District heating to ships in harbour in Gothenburg

This is an article about a CELSIUS Demonstrator.

The **district heating to ships in harbour** demonstrator is a CELSIUS demonstrator in Gothenburg. It demonstrates the district heating to ferries in harbour technology.

The Gothenburg city owned energy company Göteborg Energi runs the EU Smart Cities CELSIUS project through which the shipping company Stena Line has connected one of their regular ferries, Stena Danica, to the district heating system when at quay. The Göteborg Energi district heating system stretches for 1200 km and covers about 90% of the city's apartment blocks. 30% of the district heating origins from waste CHP plant Sävenäs. The ferry carries up to 2274 passengers and 480 passenger cars, and docks in Gothenburg Port two times per day.

The overall objective with the pilot or demonstrator project is to limit emissions: both regulated emissions such as SO2, particulate emissions and NOx, as well as CO2 and noise from ships when docked at quay in Gothenburg. Efforts targeting the main emission sources heating of buildings, power generation and road traffic have been successful. Emissions from ships at quay can be reduced if heating and power generation is switched from the ships marine gas oil (MGO) fueled engines to more sustainable energy sources. The option to connect ships to the power grid is available in Gothenburg Port. Though the need for heating and hot tap water on board remains. This pilot project shows the possibility to further reduce emissions from ships at quay in the central part of the city.

Stena Lines input was EUR 77 000 worth in working time, and the EU contribution for hard ware was EUR 52 000. The project was evaluated after the first full year of operation. The adaption of the ferry connection to district heating includes installation of a heat exchanger in a container on the quay, flexible pipes to the ferry's four heat exchangers. It was assumed that the demand for district heating would mainly occur during the cold season. However, the environmental advantages to heat the ship's main engines when at quay has led to a demand for district heating also during the summer. The ferry's consumption of district heating during 2015 was estimated to 800 MWh.

The pilot project is regarded as a successful project to improve environmental performance, even if it is not increasing profitability for the shipping company. From the Gothenburg city perspective the project is a good example to show the possibilities to improve the environment by reducing both global and local emissions through a wider system perspective, including several sectors. Reduced noise from ships at quay enables housing development in port areas. The expected reduction of CO2 emissions is estimated to more than 200 tons per year with district heating instead of marine gas oil for the ship generators and heaters at quay in Gothenburg.

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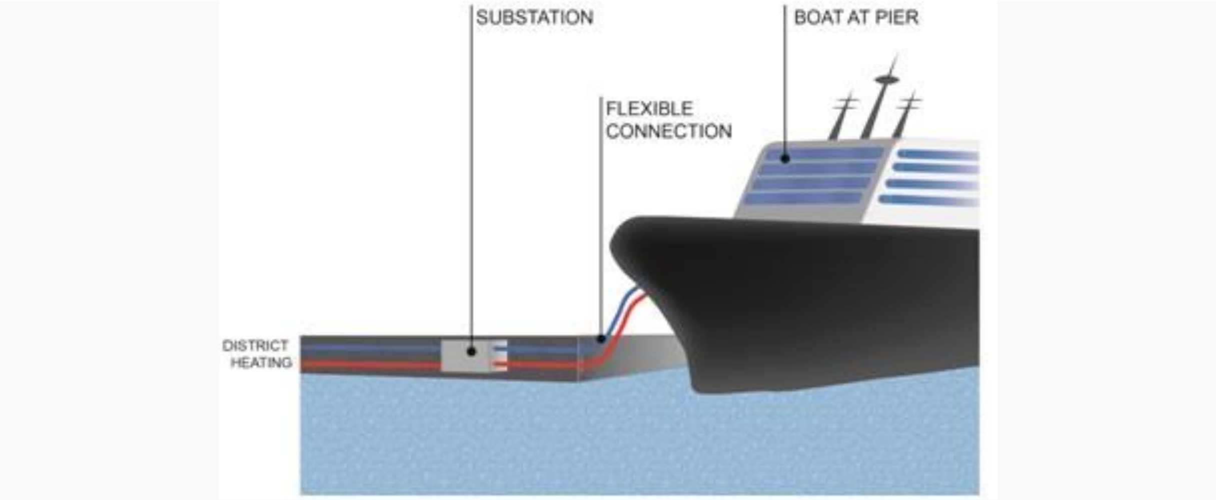
Traditionally, when a ship is at quay, electrical generators and heating equipments are needed to be run, usually consuming bunker oil. In Gothenburg there are already possibilities to connect ships at quay to the electrical grid while heating equipment on board, i.e. oil fired boilers, still need to be used. The technology demonstrated within this case study is to supply ships at quay in Gothenburg's harbour with heat distributed through the district heating network in order to avoid them using on-board oil fired boilers for heating purposes covering the heat demand related both to achieve thermal comfort and to preheat the ship engines. In particular the installations have interested the ship Stena Danica, a combined passenger and cargo ship (approx. 2300 passengers and 500 cars) that operates daily between Gothenburg and Fredrikshamn in Denmark, stopping at Gothenburg's quay 6 hours per night. This will result in reducing bunker oil consumptions consequently decreasing the emissions level and contributing to the improvement of air quality in the city. Numerically, quantifying replication potential is quite straightforward – multiply the number of hours per year a vessel spends in port (with a minimum of two hours per instance) with its fuel consumption and the share of actual heat production from that, applying seasonal climate corrections if necessary. Contrary to white goods however, passenger ships come in greatly varying sizes and have greatly varying schedules depending on the location, therefore providing indicative default figures is not possible. The ability to shut down the engines while at port however will eliminate bunker oil related to shipboard CO_2, SO_2, particulate matter and other emissions. These ships frequently moor in more densely inhabited areas of cities which means the environmental outcomes of this demonstrator are likely to be of interest to other cities.

