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 Ljutomer

Ljutomer (Slovenia)

District heating in the industrial zone of Ljutomer

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 the industrial zone of Ljutomer.

2 General description of the current situation and concept

The CoolHeating target community in Slovenia is the city of Ljutomer, which has 4,523 households (STAT 2015[1]). The Municipality of Ljutomer selected the industrial zone as one of two perspective locations for developing a DHC project.

The industrial zone of Ljutomer is organised in three sectors:

1. Puchova business zone
2. Industrial zone south
3. Industrial zone east

The area of the business zone is regulated by the Municipal Detailed Spatial Plan for the area of the Puchova business zone in Ljutomer. The area is approx. 14.7 ha big and is located on the far western side of the administrative area of Ljutomer. On the south side, the cone is bounded by the Ščavnica River, on the east side of the Globetka River, on the north side there are four corridors of 110 kV high voltage lines, and on the west side there is a channel of regulated trench that flows into Ščavnica. The zone is located in the area of the registered Ljutomer site - Archaeological site near Globetka, and near Ščavnica there is also a part of the habitat of the protected type of otter, which represents its migratory corridor. Natural and cultural conditions limit the expansion of the existing business zone.

The zone is intended for business activities (industrial, production and accompanying service and service activities - also craft, storage, transport, trade and various business activities) and ancillary infrastructure, energy, communal and temporary facilities.

The zone is on the eastern side related to the business zone "Ljutomer industrial zone II" and to the already existing economic public infrastructure.

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

Puchova's business zone is defined by squares or building plots, inside which the facilities can be positioned arbitrarily according to the spatial and technological needs of individual investors, the necessary manipulation and parking surfaces, the deviations that guarantee fire safety, green surfaces and distances from public infrastructure.

There are currently three companies operating in the zone (Panorganic, Karba MGE, Nograd) and there is some free land still available (about 1.3 ha).

The industrial zone south covers the area south of the Krka plant. The municipality of Ljutomer is planning to produce a detailed municipal spatial plan with the corresponding economic public infrastructure for this area. In the zone there are approx. 5 ha of land available for new companies, so there are no plans to expand the zone. The area is intended for industrial, craft, storage, transport, trade, business and production activities. Inside the zone there are two companies: SEMS d.o.o. and Transport Filipič.

The industrial zone east is located east of the Krka plant. The municipality of Ljutomer is planning to produce a detailed municipal spatial plan with the corresponding economic public infrastructure. The zone is approximately 24 ha big. There are still some free plots inside the zone (approx. 3.3 ha), so there are no plans to expand until all plots are occupied.

The area is intended for industrial, craft, storage, transport, trade, business and production activities. Inside the zone are located the following companies: General Agricultural Cooperative Ljutomer Križevci, Murales d.d., Segrap d.o.o., Elektro Maribor d.d., KSP d.o.o., MOL Slovenija d.o.o, Jata Emona d.o.o

There are some large industrial heat consumers that are located outside of the industrial zone (Komptech, Farmtech, Pomurske mlekarne). As these heat consumers are significant for the technical concept, they will be included in the heat demand scheme used in the concept. The economic viability of extension of the DHC grid for connecting the heat consumers outside of the industrial zone is possible, but not focus of this concept.

The objects in the industrial zone are using heat energy for heating and preparation of sanitary hot water, but the largest proportion of heat energy is used for industrial processes. These industrial processes and their energy demand are not homogenous. There are industrial consumers with the need of 10 bar steam supply. These consumers have a relatively stable heat demand during the whole year with approximately 30% lower heat demand during summer. The large dairy company Pomurske Mlekarne d.d. has a similar regime with a high, all year 6 bar steam demand covered by natural gas. And there is a furniture factory Murales d.d. which uses more than 3,000 m³ of wood for its industrial processes (wood drying). The last of the large heat consumers is the nautical equipment production (composite materials) company with high demand for heating in winter. Other companies are smaller and predominantly using natural gas.

The municipality of Ljutomer is consequently developing and managing the industrial zone. It is interested in offering existing and potential new companies also heat energy at competitive or cheap price. Therefore, the municipality it is interested in a heat supply concept for the industrial zone.

Within the concept it is planned to connect all assessed consumers, shown in Figure 1. Some consumers will be provided with steam at 10 bar and additional heat from the DH grid. The dairy Pomurske Mlekarne will not be supplied with steam from the planned plant (too long distance), but only supplied with DH for cooling issues (absorption chiller operated with heat from the DH grid). Company Kmetovalec is drying agricultural products/corn especially in autumn.

