Supermarket's Waste Heat Recovery for District Heating Networks

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Introduction

As society is moving towards a more sustainable and efficient energy consumption, the integration of energy systems, particularly losses of energy in multiple areas should be assessed since it would hugely save energy in the long term. Main potential heat sources to be connected to the district heating network is the vapor compression systems in supermarket (commercial refrigeration). Great amount of heat is rejected to the ambient from such systems which can be upgraded and recovered into the district heating network.

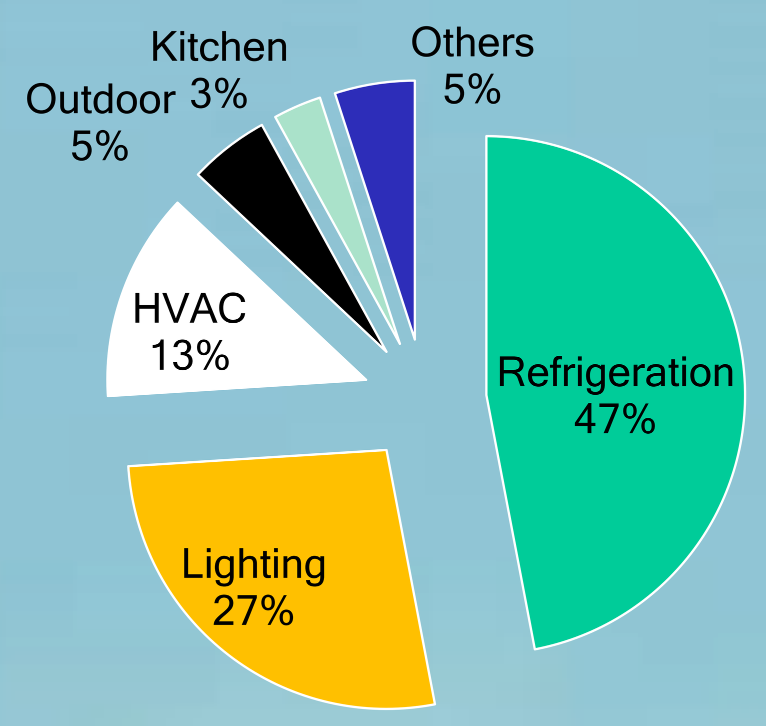


Figure 1 Energy Breakdown - Supermarket in Sweden (Arias, 2005)

There are about 3400 supermarkets in Sweden with an average total cooling demand of 150kW. This will provide an available heat recovery capacity of about 200 MWh/year for each supermarket - approximately equivalent to 1200 tons/ year of woodchips fuel at CHP plant.

Objective & Methodology

The development of scenarios are based on the different possible configurations which can be made from supermarket's vapor compression cycle. On top of that, two of most common supermarket's cooling load are also taken into consideration as both have influence towards the performance of the process. Once all technical input data has been simulated using EES ©, the next important step would be evaluating its economic analysis, which for the purposed of the study is based on the operating costs:

