SUMMARY

The subject of our application is a district cooling system in the city of Velenje, Slovenia. There the cooling energy is produced in absorption chillers. The heat for their operation is supplied from an existing district heating system. In it the supply temperatures are sufficient to power the absorption chillers through the whole year, due to industry consumers. The heat source for the district heating system is surplus heat from a power plant. The system is facing problems with low energy and economic performance in the summer months due to relative low heat demands by consumers. As a consequence an opportunity was recognized to use the heat from the distribution network to power the absorption chillers and by doing so improving the distribution network performance, as well as producing cooling energy from surplus energy, instead of using the electric energy for the electro-compressor technology. Thus there are several direct and indirect benefits to the community in the area where the system is in operation. The key system information are given in table a.

Table a: Key district cooling system information

Overall floor area in cooled buildings	23,495	m^2
Cooling energy delivered to buildings	1160	MWh/year
District cooling system temperature regime	6/12	°C
Cooling power of the system	970	kW
Start of system operation	2009	
Consumption of surplus heat	1,547	MWh/year
Overall consumption of electric energy in the case of absorption district cooling system	69	MWh/year
Price of cooling energy	105	€/MWh
Electric energy consumption in comparable electro-compressor cooling system	396	MWh/year
Price of cooling energy in comparable electro-compressor cooling system	123	€/MWh
Non-renewable/surplus energy savings (electric energy)	327	MWh/year
Direct financial savings for consumers of cooling energy	18	€/MWh
CO_2 emission savings	$180 \cdot 10^3$	kg/year

DISTRICT COOLING SYSTEM DESCRIPTION

In modern times the demands for increased sustainability of energy consumption, lowering of heating demands (due to improved building insulation) and rising energy prices are creating pressure for district heating system operators to find new consumers of heat in the district heating areas, to maintain the cost and energy benefits of district heat supply. A general problem of district heating systems are variable heat demands thorough the year. Because of it, in the summer months, when there is no need for space heating, low heat flows are being transported through the network to ensure heat for the hot tap water and industrial needs. As a consequence in these months as much as 50 % of heat, supplied to the network, can be lost to the surroundings. In addition to this the fixed monetary costs of the district heating system are allocated to lower quantities of heat, sold by the utility company. This results in higher costs of heat supply. An important solution to this problem presents itself with implementation of absorption chillers, powered by the heat from the distribution network of a district heating system. In such configuration the absorption chiller presents a new consumer in the distribution network and thus improves the network performance. Another important benefit of the absorption chillers is also the consumption of low quality surplus or renewable heat instead of high quality electric energy for cold production.