In this demonstrator, Stena Danica ship is connected to the district heating network through:

- The adaptation of ship to receive district heating (connections, heat exchangers etc.);
- The installation and connection of a flexible connection at quay, for the supply of district heating hot water.



Impact[edit]

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[edit]

Replication Potential[edit]

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[edit]

- Ships at quay for stops long enough to allow the connection ship-district heating network (at least five hours are required)
- Ships equipped to be connected to DHN
- The amount of heat supplied to the ship is enough to allow the ship to switch off the on-board oil-fired boilers

The overall objective with this demonstrator is to limit emissions (both regulated emissions such as sulphur, particulates and nitrogen oxides, and carbon dioxide) from ships when they are at quay in Gothenburg. When virtually all other emission sources (heating of buildings, traffic, etc.) are decreasing their emission levels, ships at quay become one of the worst emission sources in town.

Traditionally, when a ship is at quay, it still needs to run electrical generators and heating equipment, normally consuming bunker oils. In Gothenburg there are already possibilities to connect ships at quay to the electrical grid, but heating equipment on board still need to be used. When applying district heating from town to heat the ship, no emitting machines on board ships would need to be used at quay. The ships will be connected to the district heating system through a mobile tube when they are at quay.

On the ferry steam is used for the heating system. The steam is produced by an oil furnace, and the heat from flue gases. Steam system is designed to 7 bar and 170 ° C. These heating systems have different power and temperature requirements.

On the ferry there are two hot water circuits for heating; "Pre-treatment" system and "Reheating" system. In the "Reheating" system air is heated to the desired temperature in the AC units. Two steam condensers are used in the current situation to heat the system.

Pretreatment "system is part of the air conditioning system that has as a main objective to cool the air and condense water out. In the winter, the heat is transported through the circuit used for heating the air. For this purpose one-used in the current situation exchanger heated by either steam from the boiler or hot water from the engine cooling.

To pressure drop and water velocities in the secondary network shall be held within the re-commanding limits required lines with DN125 from the DHC to the quayside. From the quay and on to the connection point in engine selected DN100

Stakeholders[edit]

Stakeholders	Organization Name	Organization Type	Organization Domain	Benefits from demo
District heating network operator	Goteborg Energi AB	Publicly owned	Utility	
Stena line AB	Stena Line AB	Private company	N/A	N/A

Finance[edit]

CO2 emissions in this project will be reduced by 172 tonnes or 63% per ship and year when the ship is in port. Bunker oil is replaced by district heating with the emission factor 101 g CO2/ kwh. As the ship’s engines will be turned off and kept warm by district heating, the environment around the harbour will improve and the sulphur emissions will decrease.

District heating to a ship in harbour will also affect the noise for those who live near the port, and this is a notable accomplishment for Stena. The project has furthermore proven to be a less expensive heating solution for Stena Line, and the return on investment is expected to be less than three years. The total investment cost is approximately E 390 000

Lessons learnt[edit]

Demonstrator development[edit]

What was learned from this project was to include the quay in the feasibility study. The quay where the ship is moored was not in the right condition for construction and needed renovation before the district heating installations could begin. Repairing the quay delayed the project for several months. The initial feasibility study included technical information, but there were gaps in the data to be able to deduce how much installed power the ship would need. To remedy this, extensive measuring on board the ship while at sea were made during the winter to determine the power load. The initial feasibility study concluded that 740 kW installed power was needed; power to the ship was approximately 2 MW. With the addition of pre-heating the ship’s motors to 70 degrees, the resulting requirement was 1,2 MW of power. In the event that Stena might move the ships to a new mooring location, Göteborg Energi and Stena needed to find a solution to be prepared for that. The heat exchangers and control equipment are placed in a container, so that if the mooring location for the ships will relocate, the installation can be moved to the new mooring location. This may also happen in other cities and could be something important to consider. In this project we have used some part of lessons learnt from a test project concerning heating streets. This project uses a special control system of temperature and flow, and this system was used on the ship.

Demonstrator performance monitoring[edit]

In December 2014 the “District heating to ships” demonstrator was started up and it is currently in operation. In January 2015, performance monitoring system was activated to measure the delivered heat enabling the estimations of performance indicators. Monthly heat delivered [kWh] to STENA ship is presented in figure below together with key performance indicators assessed against the baseline situation that is the same the same ship, using standard oil fired boilers for heating purposes at quay. Positive effects have been highlighted with regards to different dimensions (energy, economic, environmental and social) but the most important impact is related to citizens’ quality of life since demonstrator start up has drastically reduced GHG and acoustic emissions in the area next to the harbour.

Key performance indicator	Value
Oil use reduction	200 kg diesel/hour
Reduced CO2 emissions	400 t CO2/year
Payback	< 2 years

Gallery[edit]

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Walk around[edit]

Read more[edit]

Introduction to District Energy

- New applications of DHC

Recordings

- CELSIUS Workshop: District heating to ship

CELSIUS contacts[edit]

CELSIUS partners contributing to this article: Göteborg Energi, D'Appolonia

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.