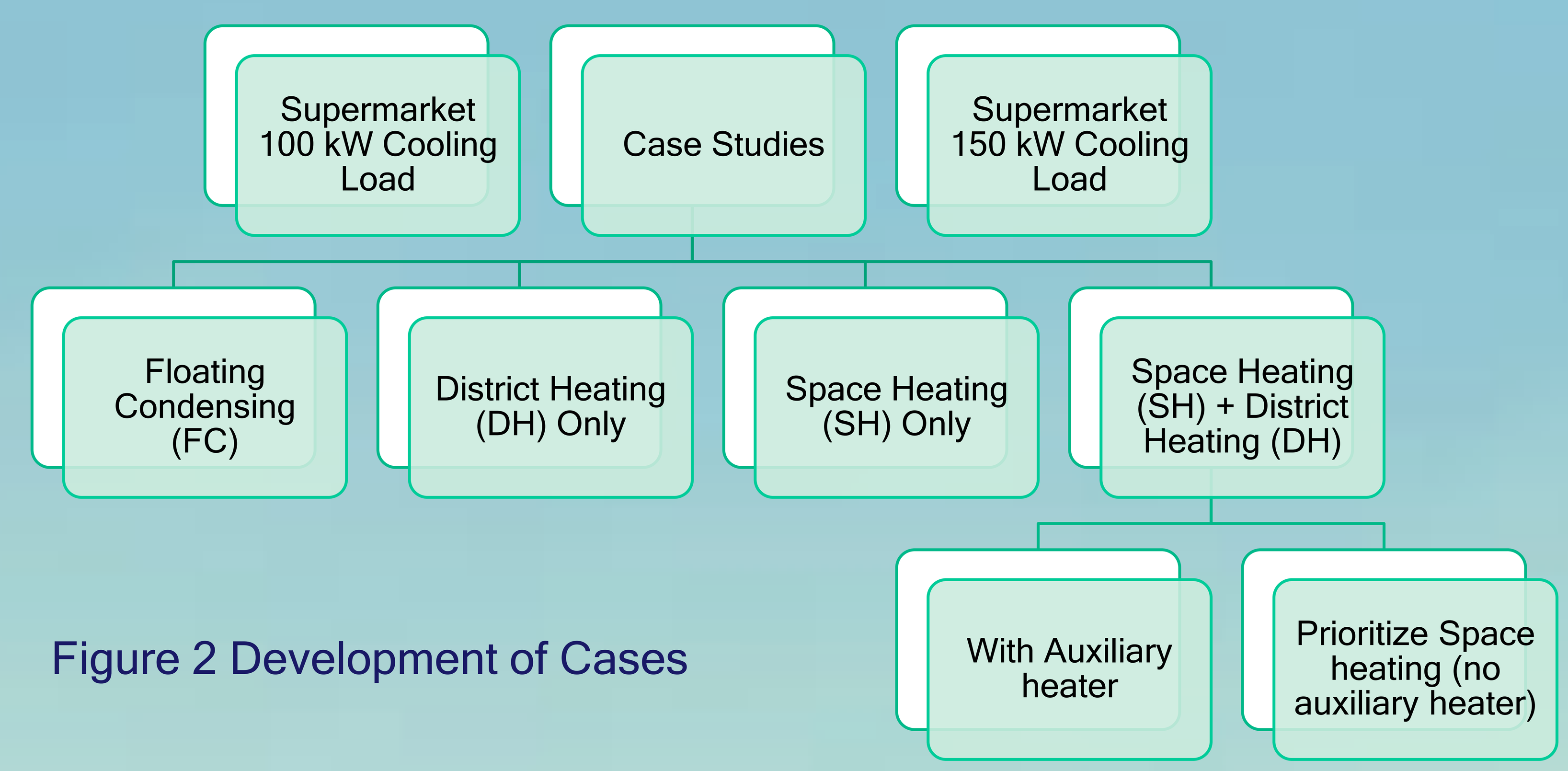


Figure 2 Development of Cases

Outcome

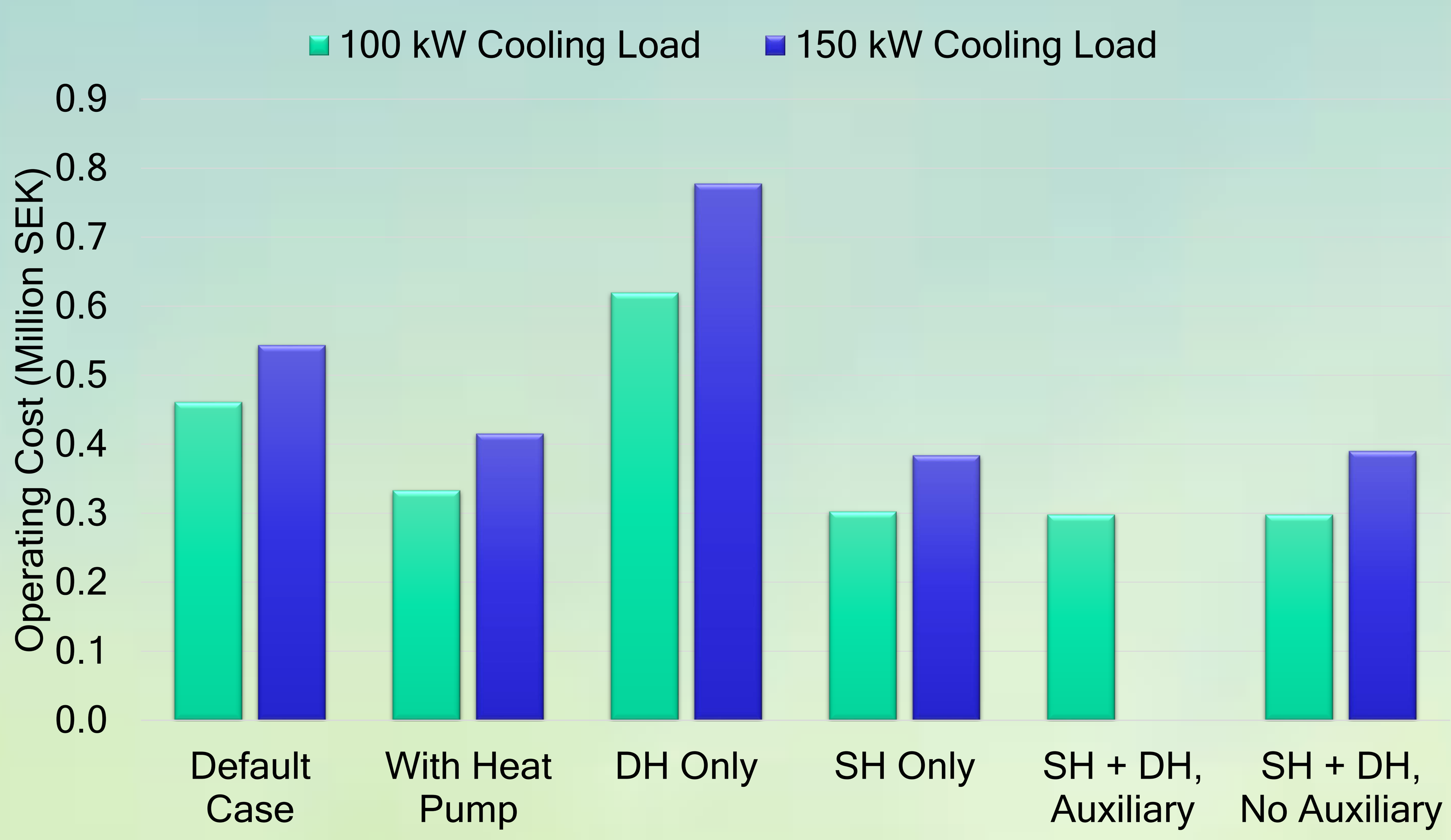


Figure 3 Operating Costs Comparison

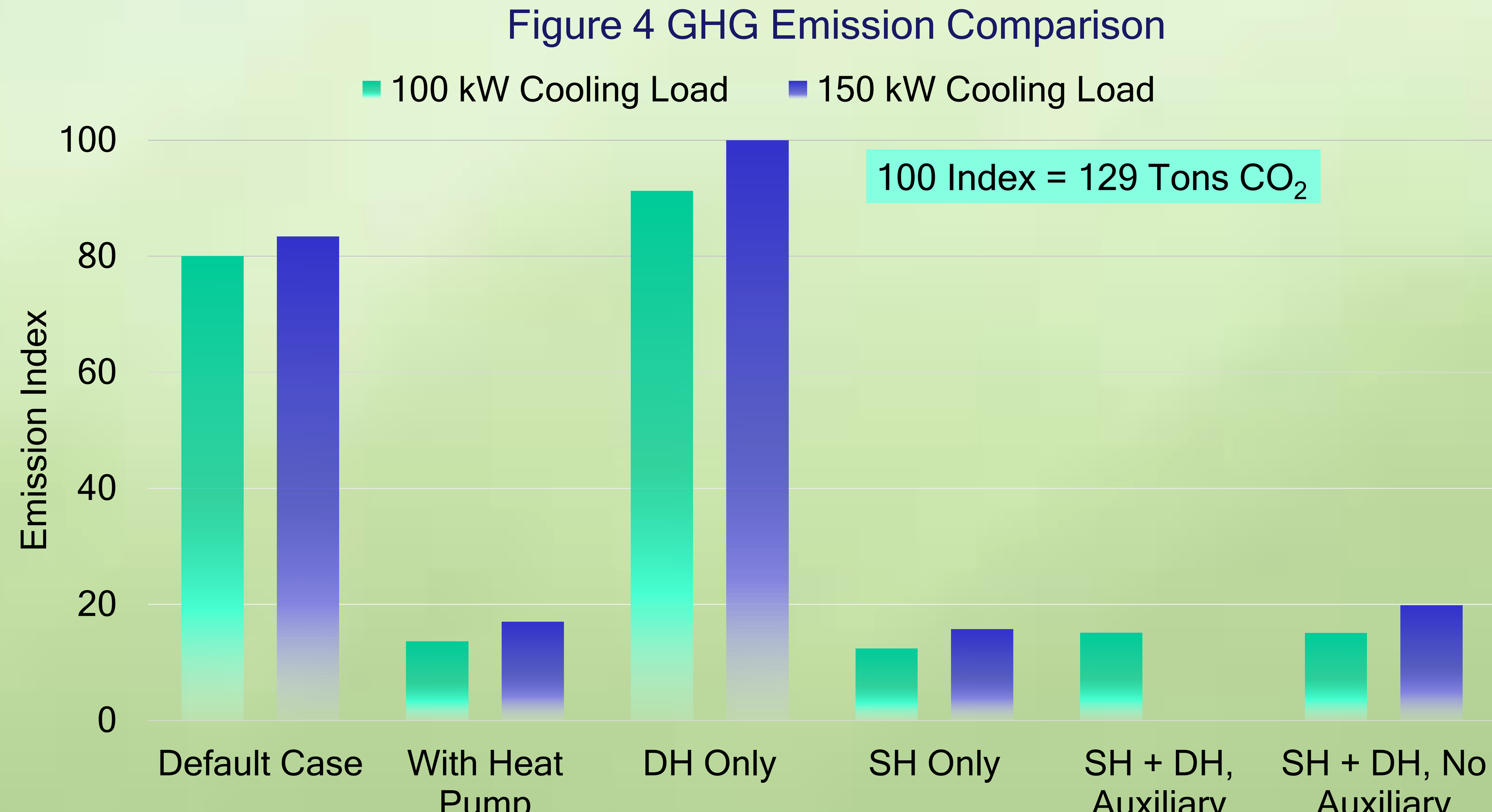
The utility costs (electricity, heat, etc.) are taken into consideration to determine fair analysis in each scenario. An additional case of operating the floating condensing (default case) without heat recovery strategy but instead with heat pump is also created to obtain rigorous results.

In both cases (100 kW and 150 kW cooling load), the incorporation of heat recovery process by adding heat exchangers have indicated decent amount of operating costs reduction as compared to the default case (floating condensing). Although the case with heat pump can save the costs for certain amount, yet SH and SH + DH cases have proven to outperform its end-results - additionally with extra revenue stream from selling excess heat to utility.

According to Figure 4, SH only scenario produces the least amount of CO_2 during its operation due to less amount of energy required to operate the system. Moreover, Sweden's national grid relies heavily from nuclear energy generation and hydropower (Intelligent Energy Europe, 2012) which results in relatively clean electricity grid in terms of CO_2 emission.

However, considering the demand flexibility and profit opportunity for the supermarket's operation, SH+DH case with no auxiliary also shows to be an attractive option since it emits far less amount of CO_2 as compared to the default case in both cooling load conditions (100 kW and 150 kW supermarket cooling load). Therefore, SH+DH case holds promising potential as the future refrigeration process.

