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BENEFITS OF MCHP XRGI USE IN THE BREWING INDUSTRY

5.1 INTRODUCTION

Energy management determines capabilities of development of enterprises to a great extent. It differs depending on the profile of activity, access to various energy carriers and the enterprises' energy policy. Electricity and heat are basic kinds of energy used in production facilities. Their generation is mainly based on processing chemical energy of fuel in thermal processes. Introduction and wide-scale use of solutions reducing operational costs as well as emissions of pollutants into the natural environment is therefore important [1].

Cogeneration, or combined heat and power (CHP) is conversion of energy carriers into heat, cooling, electricity or mechanical energy in a system or group of machines. It can be conducted on big scale in thermal power plants, as well as on a much smaller scale with micro co-generators. According to the Polish Energy Act, micro co-generation is production in one device of up to 40 kW of electric power and up to 70 kW of thermal energy. MCHP – Micro Co-Generation of Heat and Power – is the abbreviation commonly used for micro co-generators. Of distinction among the known micro co-generation technologies is the MCHP XRGI (XRGI as exergy), which provides higher efficiency than traditional MCHP systems. The complex solution in question, the MCHP XRGI system, consists of an electricity generator powered by a gas engine, and an integrated intelligent heat distributor [5].

Among the various industrial branches of modern economy, food industry is one, where heat and electricity form a major part of production costs. Brewing is in turn one type of food production, which requires relatively considerable input of electricity and heat. The side-effect of electricity generation are emissions of CO_2, CO, NO_x, SO_2 and other gases originating from both the local energy sources at the brewery (most commonly a gas fueled boiler) as well as from its sources of power (power plants) [6]. This paper shows the applicability of the micro-cogeneration in breweries of different production volumes.

5.2 THE BREWING PROCESS

Operations of the brewery are typically consisting of seven steps: mashing, lautering, boiling, fermenting, conditioning, filtering, and filling. The brewing process consist of three major processing stages, namely the brewhouse (black), storage & fermentation

(grey), and bottling (white). The processing steps within these stages require energy, in the form of electricity, heat or cooling [2]. Detailed processes vary but essential flows of materials and energy are shown on Fig. 5.1.

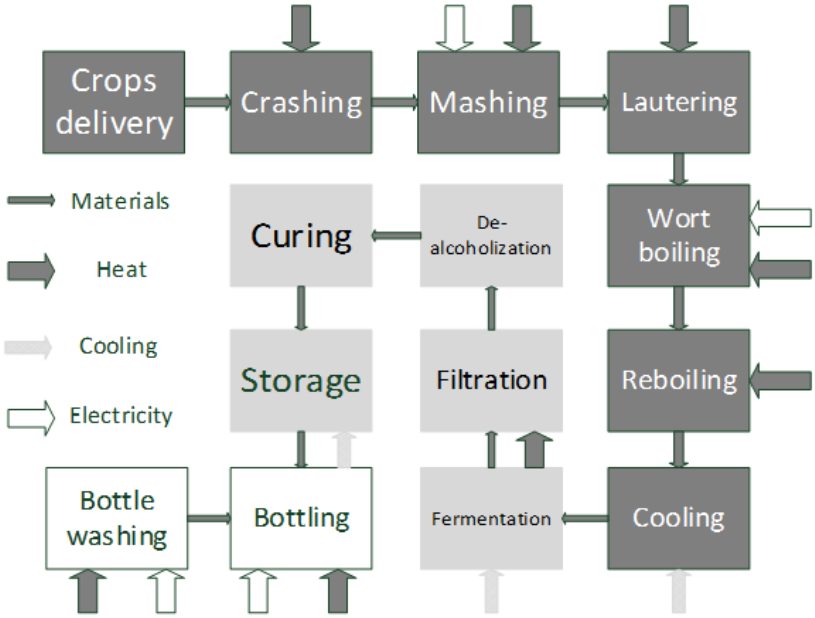

Fig. 5.1 Characteristics of the brewery operations

Source: [2]

5.3 ENERGY USE IN A BREWERY

Brewing is an energy-intensive process, and the objective for almost every brewing company is the development of a sustainable process with efficient energy consumption to obtain savings in fuel and energy costs. The major consumers of heat in brewery are mashing, wort boiling, bottle washing, clearing in process (CIP), space heating, beer pasteurization and packing. Electricity is used mainly in beer packing, wort cooling, air compressing, boiler cooling, and various devices such as pumps, fans and lighting.

The European Commission (EC) published best available techniques reference (BREF) documents. BREF documents can be considered as guidelines for reduction of energy consumption and sustainable production technologies in European industry in general [3]. References for brewing are shown in Tab. 5.1 and Tab. 5.2.

In general, heat consumption in Polish breweries varies from 27 up to 54 kWh/hl, while electricity consumption varies from 8 to 12 kWh/hl of beer produced.

