Industrial Process Heat: case study 4

Waste-to-Energy for the production of steam for paper production

Contribution of Task 36 to the intertask project on industrial heat

September 2020

Industrial Process Heat: case study 4

Waste-to-Energy for the production of steam for paper production

Henrik Bristav, RISE – Research Institutes of Sweden

Contribution of Task 36 to the intertask project on industrial heat

September 2020

ISBN 978-1-910154-83-0

Published by IEA Bioenergy

PREFACE

The role that bioenergy plays in the global energy mix has expanded over the last decades, from predominantly domestic space heating and industrial heat until the 1990's to increased use in the electricity sector and more recently also large scale production of transportation fuels. According to the IEA SDS scenario, the use of biomass to produce high temperature heat in industry will not decrease, but quadruple from 8 EJ today to about 24 EJ in 2060.

Traditionally, the application of bioenergy in industry was performed in industries that can use their own biomass process residues to cover (some of) their own heat demand, e.g. sugar, palm oil, wood processing, pulp and paper, etc. With the increasing motivation in industry to reduce CO_2 emissions, several other industry sectors are also shifting towards biomass based heat generation in cases where there are suitable biomass resources and technologies available nearby.

While there is a large potential to displace fossil fuels with biomass fuels in the large and energy intensive industries (steel, cement, etc), there are also many small and medium sized process industries such as food industries, paper industries, etc. In contrast to the larger energy intensive industries where these case typically require that large volumes of biomass are shipped to an individual site, the heat demand in these smaller industries can often be better matched with the biomass resources that may be locally available, resulting in smaller transporation distances.

This case study is part of a series of reports on the use of bioenergy in industry to supply process heat. In the framework of an intertask project, five of the tasks involved in the IEA Bioenergy Technology Collaboration Programme collaborated to produce four case studies and a policy synthesis report on biomass based industrial heat. The cases were selected carefully to illustrate that a wide diversity of bioenergy conversion technologies is readily available for market application, the optimum configuration depending on local availability of biomass resources, characteristics of the heat demand, availability of space, capital, etc. The cases are:

1. Combustion of wood chips and composting residues for process steam generation in a potato processing industry
2. Gasification of paper reject to displace natural gas usage in a pulp and paper process
3. Process steam in a dairy factory via fast pyrolysis bio-oil
4. Waste-to-Energy for production of steam for paper production

Early in 2021, a policy synthesis report will also be published that provides strategic information on market opportunities/potential and effective ways to address technical and non-technical barriers to implement bioenergy based process heat. The report builds upon the lessons learned in the cases, but also provides a more generic analysis of the market potential, and how its implementation can be supported, in order to unlock the enormous potential already mentioned above. All reports are available on the project website http://itp-hightemperatureheat.ieabioenergy.com/

SUMMARY

In order to reduce its dependence on oil and electric power, Nordic Paper decided to start their own energy production with municipal waste as fuel. The reason was mainly economic in a time with volatile energy prices around 2005–2008. For this reason, Åmotfors Energi was founded with the main purpose to provide the paper mill, owned by Nordic Paper, with steam. The steam is used in the drying of the wet paper as a last step of the process. After a thorough investigation and feasibility study the best alternative was to build a custom-made combined heat and power waste-to-energy plant.

The main reason for choosing waste as fuel was foremost economical. As a spin-off the plant also has capacity to deliver district heating to the nearby village of Åmotfors. The waste fuels are mainly municipal solid waste from nearby municipalities in Sweden and Norway. The carbon dioxide emissions are nearly the same as before the waste-to-energy plant was built with the difference that the paper mill minimized its dependence on fossil oil and electric power. Beside the steam delivered, about half of the power consumption is covered by the power production from the CHP-plant. Over 95 % of the fossil carbon dioxide emissions originate from the content of fossil plastics in the waste fuel. Even though there was some initial criticism about the new plant during the application process, it is now fully accepted by the society. One lesson learned is that sufficient data should be gathered about the energy needs of the paper mill to fully understand the specification of the delivery. Also, to dare to think outside the box and to dare to take calculated risks.

INDEX

BACKGROUND INFORMATION

Åmotfors Energi is a private owned company that owns and operates a waste to energy (WtE) plant in Åmotfors with the main purpose to provide the neighbouring paper industry with steam. It also provides the nearby village with district heating.

