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 Cven*

## Cven (Slovenia)
## District heating in settlement Cven

*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 in Cven.

# 2 General description of the current situation and concept

Target community in Slovenia is city of Ljutomer, which has 4,523 households (STAT 2015[1]). The Municipality of Ljutomer selected the settlement of Cven as one of two perspective locations for developing a DHC project. The settlement of Cven has 226 households and a few larger objects – the school, a culture hall and a shop. There is also one large industrial object – a polyethylene foils factory Makoter.

The households are predominantly heated by a centralised heating systems generating both heating and sanitary hot water, using mostly biomass (logwood and in a smaller extent pellets and woodchips) with more than 50% of energy for heating generated from biomass and in more than 40% heating oil. Households are predominantly not insulated well and majority of houses were built before 1980. As a lot of households use old inefficient stoves the environmental impact in winter is significant with a lot of smell and smoke from inefficient logwood stoves. In households heated by heating oil the costs for heating are relatively high. Therefore a lot of inhabitants are searching for alternatives with some households already changing to heat pumps and solar heating.

The technical concept for Cven considers a small biomass CHP (combined heat and power) for the baseload, a biomass boiler and a natural gas peak load boiler. All public buildings should be connected to the DH grid, as well as 90% of the households (90% connection rate, about 156 households) in the DH grid supplied area. The domestic hot water production could also be done in summertime. A buffer storage tank could decrease the peaks after night setback time in the morning, when most households starts heating again. Biomass (e.g. wood chips) is available in this region.

[1] http://www.stat.si

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

The key results of the survey (Puksec et al. 2016[2]) shows that most of the buildings in Cven are households, about 61% have outer wall insulation and 48% have insulation on the rooftop. 96% of the buildings have a central heating system.

About 40% are heating with logwood, 15% with natural gas and 13% with logwood and heating oil. About 22% are producing their domestic hot water with electricity, 22% with logwood and 19% with natural gas. 65% of the households have no cooling needs.

# 4 Heating/cooling demand for the concept and initial situation

Cven is a settlement which is situated among two main roads which intersect in the middle of the settlement. Therefore the settlement has developed in an X shape with two prolonged parts. The technical concept shall cover as much of the settlement as economically feasible. All public objects shall be connected to the DH concept also the Shop. The Makoter factory can be included only for heating of their objects, if feasible.

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

The needed flow temperature of the buildings is up to 80°C. Most of the buildings use night setback, so the heating temperature is lowered at night.

The map in Figure 1 shows the consumers, the planned DH grid and the potential location of the heating plant.


**Figure 1: Cven settlement consumers and the DH grid (red line), location of the possible plant**

[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

The public buildings in Cven are culture hall (Figure 2) and ground school (Figure 3). Additionally there is a Mercator shop (Figure 4).

**Figure 2: Culture hall Cven**

**Figure 3: Ground school Cven**

**Figure 4: Mercator shop in Cven**

### *4.2 Assessment of heating/cooling demand*

Doe to the small size of the DH project in Cven it is expected that a large proportion of the settlement could be connected to the DH project in the initial phase of the project. This will be a prerequisite for the project to start at. Nevertheless it is to be expected that some additional connections will occur also after the initial project setup.

All households, public buildings and the shop where assessed and unavailable data was estimated based on the existing buildings. The total annual heat consumption (useful heat for space heating and domestic hot water at 90% connection rate) was calculated with 2.24 GWh plus 0.94 GWh for a wood dryer installed in the DH grid. Company Makoter is not included for heating with DH. The annual load line to supply the DH grid in Cven is shown in Figure 5.

There is no need for cooling the public buildings or households, that’s why the focus will be on heating.