The concept includes the usage of a biomass CHP (combined heat and power) for the baseload, as well as a biomass boiler and a natural gas peak load boiler. The technology for the proposed biomass CHP consists of several small-scale gasifiers which require very dry wood as fuel. A wood dryer will be installed in the DH grid to feed the CHP with dry wood. A buffer storage tank should decrease the peaks of the heat production, especially the

consumption of the peak load boiler. An additional steam boiler with a steam pipeline will be installed to supply consumers in the area and close to the industrial zone east.

If the CHP version including the cooling of Pomurske Mlekarne is not feasible, there will be only a biomass boiler, a peak load boiler and the biomass steam boiler installed.

3 Key results of the survey for heating/cooling demand

The survey for the heating and cooling demand in the target community (Puksec et al. 2016[2]) only covered the settlement Cven and not the industrial zone of Ljutomer as it was not yet considered at that time. That's why there are no key results to analyse for that concept.

Thus, a short assessment of the heating and cooling demand in the industrial zone was made and it can be said that most of the companies heat with natural gas (68% of the heat consumption), one with wood pieces from their production and a few with heating oil, electricity or LPG.

4 Heating/cooling demand for the concept and initial situation

The industrial zone in Ljutomer is situated at the northern part of the Ljutomer city. The industrial zone is separated from the city by a creek and a railroad. As a coherent unit, the industrial zone represents a viable option for an effective DHC project with a relatively high energy demand density, a relatively low number of high demand heat consumers. The initial concept shall focus on the core industrial zone with railroad and the creek as the boarders of the project. However, as it was already outlined in previous paragraphs, the final project could expand on the predominantly industrial objects just outside of this parameter where some additional large industrial heat consumers are situated (e.g. dairy production company Pomurske mlekarne).

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

The map in Figure 1 shows the consumers that should be connected to the new DH grid. There are additional consumers that can connect in the future and higher the economy of this project. Most of the companies are industrial heat consumers that also need heat in summertime. Some consumers needs 10 bar steam and heat from the DH grid. Kmetovalec dries agricultural products/corn and needs the heat especially in autumn. They need a supply temperature of about 120°C, otherwise there is a need to install additional heat exchangers to heat it also with a lower temperature level. Pomurske mlekarne is a dairy and needs steam. However, this company will not be supplied with steam within this concept, as the distance is too far for the economic installation of steam pipes. Pomurske mlekarne will only be supplied with heat from the DH grid to supply an absorption chiller (about 1,500 MWh/a heat to cover the baseload for cooling with 200 kW cold water) for cooling their products.

The potential plot for the DH plant is shown in Figure 1. A more detailed look to the companies and roads are shown in Figure 2 to Figure 4.