Previous situation

Åmotfors i a small village with about 1 400 inhabitants located in Sweden. Nordic Paper is a big paper producing company with factories in Bäckhammar, Säffle and Åmotfors in Sweden, as well as in Greåker in Norway. Nordic Paper holdings AB is owned by Shanying International. The products from Nordic Paper Åmotsfors is kraft paper used in technical applications such as steel interleaving paper in the steel industry and as insulation paper in power cables and transformers. The paper mill in Åmotfors was founded in 1896.

The paper making process is typically quite energy intensive. The last step in the production of paper is dewatering the wet paper. This is first done with pressing cylinders for mechanical dewatering. The next step of dewatering is thermal drying where the paper passes hot drying cylinders. The drying cylinders can be heated in different ways, in the case of Nordic Paper it is by using steam (6 bar, 180 °C). In 2005, a discussion started concerning the papermills dependence on oil and electric power for the production of steam for the process.

Soaring energy prices in combination with old oil burners with poor environmental performance made it clear that something had to be done and a switch of fuel was necessary. There was also an expectation of high prices on electrical power at the time. In 2010, the new WtE plant was commissioned. Other alternative fuels (incl. biomass) were considered but rejected in an early stage.

The main driver for switching to biomass-fuelled process heat

The high prices of oil and electric power forced the papermill to look for more economic energy solutions that could ensure that the industry could survive over time. In the evaluation of different energy production methods, waste to energy was considered as the most favourable alternative from the economic point of view. At that time, climate implications were considered, but this was not the main driver. According to the company there were no policy measures or financial incentive in place at that time that had any considerable influence on the decision to change fuel.

FUEL SOURCING AND LOGISTICS

The decision to use waste as fuel was, to a large extent, driven by the fuel prices at the time. Waste fuels in general have a negative price which means that the fuel itself becomes a revenue stream. This compensates for the high investment and operating costs (excluding the fuel cost) as can be expected from a waste to energy plant. When taking the investment decision, the pay-back period was estimated to be seven years. At the same time, there was also a demand for treatment capacity and a surplus of waste fuel in both the region and in Norway. The proximity to the Norwegian border (23 km) makes Norway a natural part of the uptake area. It was also important to secure waste deliveries for a long time to come with long term agreements (twenty years). The waste is delivered from nearby municipalities in Sweden (60 %) and from municipalities in Norway (40 %). It is estimated to be about 75–80 % household waste and the remaining is different kinds of commercial and industrial waste. The MSW are source separated where packages (metal, glass, plastic and paper) and paper (mainly newspapers and journals) are to be separately collected. In some cases, organic waste is also separated. Despite the legal demands regarding the source separation, the MSW still contain a significant amount of these materials. The commercial and industrial waste is also sorted as combustible waste at the source. The waste is not additionally processed in any way before its delivery to the waste to energy plant.

The municipalities and the commercial and industrial business deliver the waste to the plant. There on-site storage capacity is limited to the fuel bunker. The bunker holds 1600 tonnes which is equivalent to 7 days full production. Outdoor waste storage on the site is not allowed. Therefore, the production depends on well planned logistics.

Figure 1. Unloading waste fuel from Norway into the fuel bunker.

TECHNICAL IMPLEMENTATION

The plant has permission to receive and incinerate 80 000 tons of waste (both municipal and commercial and industrial) annually. The WtE plant has an inclined moving grate burner designed for unprocessed solid waste fuels. Early in the project, it was decided to avoid having to pre-treat waste before incineration. The plant was delivered by the Belgian company, Keppel Seghers. The total thermal output is 23 MW and the steam data is 40 bar and 380ºC. In order to fulfil the paper mill requirements, pressure and temperature is reduced to 6 bar and 180ºC in custom-made two-part turbine with a high-pressure section and a low-pressure section connected to a generator which produces electricity (3 MW). The high-pressure steam is first passing the first section of the turbine reducing pressure and temperature to the paper mills requirements and the surplus steam that the papermill don't need is passing the low-pressure part of the turbine. Total annual production is 173 GWh heat (steam and district heating) and 20 GWh electric power.