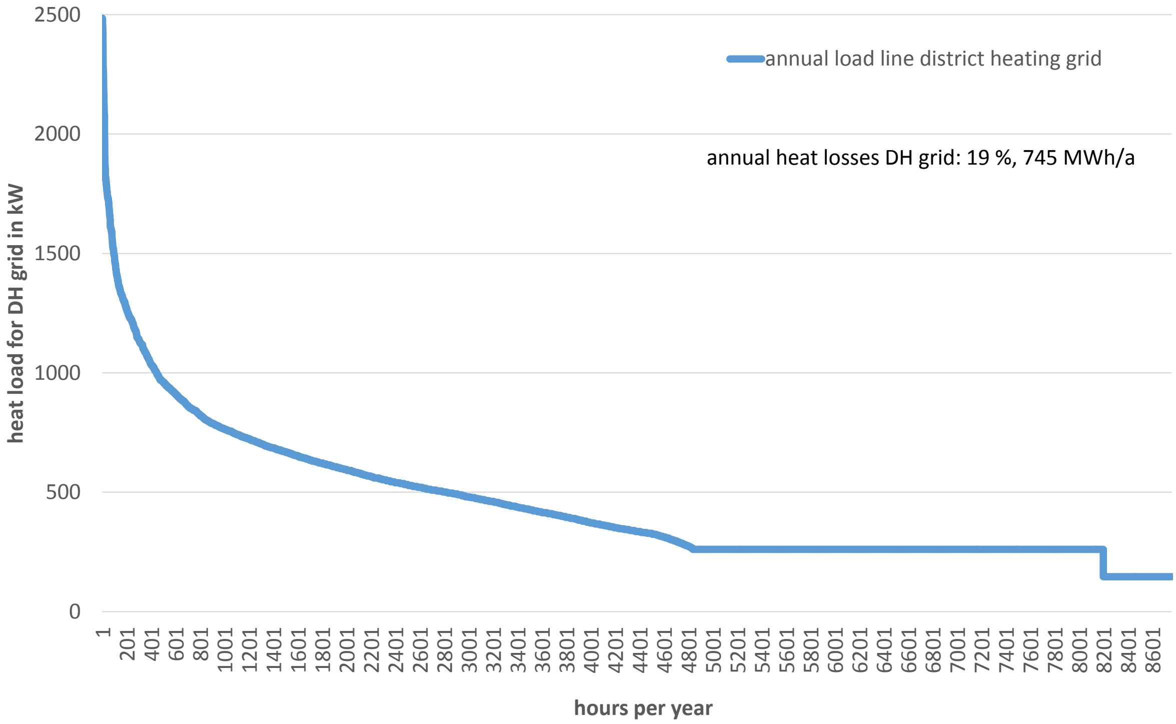


**Figure 5: Annual load line for the planned district heating grid in Cven at 80% connection rate**

# 5 Technical concepts for heat/cold generation

Cven is located in the rural area of north east Slovenia. The area is rich in biomass from both woods and agriculture (waste) and the area is rich in solar energy with as much sunny days as the southern parts of Slovenia.

The technical requirements should meet the minimal specifications of the Slovene national support scheme for DH projects:

- Annual minimal grid density of 800 kWh/m, with preference of more than 1,000 kWh/m
- Target temperature difference between flow and return pipe 40K
- Annual efficiency of the project 50% (relationship between produced heat and sold heat)

In general most welcome technology in Cven would be based on biomass – both agricultural residues and wood biomass could be also purchased from Cven inhabitants. Also solar thermal technologies would be accepted and sufficient land could be arranged. Also heat pumps could be used even if the permit procedures for use of groundwater can be long and problematic in Slovenia. However biogas use should be avoided as this technology has a very bad image in Slovenia due to inadequate use in the last years.

The technical concept for Cven considers a small biomass CHP (combined heat and power) for the baseload, a biomass boiler and a natural gas peak load boiler. All public buildings could be connected to the DH grid, as well as 90% of the households (90% connection rate) in the DH grid supplied area. Additionally there should be installed a wood dryer in the DH grid. The domestic hot water production could also be done in summertime. A buffer storage tank could decrease the peaks after night setback time in the morning, when most households starts heating again. Biomass (e.g. wood chips) is available in this region.

In the first concept all household areas where supplied by a DH grid (90% connection rate), but due to a lower grid density the south-west part of the town was not connected (wider distances between households) to higher that value.

## *5.1 District heating / cooling grid*

The wish was to connect 90% of the houses in Cven, so Figure 6 shows the DH grid (red line) to connect the consumers. Production company Makoter, as well as the south-west part of the town is not connected in this calculation, to higher grid density.

The main DH pipelines at the roads have about 2,000m, plus about 1,400m pipes to the consumers (average 9m connection to each consumer). The length of the grid here is only the length of the flow pipe. This leads to a total length of the DH grid of 3,400m.

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 Cven is 934 kWh per meter pipeline and per year. The minimum value of 800 is achieved, according to the Slovene national support scheme.

The annual heat losses for the DH grid in Cven were calculated with 19%, or 745 MWh/a, based on real DH grids data in Austria (calculation based on Malik (2012)[3]), for the grid density shown above.

About 2.24 GWh per year could be sold to the consumers, plus 943 MWh per year for wood drying. So in **total 3.93 GWh/a** are needed to feed the DH grid.

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. The calculation is based on 50% of the consumers having night setback. That’s why the peak load of the grid is higher than without night setback. The thermal peak load of the DH grid was calculated with about 2.5 MW.

The material of the DH pipes could be steel or plastic. Simultaneity of the load was calculated with 100%.

The possible location of the heating plant is shown in Figure 6, it’s a triangle plot with 596m². It needs to be carried out if this space is enough for the plant.