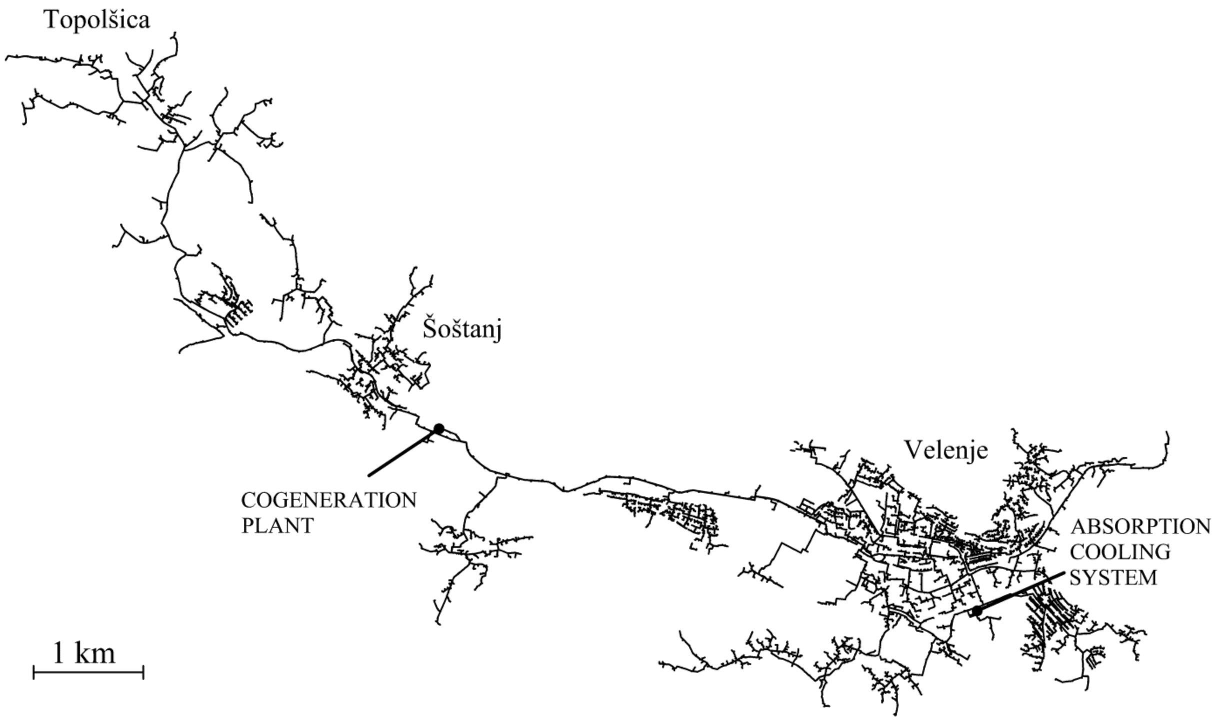

Figure 1: District heating system in the Šaleška Valley with the location of the absorption cooling system

In Slovenia 9 % of total heat demand in residential, services and other sectors is supplied by district heating. In Šaleška Valley, which is positioned in the northern part of the country, Slovenia's second largest DHS is in operation. The heat is produced by a coal-fired cogeneration plant. Coal is extracted locally in one of the largest and most modern underground thick layer mines in Europe. The electrical power of the cogeneration plant is 779 MW and the maximal heating power supplied to the DN is 192 MW. Accordingly the plant is primarily a power plant. Cooling towers are used for the heat, which has to be transferred to the surroundings in the electricity production process and is not supplied for district heating. Therefore the heat supplied for the district heating can be considered as surplus heat. The district heating system in Šaleška Valley has got a long history of over 50 years. The consumers of the heat are both industry and households. Approximately 30 % of the heat in the DH system of the Šaleška Valley is consumed by industry, which requires heat at relatively high temperatures. That is why the supply temperature of the primary network has to remain high through the whole year. The temperatures are adequate to run the absorption chillers. This option was recognized and 1 MW district cooling system was implemented, where cooling energy is produced in absorption chillers, powered by heat from the network. Figure 1 is showing the distribution network of the Šaleška Valley. There three cities (Topolšica, Šoštanj, Velenje), the location of the cogeneration plant and the location of the absorption cooling system are marked. At the location of the absorption cooling system a centralized production of cooling energy is taking place. From this location the cooling energy is distributed through the newly build distribution network. This district cooling system is the subject of our application.

SYSTEM DESIGN AND INSTALLATION

The cooling system of 970 kW cooling power was built in 2008 on the location of an abandoned summer pool in Velenje. There two cooling towers were also built. The installation of the system and the outside view of the completed cooling station are displayed in Figures 2 and 3. The absorption chillers are powered by the heat from the district heating distribution network. The temperature regime of heat supply 105/87 (°C) is available.

Figure 2: Installation of the absorption chiller

Figure 3: Outside view of the cooling station with two cooling towers

It is planned to supply cooling energy to several, relative large consumers in the vicinity of the absorption cooling system. The potential distribution network layout is displayed in figure 4. The main consumers of district cooling energy are displayed in figure 5. The system is designed to supply cooling energy to different types of buildings with an overall floor area of 23,495 m^2, as is shown in table 1.