[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

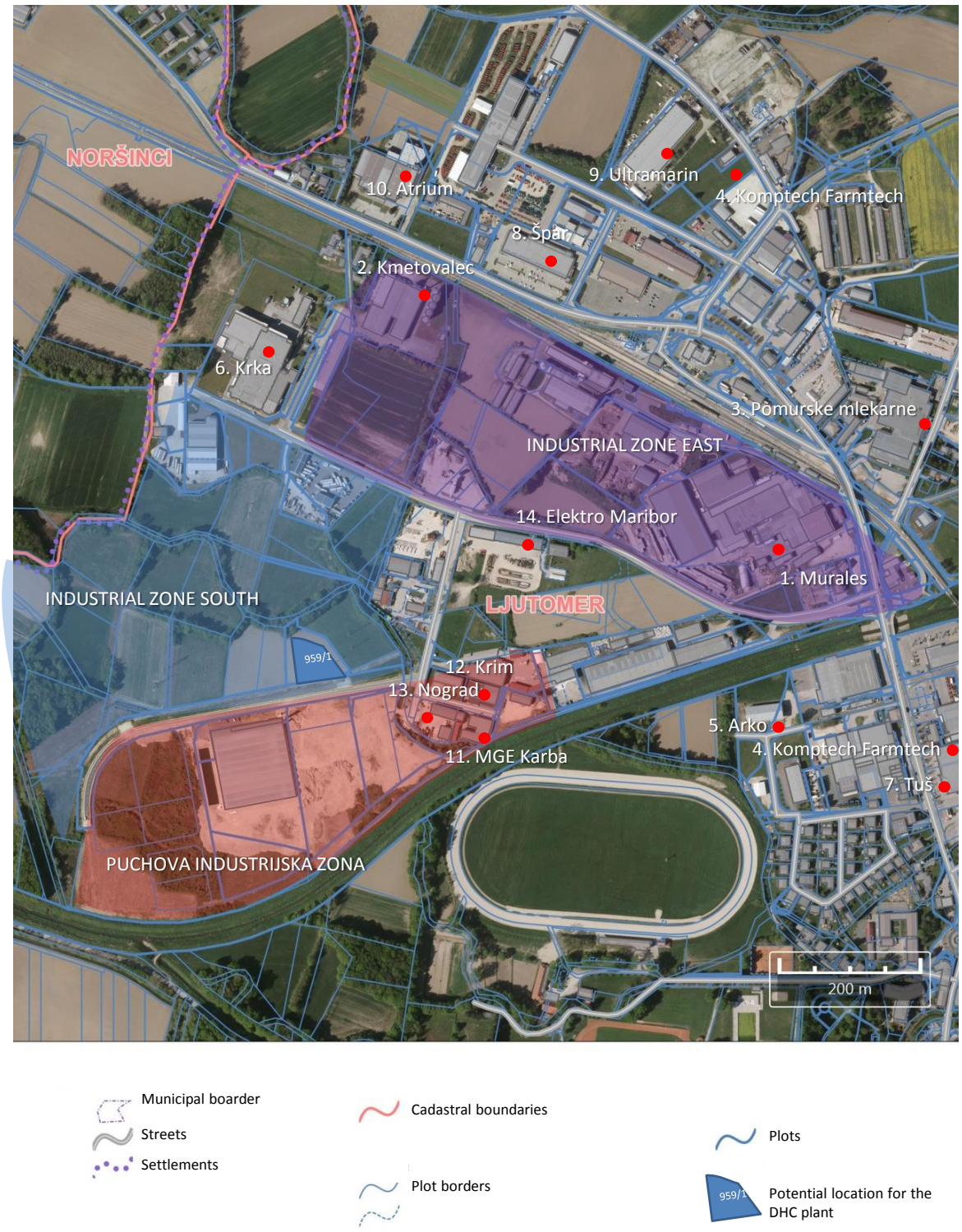

Figure 1: Ljutomer industrial zone heat and cooling supply concept. Including the potential plot for the DHC plant – plant number 959/1

Figure 2: Main road to the Krka d.d. plant in the Ljutomer industrial zone

Figure 3: Main road to the Segrap company in the Ljutomer industrial zone

Figure 4: Main road to the Murales company in the Ljutomer industrial zone

4.2 Assessment of heating/cooling demand

The technical concept for supplying heat to meet the energy needs of the industrial zone in Ljutomer is very specific. It is designated to cover mainly needs of the industry in the industrial zone. Therefore, the heat consumption is covering heat energy for industrial processes needs in a larger proportion than space heating. This parameter influences the technical concept a lot. To cover all industry needs, the heat output parameters have to be aligned with the consumer with the highest energy demand. In case of the Ljutomer industrial zone this is the demand of some companies for a 10 bar process steam. The DH grid has to be planned with potential grid extension to the plots in the industrial zone which are currently not used. All assessed companies are planned to be connected to the DH grid.

The heating and cooling demand was assessed for the companies as shown in Figure 1. The total heating needs (at consumer side) are about 7,950 MWh/a for steam, about 9,442 MWh/a for heating the industrial consumers, about 1,500 MWh/a for heat to run the absorption chiller at Pomurske mlekarne and about 3,772 MWh/a for the wood dryer.

There is a total heat demand of 22,664 MWh/a (at consumer side) for these heat consumers. Including heat losses of the DH grid, there is a total heat demand of **23,715 MWh/a**. The annual load line including losses is shown in Figure 5. The heat consumption also in summertime is quite high.