[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 6: Cven settlement consumers and the DH grid (red line), location of the possible plant**

## *5.2 Heating / Cooling generation*

The technical concept for Cven considers a small biomass CHP for the baseload, a biomass boiler and a natural gas peak load boiler. A buffer storage tank could decrease the peaks after night setback time in the morning, when most households starts heating again.

Figure 7 shows the annual load line of the planned heat production units. The baseload, especially also in summertime could be covered with 2 small biomass CHPs with $56kW_{el}$ each (based on a biomass gasifier CHP by Fröling). About half of the heat output could be used in the DH grid for drying the soft wood to 10% water content. The rest will be used for heating the DH grid consumers with about $57kW_{th}$ each. The wood dryer needs an annual heat demand of 943 MWh/a. The CHP should be operated 8,200 hours per year. About 918 MWh of electricity (gross) is planned to be produced annually to feed into the public grid.

The annual fuel consumption is 3,231 MWh/a of soft wood (at 10% water content) for the 2 CHP units, 2,338 MWh/a of wood chips (about 30 to 35% water content) for the biomass boiler (~82% annual efficiency, 800 kW nominal capacity) and 163 MWh/a for the natural gas peak load boiler (~80% annual efficiency, max. 2.2 MW).

The nominal capacities (thermal load) of the boilers and other data are shown in

Table 1.

The buffer storage tank with 50 m³ could cover about 3 hours with 800kW load, to reduce the usage of the peak load boiler and to lower the peak loads at production.

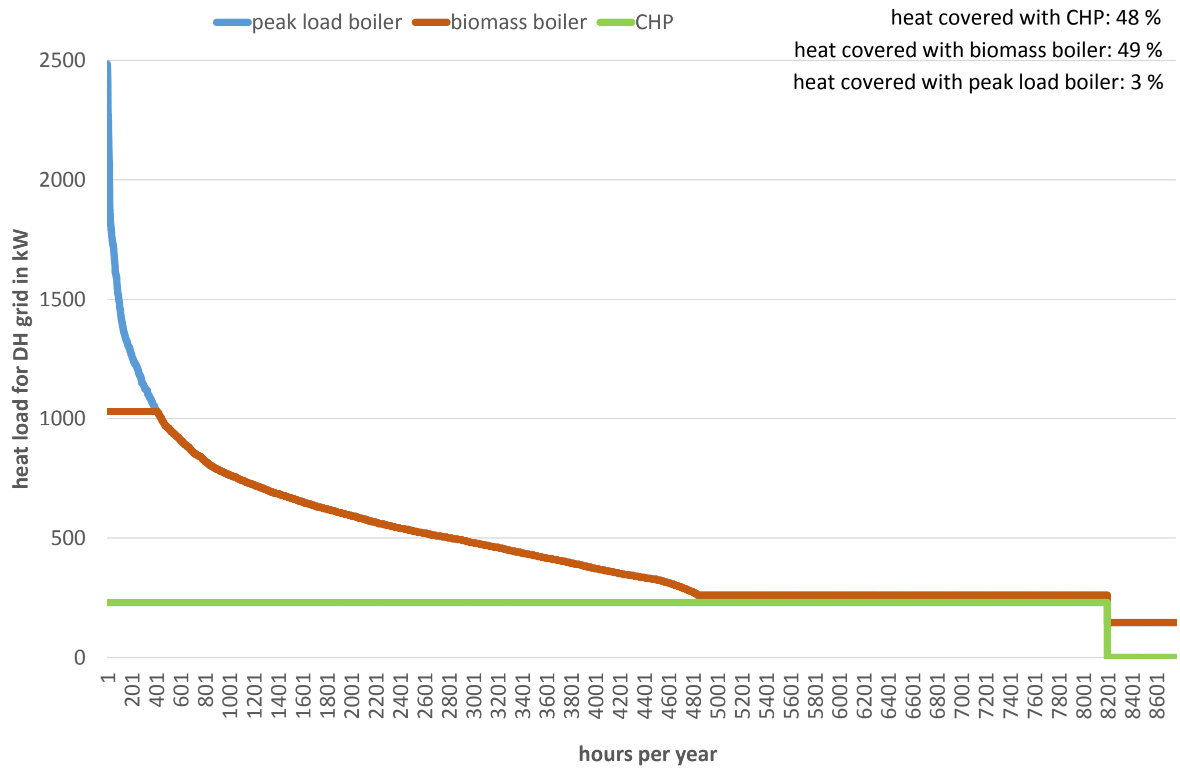


**Figure 7: Annual load line of heat production units for DH grid Cven**

**Table 1: Calculation details for heat production units**

| | th. load in kW | produced heat in MWh/a | needed fuel energy in MWh/a | annual efficiency in % | share of total heat for DH in % | full load hours per year |
|---|---|---|---|---|---|---|
| CHP | 230 | 1,886 | 3,231 | 87% | 48% | 8,200 |
| Biomass boiler | 800 | 1,917 | 2,338 | 82% | 49% | 2,397 |
| Natural gas peak load boiler | 2,225 | 130 | 163 | 80% | 3% | 58 |

The calculation shows that about 48% of the annual heat demand is produced by the CHP, about 49% with the biomass boiler and only 3% with the peak load boiler.

