic operation of the system. The domestic hot water could be produced via the DH grid, also in summertime.

The overall heat demand which could be covered by a district heating system equals to 41,755 MWh/a in the central scenario and **66,413 MWh in the expanded scenario**. These figures include the grid losses.

A biomass boiler could supply the DH grid with about 65.6% (Central Scenario 2) to 88.1% (Expended Scenario 1) of the annual heat demand and a fuel oil peak load boiler needs only 3.4% (Expended Scenario 2) to 5% (Central Scenario 1) of the annual heat demand.

The flat plate solar collectors could cover about 8.1% (Expended Scenario 1) to 30% (Central Scenario 2) with a size of 8,000 m² (Central Scenario 1) to 30,000 m² (Expended Scenario 2).

The buffer storage tank with about 300 m³ could reduce the usage of the peak load boiler, mainly caused by the night setback of some consumers.

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.