APPLICATION FOR DISTRICT ENERGY AWARD

FOR A CLEANER WORLD –

FROM SOVIET TIME DISTRICT HEATING SYSTEM TO EFFICIENT DISTRICT HEATING AND COOLING SYSTEM IN TARTU, ESTONIA

(from DH to DHC)

Tartu Downtown district cooling plant with solar panels. Photo: Karita Kivi

fortum Tartu

Tartu city of good thoughts

1. SUMMARY

Over the years Tartu district heating and cooling system has undergone several changes and technology upgrades, becoming from Soviet time district heating network to well-functioning and efficient district heating and cooling system.

Nowadays Tartu DHC system is one of the best functioning in the country. It has been achieved in the alignment of interests between the municipality, customers, end users and DHC company. Tartu's City Council has strongly supported the deployment of DH in the city, mainly through a comprehensive city planning and DH zoning. User acceptance and customer satisfaction is increasing year by year.

With the support from the community and increasing user acceptance DHC system owner Fortum Tartu has had the certainty to invest into innovation and technology to make the DHC system efficient and environmentally friendly. In this application the main benchmarking period is from 01/01/2008 to 31/12/2016.

Technology and innovation highlights from 2008 to 2016:

- 2009 Tartu combined heat and power (CHP) plant fuelled by biomass and peat was commissioned.
- Between 2009 and 2014 the district heating (DH) system continued expanding, mainly through the acquisition of another local DH system in 2013 in the "Tamme" area (90 GWh of sales, 3 production units, 34 km pipeline) and the installation of new peak capacity and closing of old boiler house in the city centre.
- In 2014, the development of district cooling (DC) projects started and the first DC plant was commissioned in May 2016, becoming the first DC network in the Baltics and Eastern-Europe.
- In 2015 tailored made DH and DC solution for customer Estonian National Museum.
- In 2016 tailored made full DH and DC solutions for customer Lõunakeskus Tradepark.
- In 2016 automatic smart meter readers installed to 72% of customers.

Between the period 2008 to 2016 CO2 emissions have been reduced from 123553 t to 89023 t. District cooling will be environmentally beneficial by reducing CO2 emissions by 52 % (2700 ton/year) compared to the customers own alternative. 71% of decrease will be in primary resources and 70% of decrease in electricity demand.

Both district heating and cooling networks are expected to continue growing. They are one of the main enablers of Tartu's environmental strategy.

2. BACKGROUND INFORMATION

2.1 City of Tartu and its district energy system

Tartu is the second largest city in Estonia located in southern part of the country. The city lies on the Emajõgi ("Mother river"), which connects the two largest lakes of Estonia - lake Peipsi and lake Võrtsjärv. Nowadays approximately 97 000 inhabitants are living in Tartu. The city is often considered as the intellectual center of Estonia as the oldest and most known Estonian university – the University of Tartu – lies there. The Supreme Court of Estonia, the Ministry of Education and Research and Estonian National Museum are also situated in Tartu. The food industry has traditionally been important for the town's economy and some bigger companies in the field are A. Le Coq, Tartu Mill and Salvest. The leading printing press company in the Baltic States, Kroonpress is also in Tartu.

Picture 1. City of Tartu. Photo: Mati Meos

Over the years Tartu's district heating (DH) system has undergone several changes in ownership and technology upgrades that now make it one of the best functioning in the country.

DH was established in Tartu in 1967 and was firstly owned by the State and later by the municipality. In 1995, the system participated in a renovation program financed by the World Bank and the EBRD35 consisting in switching its fuel from gas and oil to local and renewable sources, namely peat and biomass. In year 2000, DH went through a privatization process and became part of the Finnish company Kotka Energy Holding SA, which sold its shares in 2004 to Fortum Heat and Power OY (60 %) and AS Giga (40 %) with the name AS Fortum Tartu (current

situation). Since then, a number of new products were introduced and the network was extended, representing important investments and resulting in an improved efficiency and quality service:

