

# HELSINGIN ENERGIA'S DECENTRALIZED DISTRICT HEATING AND COOLING SYSTEM

The most energy efficient solution for providing  
energy for the smart city of Helsinki



**HELSINGIN  
ENERGIA**



## SUMMARY

Helsingin Energia's DHC smart city- solution combines CHP, district heating and district cooling in the most energy-efficient way in the world. Helsingin Energia is business based and profitable energy company not subsidized by the municipality. We promote end-use energy efficiency by monitoring, reporting and providing customer guidance, and help them to make cost- and energy-efficient choices and use energy wisely. During the year 2012, we updated our strategy and action plan towards a CO<sub>2</sub>- neutral energy production.

Helsinki Energy's DHC and CHP infrastructure consists of four CHP plants. The system is supported and diversified by harnessing waste heat accumulated along the energy chain. The DHC system enables the production of electricity corresponding double the amount of the need of Helsinki and simultaneously Helsingin Energia can supply over 90 % of the need of heat and produce cooling. Helsingin Energia manages an efficient district energy

supply with energy storage and by optimising the energy use of our customers. We also aim to maximise the use of our system wherever there is need for heating or cooling.

Our DHC system enables our customer to gain a LEED certified way of housing and living. The operational reliability and guarantee of delivery of the DHC system in Helsinki is high. The energy production of Helsingin Energia is increasing while carbon dioxide emissions are falling. Future energy solutions are constantly being planned and tested.

Interaction with our customers and energy end-users is one of the key elements of our operational principles.

## HELSINGIN ENERGIA'S SMART SYSTEM - PROVIDING THE CITY WITH DISTRICT ENERGY

Helsingin Energia is business based and profitable energy company not supported by the municipality. We are a public energy utility owned 100 % by the City of Helsinki. As one of the largest energy companies in Finland, Helsingin Energia supplies electric energy to about 400,000 customers in Finland and covers more than 90 percent of the heat demand of the capital city with district heat. Helsingin Energia produces and sells also district cooling, which is considerably expanding in Helsinki. The production of district heating and cooling (DHC) is managed in an integrated way, which means that free energy sources, such as cold sea water, waste energies and solar energy are efficiently utilised. More than 80 per cent of the district cooling energy is produced from energy sources that would otherwise be unutilized. Helsingin Energia manages and maintains all energy production and distribution related operations in Helsinki.

### SINCE 1953

#### *1953 - 1960 District heating is developed*

In autumn 1953, it was the task of the electrical works to also start producing steam district heating after the approval of the City Council. The new power plant, Salmisaari A, was commissioned in the same year. In 1957, hot water district heating was introduced when the first customer, one of our customers today, the Helsinki Culinary School at Perhonkatu 11, was connected to water district heating on 14 August.

Combined Heat and Power production (CHP) began in Hanasaari on 18 October 1960. The Hanasaari A power plant was also commissioned in the same year. More power plant output was constantly required, and Hanasaari was built 14 years later.

#### *In 1998 district cooling business started in Helsinki*

The decision to start the district cooling business was based on an estimate that cooling demand will grow together with environmental concerns quite rapidly in Helsinki. The aim was to provide a reliable, economical and eco-efficient cooling solution for all types of property owners. The benefits for property owners were related to energy efficiency and CO<sub>2</sub> savings. It was noticed that district cooling provides the easiest way to improve the energy efficiency and reduce the CO<sub>2</sub> emissions of a building located in Helsinki. At the moment, the total number of customers connected to the district cooling network is over 250. It is estimated that growth will continue as rapidly as it has done in the last couple of years.



*The first customer connected to the water district heating was the Helsinki Culinary School Perho in 1957.*

### DESCRIPTION OF THE DHC SYSTEM

Helsinki Energy's DHC and CHP infrastructure consists of four CHP plants: two main combined cycle plants with natural gas in the suburb of Vuosaari, and black hard coal-fired CHP plants in Hanasaari and Salmisaari in the city centre. The CHP plants were constructed between 1970 and 1990 and the peak-load and reserve power plants between 1960 and 2000. DH also needs heat-only boilers for peaking and reserve. The capacity is high and the usage time is normally very short. The annual share of CHP with 7,200 GWh is over 93% of the total heat production and the fuel efficiency approximately 90 %.