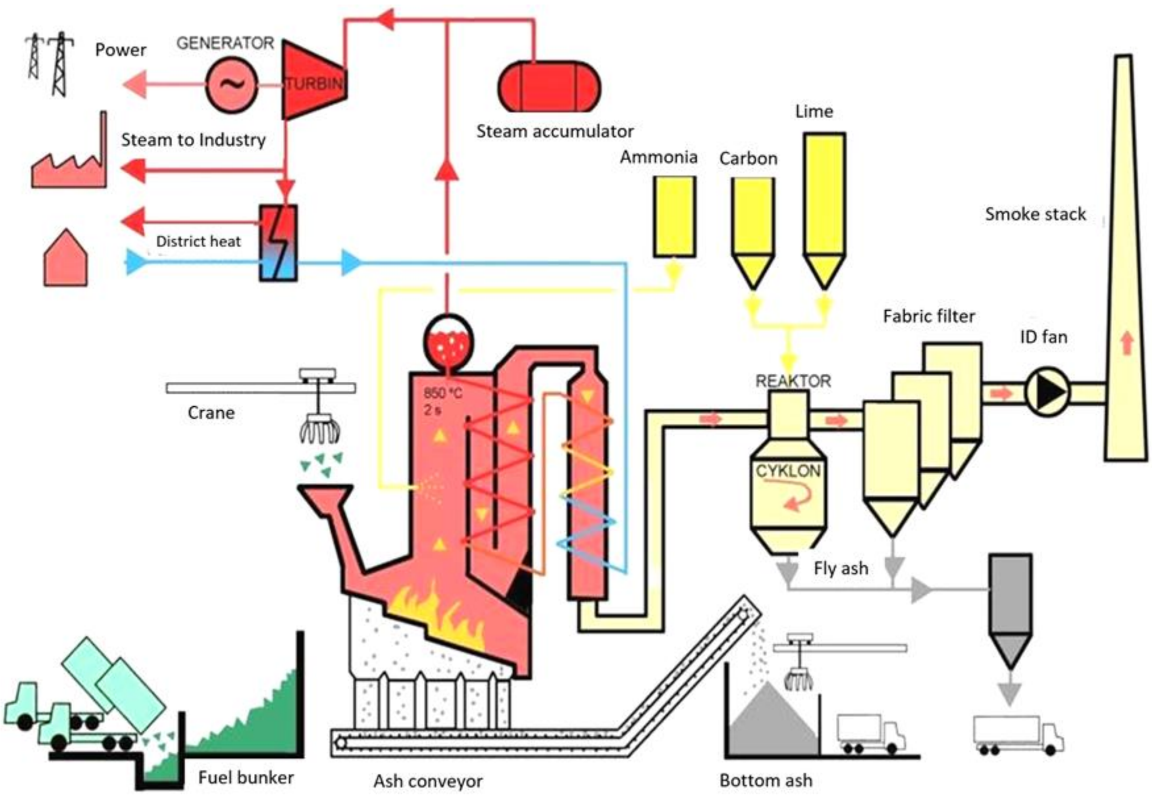

Figure 2. Principle layout of Åmortfors waste-to-energy plant. (Source: Åmotfors Energi)

Approximately 5 % of the total production is delivered as district heating to the Åtmotfors village by the municipal energy company Eda Energi and the remaining 95 % is used by the paper mill. There are also backup burners in the WtE boiler for start-up and stop. In addition, there is also a oil-fired backup boiler capable of producing 17 MW of steam. For four weeks in the summer, both the paper mill and WtE plant have planned shutdowns for annual maintenance. There is also one week of planned shutdown of the WtE plant in the wintertime for short maintenance and cleaning of the boiler. During that time the steam are produced by the oil boiler. There is also an electric boiler at the papermill that is used as redundancy.

ECONOMICAL ASPECTS

The total investment was about 500 MSEK. About 10 % of these costs relate to project management, construction planning, permission application and application process. A waste-to-energy plant is more expensive to build than a conventional biomass boiler because waste fuels give rise to greater wear on the boiler which causes higher requirements on the boiler material's durability. The wear from the chemical composition of the waste fuel and the fact that waste fuel presents a very heterogenous composition also renders higher maintenance and operational costs. In addition, there is also a need for a more advanced flue gas cleaning then what is generally used on other types of fuel (Figure 3 shows the flue gas cleaning in Åmotfors), which also affect both investment cost and operational costs. On the other hand, this kind of plants get revenue from waste treatment fees and energy sales. At the time (2005-2008), the gate fee for waste treatment was about 800 SEK/tons.

