COMBINED DISTRICT HEATING AND COOLING

QUALITY OF LIVING WITH GLOBALLY EXCEPTIONAL AND ECO-EFFICIENT DISTRICT COOLING

HELEN THE BEST URBAN ENERGY IN THE WORLD
HELEN.FI

SUMMARY

We were awarded an award of excellence in the previous Global District Energy Climate Awards in 2013. The award was granted in the expansion expansion category for our efficient Combined Heat and Power (CHP)-based District Heating and Cooling (DHC) system. We, however, constantly make investments, research, and efforts to maintain the level of service as well as develop the system even further. Thus, we apply for an award of excellence yet again, this time for what can really be seen as the future of district energy: Combined District Heating and Cooling (CHC). CHC is a model which integrates CHP, district heating and conventional district cooling as well as recirculation of energy flows from district cooling back into the system. It is a new integrated, highly efficient energy ecosystem where only a minimal amount of energy is wasted.

The CHC system in Helsinki, the capital of Finland, is enabled by Katri Vala heating (90 MW) and cooling (60 MW) pump plant station. As the customer base for district cooling has grown steadily, the heat pump station has finally grown to its full potential. The significance of Katri Vala in the CHC system can be seen in improved energy efficiency and in the increase of the share of renewable energy in energy production. Currently, more than 80 per cent of the district cooling energy in Helsinki is produced from energy sources that would otherwise be unutilized. The amount of renewable heat harnessed from the CHC system is growing year by year.

We would like to highlight the following achievements:

• A record amount, over 40 000 MWh (in only three months) of renewable district heat was collected from the sun in 2014 through our district cooling system and the total amount of renewable district heating grew to 90 000 MWh in 2014.

• The cumulative amount of CO2 emissions saved by Katri Vala and CHC cooling by the year 2014 equals to 200 000 000 tons, as the carbon footprint of district cooling is only a fraction of the carbon footprint of a property-specific cooling system.

• A new underground energy storage, an underground lake of 38 000 000 litres is being built and will been completed and brought to use for district cooling in 2015 to optimize cooling demand fluctuation.

• We have played a major role in building consistent quality standards, recommendations and guidelines for designers for district cooling (published in 2014) in Finland in close co-operation with the Ministry of Employment and Economy and The Ministry of Environment.

• We have initiated a reasearch programme in 2014 to create a new innovative energy solution for areas connected to district heating and cooling. The aim is to investigate an innovation that utilizes the building stock as a large solar energy collector to recycle energy and produce renewable energy through district cooling. Results will function as a base for new innovative applications of the CHC system together with building structure design of zero energy buildings and urban planning.

The CHC system in Helsinki is one of its kind; efficient CHP production, district heating and district cooling complement each other perfectly. We provide a replicable and scalable innovative energy production and distribution model for the whole of Europe and why not for the whole of the world to use.

HELEN – PROVIDING HEATING, COOLING AND A ZERO CO_2 FUTURE FOR HELSINKI

OUR FIGURES TODAY SHOW A STEADY GROWTH

Helen Ltd, former Helsingin Energia, is one of the largest energy companies in Finland supplying electricity to about 400,000 customers in Finland and covering more than 90 percent of the heat demand of the capital city with district heat. We also produce and sell district cooling which is expanding continuosly. Besides eco-efficiency, we provide careless and pleasant indoor conditions with our heating and cooling, evident for everyday housing and working, by ensuring the right indoor temperature. Helen is a profitable company owned 100 % by the City of Helsinki managing all energy production and distribution related operations in Helsinki.

Energy efficient district heating covers today over 90% of the heat demand in Helsinki. The connection capacity of the network is over 3,300 MW with nearly 15,000 customer connections and approximately 186 000 000 cubic meters are heated by district heating. The length of the district heating network in Helsinki totals over 1,350 kilometers, expanding by 15-20 kilometers annually.