The company also added a combined heat pump plant to the infrastructure after 2006. The Katri Vala heating and cooling plant is the largest plant in the world to produce heat and cooling from sea water and from the waste heat of purified sewage water. The sewage water flow utilised for district heating and cooling in the Katri Vala plant is 11,000 m<sup>3</sup> per hour. Katri Vala also processes cold sea water for cooling in the winter months and recovered thermal energy from the district cooling network producing both heat and cooling in the same process during summer. The output of CO<sub>2</sub> emissions from the Katri Vala plant is over 80% lower than that of equivalent separate energy production using crude oil or compressor-operated cooling production. The annual energy production is enough to heat a small Finnish town.

In Helsinki, district cooling and heating produced in the same processes complement each other in an excellent way. This entity is extremely efficient and pro-environmental, implemented in Helsinki by maximising energy efficiency.

**“Finland – the coldest country in Europe, the best country of district heating.” - Alexander Stubb, Minister of European Affairs and Foreign Trade Finland**

Helsingin Energia's district heating system covers more than 90% of the heating need of the buildings in Helsinki. The connection capacity of the network is 3,300 MW with over 14,500 customer connections. Helsinki has over 800,000 people whose homes and workplaces are heated with energy-efficient district heat. The length of the district heating network in Helsinki totals over 1,300 kilometers, expanding by 15 kilometers annually.

Customers' cooling connected capacity is more than 145 MW and approximately 12,500,000 square meters are cooled by district cooling. The length of the distribution network is approximately 50 km and its volume is equal to 20,000 m<sup>3</sup>. More than 10 km of distribution

pipelines are located in energy tunnels 40-70 m under the ground. Production consists of 5 heat pump and 10 absorption units. Every heat pump produces 12 MW of cooling, and therefore the total heat pump cooling capacity is 60 MW. Production is distributed to three different production plants. The absorption is designed for units of 3,5 MW, and the total absorption capacity is 35 MW.

The operational reliability and guarantee of delivery of the DHC system in Helsinki is extremely high. The average duration of interruptions in the energy delivery in district heating is less than 2,5 hours and zero in the district cooling. Helsingin Energia delivers 100 % of the heat demand, 21 degrees of indoor temperature at home and at work all year round, despite outside temperatures reaching up to 30 degrees below zero. Our critical customer including major hospitals, schools, administrative and cultural real estates, banks, the biggest shopping centers in the Nordic region and the major sports arenas in Helsinki are connected to our DHC system due to its security and reliability.

*Our figures today*

District heat sales grew last year, and our customers continue to show a lively interest in district cooling with an annual growth of 15-20 MW.

There are several development projects under way in the heating market, aimed at assessing alternative and green production forms and new dynamic pricing models. In urban areas, district heating is definitely still the most energy-efficient and environmentally friendly heating method. We are developing new heating-solutions for areas outside the district heating area such as hybrid systems using thermal heat, solar energy and fuel oil, and possibly also bio-oil.

The amount of district heat sold is annually between 6,700-7,400 GWh and the sales volume increased by 5% on the previous year. In spite of the growth, the heating require-

ments in 2011 and 2012 were lower than in a normal year, due to the warmer winter seasons. The amount of district cooling sold was 94 GWh in 2012. The connected cooling load was 145 MW including residential and commercial buildings and server halls, at the close of 2012, and the number of new district cooling sites was more than 250.

#### *What we accomplished in 2012*

Key projects implemented in the operating year 2012 were the modernisation of the electrical and automation systems of the Vuosaari A power plant, the upgrade of the Salmisaari turbine power plant, the renovation of the Kellosaari gas turbine power plant and the Ahvenkoski hydroelectric power plant, the second phase of the modernisation of the Alppila heating plant, the renovation of the Myllypuro heating plant to be fired by natural gas instead of heavy oil, the Pasila underground chilled water storage facility, as well as the excavation of the chilled water storage facility to be located under the Esplanade street.

Helsingin Energia is making preparations for increasing the use of biofuels at the Salmisaari and Hanasaari power plants. As from 2014, the share of biofuels in those power plants will be 5–10 per cent, corresponding to about 100,000 tonnes of wood pellets a year. Necessary modification investments will be investigated at the same time if the City Council decides to increase the share of biofuel to 40 per cent in 2015. As a parallel we are making substantial investments of 3 billion euros for the preparation of a new multi-fuel power plant construction to Vuosaari.