Figure 3. Flue gas treatment at Åmotfors waste-to-energy plant.

During recent years the gate fee in Sweden for incineration have been around 500 SEK/tons (Swedish Waste Management Association, 2019). High investment, operation costs, together with expectations of high revenue from waste treatment and high future energy prices made a very compelling case for investment. The result was slightly different due to lower energy prices than expected and increased competition on the waste fuel market resulting in decreasing gate-fees. The diminished dependence on prices on the energy market has made the company and the paper mill more financially resilient. During 2018 the company made a profit of 10 MSEK.

ENVIRONMENTAL ASPECTS

Locally, the situation improved due to the decommission of old oil-fired burners with less emissions of dust, VOC and other pollutants. Besides the oil-fired boiler, the paper mill also had electric boilers for steam production. With the commission of the WtE-plant, the use of electric power for steam production dropped significantly. The emissions of fossil carbon dioxide and emissions of NOx is about the same as before. Carbon dioxide emissions from waste incineration are calculated using a template provided by the Swedish Environmental Protection Agency for the declaration to the EU Emission Trading System (ETS) (EPA, 2019). Plastics account for 97 % of the fossil parts of the carbon dioxide. In typical Swedish Waste to Energy the biogenic part of the total carbon dioxide emission is about 60–62% (mixed waste) (Nordberg, 2020). On average, about 3 % of the carbon dioxide emissions come from the use of auxiliary oil burners and backup boilers.

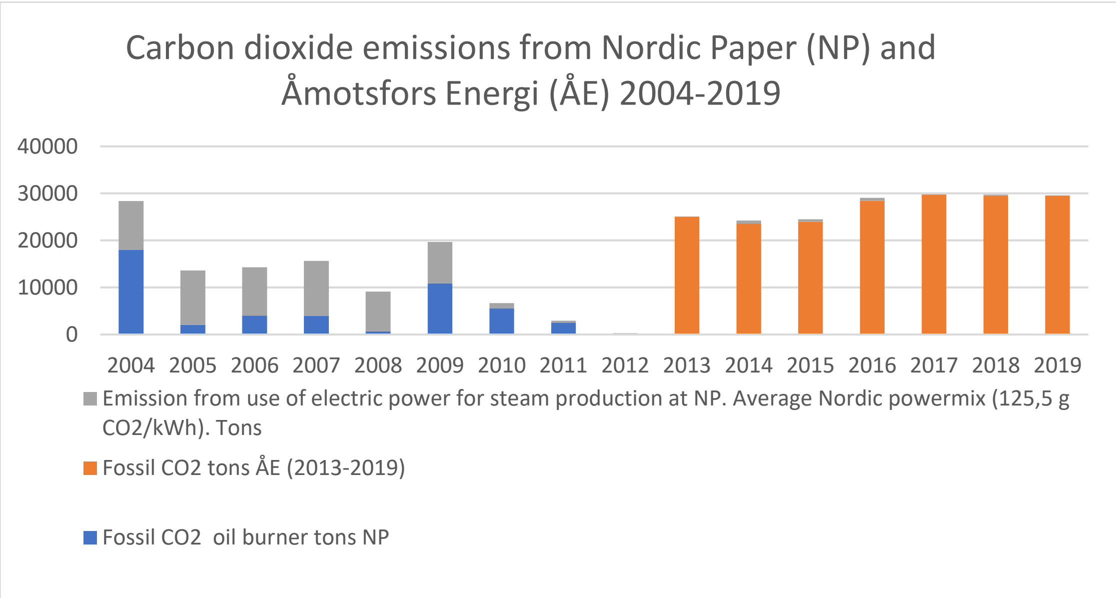

Figure 4. Emissions of fossil carbon dioxides. Data from Nordic Paper and Åmotfors Energi. Emissions from Average Nordic powermix (Martinsson, Gode, Arnell, & Höglund, 2012).

The expansion of district heating in the village resulted in decommission of several smaller boilers which improve local air quality and decreased carbon dioxide emissions. This should be considered when comparing the emissions before and after the commission of the WtE plant and is not included in the diagram below.

