EFFICIENT USE OF ENERGY AN IMPORTANT APPROACH IN MINIMIZING ENVIRONMENT AND OPERATIONAL COSTS IN ALBANIAN BREWERIES

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Abstract: *The objective of this paper is to provide information for identification of energy efficiency opportunities available for breweries. Breweries are relatively large scale plants and highly energy consuming industry. There are different ways to reduce energy consumption in the brewing industry. The overall specific consumption of energy used in a brewery, vary with the mix of package types, processes and equipment employed, the brewery's size, age, and the overall level of efficient energy utilization. Energy consumption is equal to 5% of the production costs of beer, making energy efficiency improvement an important way to reduce costs. Efficient use of energy consists on conservation and recovery.*
Energy conservation, reduce the amount of pollution generated from production processes (e.g., CO_2, NO_X, SO_2, ash, etc.) and reduce the energy requirements for waste handling and treatment. These measures give significant results in lowering the operational brewery costs. There are several methods of energy recovery proposed in this paper that can be considered by breweries to reduce energy consumption
In the brewing industry, 80% of the energy used is for process heating. It is pointed out, that most of the electrical consumption in a brewery is used for powering refrigeration plants. The areas of action which will produce immediate results include: condensate return systems, recycling of cooling water, effective control of boiler efficiencies and the latest developments in electrical power consumption. Longer range possibilities directly affecting the process are also considered, including water and heat recovery in pasteurizers, flash pasteurization techniques, heat recovery from brew house and reduced wort boiling times.

Key words: *Energy, recovery, conservation, efficiency, environment, operational costs.*

1. INTRODUCTION

Breweries are large energy users. There are different forms of energy used in a brewery such as thermal energy, electricity and fuel. Beer production process is divided in to three main processes, brewing, fermentation and packaging. Brewing consist on wort production and requires high heat consumption, particularly the wort kettle consumes one third (1/3) of steam consumption of entire plant. Fermentation process consumes large cooling energy by refrigeration system. This process consumes 60 to 70% of entire cooling capacity.

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Packaging process consumes a lot of heat energy (steam) and electricity too. In the Brewing Industry, 80% of the energy used is for process heating. It is pointed out, that most of the electrical consumption in a brewery is used for powering refrigeration plants. In order to control energy consumption it is very important to perform periodical energy audits in order to ensure continual improvement through parameter monitoring.

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Heat consumption is influenced by process and production characteristics such as packing method, pasteurization technique, type of equipment, by-product treatment, etc. Heat consumption in a well run brewery is 150-200 MJ/hl. Electricity consumption, in a well run brewery, is about 8-12 kWh/hl, depending on process and production characteristics. Some breweries consume up to twice as much due to inefficient production.

Energy conservation, reduce the amount of pollution created in the production or use of energy (e.g., CO_2, NO_X, SO_2, ash, etc.). On the other hand pollution prevention measures reduce the energy requirements for waste handling and treatment, as a result a reduction in energy consumption is an important consideration in lowering the operational cost.

Energy recovery consist on reuse of energy on various operational processes; thus reducing the requirements for new resources and the amount of energy being discharged as waste. Resources recovery is based continuous maintenance, effective management and good housekeeping.

There are several methods of energy recovery that can be considered by breweries to reduce energy consumption; however, most are expensive and should only be considered once measures for reducing energy consumption have been made first.

2. MONITORING AND REPORTING

Monitoring of parameters listed in this document were carried out at least once per month, or more frequently. Measurements were carried out at “Stefani & Co” brewery (Albania). Monitoring data were analyzed and reviewed at regular intervals and compared with the operating standards. Our energy efficiency case study is compared with references to technical literature.

Energy input at “Stefani & Co” brewery is supplied in the form of oil, gas, steam, high temperature water and electricity. Meanwhile energy is discharged from the brewery in the form of hot flue gas, and steam; as warm wastewater; as moisture with the trubs and the spent grain.

Resources recovery is based on three main procedures.

To reduce energy consumption we implemented the following conservation strategy, based in terms of electricity, thermal energy and fuel.

Electricity conservation strategy	***Thermal Energy conservation strategy***	***Fuel conservation strategy***
- use of more efficient equipment when replacing old equipment - use of fluorescent lights and/or lower wattage lamps; - implementation of good housekeeping measures such as turning off equipment and lights when not in use; - installation of timers and thermostats to control heating and cooling; and, - Preventative maintenance of operational processes and pipes to improve efficiency and minimize losses. - installation of computerized controllers to better regulate motor output;	- perform strictly the preventative maintenance to reduce leakages and avoid steam trap bypass. - improve or increase insulation on heating or cooling lines, pipes, valves or flanges, refrigeration systems, bottle washers and pasteurizers. - Use of more efficient equipment, - ensure a systematic maintenance of process operations to ensure their efficiency; - use a hot water tank of appropriate size to optimize hot water production; - perform a hot water balance of the entire facility to determine when, where and how hot water is being utilized, and identify areas where reductions in consumption can be made.	- reducing the consumption of fuel (e.g., oil and natural gas, etc.) through minor adjustments to operating processes - implementing the preventative maintenance program - implement the preventative maintenance of steam pipes which represent a significant opportunity to reduce resource consumption and increase cost savings for a facility.

