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Practical experience of feasibility in some real industrial waste heat recycling utilizing heat pumps

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Abstract

This paper will bring out the feasibility of waste heat utilization in energy intensive industry by using heat pump. The paper will introduce real carry out cases where heat pumps are used to utilize waste heat produced in industrial processes. The technological principal and the feasibility are shown in cases the fish feed pellet drying and the data center heat utilization to district heating

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Keywords: waste Heat; heat re-use; waste heat utilization; heat pumps

1. Introduction

The recent development in heat pump technology combined with the souring energy prices has added significantly the feasibility of waste heat utilization in industrial processes. The technology of heat pumps has been evolved from cooling to heat production, and outlet side higher and higher te,peratures have been accomplished achieved. Even though crude oil price has dropped in the past two years the consumer prices of fossil fuels are still high. These factors have increased the use of heat pumps in energy production mainly in households but also in industrial use. But still a lot that can be done by re-using heat in industrial processes to add competitiveness of European industry.

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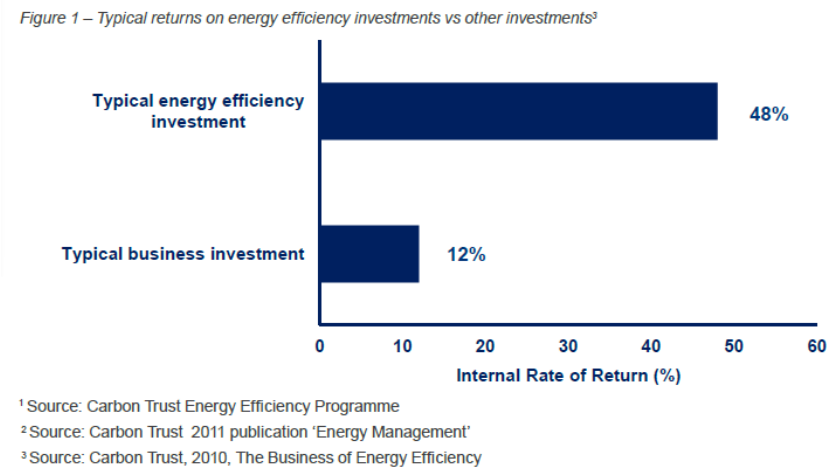

Figure 1. Typical returns of energy efficiency investments vs. other investments

Investment in heat re-use is an environmental act but is also a profitable way to add competitiveness. After the potential of a processes waste heat utilization have been measured and the amount of investment is known the only uncertain factor is technological performance of the system. The uncertainty of this factor can be minimized using robust and tested technology. Since heat recovery is mainly pipes, heat exchangers and heat pumps there is no big risk on this side. Energy saving is also a low risk investment because the production of waste heat and the utilization is completely on investors own control.

2. Case Data center's heat utilization

With the project of waste heat recovery and recycling to district heating networks Nivos Oy was able to move towards renewable energy.

The rising costs of natural gas made Nivos to search alternative ways to produce heat and add competitiveness in district heating. The Russian search engine company Yandex built a data center in Mäntsälä in 2014. Yandex data parlors generate heat amount of 200 stoves every second. Nivos Oy the local energy company in Mäntsälä saw and seized the opportunity of co-operation. Nivos wanted to reduce the costs and improve competitiveness in district heating and Yandex had the need to reduce the operational costs of the datacenter . Now Yandex sells the waste heat generated in the data center to Nivos Oy, which utilizes this excess energy in its district heating network. Waste heat utilization reduces the need for natural gas in the network by approximately 50 percent at the moment, and in the future, it may even replace natural gas completely. The heat recovery unit was designed and supplied by Calefa Oy.

The heat recovery unit produces approximately 20 GWh, about the half of the district heat required for central Mäntsälä. The unit has reduced the carbon dioxide emissions of the municipality by about 40 percent, and Nivos has been able to cut the price of district heating. Heat recovery also improves the energy efficiency of the data center significantly and reduces operational costs with the energy sold. On this scale, the unit is globally unique.

The heat recovery unit is based on Calefa Oy's CDH Combined data and heat consept. The unit utilizes the waste heat of the data center and recycles it into the district heating network. The temperature of the air exiting the data center is about 40 degrees Celsius and has been used to cool computers. With a heat pump, the heat recovered from the exhaust air is used to heat water to about 80 degrees Celsius, after which it can be used in the district heating network.

The total investment in the heat recovery system was 2.5 million euros. The COP of the system is 3,7. With current electricity prices this means that the price of the heat produced is 23 €/MWh. The cost comes from electricity purchased for the system to produce district heating temperature heat of 80°C. Because natural gas is replaced as a source of the energy the annual savings are 540 000 €. This results to a project payback time of 4,6 years and to a 22 % of return of investment.

