

Utilizing excess heat: from possibility to realization on the basis of industrial symbiosis

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Introduction

One of the unintended “products” of intensive energy using production processes is excess heat, also called waste heat. Excess heat can for instance be found in the chemical, cement, iron and steel making, and the pulp and paper industry. The constantly growing demand for energy and resulting climate change effects are reinforcing interest in the application of excess heat, while increasing knowledge about industrial symbiosis makes facilitation easier. The growing costs of energy and the big loss of waste heat is the basis for the fact that recovering of waste heat is the most promising and cost effective option to reduce the world-wide amount of industrial energy consumption (International Energy Agency 2010). Waste recovery and reuse also provide financial savings, reduction of CO₂ and NO_x, and innovation by quality improvement of processes and products. Besides the single company’s internal improvement of excess heat recovery, the concept of industrial symbiosis provides a basis for waste heat exchange between companies as examples in the Netherlands and Sweden illustrate.

Examples of excess heat application in the Netherlands

The Industrial EcoSystem (INES) project in the Rotterdam harbour and industry area started in 1994 at initiative of the industry association Deltalinqs (Baas 2005). An inventory of the material and waste streams in the area showed that waste heat was an important topic for many respondents. There were companies that needed heat and companies that emitted heat in the industrial area. Waste heat was described as the heat that was not utilized in the industrial processes and emitted to the air or water. The total excess heat emissions in the Rotterdam harbour and industry area were estimated at more than 5,000 MW in the mid 1990s (2,200 MW in air emissions, 3,000 MW in water emissions). As this amount was equal to 35% of total Dutch electricity use, attention to the application of waste heat must be high. However, waste heat utilization was not a new idea: earlier attempts of application in a neighbouring city stranded in the late 1970s. The application of waste heat was not acceptable for the municipality board and they qualified it as the “dirty heat of the industry” so the issue subsequently lost attention and momentum.

In this context, renewed attention for waste heat in the INES project in the mid 1990s was not easy to realize. The first option was that the waste heat available should only be applied in the companies in the Rotterdam harbour and industry area. The geography of the industrial harbour and industry area – a rectangle of approximately 45 by 2 kilometres - did not provide an optimal structure for a pipeline loop for heat exchange. The costs would be € 112.7 million and the question of who should fund the infrastructure that was needed to distribute this renewed source

of energy within the industrial region remained unanswered, meaning that construction was not economically feasible for the industry. Also, a project with heat exchanges in 8 bilateral combinations of companies was economically not feasible. After that, the “Botlek loop” project started as an inventory of both the technical feasibility of waste heat exchange as well as the commitment of companies in 2004. The Botlek area is a geographical territory in the older part of the Rotterdam harbour and industry complex with about 20 chemical companies and refineries, with a mixture of companies that have excess heat and companies that are producing heat themselves. A pipeline loop with terminals in each company provides a closed system of warm water. The companies with leftover heat can supply it to the system and companies in need of heat can be supplied from the system. Figure 1 shows a drawing of the Botlek loop and the projection of the pipeline where the dotted line has to be constructed to connect preexisting pipelines.



Figure 1. The projected Botlek loop (source: Deltalinqs)

One of the biggest challenges for the Botlek loop project was not related to technical issues, but the coordination of the requirements/wishes and commitment of all potential companies. This has been a time-consuming process for building trust in the Botlek loop system and even now, the start of the Botlek loop will be in phases. A grid management organization started linking the excess heat of a waste incinerator with a chemical company that needs heat in 2012. The hope is that this realized link will challenge other companies in the Botlek area to connect in a growing network of excess heat and cooling exchange in the near future, and forms the basis of the business model.

Another example in the Netherlands is the model that is applied in the Eemshaven area in the province of Groningen. There is a unique link of a 4 kilometre pipeline between a waste incinerator and a chemical company in a two-way exchange: during the day the chemical company delivers electricity on the basis of waste heat to the waste incinerator and during the night this process reverses.

Examples of excess heat application in Sweden

Traditionally, several Swedish pulp and paper factories have been exploring cascade flow management and integrated diversification for efficient resource use (older semantics for industrial symbiosis). An inventory of the existing exchanges of material and energy in the Swedish forest industry illustrates that industrial symbiosis in the form of by-product exchange networks exist in the forest industry sector: more than a third of the investigated companies have some kind of material or energy exchange with adjacent entities (Wolf and Petersson 2007). The Swedish forest industry example of the Mönsterås network demonstrates an integrated industrial symbiosis application in business practices in Figure 2 (Wolf 2007), where excess heat from the pulp mill is delivered to a saw mill and pellet production plant, and to the district heating system of the municipality of Mönsterås.