Figure 8 shows the draft of the hydraulic scheme of the 3 heat production units to supply the DH grid Cven. A buffer storage tank is used for peak loads, as well as for night setback load fluctuations.

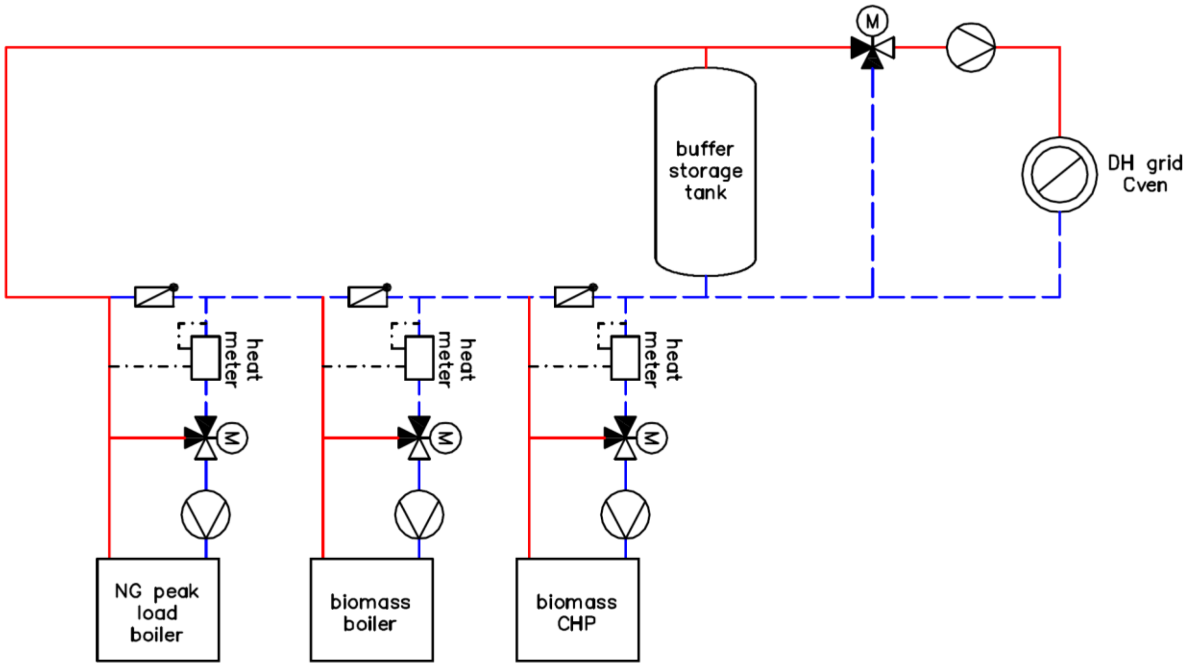


**Figure 8: Hydraulic scheme of the DH grid Cven feeded by 3 heat producers**

It is planned that only one scenario will be calculated for the following feasibility checks. The loads of the biomass heat production units are designed optimal to reach high full load hours. The natural gas peak load boiler only needs about 3% of the annual heat demand.

If the CHP unit might not be feasible, the biomass boiler will be calculated with about 900 kW, without a CHP. In that case the operation only in the heating season should be proved.

The possible location of the heating plant is shown in Figure 9. If this space is enough must be figured out.


**Figure 9: Possible location of the DH plant for the Cven settlement. Parcel no. 466/5 (596m²) Equilateral triangle, side length 35m**

# 6 Summary of the technical concept

The technical concept Cven shows the heat supply for mainly households in a rural area. That's why the grid density is lower, so the south-west part of Cven is planned not to be connected, due to longer distances. The DHW could be produced via the DH grid, also in summertime. A wood dryer could be installed in the DH grid. The summer load is perfect using a small biomass CHP to operate the grid and produce electricity.

About 2.24 GWh per year could be sold to the consumers, plus 943 MWh per year for wood drying. So in **total 3.93 GWh/a** are needed to feed the DH grid, including heat losses.

Additionally a biomass boiler supplies the DH grid with about 49% of the annual heat demand and a natural gas peak load boiler needs only 3% of the annual heat demand.

The buffer storage tank with 50 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.