## **RESPONSIBILITY CARRIES US FORWARD**

For Helsingin Energia, environmental responsibility means efficient energy production, reduction of environmental impacts, and promotion of energy savings. During the year 2012, we updated our strategy and action plan towards a CO<sub>2</sub>-neutral energy pro-

duction. Its cornerstones are still sustainable development, reduction of environmental impacts and open interaction with all stakeholders. The new strategy supports our targets through an action plan striving towards a CO<sub>2</sub> neutral Helsinki in 2050.

#### *Energy production is increasing, carbon dioxide emissions are falling*

Carbon dioxide emissions of the total energy production (electricity, heating and cooling) in the Helsinki region amounted to about 3,4 tonnes and those from power assets outside the Helsinki region and purchased electricity to approximately 0,1 million tonnes. Specific carbon dioxide emissions caused by energy procurement were at the same level as in 2011. Since the turn of the millennium, regional emissions in Helsinki have varied between 3,2 and 4,8 million tonnes and specific emissions from energy procurement between 240 and 330 g CO<sub>2</sub>/kWh. Equivalent specific emissions from both district heating and cooling were approximately 130 g CO<sub>2</sub>/kWh (Eco-heat4Cities calculation tool) in 2012.

**”In my opinion, Helen is co-operative and socially responsible in its operations; it broad-mindedly introduces and develops methods to introduce new pro-environmental technology and carries out diverse investment in customers’ energy advisory services.” - Pekka Kalliomäki, Building Counsellor, Department of the Built Environment, Ministry of the Environment, Finland**

#### *Acidifying emissions have settled at a low level*

Sulphur dioxide and nitrogen oxide emissions settled at a low level. This is seen in the fact that emissions for 2012 are approaching the five year moving average figures. As the current decade progresses, acidifying and particulate emissions will continue to fall, eventually to be halved by 2010 at the latest, by which time the full impact of the reformed environmental legislation will be felt.

Acidifying emissions increased slightly. Sulphur emissions from energy production in the Helsinki region increased by 13% on 2011, and nitrogen oxide emissions fell by 2%. The impact of Helsingin Energia's production on the air quality of Helsinki remained low. The annual average sulphur dioxide contents at the Vallila monitoring station, which illustrates the impacts of energy generation on the air quality of Helsinki, was 2,1 µg/m<sup>3</sup> (electricity, heating and cooling), which is slightly lower than in the previous year (2,4 µg/m<sup>3</sup>). This was clearly below the limit value of 20 µg/m<sup>3</sup>, which has been set to protect the ecosystem.

In 1990, the annual average sulphur dioxide contents at the Vallila monitoring station was 16 µg/m<sup>3</sup> (electricity, heating and cooling). Before introducing district heating, the annual average sulphur dioxide contents in the city centre of Helsinki were typically between 50 and 100 µg/m<sup>3</sup>.

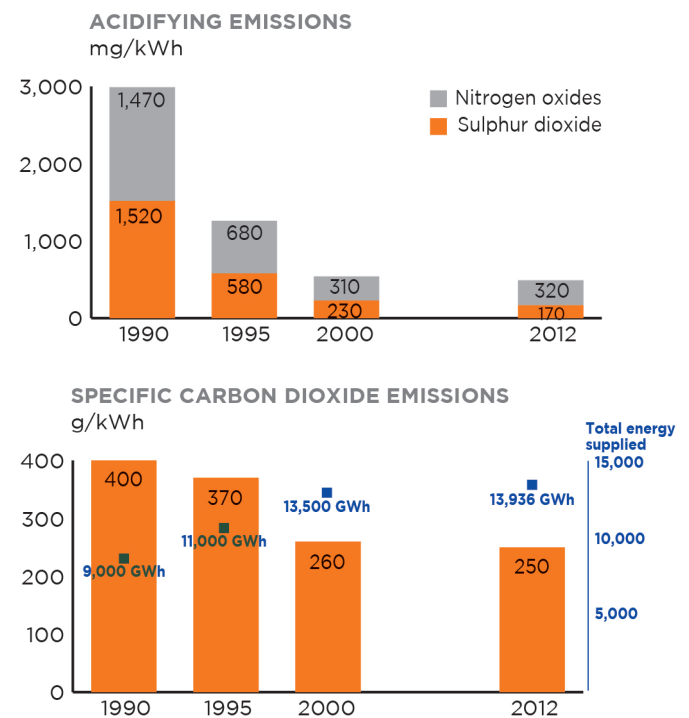
### SMART ENERGY SYSTEMS ARE ABOUT PROVIDING ENERGY AND MAINTAINING A GOOD QUALITY OF LIVING WITH MARGINAL EMISSIONS