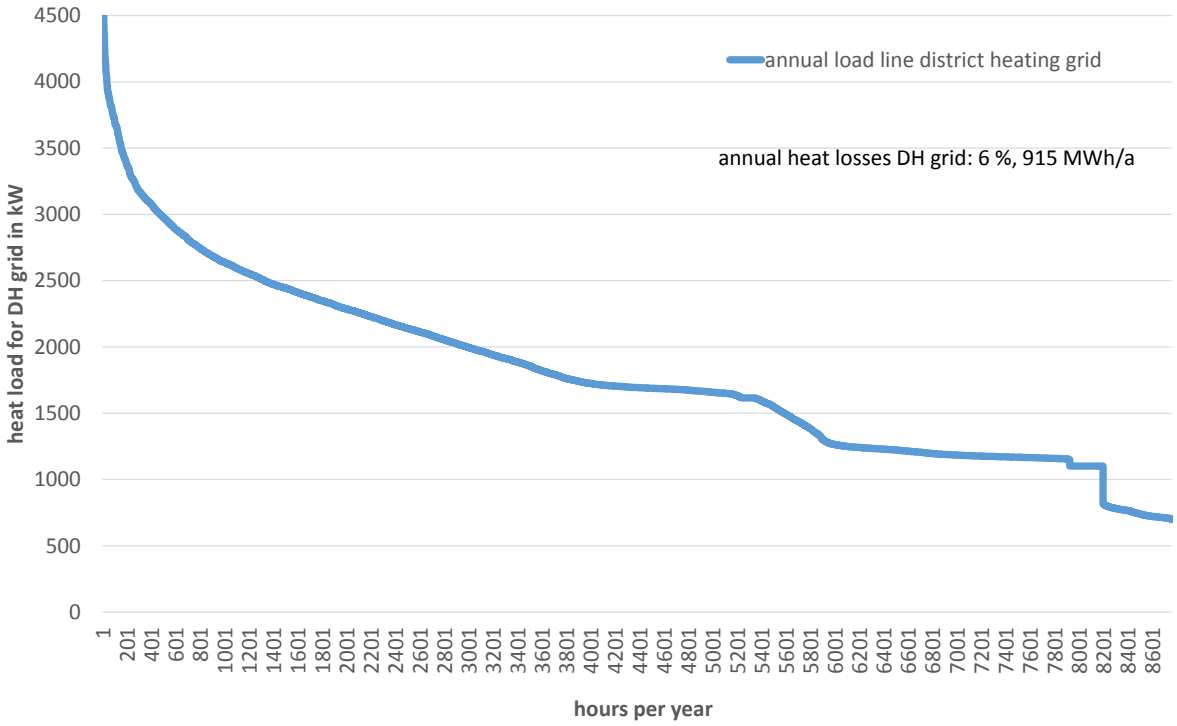

Figure 5: Annual load line for the district heating grid in industrial zone Ljutomer (hot water, no steam)

5 Technical concepts for heat/cold generation

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

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

- Minimal grid density of 800 kWh/m per year, with preference of more than 1,000 kWh/m

- Target temperature difference between flow and return pipe is 40 K
- Annual efficiency of the project 50% (relationship between produced heat and sold heat)

In general, the most promising technology in the industrial zone of Ljutomer would be based on biomass. Both agricultural residues and wood biomass could be also purchased from farmers and forest owners within a radius of 30 – 50 km. Solid biomass is the preferable energy source for the technical concept due to the high heat demand. Furthermore, the inclusion of solar thermal technologies would be good, but the collector system would need to be very large to cover the winter load. Furthermore, it would be in competition with the CHP in summer.

The application of CHP technologies could help to make the project more economical, but it would also increase the fuel demand. For peak and backup boilers, natural gas can be used.

That's why this technical concept includes the usage of 8 units of biomass CHPs, a biomass boiler, a buffer storage tank and a natural gas peak load boiler. The steam will be produced by a biomass steam boiler. A dairy will be cooled with an absorption chiller, supplied with heat from the DH grid.

5.1 District heating / cooling grid

Figure 6 shows the DH grid (black line) to connect the consumers. The location of the heating plant is also shown in that figure. The yellow line is the steam pipe with about 530 m to some steam consumers.

The planned DH grid has about 4,175 m in total. The length of the grid here is only the length of the flow pipe.

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 DH grid in the industrial zone in Ljutomer is 3,524 kWh per meter pipeline and per year. The minimum value of 800 is reached easily, according to the Slovene national support scheme. The grid density for the steam pipe is 15,001 kWh per meter pipeline and per year.

The annual heat losses for the DH grid were calculated with 6%, or 915 MWh/a, based on real DH grids data in Austria (calculation based on Malik (2012)[3]), for the grid density shown above.

About 10,942 MWh per year could be sold to the consumers via the DH grid, plus 3,772 MWh per year for wood drying. Additionally, about 7,882 MWh per year of steam could be sold. So, in total 15,629 MWh/a heat are needed to feed the DH grid, including heat losses.

The temperature level of the DH grid will be designed with 100°C flow and 70°C return flow temperature. The real temperature levels can be adopted to the needed consumer requirements and also depending on the seasonal time. The consumers will be connected with an indirect system, so to divide the DH grid from the consumer side with a heat exchanger.

The practice of night setback (reduction of room temperature at night and heat up in the morning) by some industrial consumers causes higher peak loads in the morning and could also cause very low loads at night. The calculation is based on 10% 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 4.5 MW.