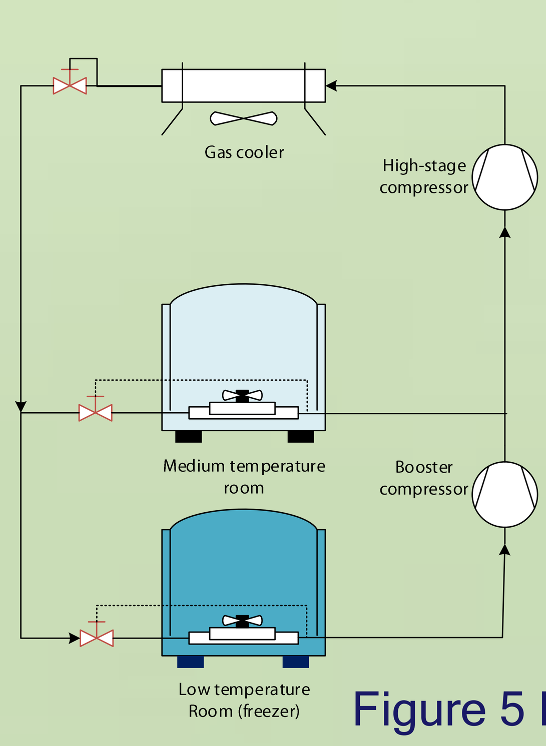
Figure 4 GHG Emission Comparison



Conclusion

From the study that has been conducted to investigate waste heat recovery potential in Swedish Supermarket, it can be concluded:

1. CO_2 (R-744) is a good candidate to replace conventional refrigerant for supermarket's application
2. SH + DH scenario without auxiliary heater is shown to be the preferable scenario with the most economical results
3. Implementing heat recovery in Supermarket has an implication to reduce CO_2 emission in the long-term.



Conventional CO_2 (left)

Proposed CO_2 (right)

Refrigeration system

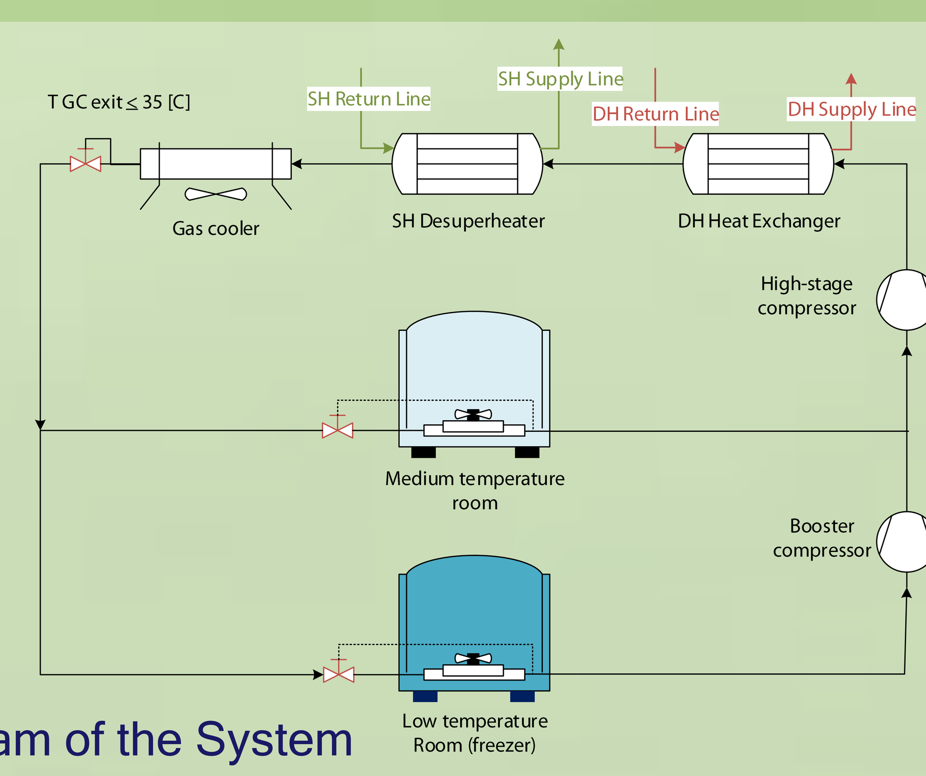


Figure 5 Process Flow Diagram of the System