*Helsingin Energia is managing all energy flows in Helsinki*

The more than 14,500 clients, 185,000,000 m<sup>3</sup> or 330,000 locations are connected to the system of Helsingin Energia with both the physical energy chain and a smart metering network. We promote end use energy efficiency by monitoring, reporting and providing customer guidance, and help them to make cost- and energy-efficient choices and use energy wisely. We provided more than 14,000 energy advisory activities for our customers via phone, e-mail or face-to-face in 2012. A total of 99% of our customers are set up with a remote energy metering equipment for monitoring hourly energy consumption, costs and environmental impact, and check the performance level of their building-specific heating system by the end of the year 2013. This is the precondition for optimising the entire

energy chain. Helsingin Energia also manages the DHC customer installation with its quality control process, including a series of inspections for customer protection reasons.

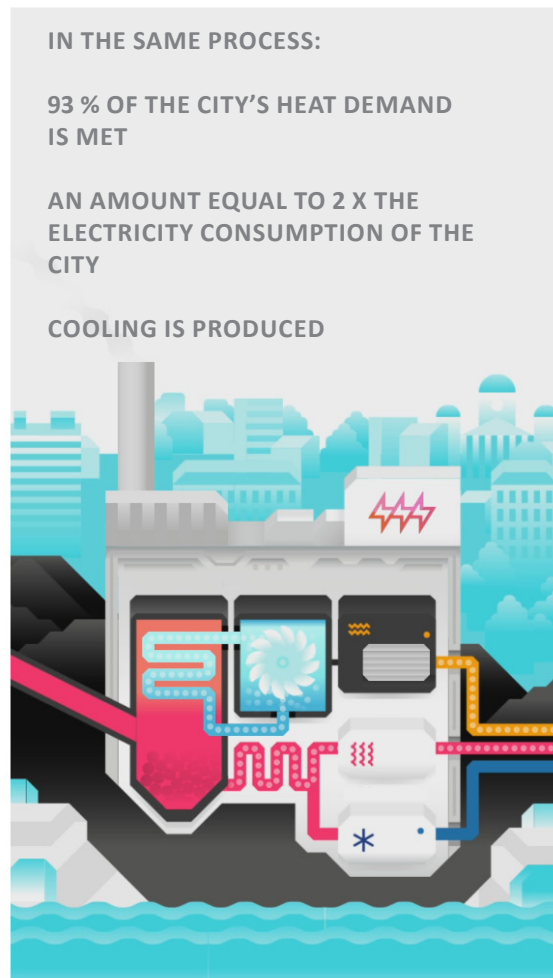
Our system is built to utilise the internal heat loads in buildings as a result of the sun, people, electronic devices and household appliances by transferring it via the cooling network to the heat pump plant and further to the DHC network.



*Emissions of the total energy production of Helsingin Energia.*

The system enables the production of electricity corresponding double the amount of the need of Helsinki and simultaneously Helsingin Energia can supply over 90 % of the need of heat and produce cooling. All production plants are interconnected by a 60 km underground utility energy tunnel network. This system with its high capacity transmission pipelines makes it possible to optimise production and thus maintain an extremely high annual degree of energy efficiency. The production plants and the transmission and distribution networks are all designed, oper-

ated and maintained by Helsingin Energia. The DHC system is remotely monitored and operated from a central control centre.



#### *Impacts on society and community*

The construction of the DHC system has resulted in annual reductions of over 35% in emissions and fuels compared with alternative heating and cooling systems and almost 50% savings in fuel costs in Helsinki. The reductions in emissions and particles have clearly improved the air quality in Helsinki, which has been verified through studies carried out by the National Meteorological Institute.

The energy services of Helsingin Energia have a high quality/cost ratio and a very low living cost burden on the average resident with a share of only 4% of their income despite the cold climate. The consumer price level is less than 60 € per MWh including additional energy taxes.

