IEA Bioenergy
Technology Collaboration Programme

Industrial Process Heat: case study 5

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Contribution of Task 32 to the intertask project on industrial heat

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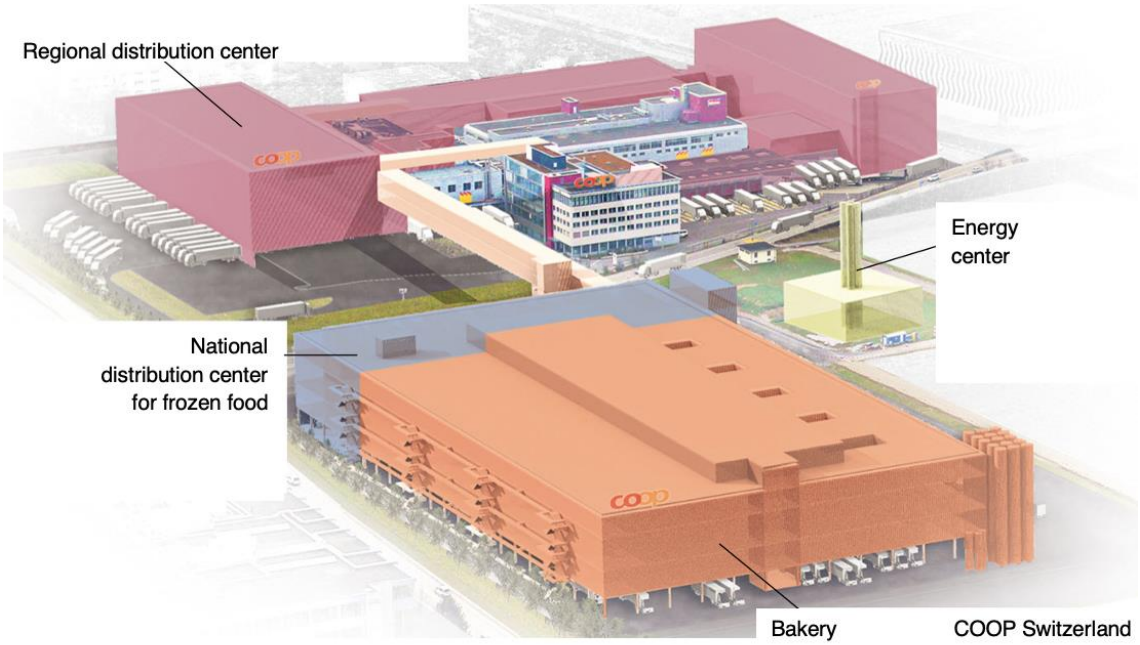

Industrial Process Heat: case study 5

Combustion of wood chips and grain residues for process heat supply in the largest bakery in Switzerland

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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 cases 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 transportation 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 Program collaborated to produce five 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
5. Combustion of wood chips and grain residues for process heat supply in the largest bakery in Switzerland.

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 following project website:

http://itp-hightemperatureheat.ieabioenergy.com/ d

Summary

The Coop Group is Switzerland's largest retail and Europe's second largest wholesale company with a workforce of around 85 000 in total and 54 000 in Switzerland. In 2015, Coop built a new production and distribution center in Schafisheim in the Swiss midlands with a total investment of more than Euro 500 million and 1 900 employees on the site. The existing buildings were extended by a new building measuring 185 x 100 m in size and 58 m in height, of which roughly 50 % is below ground level in a former gravel pit. The building complex incorporates a high-bay freezer warehouse and Switzerland's largest bakery and confectioner with an annual production of 60 000 tons of baked goods.

Coop is committed to sustainability. By merging production and logistics to one single site and implementing modern technologies, significant savings in energy consumption and road transport were achieved. To additionally substitute fossil fuels, an energy production based on a biomass combustion plant was realized to provide process heat for the bakery by thermal oil. Since the production of the raw materials for the bakery causes residues in the up-stream milling process, the vision to use milling residues as energy for the bakery arose. The potential and technical opportunities were evaluated and a concept of co-firing wood chips and grain residues developed. Swissmill, the largest mill of Switzerland located in Zurich and owned by Coop, was involved to provide fractions of grain residues, which are of low value for other purposes. To ascertain a flexible operation of the bakery, the decision was taken to implement a concept which enables a variable energy production by 50 % wood chips and 50 % grain residues with the opportunity to switch to 100 % wood chips. Consequently, a combustion system was designed, that enables the use of forestry wood chips from a respective silo with addition of pellets from grain residues from a separate storage compartment. The thermal oil boiler and the flue gas cleaning were adopted to comply with the challenges of increased slagging and fouling and with increased NO_X emissions due to the high ash and nitrogen content of grain residues. To cover the rapid load changes of the bakery process, a gas fired peak boiler complements the heat production.