The number of customers connected to the district cooling network is today nearly 300 buildings. Customers' cooling connected capacity is approximately 200 MW and approximately 14,000,000 square meters are cooled by district cooling. The length of the distribution network is approximately 65 km and its volume equals to 20,000 cubic meters.

District cooling, our growing business, covers today the entire Helsinki inner city, and is expanding into new areas every year. Our customers continue to show a lively interest in district cooling and the growth since the early 2000s has been 15 to 20 MW annually. In Helsinki, district cooling is used in various types of real estates including shopping malls, hotels, office buildings, public premises and data centres. Today, district cooling is also available for most residential properties in central Helsinki.

TOWARDS ZERO CO_2 EMISSIONS

Our emissions are to fall while our district energy business grows as Helen aims to achieve carbon-neutral energy production by 2050. For the planned emission reductions, we have launched a development programme with a goal for a carbon-neutral future. The actions within the programme include improving our district heating and cooling system which is already among the most energy efficient in the world.

Our intermediate target is to increase the use of renewable energy sources to 20% by 2020. To achieve this we are using biomass in our energy production and supplementing our energy palette with offshore wind power. In the first stage, in 2014, wood pellets will be introduced among coal to be used at the Salmisaari and Hanasaari CHP plants with a share of fuel that will mount to 7%. The second stage will be decided by Helsinki City Council in 2015. The alternatives, currently under careful investigations, are to build a new CHP plant in Vuosaari or to replace 40 % of the coal used in Hanasaari and Salmisaari with biomass.

District heating and cooling play an important role in our mission for a CO_2-neutral future. Future energy planning is done in interaction with customers and citizens.

ECO-EFFICIENCY AND NEW KIND OF QUALITY OF LIVING WITH DISTRICT COOLING

INNOVATION FROM SURPLUS ENERGY AND THE SUN

Our business, energy efficiency and emission reductions today are due to our new Combined District Heating and Cooling (CHC) production and our Katri Vala pump plant combined with CHP production. Our system can be replicated to any city block that needs both heating and cooling. The system can be scaled up to starting from one to two city blocks.

CHC stands for production of cooling in the same process with electricity and district heat production. CHC enables the production of heating and cooling with efficient utilization of free energy sources, such as cold sea water, solar energy and cogeneration i.e. recovering waste heat from properties with district cooling. In other words, the new CHC production enables energy recycling with highest possible efficiency with existing technologies.

OsmoSoininvaara@OsmoSoininvaara: #Helen transfers heat from the presidential residence through district cooling into district heating. Citizens of Helsinki can feel the warmth of the Independence Day celebrations while taking a shower!

- Member of the Green Party and the Finnish Parliament tweets on Finnish Independent day 6th December 2014 (translated from Finnish)

District cooling was introduced to the CHP system to meet the growing need of cooling. The amount of primary energy used for cooling before our CHC system was 2 000 GWh annually with an enormous heat loss. Helen's initial cooling solution, when built in 1998, offered an alternative solution and achieved a primary energy factor of 0,2 enhancing the energy efficiency of cooled buildings by multiple compared to the conventional building specific solutions.

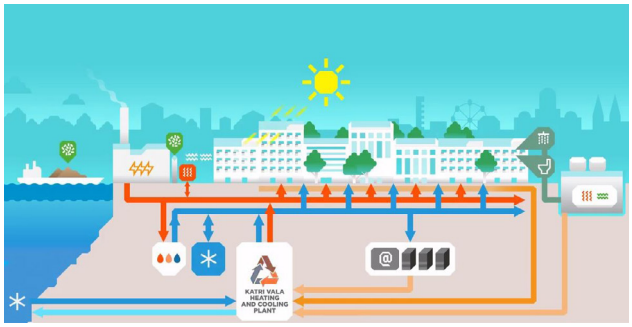
The district energy system was not yet complete and as the result of growing cooling need and an innovation using the thermal heat of the sun from buildings, Helen supplemented the system with The Katri Vala heat pump plant in 2006. The new solution based on an integrated usage of heat pumps, waste heat of purified sewage water and the recycling of heat gathered from the building stock and the sun.

