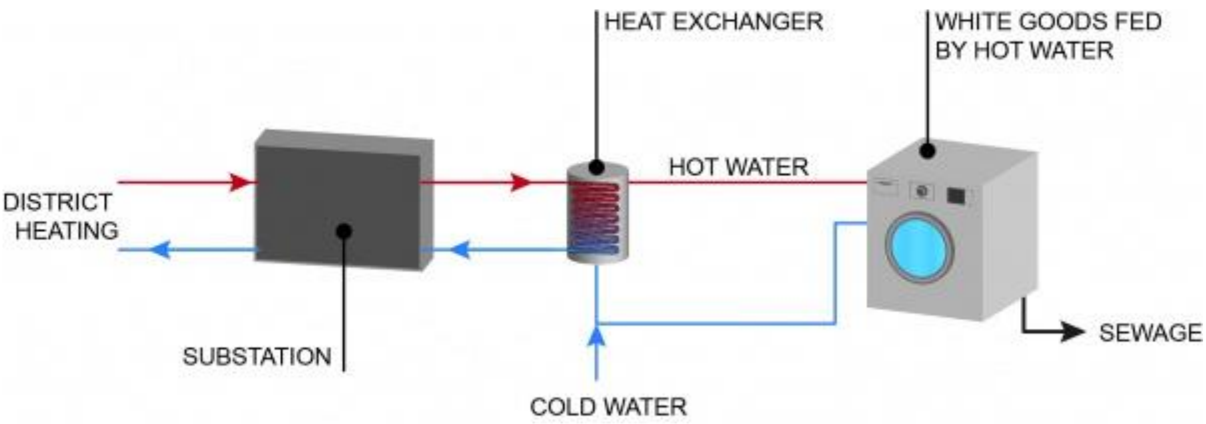
District heating to white goods in Gothenburg

White goods - washing machines and tumble dryers - are connected to district heating in buildings in Gothenburg, resulting in decreased use of electricity.

Asset

Idea and layout

The overall objective of this demonstrator is to install innovative white goods (i.e., washing machines and dryers) using low-grade energy (district heating hot water), replacing conventional machines typically using high-grade electric energy both for running the moving parts and for heating purposes. The machines are connected to district heating supply, independently from heat and domestic hot water supply and they can be installed in laundry rooms of residential multi-family buildings as well as in other typology of buildings (i.e., sport facilities). Ten machines (5 washers and 5 dryers) were installed and started up in July 2014, in a football club, while 192 have been recently installed.



Impact

The overall demonstrator's performance is summarized in the following table according to 5 evaluation criterions. It can be noticed that the assignment of all the scores is directly linked to the values calculated for the Key Performance Indicators, except for socio-economic benefits where a qualitative assessment is carried out based on this cluster's indicators and on separate interviews.

Overall Impact	**Fair/Medium**				
Size [MWh/y]	1-100	100-1000	1000-5000	5000-10000	>10000
Primary Energy Savings	0-10%	10-20%	20-40%	40-60%	>60%
GHG Emissions Reduction	0-10%	10-30%	30-60%	60-90%	>90%

Pollutant Emissions Reduction	0-10%	10-30%	30-60%	60-90%	>90%
Socio-Economic Benefits	Low	Fair	Medium	High	Extrem

Replicability

Replication Potential

Replicability	Low	Medium	High
Authorizative easiness		x	
Adaptability to different climate conditions			x
Technology easy-to-implement (No needs of specific technical requirements)			x
Easy-to-implement (No needs of specific technical requirements)		x	
Easy-to-operate (No needs of specific technical requirements)			x
Opportunity of integrating waste energy sources			x
CAPEX needed for the deployment of the solution		x	

Technical requirements

The technology being tested in this demonstrator can be replicated all over the EU, provided that a few main requirements are satisfied:

- White goods provided with hot water inlets
- White goods characterised by long time frame and a high usage rate in order to make the installation of this technology an economically viable alternative

Asko is right now the only manufacturer of heat driven machines present on the market that delivers heat driven products for households. They offer white goods in a product range called HWC (heating water circuit) which includes dishwashers, washing machines and tumble dryers, and are offered in two sizes, one for household use and one for professional use. The machines can be connected to district heating, geothermal heat or solar heat. The lowest recommended temperature on the incoming heating water is 55°C with a flow rate of 1.6 l/min.36 As a backup system the machines can also be used in a conventional way with electrically heated water and air.

There are three modes that the machines can be used in: Eco, Auto and Quick. The Eco mode optimizes the energy use by maximizing the heat use and only uses the electricity when the right temperature on the process water can't be achieved. Auto gives about the same programme time as conventional machines by using a mix between heat and electric energy. The Quick program uses heat and electricity at the same time in order to minimise the programme time. Note that also in these tests that the heating energy needed for the different settings have not been measured. The highest reduction in electricity use occurs when the dishwasher is set in the Eco mode, which means that it uses the heating water to the max and only uses electricity if the right process temperature can't be reached. The supply temperature is 80°C and the electricity use is decreased by 0.9 kWh, from 1.0 kWh to 0.1 kWh compared to using the machine with only electricity.