The DHC system in itself is typically environmentally friendly solution towards the soil, bedrock, ground water resources and waterways, thus strongly supporting the sustainable development of the city. An example of this is the large museum sea fortress of Suomenlinna, found on the UNESCO World Heritage List, choosing DHC as the heating solution for this vulnerable monument due to its low risks and impacts on the fortress. The extensive use of underground solutions as one of the features of the system, has resulted in sparing of land area for housing, commercial and public purposes, and it has also reduced disturbances such as noise, dust and traffic jams during construction. Part of Helsingin Energia's policy is to work closely with our customers and all interest groups including both national and local authorities in order to improve our services.

To minimise any inconvenience caused by the modernisation of the existing energy system, Helsingin Energia works in close co-operation with the Public Works Department of the City of Helsinki. The quality of life in the city is ensured by managing the scheduling of all repair and expansion work, concerning annually over 300 locations.

#### *The decreasing specific heat consumption in Helsinki*

As a result of long term and extensive co-operation with building owners, authorities, industrial enterprises and contractors, the specific heat consumption in buildings including domestic hot water heated with district heat has decreased from 67 kWh/m<sup>3</sup>/year in 1972 to 38 kWh/m<sup>3</sup>/year in 2012, lowest than anywhere else globally. The decreased consumption has resulted in considerable cumulative savings in fuels, emissions and costs, yet an annual saving potential of 9 to 18 million euros has been estimated if the measures recommended by Helsingin Energia to its customers were to be carried out in full.

### *LEED certified way of housing and living*

Next to the lowered heat consumption level, the quality of indoor climate in buildings has improved. Our customers can enjoy well-being and reasonable energy consumption through our services for managing indoor temperatures, radiator systems, ventilation, floor heating and domestic hot water usage.

Lemminkäinen Talo Oy selected DHC solution for housing company Asunto Oy Helsingin Hymni because, as a result, there was no need to use condensers and refrigerants in the building. The decision was made on the basis of the environmental friendliness of a refrigerant-free system and the solution will be implemented also in other projects by Lemminkäinen Talo Oy. According to Lemminkäinen Talo Oy the co-operation with Helsingin Energia was smooth and uncomplicated.

Skanska Commercial Development Finland selected district heat and district cooling to emphasise the minimisation of environmental impacts with its headquarters in Ruskeasu in Helsinki because it wanted to make the building as energy efficient as possible. The headquarters was recently awarded with the highest, platinum-level certificate in the LEED environmental rating system. The recognition was given, above all, for the energy efficiency of the building with a total energy consumption is 75 kWh/m<sup>2</sup>/year. The company provides district heating and cooling to Helsinki residents in an efficient way, using safe and healthy premises with advanced building technology.

The American Embassy in Helsinki selected as the first US embassy in the world the DHC system to become a global example in energy efficiency. The American Embassy in Helsinki, already part of the League of Green Embassies, is currently applying for the LEED platinum-level certification.

### **HELSINKI'S SOLUTIONS – AN INNOVATIVE WAY TO MANAGE AVAILABLE ENERGY FLOWS**

#### *Our energy solutions are developed in interaction with energy end-users*

Interaction with our customers and energy end-users is one of the key elements of our operational principles. For example, in 2012 Helsingin Energia reinforced the technical initialisation of a new pilot heating solution to one of our customers, a school, in co-operation with the school staff and the pupils. A three-day workshop with 300 pupils was held to improve the understanding of the current heat consumption and new energy sources and production methods to be introduced in the school. The co-operation was continued with the school staff by planning the school curriculum and a co-operative relationship was established to support energy education in the school.

Helsingin Energia also supports energy awareness by educating all the pupils from the upper comprehensive schools in the metropolitan area, up to 3,000 pupils annually and 116,000 in total since the beginning of the 40-year history of energy education. We also work together with various residents' associations, environmental organisations, Motiva Ltd and the Finnish Real Estate Management Federation building up to over 2,400 encounters in total in 2012.

We also co-create new innovations with them. In 2012, Helsingin Energia invited students nationwide to invent new energy solutions to diversify the utilisation of district heating and cooling in the city landscape. The invitation was public and the suggestions were introduced to the residents of Helsinki in the form of an exhibition. The winning proposal is currently being planned and developed further for realisation.



*Heating and cooling needs are constantly met with optimised production and distribution*

Helsingin Energia manages an efficient district energy supply with energy storage and by optimising the energy use of our customers. We also aim to maximise the use of our system wherever there is need for heating or cooling.