Content

Background and role of bioenergy in Switzerland

In Switzerland, the confederation and the cantons support efficiency measures and the substitution of fossil fuels by renewables based on a national vote on an “Energy Article” back in 1990 and a consecutive national vote on the “Energy Strategy 2050” in 2017. Consequently, the implementation of automated biomass combustion plants often combined with district heating has been supported and enables a significant increase of wood energy in the building sector. However, the potential of sustainable energy wood available in Switzerland is limited to approximately 7.5 % of the today’s energy demand. In addition, two third of the potential is already exhausted and consequently the remaining unused potential is scarce. Since modern buildings are energy efficient and can be supplied with low temperature heat, heat pumps can be efficiently used for residential heat and potentially driven with renewable electricity. On the other hand, biomass is the most promising renewable energy to provide process heat at temperatures above 100°C and even above 200 °C with high thermodynamic value. Therefor the Swiss Federal Office of Energy (SFOE) supports innovative applications of biomass for process heat and consequently supported the present plant in the framework of a pilot and demonstration (P+D) project.

Motivation for a large bakery and its energy supply by biomass

The motivation for the large bakery and its integration in a distribution center located in the Swiss midlands was to improve the overall efficiency of the food production and distribution of the Coop group. To comply with the sustainability targets, the biomass plant was designed to substitute fossil fuels to reduce the CO_2 emissions of the bakery process. A special characteristic of the plant is the combined use of forestry wood chips and grain residue pellets. For this purpose, individual storage systems were installed and a continuous mixing of the fuel prior to feeding the boiler was developed (Nussbaumer et al. 2019).

Material flow and energy balance

The decision for a CO_2 neutral biomass combustion plant was driven by sustainability criteria. The additional implementation of grain residue pellets was driven by the vision to use residues from the raw material for the production of the good and therefor close the material cycle. Figure 1 illustrates the material flow and the energy balance from the initial processing of cereal to the production of bakery goods illustrated by the example of 1 kg of bread.

An evaluation of the whole production chain for the example of bread reveals that 30 % of the grain residues accumulated during the milling process would be sufficient to cover the heat production for the bakery, if the efficient energy conversion and bakery technologies as realized in the new plant in Schafisheim are applied. The Coop plant, however, is operated with 50 % to 100 % wood chips ensuring a high flexibility.

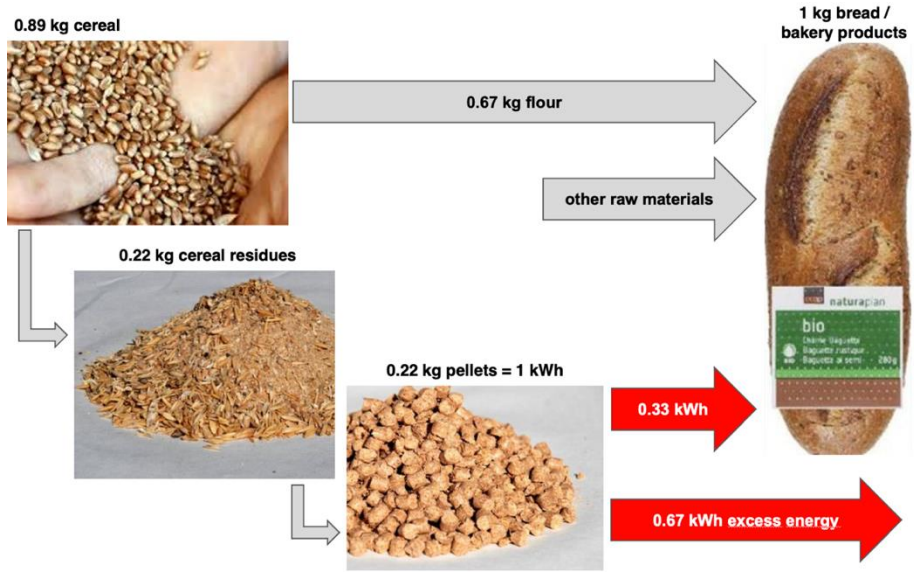

Figure 1. Material flow and energy balance of production of bread from cereal with use of cereal residues to supply the process heat for the production of bread in the bakery [Weinhofer et al. 2016].

Technology

On the building complex in Schafisheim shown in Figure 2, a separate building for the process heat production was erected described as “energy center” consisting of a silo for forestry wood chips and a separate compartment of dry milling residues delivered as pellets.

On the final stage of the feeding system, grain residue pellets are continuously added to the wood chips. The mixture of wood chips and grain pellets are converted in a moving grate boiler (figure 3) and the heat is extracted to generate up to 2.5 MW thermal oil at approximately 285 °C utilized for the bakery process. In addition, up to 400 kW hot water at 145 °C is generated to provide other consumers on the site.

To comply with the emission limits, the boiler is equipped with an electrostatic precipitator for particle removal and a selective non-catalytic reduction (SNCR) for NO_X abatement (Figure 4).