ENERGY FROM URBAN CITY STRUCTURE

The basis of the CHC system is in the urban city structure and the coincident emergence of heating need, cooling need and surplus energy. Office buildings require cooling while apartment buildings next door are in need for hot water, also during the warm season when the cooling need is peaking. Office buildings including shopping centers, data centers etc. generate surplus heat that can be utilized in heat production instead of condensing it into the air.

In the winter time, Helsinki is heated with high efficiency CHP power plants, in summer time, solar waste heat is collected with district cooling network, refined and used for heating hot water. All year round, our CHC system collects the excess heat from data centers and purified wastewater for using the heat where it is needed. The renewable district heat produced with district cooling is returned to the properties connected to the district heating and cooling system for utilization.

Our new CHC based district cooling production consists of a combined heat pump plant of 5 heat pumps, added to the production infrastructure in late 2006, and 10 absorption units. The total heat pump cooling capacity of the system is 60 MW.



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KATRI VALA – THE HEART OF THE CHC SOLUTION

Katri Vala heating and cooling pump plant operates as the key element in our CHC system collecting and processing energy flows in the CHC energy chain. Katri Vala is one of the largest heat pump plants in the world utilizing heat from purified sewage water and to produce heat and cooling in a single process. The plant's heating capacity is 90 MW and cooling capacity 60 MW. The annual energy production equals to the energy demand of a small Finnish town of 40,000 residents. Katri Vala heat pump station is situated in an underground cave beneath the park of Katri Vala in Helsinki thus saving space in a dense urban area.

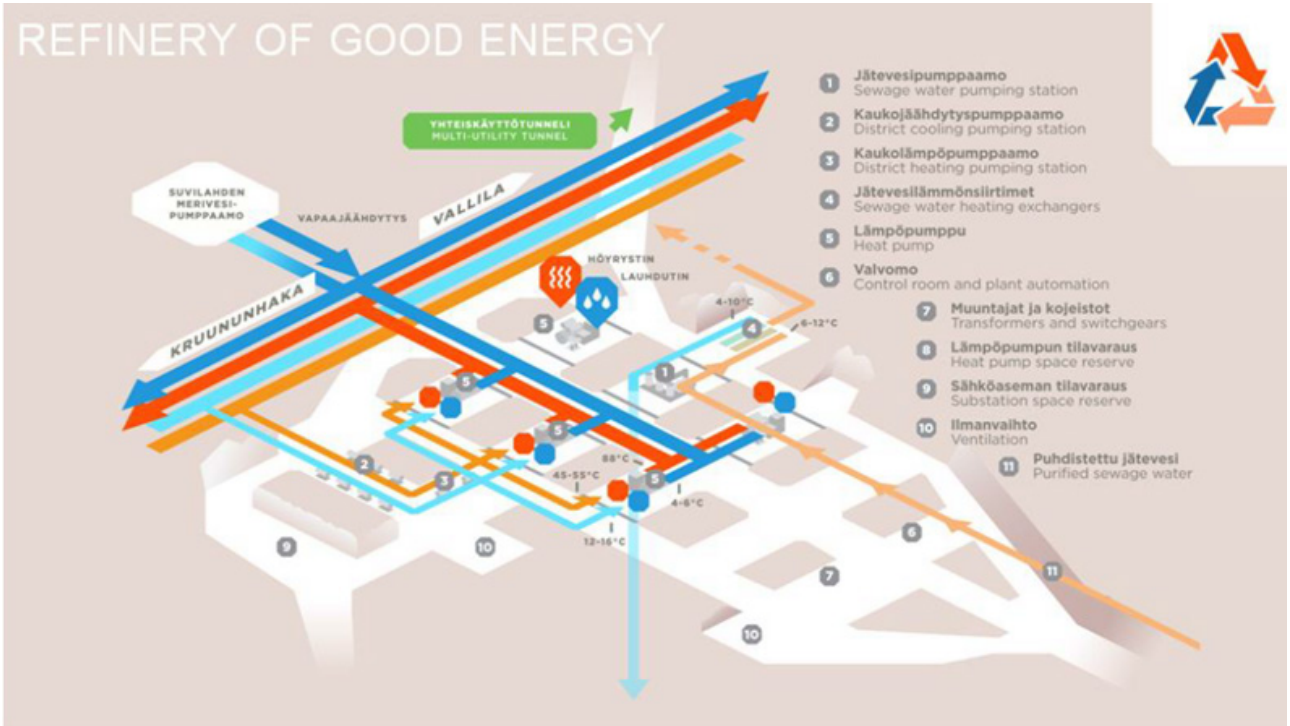
The heat energy utilised for district heating is obtained with heat pumps from the incoming purified wastewater from the Viikinmäki waste water treatment plant with a water flow of 11,000 cubic meters per hour. District cooling energy is also obtained directly from the sea with heat exchangers.