- In 2006, the company started its own local fuel supply (for biomass sourcing and peat production), to complete its vertical integration (from fuel production and sourcing to sales). Fortum Tartu has 25-year peat extraction contracts with the State, which remains the owner of the peatlands, while woodchips and wood waste are bought in the market.
- In 2007, Fortum Tartu started the development of a new CHP plant fueled by biomass and peat. The plant was commissioned in 2009.
- Between 2009 and 2014 the system continued expanding, mainly through the acquisition of another local DH system in 2013 in the "Tamme" area (90 GWh of sales, 3 production units, 34 km pipeline) and the installation of new peak capacity.
- With the restructuring of the whole DHC system, in 2013 old fossil fuel based boiler house in city center was closed.
- In 2014, the development of district cooling projects started and the first DC plant was commissioned in May 2016, becoming the first DC network in the Baltics and Eastern-Europe.
- In 2015 tailored made DH and DC solution for Estonian National Museum.
- In 2016, after long negotiations and discussions with customer Lõunakeskus (Southern Estonia's biggest shopping mall/entertainment center), next district cooling project started. Fortum Tartu offered the customer full solution of district heating and cooling. Lõunakeskus was connected to DH network in October 2016. District cooling system for Lõunakeskus started its operations in the beginning of June this year.

Tartu's City Council has strongly supported the deployment of DH in the city, mainly through a comprehensive city planning and DH zoning. There is a good level of cooperation between Fortum Tartu and the municipality, as both have managed to align their interests and establish a win-win relationship.

The first urban development Master Plan of Tartu was established in 1999 and focused on sustainable development. It included a DH zoning, aiming at improving the air quality in the city and avoiding DH disconnections. Indeed, air quality was very low at the time due to the extensive use of stoves in households –burning not only wood but also waste - and the lack of investments in the DH system, which had seriously affected the quality of the service and resulted in increasing disconnections. The City Council published a report and organized public campaigns to raise awareness about the risk of these stoves and to justify the DH zoning.
In the areas defined as DH zones, all new buildings and those undergoing a major renovation must be connected to the network. These areas are readjusted when the Master Plan is updated. The current DH areas where defined in 2006, following a negotiation process between

Fortum Tartu and the city. Around 70 % of Fortum Tartu's clients are established in a DH zone, while the rest are connected to the network on a voluntary basis. The only exceptions to mandatory connection in the appointed district heating zones are houses having an energy demand below 40 kWh/m²/year or being supplied with an environmentally cleaner heating (e.g. geothermal heating or solar thermal panels).

The City Council does not have a direct influence in the DH business, neither in the company's ownership nor in its operation. However, it takes into account DH needs when organizing their urban planning (e.g. trying to densify the city and defining DH zones in energy dense areas close to the existing network).

2.2 Key facts and figures of Tartu DHC system

- **Medium-size system**: ~80 000 end users.
- **Customers**: mainly residential and tertiary sector.
- **Network**: owned and operated by Fortum Tartu.
- **Efficient heat production**:
  - 50 MWth/25 MWe biomass CHP plant; equipped with 15 MW flue gas condenser;
  - Gas boilers for peak capacity;
  - Waste heat from a local paper industry Kroonpress.
- **Efficient cooling production** :
  - 1st DC plant in operation, May 2016;
  - *2nd DC plant in operation, June 2017*, 1 more in the pipeline;
  - Free cooling from the river;
  - A heat pump and peak chiller ~13 MW.

DH market share	50 % of buildings (75 % citizens)
Heating & cooling capacity	DH: 328 MW DC: 13 MW
Heat &Cold production	DH: 500 GWh/y DC: 1.3 GWh/y
Km network (double-pipe)	DH: 173,5 km DC: 1,8 km
Heat network losses (%) in production	2008: 15,2% 2016: 10,8%
CO2 emissions (heating)	131 kg/MWh

2.2.1 Production units

Tartu heat production is served by production units indicated in Table 1.