The flue gas treatment does not generate any wastewater. The small amount of water that's involved in the process is used for quenching the bottom ash and is eventually consumed (evaporated or bound to the bottom ash).

The solid residues consist of bottom and fly ash. The bottom ashes are utilized as construction material on a landfill and is exempted from landfill tax. The fly ash from the flue gas treatment is transported to Langøya in Norway, where it is used to neutralize acidic waste from other industries.

Figure 5. Pipe bridge for steam delivery to the paper mill.

ORGANISATIONAL ASPECTS

A new company was formed for the energy production (i.e. Åmotfors Energi). Today the staff consists of twenty employees: twelve shift personnel and eight administrative and operating personnel. The plant has some synergies with the papermill regarding maintenance.

PROJECT FINANCING

The company is owned by Nordic Paper, Kåpan Pensioner, Östersjöstiftelsen, Synskadades riksförbund, and Gålöstiftelsen. The four latter are foundations that invest in different enterprises as a part of their financial portfolio and have no specific interest in energy production in general.

The project was financed mainly by bank loan and capital from the owners.

SOCIAL AND MARKETING ASPECTS

A mandatory part of the application process for the permission to build and commission a waste to energy plant is to have a public consultation with the people living in the village, neighbouring property owners, NGO:s with a special orientation at environmental issues and local authorities.

There were some concerns about smell and rats due to the handling of household waste. There were few but loud critics and the first environmental ruling was appealed to the next instance but was overruled. The County Administration of Värmland was in favour of the project. No specific response was received from NGOs.

The shift from oil to waste as fuel has not been used for marketing purpose. There is an ongoing debate about the role of waste incineration in a circular economy since some actors consider that was incineration does not encourage reuse and recycling.

Neither Åmotfors Energi nor Nordic Paper have chosen to engage in this discussion. However, there is a high degree of acceptance from the community which is largely dependent on the papermill as a big employer. The community realized that something must be done to ensure the survival of the papermill. After ten years in commission there are very few complaints from the neighbouring village. Åmotfors Energi keeps an open approach towards the surrounding society and receive several study-visits each year.

LESSON LEARNED/RECOMMENDATIONS

Dare to take risk:
This case study proves that daring to take risks (economic, technical, reputational, social) can lead to sustainable industrial solutions. In order to achieve the goal, experts need to be part of the planning committee as well as local representatives.

Identify the industry's needs:
What is the specification on our delivery? The interface between energy production and the industry must be fully understood. When the project started, there was very limited information about the energy situation at the papermill. Very few measurements existed about energy flows, steam requirements and other relevant data. The lack of data was an unanticipated hurdle. This is an important lesson that an energy analysis should be done initially. Even if that analysis initially is an extra cost, that cost will soon be payed back through a more optimal design of the energy process.

Risk with change of ownership:
If the papermill is acquired by a new owner, the business case could change rapidly. This should be considered early in the project.

Emission of carbon dioxide from waste incineration:
Plastic in the waste made from petroleum results in a net contribution of carbon dioxide to the atmosphere when burned. The fossil content in the waste is a problem that is best addressed upstream already in the design of plastic products which makes recycling more efficient and better sorting in the households.

REFERENCES

EPA, S. (den 25 November 2019). *Bilaga 1 till beslutsprotokoll med diarienummer NV-08322-19.* Hämtat från www.narurvardsverket.se: http://www.naturvardsverket.se/upload/stod-i-miljoarbetet/vagledning/avfall/bilaga-1-hanvisningsvarden.pdf

Martinsson, F., Gode, J., Arnell, J., & Höglund, J. (2012). *Emissionsfaktor för nordisk elproduktionsmix. PM för Energimyndigheten.* IVL Svenska Miljösintitutet.

Nordberg, M. (June 2020). Environmetal engineer, Umeå Energi AB. *Personal communication*.

Swedish Waste Management Association. (2019). *Svensk Avfallshantering 2018.* Avfall Sverige.

ACKNOWLEDGEMENTS

Thanks is expressed to Anna Laggren, Environmental and Quality Controller, Åmotfors Energi and Tarjei Svensen, Environmental Engineer, Nordic Paper for kindly sharing information.

Further Information

IEA Bioenergy Website
www.ieabioenergy.com

Contact us:
www.ieabioenergy.com/contact-us/