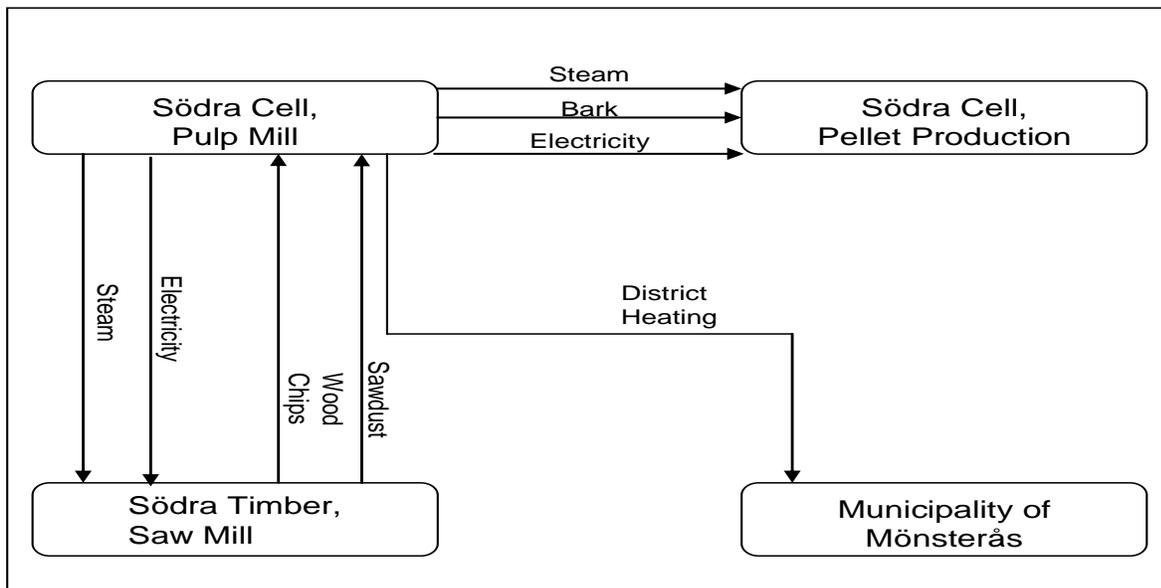


Figure 2. Mönsterås network (source: Wolf 2007)

The share of excess heat in district heating in Sweden is 6 to 7% (Klugman 2008, www.fvb.se 2010), and there is potential for increasing excess heat from industries to the district heating systems. Significantly, the use of industrial excess heat is beneficial for pulp mills and it does not necessarily conflict with process integration since higher temperatures are needed within the mills than for district heating (Jönsson et al. 2007). Another interesting example is the Södra Timber Kinda sawmill unit in Kisa and surplus heat of their boilers. This heat system is linked to the district heating system in Kisa, a town of approximately 4,000 inhabitants and waste heat is also delivered to the Swedish Tissue industry unit in Kisa. This example has overcome the

traditional barriers of industrial symbiosis application such as a lack of understanding between the companies and the perception that one is dependent on another company. Jönsson et al. (2007) also found that the necessary prerequisites for cooperation are social in terms of common goals and good communication to a larger degree than technical or economical. It is also necessary that the companies agree on profit and investment cost division.

The Swedish examples illustrate another phenomenon, namely connection to the regional economy. District heating systems are locally developed applying the waste-to-energy concept and in several cases the feedstock for the district heating power plant must be transported from other regions. This forms a growing basis for energy plants to orient themselves on industrial symbiosis links with companies that have excess heat.

Conclusion

The Swedish application of excess heat and its potential for extension shows that excess heat can be the source for 10% of the heat in the district heating systems. Given the industrial structure in the Netherlands, a similar potential is present. In Sweden, uncovering industrial symbiosis links provide examples for commercial applications in other regions. Energy companies with access to the grids are becoming interested in the distribution of excess heat. In the Netherlands, planned industrial symbiosis projects are needed to bring excess heat to the market. As a new infrastructure for the application has to be constructed in most cases, it is mainly bigger industrial areas and their surroundings that are suitable for such industrial symbiosis application.

References

- Baas L. 2005. *Cleaner Production and Industrial Ecology; Dynamic Aspects of the Introduction and Dissemination of New Concepts in Industrial Practice*. Eburon: Delft (NL)
- International Energy Agency. October 2010. *Industrial Excess Heat Recovery; Technologies & Applications*. Paris (F)
- Jönsson J, Ottosson M, Svensson L-I. 2007. *Excess heat from chemical pulp mills – a socio-technical analysis of internal and external potentials for application*. Arbetsnotat Nr 38, Energy Systems Programme, Linköping (S)
- Klugman, S. 2008. *Energy systems analysis of Swedish pulp and paper industries from a regional cooperation perspective – Case study modelling and optimization*. Gävle/Linköping (S)
- Wolf A. 2007. *Industrial Symbiosis in the Swedish Forest Industry*. Ph.D. thesis Linköping University: Linköping (S)
- Wolf A, Petersson K. 2007. Industrial symbiosis in the Swedish forest industry. *Progress in Industrial Ecology, An International Journal*. 4(5): 348-362