[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

The material of the DH pipes should be steel, because of the needed temperature level of more than 90°C. Simultaneity of the load was calculated with 100%.

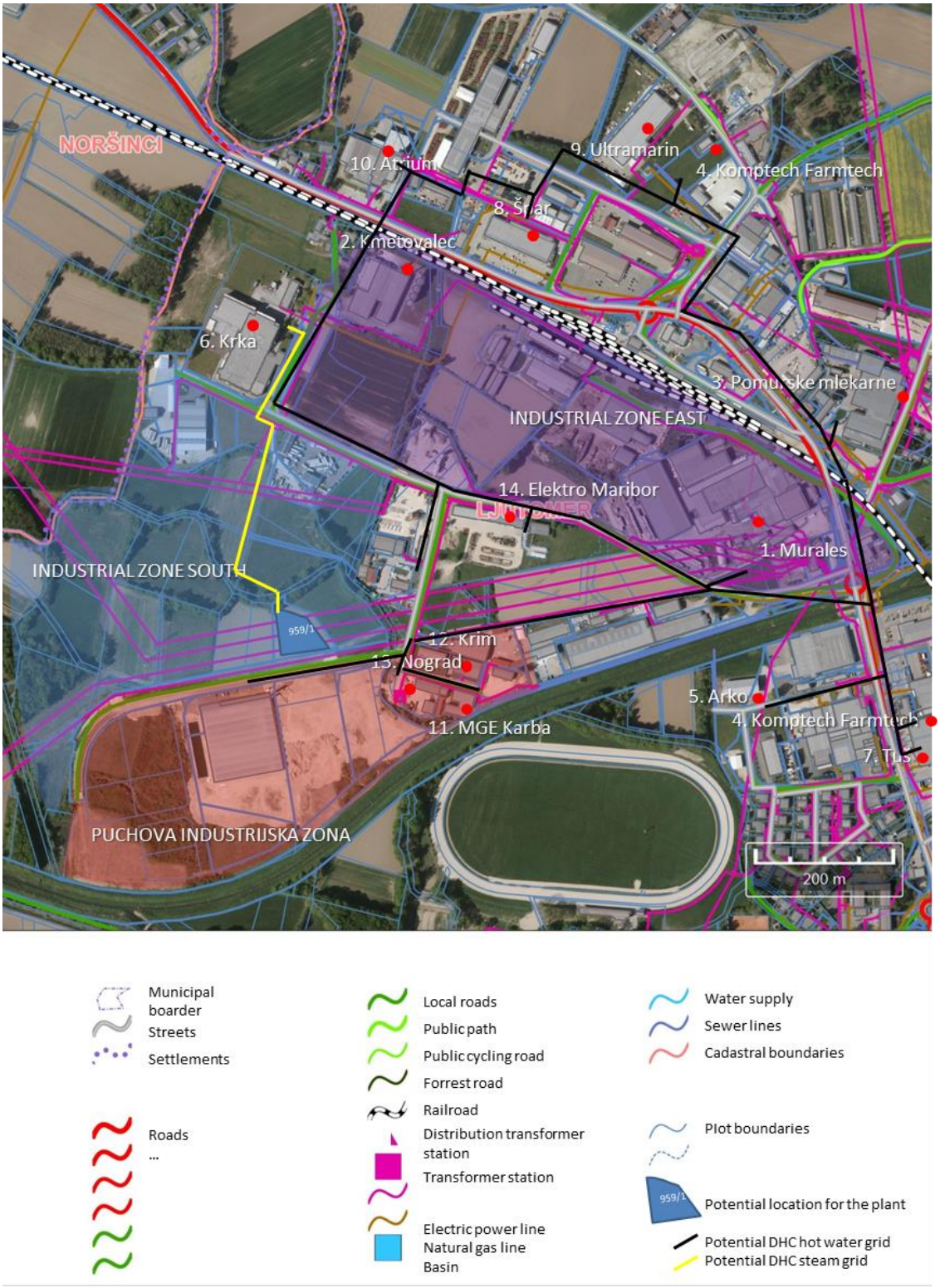

Figure 6: DH grid in industrial zone Ljutomer and possible location of the DH plant (parcel no. 959/1 with 5,022 m²)

5.2 Heating / Cooling generation

Scenario 1: biomass CHPs, biomass boiler, natural gas peak load boiler

The scenario 1 of the technical concept for the industrial zone Ljutomer includes small biomass CHPs for the baseload, a biomass boiler and a natural gas peak load boiler. A buffer storage tank will be needed to decrease the peaks and fluctuations. In addition to the normal biomass boiler, an additional biomass steam boiler will be needed to provide steam to the industry.