The washing time is also decreased by 10 min when heating water is used. If a supply temperature of 55°C instead is used the reduction for the same case is 0.4 kWh. So an increase of the supply temperature from 55°C to 80°C will in "Eco" mode reduce the electricity use from 40% to 90%. If heating water with a temperature of 55 °C is used and the machine is set in Eco mode, a reduction by 79% of the electricity use will be made. If the Quick mode is used which focuses on finishing the drying process as fast as possible by using a combination of heating water and electricity the reduction is only 15%. If a heating temperature of 80°C is used the Eco mode would reduce the electricity use by 87%.

Read more about Heat driven white goods in the Technical Toolbox.

Stakeholders

Stakeholders	Organization Name	Organization Type	Organization Domain	Benefits from demo
District heating network operator	Goteborg Energi AB	Publicly owned	Utility	N/A
Gårdstens bostäder		Publicly owned	Utility	N/A

Finance

Although exact figures on white goods and their spatial distribution in the urban environment are not likely available and habits may differ per country, studies are available on household penetration per category, which can be used to estimate the total potential for a switch to hot fill white goods. The REMODECE project (2007) investigated white goods usage for twelve current EU members, showing washing machines to be nearly universally present (95-99% of households except in Denmark and Belgium, where communal washing machines and laundries are also common). The presence of tumble driers (4-63%) and dishwashers (8-90%) varies greatly, and their DH potential therefore is highly dependent on the country involved. Furthermore, in certain countries hot fill may already be common, varying from 7% in Gerrnany to 76% in Romania, which needs to be subtracted from the total potential. Energy usage per device is approximately 184kWh/year for washing machines, 234 kWh/year for dishwashers and 347 kWh/year for clothes dryers. The share of heat consumption also varies per type of appliance but can be assumed to be about 90% for washing machines, about 60% for dishwashers and about 40% for condensing dryers (the type required for DH application). This results in potential savings per machine of 211 kWh/year for replacing a dishwasher with a hot fill model, 110 kWh/year for a dishwasher and 139 kWh/year for a clothes dryer.

Multiplying these figures with the number of households in a given area, adjusted for local device usage habits and the availability of DH supplied DHW (or the share of communal appliances), will then provide an maximum potential estimate for DH supply of white goods. As appliance penetration is either directly tied to individuals and households or registered companies (laundries, laundromats, hotels, restaurants etc), using regional and national statistics will allow an approximation of the total DH potential (and accompanying electricity usage reduction) for these.

As a final note: although exergetically speaking it would be better to not provide low quality heat energy using high quality electricity sources, which of these sources is most favourable will depend on the local situation. If abundant renewable electricity is available for example, electric appliances could be more favourable. For areas where heat supply and electricity supply are competitive, it may be advantageous to use dual source appliances (i.e. ones that can switch between hot fill and electrical resistance heating, depending on availability and price).

Challenges & Risks

The technology being tested in this demonstrator can be replicated all over the EU, provided that a few main requirements are satisfied: • Presence of a district heating network in the town of interest; • Availability of a suitable location for machines installation, such as laundry rooms in the building basement. If DH is also used to provide domestic hot water (DHW), any household will be suitable; • Short distance between the laundry room and the district heating network (e.g. approximately 5 m), to limit installation costs related to pipes installation (which cover the main part of installation costs) in case of already existing buildings; • In case of new buildings, the location of the laundry room should be defined in order to minimize the system installation costs.

Lessons learnt

Demonstrator development

- Moving machines from apartments to laundries, made installations easier for customers. As a matter of fact, short distance between the laundry room and the district heating network limit installation costs related to pipes installation (i.e., the main part of installation costs).
- Another aspect highlighted from demonstrator's operation, is related to the return temperature from machines to DHN that has to be carefully considered and optimized in order to minimize the impact on the efficiency of the network. As a matter of fact, in order to allow the machine to wash at 90°C, it has to be foreseen that the water outlet temperature would be around 60°C. This does not affect only the efficiency of the DHN, but also customers' tariffs and taxation for heat supply. For instance, in Sweden special taxes are foreseen for high return temperatures of water from DHN.

Demonstrator performance monitoring

The installed white goods are provided with monitoring equipment to allow a proper evaluation of their global performance against the baseline situation referred to conventional electricity-driven machines. The key performance indicator of highest relevance for this technology is the electricity saving in favour of thermal energy consumptions that result in environmental benefits, being the machines' GHG emissions reduced. Currently monitored data coming from 10 machines installed in the laundry room of a football club located in Gothenburg have been analyzed and processed to quantify the advantages of such a technology. A selection of relevant key performance indicators is available in the following table.

Key Performance Indicators	**Values *(July-Dec.2014)***
Amount of thermal energy produced/provided by the new system	4,821 kWh
Saved primary energy in comparison with baseline situation	8,485 kWh
Energy recovery from waste/renewable sources	4,821 kWh *(energy production mix 70% waste heat, 30% biomass)*
GHG savings in comparison with the baseline situation	15%
GHG emissions related to the project	145 ton CO2e
Carbon footprint	1.4 ton C
Ecological footprint	0.31 ha

This section will be updated as soon as all the installed machines will be fully operated and monitored, enabling a more complete quantification of technology's impact in terms of performance indicators. Consolidated monitored data will be available by the end of 2015.

References

Persson T., Renström R., (2013) Fjärrvärmedrivna vitvaror (in Swedish) Fjärrsyn rapport 2013:21

CELSIUS contacts

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For further engagement on this subject you are welcome to turn to your CELSIUS city contact person or use the contact form for guidance to relevant workshops, site visits or the expert team.