The total investment cost for the Schafisheim logistic and production center finalized in 2015 refers to approximately 600 Mio. CHF (535 Mio. Euro in 2018). As part of this site, the heat production plant caused an investment of 10 Mio. CHF (9 Mio. Euro), of which 45 % are for by the building and 55 % for the technical infrastructure. The additional infrastructure to enable a co-firing of grain residue pellets accounts for approximately 1 Mio. CHF (0.9 Mio. Euro). The biomass plant enables CO_2 savings of 4 000 tons per year.

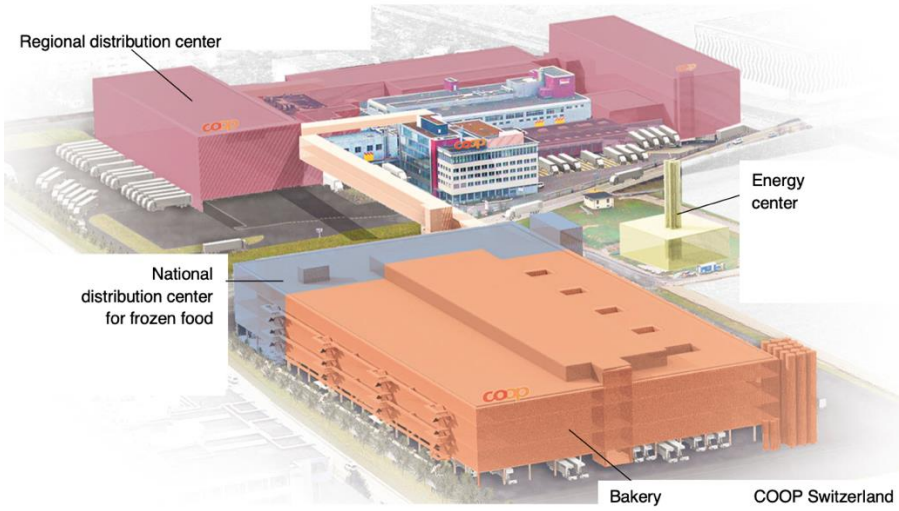

Figure 2. Overview of the Coop production and distribution center [Weinhofer et al. 2016].

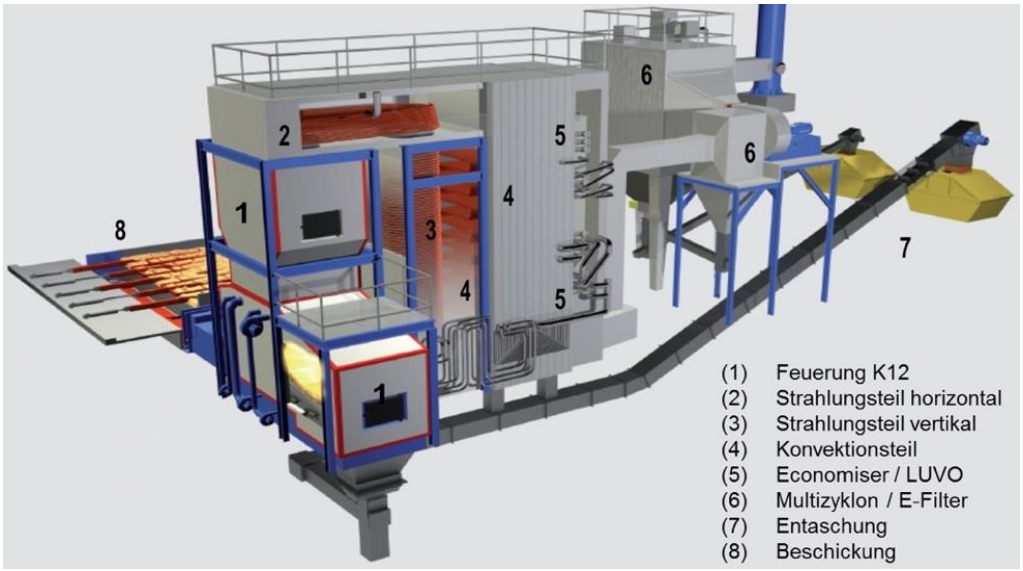

Figure 3. Biomass boiler (KCO Cogeneration and Bioenergie GmbH in [Weinhofer et al. 2016]).

Figure 4. Boiler (KCO Kohlbach) with SNCR (ERC) (left) and electrostatic precipitator (Scheuch) (right).

Lessons learned

In the conceptual phase, a market evaluation in Europe was performed to identify industrial suppliers for a biomass combustion plant with the challenge to use high ash biomass for thermal oil production enabling the use of forestry wood chips and a mixture of wood chips with dry grain residue pellets. For this purpose, combustion tests on test plants of several suppliers which are active in industrial applications were performed and the principal feasibility was proven in test runs of several days. The experiences in practice now reveal, that the challenges were underestimated. Consequently, the availability of the initial installation did not meet the requirements, which shows, that the variability of biomass fuels is still a remaining challenge for the plant suppliers.

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Further Information

IEA Bioenergy Website
www.ieabioenergy.com

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