Figure 7 shows the annual load line of the planned heat production units for the DH grid. The baseload, especially also in summertime could be covered with 8 small biomass CHPs with 56kW$_{el}$ each (based on a CHP gasification technology from Fröling). About half of the CHP heat output could be used in the DH grid for drying the soft wood to 10% water content. The rest could be used for heating the DH grid consumers with about 57kW$_{th}$ per CHP unit. The wood dryer needs an annual heat demand of 3,772 MWh/a. The CHP should be operated 8,200 hours per year. About 3,673 MWh of electricity (gross) could be produced annually to feed into the public grid.

The annual fuel consumption would be 12,923 MWh/a of soft wood (at 10% water content) for the 8 CHP units, 9,734 MWh/a of wood chips (about 30 to 35% water content) for the biomass boiler (~82% annual efficiency, 2,000 kW nominal capacity) and 299 MWh/a for the natural gas peak load boiler (~80% annual efficiency, max. 4 MW).

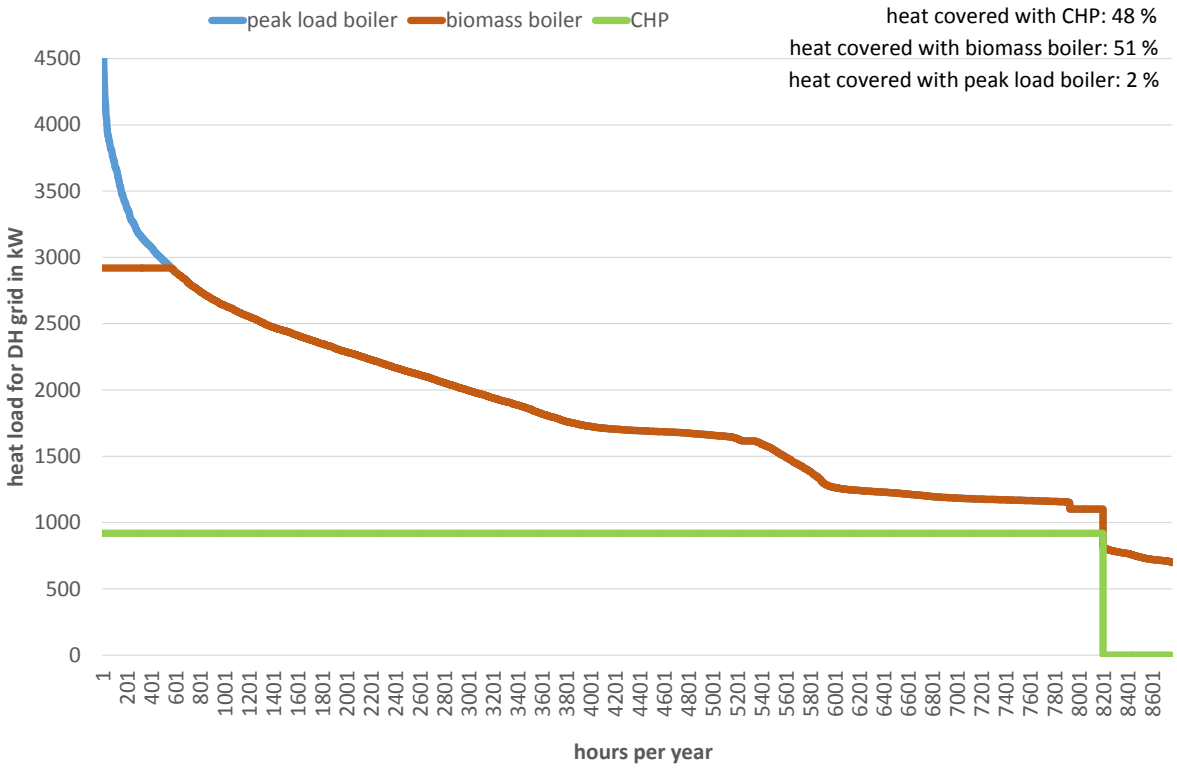

Figure 7: Annual load line of the heat production units of the heating plant at industrial zone in Ljutomer

The nominal capacities (thermal load) of the boilers and other data are shown in Table 1.

The buffer storage tank with 90 m³ will cover about 2 hours with 2,000kW load, to reduce the usage of the peak load boiler and to lower the peak loads at production.