Site	Type	Remote controlled	Boiler 1	Boiler 2	Boiler 3	Fuel	Build year/ average age	Real capacity total (MW)
Anne Soojus	CHP	Yes	50			Bio, peat	2009/24	**50**
Anne Soojus	FGC	Yes	15,7			Flue gas	2009	**15,7**
Anne	HOB	Yes	21x2	38,5 x2		Bio peat NG	1983/15	**110**
Anne	FGC	Yes	4,2				2005	**4,2**
Ropka	HOB	Yes	37	37		NG	2014/23	**72**
Turu 56	HOB		4			oil	1996/10	**4**
Tamme, Aardla113	HOB		6,5	7	7	Bio NG	2013/16	**22,5**
Tamme, Aardla 113	FGC		2			Flue gas	2013	**2**
Tamme, Tulbi 12	HOB	Ongoing	15	15		NG	2013/11	**30**
Tamme, Vaksali 51	HOB	Yes	7x2	1,3x 3		NG	2013/11	**17,9**
Summary								**328,3** MW

Table 1. Production units of Tartu district heating.

Picture 2. Tartu CHP plant. Photo: Aki Koskinen

Fuel consumption of energy production is shown in Figure 1.

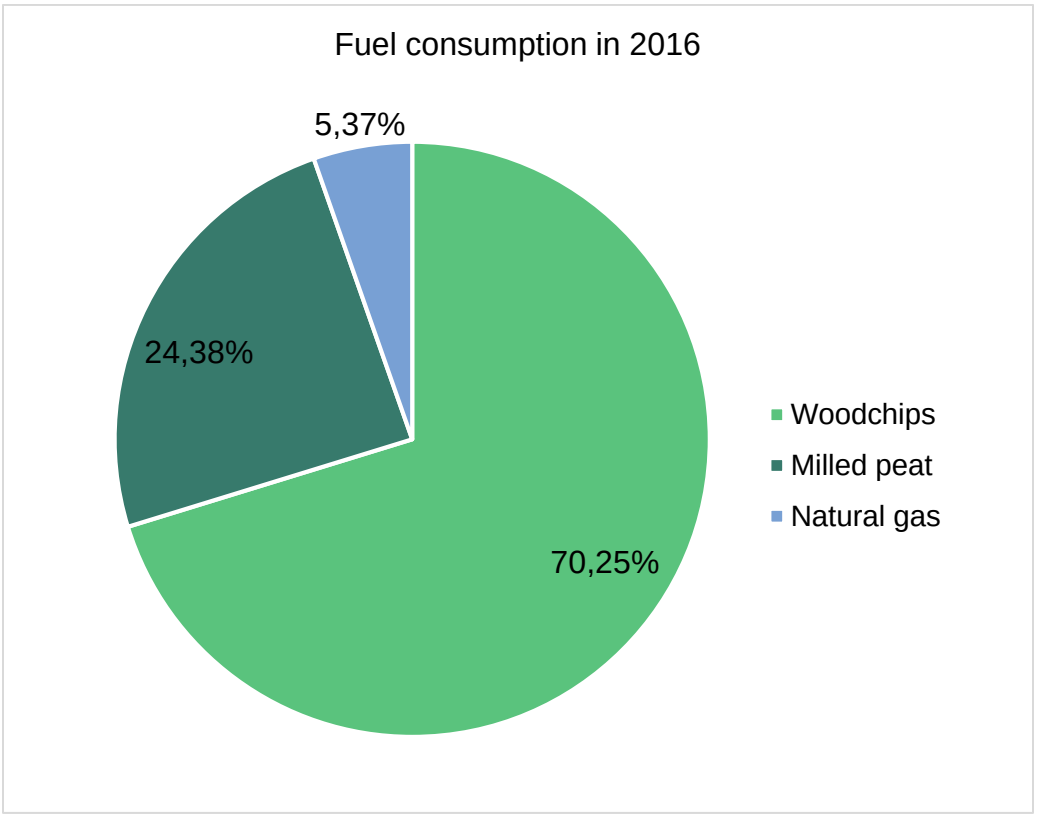


Figure 1. Fuel consumption in 2016.