To optimize cooling demand fluctuation two cooling accumulators (thermal storages), underground lakes, have been built to complete the system. Cooling energy is charged in the night and used during the day when the demand for cooling hits its peak. The first cooling reserve, 11 million litres in volume, was taken into use in Pasila in 2012. A new energy reserve of 38 million litres in volume, over three times the size of the one in Pasila, will be completed a hundred metres below the Esplanadi park in the centre of Helsinki and it will be brought to use in 2015. Along with working as means for demand response, these storages maximize the reliability and guarantee of delivery of cooling.

The significance of Katri Vala in the CHC system can be identified in improved energy efficiency and in the increase of the share of renewable energy sources in our CHC production. More than 80 per cent of the district cooling energy is produced from energy sources that would otherwise be unutilized.

The volume of solar power included in the gathered and recycled energy is already today very high: producing a similar amount of energy with solar collectors would require a space equivalent to thirty football pitches. The share of this recycled heat including also solar energy is estimated to increase as the cooling network continues to expand.

In a warm summer day in 2014, the share of district heating produced utilizing the energy gathered through the cooling system i.e. mainly the sun, grew up to 50 % of the daily heat demand.



An area equivalent to thirty football pitches would be required to produce the similar amount of solar energy harnessed through the CHC system.

QUALITY, GUARANTEE OF DELIVERY AND COMPETETIVE PRICING

Besides eco-efficiency and energy efficiency, the delivery of district heating and cooling is managed with an extremely high operational reliability and guarantee of delivery. District heating is delivered to customers with an annual interruption of less than 2,5 hours on average (including planned inerruptions) and district cooling with an annual interruption of zero hours on average! Critical facilities for the city's operations including major hospitals, administrative and cultural real estates, banks, data centers and the biggest shopping centers in the Nordic region are connected to our CHC system due to its security and reliability. The reliability is available for all our customers for an affordable costs, as the district heat in Helsinki is among the cheapest in Finland and even the whole of Europe.

Helen is leading the way also in building up quality standards for district cooling in Finland and in Europe as the cooling network continues to grow. A set of guidelines were finalized and published in Finland in the summer 2014 to create standards for designers and to ensure appropriate equipment and quality control.

FROM CHP TO CHC

The success of our CHC system is based on CHP production introduced in Helsinki in 1957 – the same time when production of district heating started.