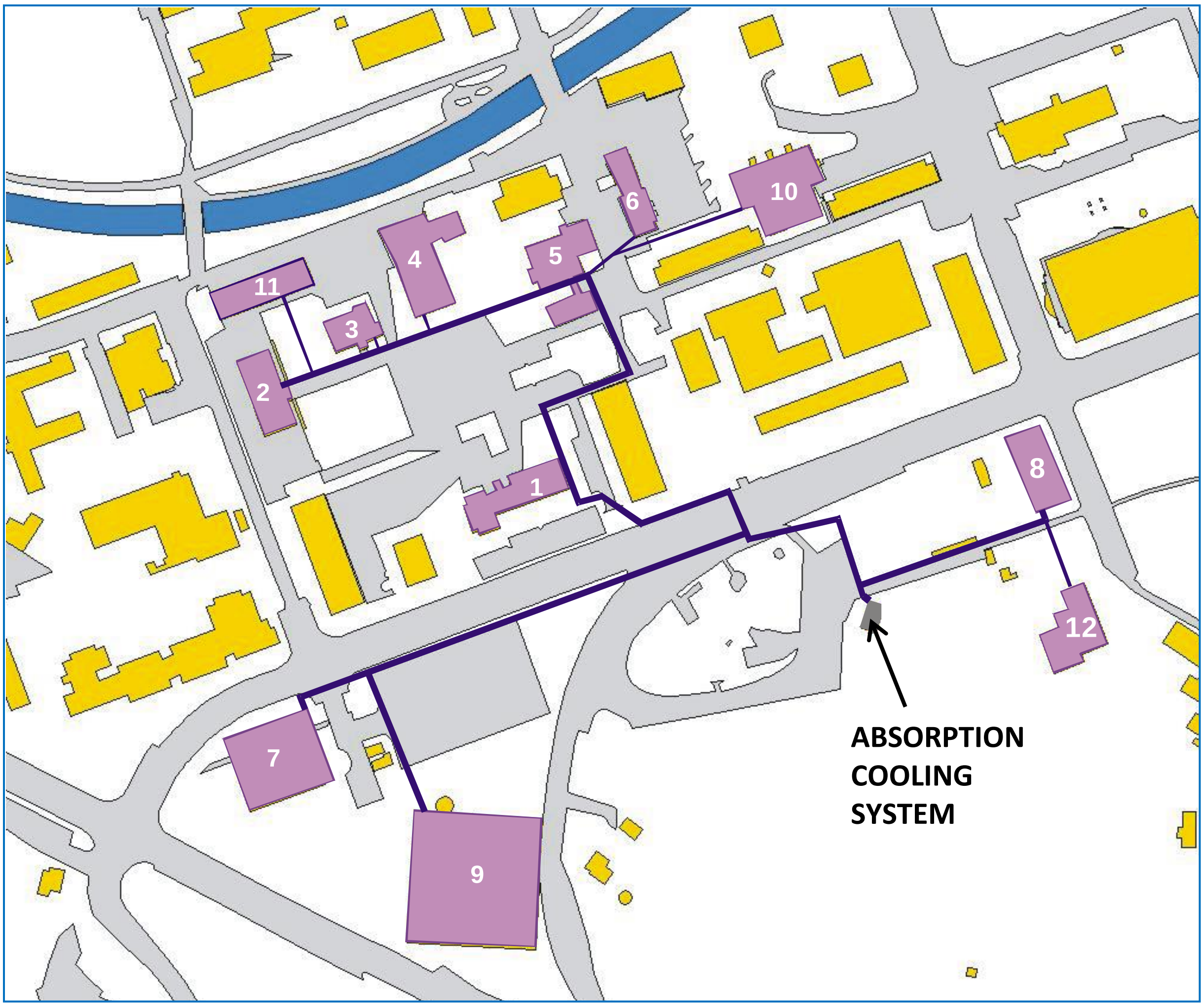

Figure 4: District cooling distribution network

In the first phase of distribution network construction the City hall (assigned number 1) and an office building (assigned number 8) were connected by a supply and return pipeline with dimensions NO 150. The temperature regime of the cooling energy distribution is 6/12 (°C). At the moment the second phase of the construction is being planned. In it all of the other buildings will be connected.