Table 1: Calculation details for heat production units

	thermal 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	920	7,544	12,923	87%	48%	8,200
Biomass boiler	2,000	7,982	9,734	82%	51%	3,991
Natural gas peak load boiler	4,000	239	299	80%	2%	60
Biomass steam boiler	1,200	7,882	9,853	80%		6,625

A separate biomass steam boiler could be installed to cover the needs for the steam consumers. This boiler should have a thermal load of 1,200 kW to produce about 7,882 MWh/a saturated steam at 10 to 11 bar. Therefore, 9,853 MWh/a biomass (wood chips with about 30 to 35% water content) would be needed. The peak demand for steam could be covered by the consumers with the existing natural gas boilers.

Figure 8 shows the hydraulic scheme of the proposed heat production units. The heat producers are arranged in a cascade, so that the heat can be utilized first from the CHPs, then from the biomass boiler and finally from the peak load boiler.

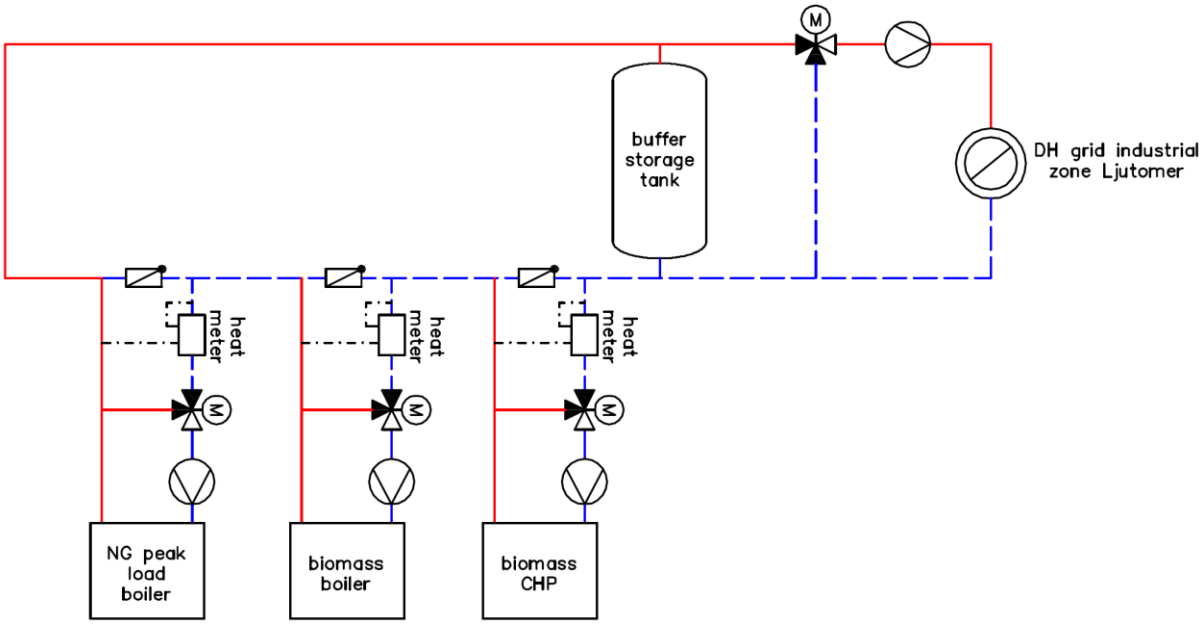

Figure 8: Hydraulic scheme of the heat production units for the DH grid in the industrial zone Ljutomer

Scenario 2: no CHP, no cooling of the dairy

The scenario 2 does not include CHP units. In this scenario, the baseload is covered with the biomass boiler. Because of higher heat production prices under this scenario, the operation of an absorption chiller with the heat from the DH grid is not recommended.

Compared to the first scenario, the data for the DH grid in scenario 2 is slightly different. The annual heat losses for the DH grid were calculated with 8%, or 875 MWh/a, based on real

DH grids data in Austria (calculation based on Malik (2012)[4]), for the grid density shown above.

About 9,442 MWh per year could be sold to the consumers via the DH grid. So, in total 10,317 MWh/a heat are needed to feed the DH grid, including heat losses. In addition, about 7,882 MWh per year of steam could be sold. The annual load line for scenario 2 is shown in Figure 9. The data for the heat production units are shown in Table 2.

About 96% of the annual heating needs could be covered with the 2,000 kW biomass boiler. The hydraulic scheme would look like Figure 8, but without the CHP.