Tab. 5.1 Benchmarks for European Breweries

Parameter	Per hectoliter
Fresh water consumption	3.7-4.7 hL
Thermal energy consumption	23.6-33 kWh
Electricity consumption	7.5-11.5 kWh
Kieselguhr consumption	90-160 g

Source: Own elaboration

Tab. 5.2 Energy consumption in the brewhouse as published in the best available techniques reference document

Energy consumer	Electric power [kWh/hl]	Thermal energy [kWh/hl]
Wort production in brewhouse	0.84	10.2
Wort production [%]	10.40	36,0
Total consumption in brewery	8.10	28.3

Source: Own elaboration

The processing steps of wort boiling and bottle washing require more than half of the thermal energy needed in breweries. Electricity is used for refrigerating purposes in storage and fermentation. Fig. 5.2 and Fig. 5.3 illustrate the energy demand, both electric and thermal, in breweries.

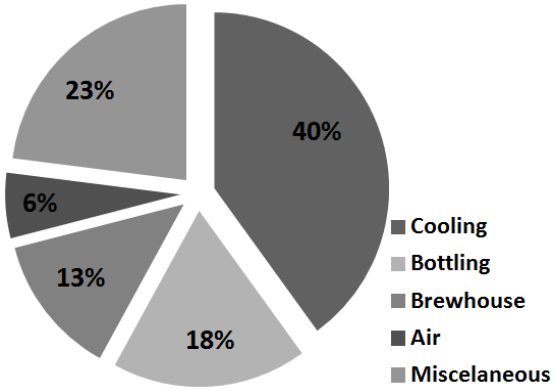

Fig. 5.2 Brewery electricity demand
Source: [2]

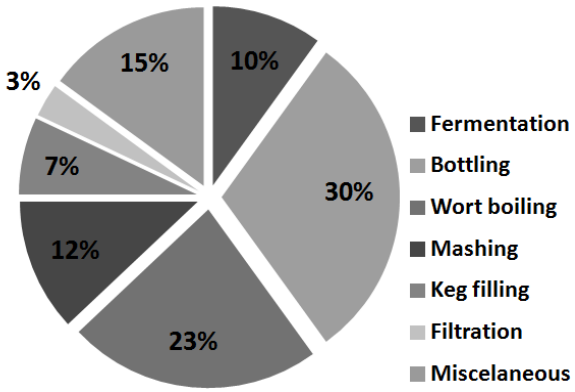

Fig. 5.3 Brewery heating and cooling demand
Source: [2]

There exists a large energy demand from low-temperature heat-consuming processes, such as bottle washing (90°C) and filtration. Two main criteria positively affect the efficiency of CHP facilities in breweries: a larger number of low temperature processes, and a constant heat and/or cooling demand. Combined heat and power (CHP) or cogeneration has significant potential in the brewery industry, enabling it to reduce operational costs and carbon emissions. Converting the heat into cooling via absorption chillers is called combined cooling heat and power (CCHP) or trigeneration, and can be deployed to support the cooling requirements of the brewery. Benefits of CHP for the brewery industry are not only energy cost savings, but also environment protection, flexibility of power supply, simplified maintenance and, in addition, CHP is scalable according to demands.

5.4 SELECTION OF MICRO-COGENERATION UNIT

According to Brewers Association, breweries can be classified, taking into consideration their output in hectoliters, in the following manner:

- macro/large brewery – over 7.000.000 hl,
- craft brewery – less than 7.000.000 hl,
- micro brewery – less than 17.600 hl.

There is no officially-defined level of beer for a brewery to be classified as a Nano brewery, but it is accepted across the beer industry that a Nano brewery is defined based on the size of its brewery system. A Nano brewery produces beer with a 4.7 hl (4 barrel) brewing system or less [1].

In recent years, regional and local (craft) breweries are gaining more and more popularity. This trend is a direct response to consumers affected by poor quality of beer produced by the large national and multi-national brewer groups. And while the craft breweries' share of overall beer market in Poland is still very small (about 6-7%), the perspective of its development is very optimistic.

On specialized fora, more and more people declare, that they do not drink any beer made by the largest brewing groups. Regional and local breweries are gradually increasing their recognition and popularity in the eyes of consumers.

In March 2015, the first edition of craft beerweek took place in Krakow, with 15 Polish craft breweries serving the best Polish craft beers. Typical beer festivals in our country are a more frequent phenomenon. There is also an increasing availability of craft beers. Beer revolution has become so dynamic, that even the most steadfast birofile are not being able to try all of its new produce. E.g. only in 2014 more than half a thousand beer 'premieres' took place [4]. Typical craft brewery in Poland has an output varying from 20000 hl up to 1.4000.000 hl. Therefore, this group of breweries can, together with micro breweries, become the target for introduction of micro-cogeneration systems MCHP XRGI.

5.5 METHODOLOGY OF SAVINGS ESTIMATION

MCHP XRGI technology is characterized by large savings in operational costs resulting from:

- low price of kWh generated by natural gas,
- exceptionally high efficiency of micro-cogeneration unit.