The described system was the first absorption district cooling system in Slovenia. Its first test start was on 20th august 2008. However, it started operation at the beginning of the cooling season in 2009. The total contract investment value until the end of first phase was 1.1 million €. It was funded by 729,000 € long term loan from the Slovenia's Eco Fund and 371,000 € of own funds.

Table 1: Buildings planned to be supplied by district cooling energy

Assigned building number	***Building type***	***Floor area [m²]***	***Cooling demands [kW]***
1	City hall	3,933	150
2	City Administration Building	3,080	118
3	Gallery and library	960	37
4	Cultural center	2,756	106
5	Learning center and restaurant	1,568	60
5	Courthouse	3,498	135
8	Office building	2,000	78
9	Sports hall	3,600	200
11	Office building	1,500	59
12	Swimming pool	650	25
SUM		**23,495**	**967**

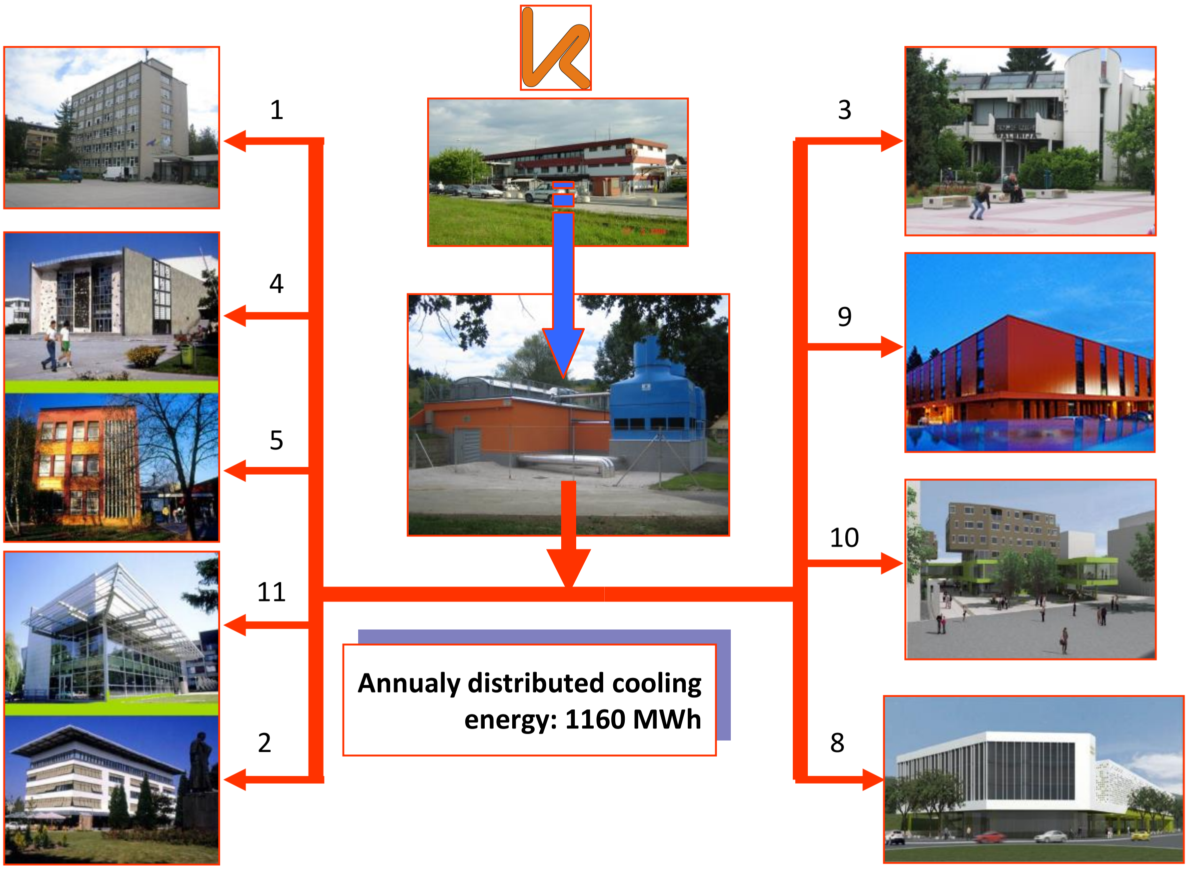

Figure 5: Main consumers of district cooling energy

IMPACT ON THE COMMUNITY