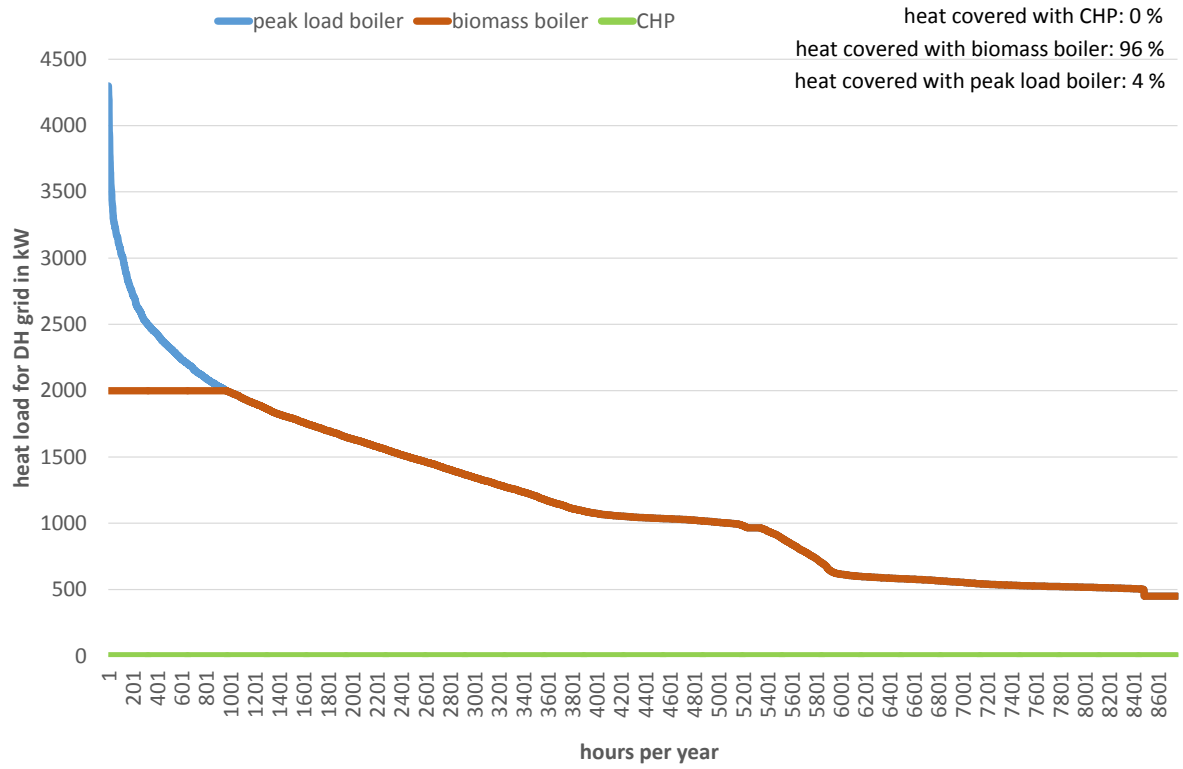

Figure 9: Annual load line for heat production units for scenario 2

Table 2: Calculation details for heat production units for scenario 2

	thermal 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
Biomass boiler	2,000	9,878	12,046	82%	96%	4,939
Natural gas peak load boiler	4,000	440	550	80%	4%	110
Biomass steam boiler	1,200	7,882	9,853	80%		6,625

[4] 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

6 Summary of the technical concept

The technical concept for the industrial zone in Ljutomer includes the industrial consumers as well as the heat production units. The total heat demand for the DH grid, including losses and steam supply is **23,715 MWh/a**. The peak load is about 4,500 kW for the DH grid.

For scenario 1 a biomass CHP, a biomass boiler, a natural gas peak load boiler, a buffer storage tank and a biomass steam boiler is considered. This scenario also covers the cooling needs from the dairy Pomuske mlekarne with an absorption chiller, heated with the DH grid. The grid density of the DH grid is very high with 3,524 kWh/m/a and about 15,001 kWh/m/a for the steam pipeline. About 48% of the DH grid needs are produced with the biomass CHP, 51% with the biomass boiler and a very low about of about 2% with the natural gas peak load boiler. The DH grid heat losses are about 6% (915 MWh/a).

In scenario 2 no biomass CHP units are included and no cooling for the dairy company Pomurske mlekarne is considered. This scenario shows an alternative if the integration of CHP units is not feasible. Because of higher heat production prices, the cooling might not be feasible in this scenario. An advantage is that there is no need for prior wood drying prior to the thermos-chemical conversion as the wood boilers can tolerate higher moisture content than wood gasifiers (CHP). The annual heat losses for the DH grid were calculated with 8%, or 875 MWh/a. About 96% of the annual heating needs could be covered with the biomass boiler.

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.