Tab. 5.3 Comparison of traditional system (purchasing electricity from the grid and using a gas boiler) and cogeneration unit (using a MCHP XRGI 20 unit)

Traditional system			
	Energy [kWh]	**Unit price [PLN/kWh]**	**Cost [PLN/h]**
Electricity purchase	20	0.40	8.00
Thermal energy generation	40	0.18	7.20
		Total:	15.20
Cogeneration unit MCHP			
	Energy [kWh]	**Unit price [PLN/kWh]**	**Cost [PLN/h]**
Electricity generation	20	0.50	10.00
Thermal energy generation	40	0.00	0.00
Profits from yellow certificates	20	-0.10	-2.00
		Total:	8.00

Source: [5]

On the basis of the above-calculated savings per hour of operation it can be seen that to supply a certain amount of electricity and heat to the processes can be ~47% cheaper when the microcogeneration system is applied (Tab. 5.3).

Knowing demands for selected processes as shown in Tab. 5.5 and Tab. 5.6, and comparing them with cogeneration unit output (Tab. 5.4) we are able to choose appropriate cogeneration unit or units. For example, considering continuous processes of brewing and cooling:

- for a micro-brewery (output 17,600 hl/year) XRGI9 unit is suitable,
- for a small regional brewery (output 20,000hl/year) XRGI15 unit is suitable,
- for a medium regional brewery (output of 350,000 hl/year) we can use 4 or 5 XRGI20 units.

Tab. 5.4 Co-generators output per year (8760 hours of operation)

	Type of MCHP XRGI unit			
	XRGI 6	XRGI 9	XRGI 15	XRGI 20
Electricity Generation [kWhe]	21,900 52,560	35,040 78,840	52,560 133,152	87,600 175,200
Thermal energy generation [kWhth]	74,460 118,260	122,640 175,200	148,920 262,800	219,000 350,400

Source: [5]

Tab. 5.5 Electricity and thermal energy consumption per hl of beer for a Polish (micro) brewery and for its selected processes

	Per hl of beer	Per year
Electricity consumption for brewery [kWhe]	8.5-12	149,600-211,200
Thermal energy consumption for brewery [kWhth]	27-54	475,000-950,000
Electricity consumption for brewing and cooling [kWhe]		79,300-111,900
Thermal energy consumption for brewing [kWhth]		180,500-361,000

Source: Own elaboration

Tab. 5.6 Electricity and thermal energy consumption per hl of beer for a Polish craft brewery and for its selected processes

Brewery output [hL/year]	20.000	350.000
Electricity consumption for brewery [kWhe/year]	170.000-240.000	2.975.000-4.200.000
Thermal energy consumption for brewery [kWhth/year]	540.000-1.080.000	9.450.000-18.900.000
Electricity consumption for brewing and cooling [kWhe/year]	90.100-127.200	1.576.750-2.226.000
Thermal energy consumption for brewing [kWhth/year]	205.200-510.400	3.591.000-7.182.000

Source: Own elaboration

CONCLUSIONS

With the above calculations made, it appears that cogeneration should be one of the essential elements of reduction of energy consumption in the brewing industry. For large-scale brewers, due to scope of their energy demand, the best solution

is a classic form of combined heat and power generation CHP, or combined cooling heat and power (CCHP) generation. For regional breweries and microbreweries a good solution is to use micro-cogeneration CHP XRGI.

Properly selected micro-cogeneration system can in 100% meet brewery demands for electric energy for the process of brewing and cooling beer, and in 30% for the heat needed for brewing. Of course, there is the possibility of increasing the power of selected co-generators in order to provide energy not only to the process of brewing and cooling, but also for other processes in the brewery. However, this requires precise electrical and thermal profiles, which are specific to a particular brewery.

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Abstract: *This paper presents basic process flows in beer-making and their energy demands. Prospect of introduction of a different types of cogeneration according to yearly output of breweries is analyzed. Capability of improvement of energy management in micro, small regional and medium size regional breweries through the use of gas micro-cogeneration MCHP XRGI is presented. Comparison of cost of operation is shown for both traditional and proposed system.*

Key words: *heat, electricity, micro co-generation, natural environment, brewing industry energy management, MCHP XRGI*

KORZYŚCI Z ZASTOSOWANIA MCHP XRGI W BROWARNICTWIE

Streszczenie: *W artykule przedstawiono zasadnicze procesy technologiczne występujące w browarnictwie oraz ich potrzeby energetyczne. Przeanalizowano możliwości wprowadzenia różnych rodzajów kogeneracji w zależności od wielkości rocznej produkcji browarów. Zaproponowano możliwości poprawy gospodarowania energią w browarach mikro, oraz małych i średnich browarach regionalnych, poprzez wykorzystanie mikrokogeneracji gazowej MCHP XRGI. Pokazano również porównanie kosztów operacyjnych dla tradycyjnego i proponowanego systemu.*

Słowa kluczowe: *ciepło, energia elektryczna, mikrokogeneracja, środowisko naturalne, browarnictwo, gospodarowanie energią, MCHP XRGI*

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