With the project Nivos Oy as been awarded with the European Heat Pump Association's heat pump city of the year 2015 award. It also received the Finnish Climate act of the year 2016 award.

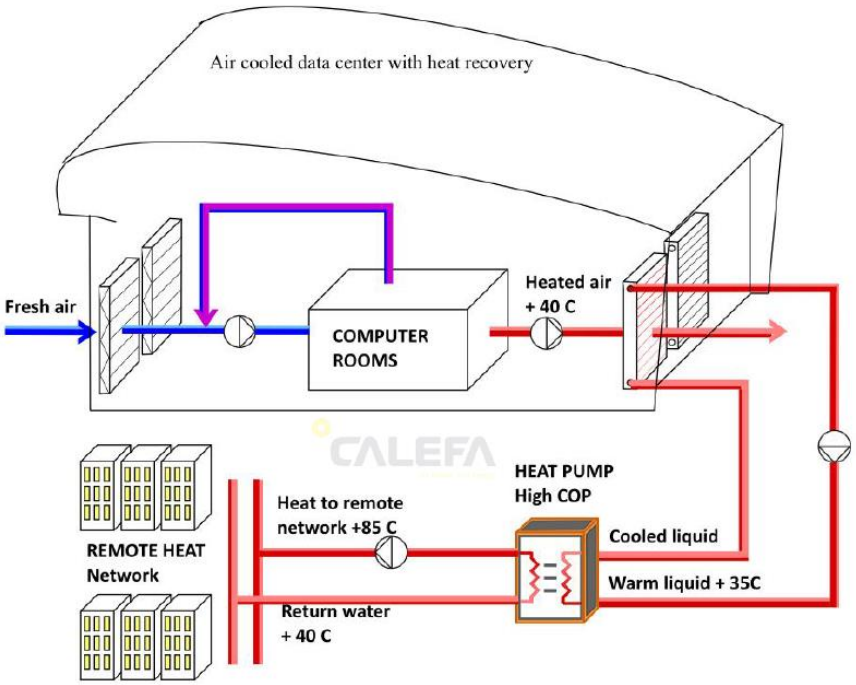

Figure 2. Data center heat recovery schema

Specifications:

- System power 3.6 MW
- Inlet temperatures: 35°C /18°C
- Outlet temperatures: 40°C /80°C
- COP 3,7 in design point
- Annual Energy 20 000 MWh
- Investment 2 500 000 €
- ROI 22%

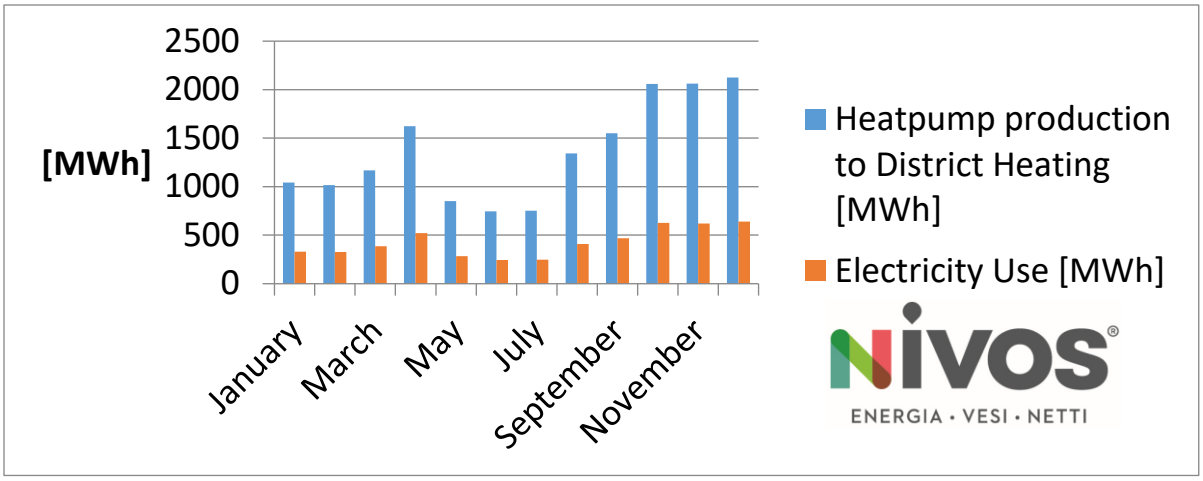

Figure 3. Heat Pump Production to District Heating network

3. Case Feed drying process

Raisio Agro is an agritrader company that produces feed. The Raisio Agro fish feed pellet factory produces fish feeding pellets. The Factory uses steam to dry the pellets before packing. Before the heat recovery renovation, the factory used 10 000 MWh of steam produced with fossil fuels. The heat recovery system was built with using heat pumps to empower it. Heat is recovered from the exhaust air with heat exchanger to water-glycol liquid. Heat pumps cool down the liquid and transfers heat into hot water with temperatures varying between 70 °C and 80 °C. This water is used for heating the incoming air to the drying process. In a nutshell the waste heat is circulated back to the process. The project was done to reduce Raisio Agro's cost on energy consumption.