There are several direct and indirect benefits to the community in the area where the system is in operation. Both of them have to be considered to discover the true potential of installation of such systems.

With the implementation of the absorption cooling, the system integration of energy supply has increased. The energy and cost performance of district heating distribution network has improved.

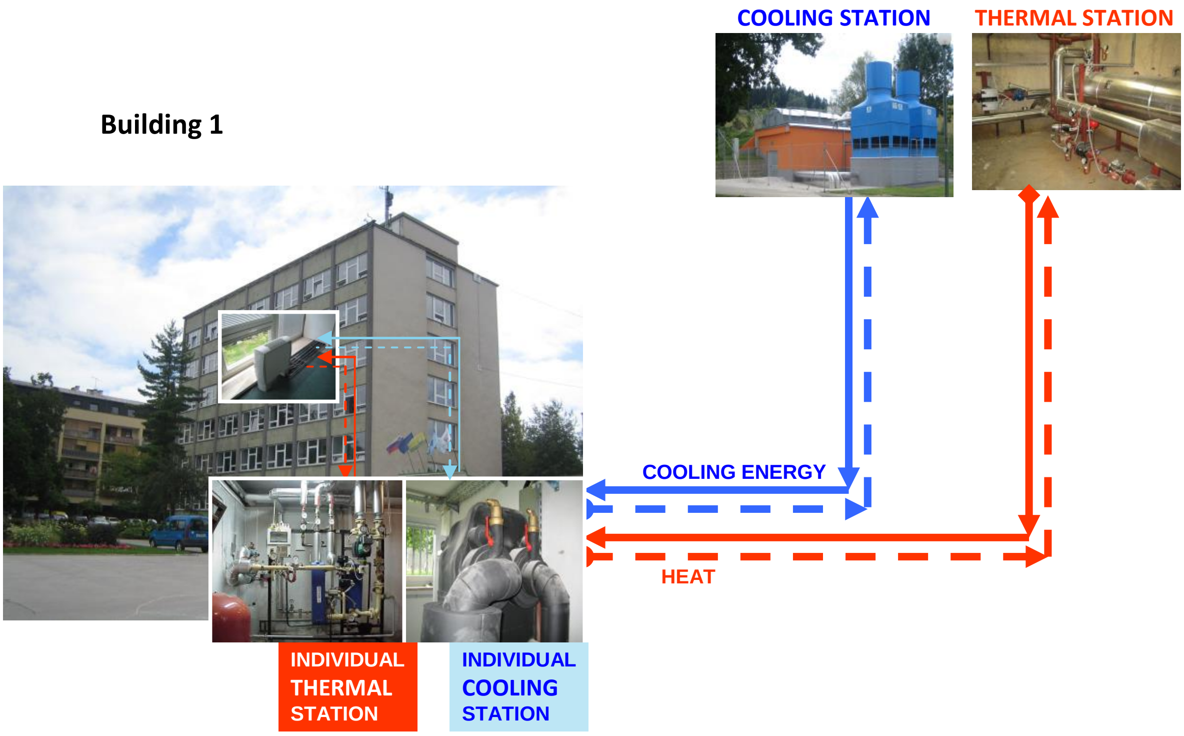

Figure 6: Integrated energy supply and comfort

The direct benefits for the community and consumers of district cooling energy are:

- Complete energy supply service, as displayed in figure 6. As a result the cooling as well as heating system installation, maintenance and operation is no longer the concern of the end consumers.
- Reduced cost of cooling energy supply, as shown in figure 7.
- Improved architectural appearance of buildings. Namely, it is an often the praxis to use a local split system to meet the cooling needs. This includes the installation of unattractive outer units.
- Lower dependency on increasing electricity prices.
- Reduced risk of overloading the electricity grid in the times of peak cooling demands.