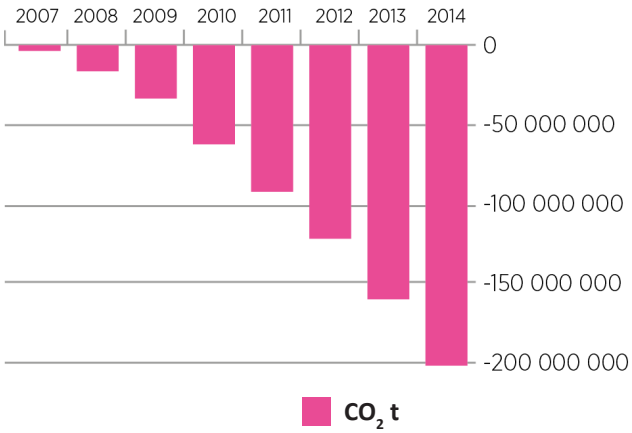
The four CHP plants providing the CHC system with heat were constructed between 1970 and 1990 and the peak-load and reserve power plants between 1960 and 2000. District heating also uses heat-only boilers with a high capacity for peaking and reserve. Their usage time, however, is normally very short. Heat-only-boilers are needed as the production is weather dependant and the weather changes a lot annually. The produced CHP heat amounts to around 6,000-7,000 GWh annually and covers over 93% of the total heat production. The fuel efficiency of 90 % is among the best in the world. The production system as a whole is designed to work optimally in Finnish weather conditions.

KATRI VALA – POSITIVE IMPACTS ON BOTH ENVIRONMENT AND COMMUNITY

KATRI VALA– A LEAP TOWARDS CO_2 NEUTRAL HELSINKI

The start of the new CHC business was iniated by the disovery that district cooling provides the easiest way to improve the energy efficiency and reduce the CO_2 emissions of buildings located in Helsinki.

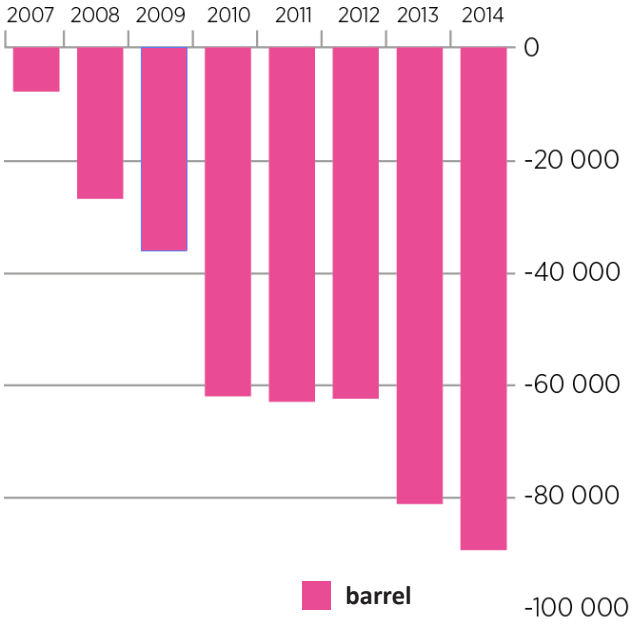
CUMULATIVE CO_2 EMISSION SAVINGS GENERATED BY THE CHC SYSTEM COMPARED TO AN ALTERNATIVE SYSTEM



The consumption of electricity is included in the comparison as in the surplus district heat production.

The positive climate impacts achieved with the CHC cooling with Katri Vala are identified as lower emissions generated in the energy production when compared to an equivalent building specific cooling system using crude oil or compressor-operated cooling production.

ENERGY SAVINGS COMPARABLE TO BARRELS OF OIL



The cumulative amount of CO_2 emissions saved by CHC cooling by the year 2014 equals to 200 000 000 tons, as the carbon footprint of district cooling is only a fraction of the carbon footprint of a property-specific cooling system. The annual amount of energy saved corresponds to over 300 million kilometers driven by car and 90 000 barrels when compared to the energy content of oil.

The climate impacts of cooling are reduced further by utilizing surplus heat generated by the thermal impact of the sun, heat produced by people and other excess heat. The surplus heat is gathered from the building stock and processed to be used as recycled district heat thus decreasing the need to produce heat using other production methods. Even the already relatively minimal share of emissions caused in the efficient CHP production are removed as equal amount of energy is used as recycled energy from the new CHC system.

The plant's only direct environmental impact is the emissions caused by the production of the electricity required by its heat pumps and other equipment. Its carbon dioxide emissions are a fifth of what producing an equal amount of energy in a power plant or heat plant would cause.