The savings are generated from the savings in steam purchasing. With the heat utilization system, the steam purchasing costs has reduced with more than half and the return of investment is 40%.

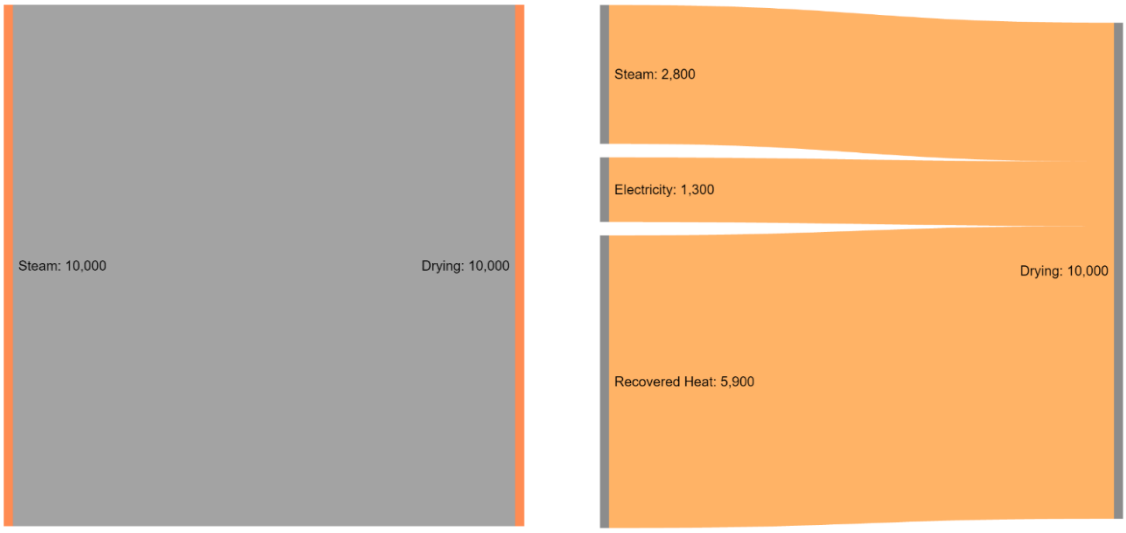

Figure 4. Fish feeding pellet drying energy use before and after

Specification:

- System power 1,500 MW
- Inlet temperatures: 8°C / 20°C
- Outlet temperatures: 67°C /82°C
- COP 3.7
- Annual Energy 10 000 MWh
- ROI 40%

4. Case Plastic manufacturer

Plastep is plastic manufacturing company that produces plastic components by using injection molding. After molding the hot plastic products have to be cooled down. The heat utilization system is built in two different cooling circuits through heat exchanger. The water cooling circuit's temperature is 23 °C outlet and 17 °C inlet. The water is cooled with heat pump utilizing the heat to the factory's heating network. The temperature of the outlet heat is 57 °C. The power of the heat pump is 90 kW. The project was done to reduce Plasteps's cost on energy consumption and to cut down the use of water.

Before the heat recovery system was built, the factory premises were heated with oil boiler, and the injection molding machine was cooled with tap water. After the implementation of the system, the factory was able to quit oil consumption, and cut water consumption with 80 %. The savings are generated from the heat and water and the investments payback time was three years and return of investment was 33 %

Figure 5.Plastep Heat pump system in operation

Specification:

- System power 90 kW
- Inlet temperatures: 23°C /17°C
- Outlet temperatures: 20°C /57°C
- COP 4
- Annual Energy 180 MWh
- Peak usage time 2000 h
- ROI 33%

5. Conclusion

Heat pumps as a technology provide a missing link between the low temperature waste heat source and the higher temperature utilization. With each megawatt hour purchased for an industrial process the same amount of waste heat is usually generated. This mindset opens the view for the potential of waste heat utilization. Following the heat pump technology constantly evolving and the outlet temperatures increasing, even more utilization applications can be implemented in the future. The return of investment in heat pumps is much better than an investment in any other productional system, and should fit in every company's investment portfolio.

Appendix 1 Case Plastep Design