Helsingin Energia enhances the production and distribution of energy in the network of 138,572 cubic metres with a heat loss of less than 6 % by storing the energy in large underground heat and cooling batteries located in different parts of Helsinki. The thermal storages located in Vuosaari and Salmisaari, together comprise a storage energy capacity of 2,000 MWh recharged at night, again to be discharged during the day. The demand and supply sides are also managed through peak hours, and the need for heat only boilers is less than a few hundred hours during the winter months.

The storage of district cooling is managed with two thermal storages comprising storing energy of 80 MWh and 200 MWh. One of the storages, an 11,500 m<sup>3</sup> underground storage facility in Pasila, has been operating since 2012, and the second one of 25,000 m<sup>3</sup> is currently being built at a depth of over 100 metres below the Esplanade park in the city centre and will be operating in 2015. The chilled water storage is stored in large underground tanks with a capacity that equals the water volume of an average lake.

The energy system is optimised by offering district heating as the primary heating solution for all possible heating purposes. All hot water used in the households, 40 % of all used water, connected to Helsingin Energia's system is heated by district heating, and a major share of our customers receive the distribution of their indoor heating through floor heating and ventilation heating systems with district heating, which is an option offered to all of our customers. District heating is also used in most of the shared laundry services

available for residential use, offered by large housing companies. District heating and cooling are used in a versatile way also in the city scale to meet the more distinctive heating and cooling needs. The ice-breakers used on the south coast, major hospitals, schools, art institutions, shopping malls and sports arenas in Helsinki are all connected to the district energy network. The main streets in Helsinki, Aleksanterinkatu and North Esplanade, are using district heating for the prevention of ice and to improve safety in the pedestrian lanes.

Our customers can ask for an analysis and a review of their heat capacity in case of changed energy consumption levels, potentially leading to lower costs in energy use and contractual water flow. The customer benefits of the service have resulted in energy savings of 5-15%. This was achieved, for example, with one of our customers, the housing co-operative Kaarikuja 5 where the annual savings in heating energy reached 25% and in the contractual water flow 5%. As experts in district energy, we always seek to provide energy for the accurate heating capacity.

*No energy source available is left unused, but turned into an innovation*

The DHC system is supported and diversified by harnessing waste heat accumulated along the energy chain. Cogeneration is supplemented with energy gathered from purified sewage water, server hall solution, recovered energy from the production of district cooling, and cold sea water.

One of our innovations in district energy management is the eco-efficient data centre solution where computers are cooled by district cooling and the heat produced by the machines is gathered from the district cooling network through Katri Vala plant and piped into the district heating network. Helsingin Energia manages three data centres, one in Suvilahti, Katajanokka and Viikinmäki, together with our partner company TeleCityGroup. The Viikinmäki data centre, for example, can generate in its full capacity an amount of heat

energy corresponding to the annual heat demand of 500 new 80 square meter-sized apartments in Helsinki.

Helsingin Energia has a system for utilising waste heat from purified sewage water as one of the energy sources used for the production of district energy. The waste heat is taken from the largest wastewater treatment plant in Finland, located in Viikinmäki, processing 11,000 m<sup>3</sup> per hour of hot sewage water every day generated by the households in the metropolitan area. The waste heat is collected, refined and conducted into the district heating network through Katri Vala plant before it is purified and let into the sea.

The sea water in the Gulf of Finland is one of the three district cooling production forms. The cold sea water is used for cooling between November and May when the sea water temperature reaches 8 C° or below. District cooling is produced from sea water whenever possible.

Future energy solutions are constantly being planned and tested. A new housing area in Östersundom in Helsinki operates as one of the testing grounds for future district en-

ergy solutions. Utilisation of bio fuels, energy storage and different kinds of hybrid heating solutions are being examined and a new solar system is currently under construction to serve the energy need in the extremities of the existing energy network.

The first undertaking to be realised within the area of Östersundom is a pilot heating solution utilising renewable energy sources in the school of Sakarinmäki. The solution consists of 100-400 square metres of solar collectors, a thermal heat pump and a heat storage facility. The existing school-specific heat production plant is also prepared for the utilisation of bio fuels. The annual 900 MWh heat demand of the school will be supplied with 80-100% of renewable energy production once the system will be completed in 2014 and it will provide research data enabling possible scaling and further implementation of the system in Östersundom and in other areas outside the district energy network.

**What if all countries in the Nordic hemisphere applied our energy system of 90 % of market share, 90 % of fuel efficiency and 90 % of CHP share? Or just in EU?**



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