GHG EMISSIONS ARE FALLING THROUGHOUT THE ENTIRE ENERGY CHAIN

In this millennium, carbon dioxide emission levels have varied, e.g. depending on the Nordic hydropower situation and the weather conditions, but the emissions have been falling steadily since the last decade. In the reference year of 1990, carbon dioxide emissions from energy production in the Helsinki region totalled approximately 3.4 million tonnes. Since then, the city has grown, demand for heat has grown and energy production is now over 50% higher than 20 years ago. However, specific carbon dioxide emissions have fallen rapidly. In the reference year of 1990, the specific emissions of carbon dioxide were 400 gCO_2/kWh while in 2013 they were about 250 gCO_2/kWh.

Year	1990	2000	2013
Acidifying emissions			
Nox (mg/kWh)	1 470	310	300
SO_2 (mg/kWh)	1 520	230	180
Specific carbon dioxide emissions			
CO_2 (g/kWh)	400	260	250
Particle emissions			
(mg/kWh)	200	22	10

Using the Ecoheat4cities calculation tool, equivalent specific emissions from combined district heating and district cooling were 122 kg CO_2/MWh (Ecocities default) in 2013. Values for 2014 are still under calculation. The figures are low and even more so considering the cold climate in Finland and need for considerably higher share of peak production than in many warmer countries.

Before the era of district heating, the annual averages of sulphur oxides content in the Helsinki inner city ranged from 50 to 100 µg/m3. Currently, the content limit of air quality is 20 µg/m3.

The achieved decreases in the amount of sulphur dioxide and nitrogen oxide emissions are due to our long-term modernization procedures preparing for the new restrictions in acidifying and particulate emissions. The new EU legislation will come to effect in 2016 and we have been preparing for this by renewing the technology in our power and heating plants to achieve required decreases.

The impact of our energy production on air quality is the lowest for decades. Based on our measurements, the annual average of sulphur dioxide content, which depicts the impact of energy production on the air quality in Helsinki, is currently the lowest for decades or even for a hundred years. In 1990, this measurement was ten times as big. Energy production causes consideraby less small particles in Helsinki than e.g. traffic.

CHC – A SOURCE FOR CUSTOMER SATISFACTION

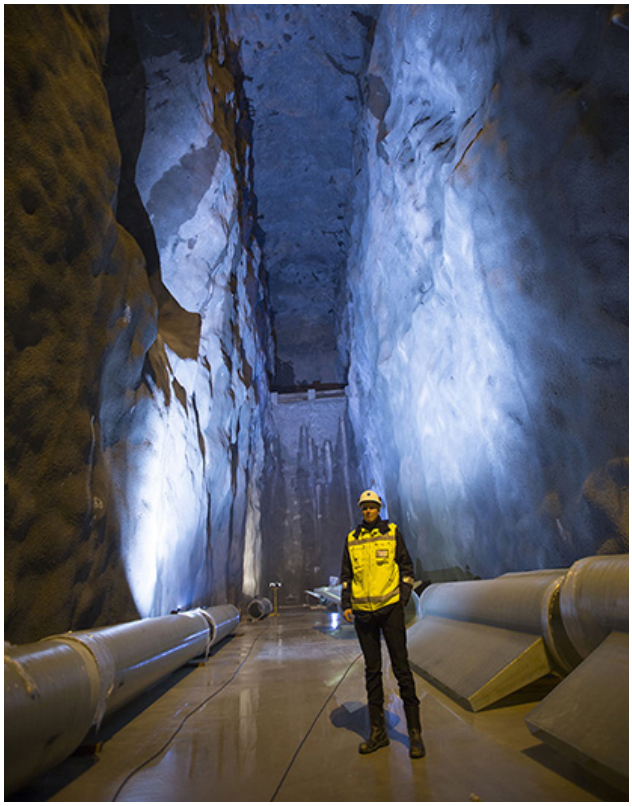
Our customers see district cooling as an environmentally friendly, easy, effortless and secure way of taking care of their cooling needs. Customers' buildings connected to the district cooling network act as sources for renewable heat. Through district cooling renewable heat is targeted for the customers connected to our network turning a large share of their district heat CO_2 neutral which is seen as a great advantage and a source for customer satisfaction. Due to combined heating and cooling in Katri Vala, the price for cooling is lower than before. Also, the price of district heat in Helsinki is among the cheapest in Finland.