Tartu district cooling is served by production units indicated in Table 2.

Site	Production	Build year /average age	Real capacity total (MW)
Tartu Downtown	free-cooling source river Emajõgi (Apr-Oct) + chiller condensers; solar panels for own electricity consumption	2016/21	**13**
Aardla	*Chiller condensers*	*2017*	***8,4***

Table 2. Production units of Tartu district cooling.

Waste heat for DHC system is used from three sources. In 2015 Kroonpress started to distribute its waste heat to Tartu DH network. In 2016 surplus heat from DC production and Estonian National Museum's cooling solution is distributed to DH network with heat pumps.

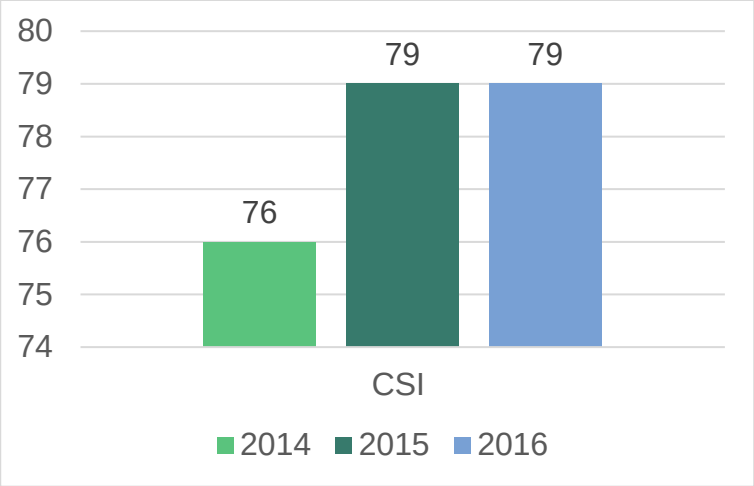
2.3 Heat market: customers and customer satisfaction

Tartu DH network supplies around 50 % of the buildings in the city and 75 % of its citizens. The typical heat consumption (heat for heating and hot water) for old buildings is **150-180 kWh/m2/y** and **80-110 kWh/m2/y** for new and renovated buildings (theoretical assumption). The weather conditions in Tartu are quite favorable to DH: 3894 heating degree days (with reference temperature of 18 °C) and a rather long heating season (7 months).

Tartu district heating price in 2016 is around EUR 51.05/MWh (ex. taxes), which is lower than the average national price for DH (approximately EUR 60/MWh). The main competitors for DH are individual natural gas boilers and in some cases wood-burning stoves (mainly in one-family houses) or direct electrical heating.

The client base of Tartu's DH system has been increasing since 2000. During the last 15 years, the average increase in capacity was 21.5 additional MW/year and the capacity was multiplied by 2.3, which shows the good health of DH system. In 2016, there was a capacity increase of 17 MW, corresponding to 46 new clients. Connections to DH network are exprected to grow in coming years.

Customer satisfaction survey is performed every year and shows that the level of satisfaction is very good and stable (shown in figure 2). Suvery compares similar systems in Scandinavia, Poland and Baltics.



Reputation index 2016	85
Company I trust	91
Company I like	82
Company I respect	82

Figure 2. Customer satisfaction index.

2.4 Cooling market: customers and potential to grow

Fortum Tartu identified four areas for DC development, illustrated in Figure 3. The district cooling network commissioned in May 2016 is the first DC network in the Baltics and is based on free cooling from the city's river (nr 1 in figure 3). Its first customers were a new shopping centre and a hotel located in the city centre, and it will supply other tertiary buildings as the network grows. Most of the DC customers are expected to be also DH customers.

Estonian National Museum DC solution started production in 2016. Next DC plant (classical centralized cooling production plant) for customer Lõunakeskus started production in June this year (nr 3). DC project nr. 4 is in starting phase.