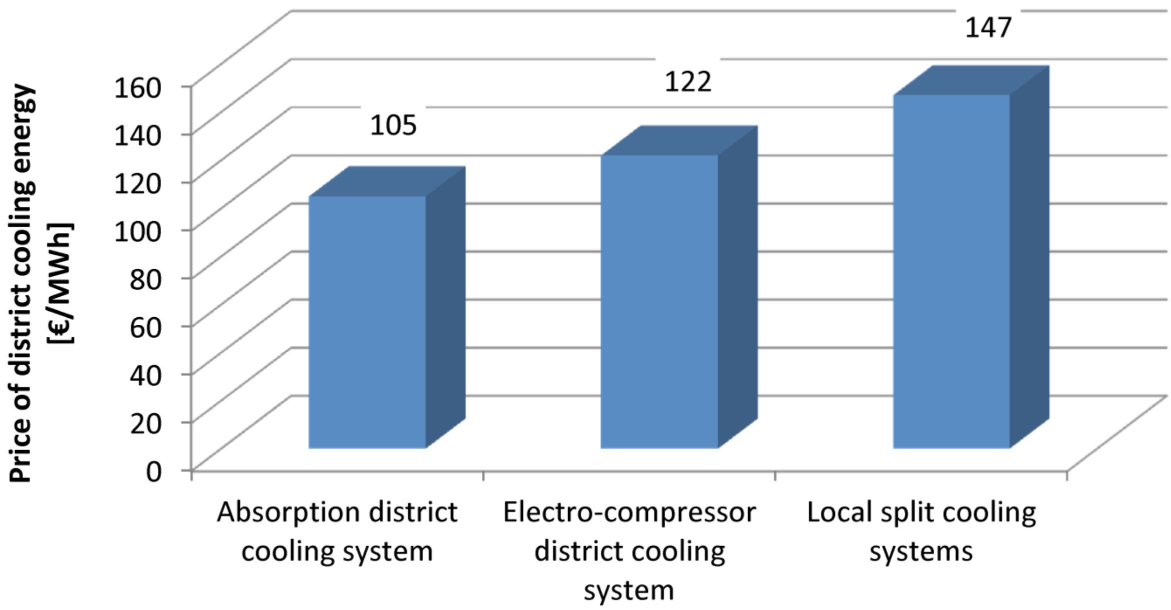

Figure 7: Price of cooling energy

IMPROVED SUSTAINABILITY OF ENERGY CONSUMPTION

By comparing the consumption of non-renewable/surplus energy in the case of providing cooling energy for consumers using the electro-compressor technology and the case with the absorption technology we can investigate the potential savings of our system design. The results for the final planned extent of the district cooling system are shown in table 2. It is important to emphasize that the heat, powering the absorption chillers, is surplus heat. Accordingly the greenhouse gas emissions reduction and other environmental benefits are connected with the savings of 327 MWh of electric energy per year. In four years of operation this amounts to 720 tons of CO_2.

Table 2: Non-renewable/surplus energy savings in the case of absorption chillers

Overall floor area in cooled buildings	23,495	m^2
Cooling energy delivered to buildings	1160	MWh/year
Electric energy consumption in the case of electro-compressor cooling system	396	MWh/year
Consumption of heat	1,547	MWh/year
Overall consumption of electric energy in the case of absorption district cooling system	69	MWh/year
Absorption non-renewable/surplus energy savings	327	MWh/year
CO_2 emission savings	$180 \cdot 10^3$	kg/year