Today, district cooling customers reduce carbon dioxide emissions of properties by about 80 per cent compared to alternative ways of cooling. Our average business property customer reduces their emissions by over 100,000 kg per year. A similar reduction in emissions would be achieved by reducing passenger vehicle use by about 600,000 kilometers per year.

"The decision to choose district cooling to one of our housing companies was made on the basis of the environmental friendliness of a refrigerant-free system."

- Lemminkäinen Talo Ltd (one of the biggest construction companies in Finland)

Other benefits gained with our cooling system are in the use of refrigerants. No refrigerants harmful to the environment are used in the process. In our system the amount of refrigerant per MW is 112,5 kg compared to over three times more in a building specific cooling solution. In addition, customers do not need any refrigerants in their own facilities.



A new energy reserve of 38 million litres in volume will be completed a hundred metres below the Esplanadi park in the centre of Helsinki and it will be taken into use in 2015.

The system would not exist without the customers and is a result of customer needs. During early expansion frame agreements with customers where drawn to be able to invest in the massive system.

In addition to customer satisfaction, expanding and modernizing the network has brought positive impacts in employment in Helsinki. Building the network and connecting customers to the system generates work every year as the customer base grows: around 230 new connections to the district heating network and over 35 connections to the cooling network annually. On top of the annual effect of growth in the network, the expansion and modernization of the production system has created employment in construction, while planning and building the underground heat-pump station Katri Vala 2006, the cooling accumulator in Pasila in 2012 as well as the accumulator under the city center in 2015. Helen Ltd itself, employs over 1,000 people.

FUTURE DEVELOPMENT OF THE DISTRICT ENERGY NETWORK – CLEANTECH FROM THE SUN

AN INITIATIVE FOR FUTURE DISTRICT COOLING SOLUTIONS

We are continuosly developing the CHC further by using it as a development platform. Our system is expanding and the dense urban structure provides future opportunities for increased use of renewable energy, recycling of energy flows and emission reductions.

In practice we are currently conducting a research project SunZEB (zero energy building) – PlusEnergy in the City launched in the spring 2014. The aim is to create an optimal energy solution for areas connected to district heating and cooling and to investigate innovative recirculation and reuse of energy. Could a cooled building operate as a source for renewable energy rather than a mere consumer of cooling energy? The problem of removing waste heat is turned into an advantage. I.e. we are proposing a new, cost-efficient way of looking at the consept of a zero-energy or even a plus-energy building.

HELEN IS TAKING FURTHER THE INTEGRATION OF BUILDING STRUCTURE AND ENERGY MANAGEMENT

Results of the study and piloting of the innovation will function as a base for new innovative applications of the CHC system together with structure design of zero energy buildings and urban planning.

The pioneering solution combines building structure design and the CHC system to meet the increasing needs for housing comfort, right temperature and daylight, with minimal environmental impacts. The innovation is in the utilization of district cooling and building structure as a large solar energy collector to recover and recycle used energy, waste heat from electrical appliances and heat from tap water. The energy is captured with the aid of advanced windows and building services technology combined with a regional CHC system.

The energy system in Helsinki already utilises renewable energy sources in a very efficient way: biomass, seawater and solar heat. The total amount of renewable district heating harnessed through district cooling grew to 90,000 MWh in 2014. During a warm summer week, up to 1,000 MWh of solar heat can be produced with district cooling. This amount corresponds to one week's hot water need of 250,000 people. In the summer of 2014 alone (3 months), over 40,000 MWh of renewable district heat was produced for district cooling customers. 40,000 MWh corresponds to the annual district heating need of around 20,000 new apartments of 80 square meters. The amount of renewable heat harnessed from the CHC system is growing year by year.

A CHC solution is particularly well suited for the new zero- and plus-energy houses where the management of heat and energy flows is extremely important. The shading of structures

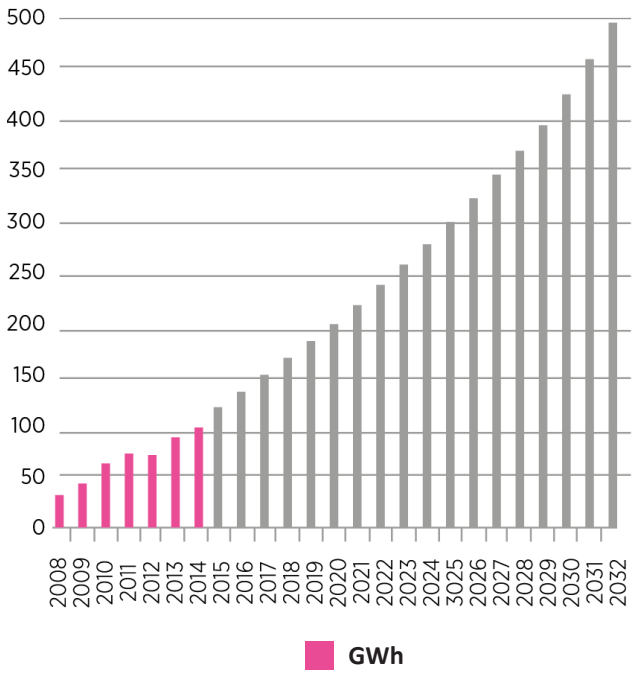
and cooling of indoor spaces in the summer are a necessity if the surplus energy is not recovered. It is also necessary to prevent a building, which uses only a little energy in the winter, from turning into an energy guzzler in the spring, summer and autumn.

The CHC system using heat pumps can collect solar energy and other waste energies with district cooling enabling the building to act as a source of renewable energy. The CHC system collects energy and produces simultaneously cooling. In the summer, renewable solar energy is collected into the district heating system with cooling and in the winter, solar energy is utilised as much as possible for heating the building. Different energy flows are separated and processed to the correct temperature levels in the CHC plant for reuse in heating and cooling.

CLEANTECH BRINGS ADDED VALUE TO CUSTOMERS

The management of energy flows in a SunZEB building brings added value to the real estate owners and residents in the form of architectural opportunities and energy efficiency raised to a whole new level.

RENEWABLE CHC DISTRICT HEATING



Our vision is to considerably increase the share of renewable district heating produced with our CHC system.

The properties and size of windows are designed so that solar energy can be utilised as much as possible with the aid of building services technology for heating and cooling the building. We can already see the solution having a full potential of achieving a situation where a property cooled with district cooling in the summer period produces solar energy in excess of its own need. All this renewable energy produced is collected without separate solar heat collectors. Buildings connected to the district heating and cooling system will also give a new look to the future cityscape.

Large window surfaces allowing natural light and heat of the sun to access indoors in the summer and winter can also be widely used in low-energy solutions.

IMPACT ON FUTURE CONSTRUCTION AND URBAN DESIGN IN HELSINKI

Larger windows enables the collecting of surplus heat generated by the sun and the utilization of this recovered heat in the CHC system. The utilization of the recovered heat through the CHC system again enables the building of extremely energy-efficient net-zero energy buildings and even energy-plus buildings in the urban structure.

For the real estate owners and the residents, this innovation enables eco-efficient apartments with natural lighting and enhanced living comfort. In the scale of a city the SunZEB innovation is significant. An equivalent level in energy efficiency and production of renewable energy would not be possible to achieve in the scale of an individual building or a city block even with energy storages due to the high variations in consumption and production.

The innovation enables increased use of solar energy in towns, which will have an impact on the entire energy system. As a result of our invention, cooling of properties is not the same as wasting energy – on the contrary.