Energy recovery consists on reuse of energy on various operational processes; thus reducing the requirements for new resources and the amount of energy being discharged as waste. There are several methods of energy recovery that can be considered by breweries to reduce energy consumption; however, most are expensive and should only be considered once measures for reducing energy consumption have been made first. The recovery of vapors condensate in ”Stefani & Co” brewery represent a major saving in energy consumption. (the loss of 1 m^3 of vapors condensate at 85^0C is equivalent to the consumption of approximately 8.7 kg of oil). Utilization of CO_2 energy during transformation from liquid in gaseous form, is also a well known procedure in water cooling for compressors towers.

Energy consumption at the brewery for the period 2015 – 2017 has the following figures.

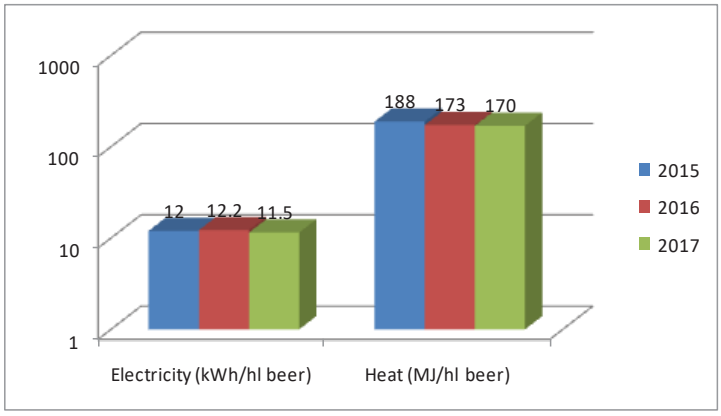

Figure 1. Energy consumption in terms of thermal and electricity at "Stefani & Co" brewery

The vast majority of thermal energy is used in brewing operations and pasteurization, while electricity consumption is more evenly divided among fermentation, beer conditioning and space and utilities. 60% of thermal energy is used in brewing. The specific electricity consumption for "Stefani & Co" is rather high compared with international benchmarks and could be subject to a separate assessment. Indicatively, the electricity costs for the site is 19,5 mill LEK/yr (140 000€/yr). Compared to good performers within the sector, the specific consumption could be reduced by almost 40%.

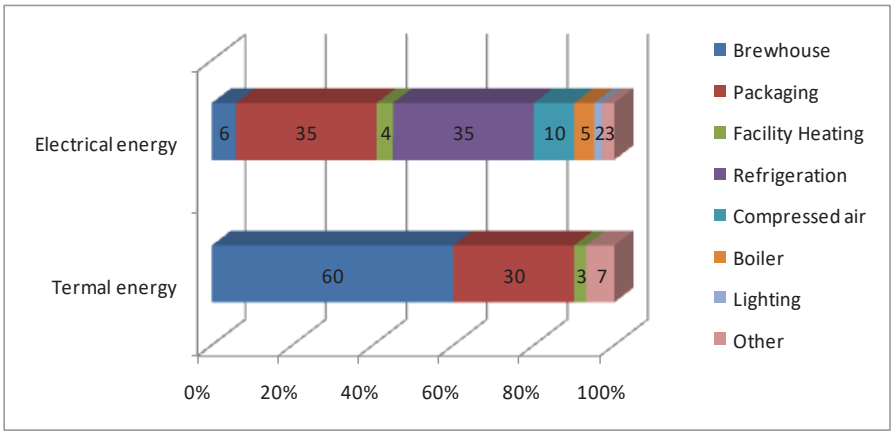

Figure 2. Energy consuming percentage for different processes in brewery for 2017

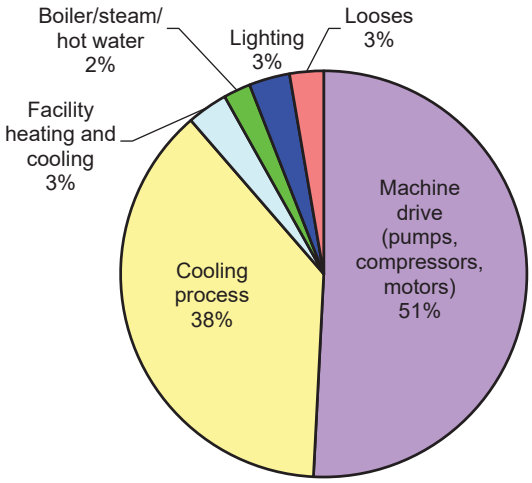

Figure 3. Electric energy defragmentation in the brewery for 2017

For a well run brewery optimal figures of thermal energy are in the range of 100 – 200 MJ/hl. The consumption is decreased as a result of conservation techniques implemented to the brewery [7]. The most important measures undertaken in the facility consist on improving energy balance in the main heat consuming processes.

1. Optimizing wort producing process through automatization and control of the process. Proper insulation and good maintenance level.
2. Shortening boiling time with 30 minutes (from 90 min boiling time is 60 min).
3. Minimizing evaporation rate (ER) in the wort cattle (1% of ER result in around 2 MJ/hl wort reduction). Evaporation rate is reduced also through controlling inlet and outlet extract of the wort. At 2015, evaporation rate was around 9% at 2017 was decreased around 5.6%. Continuous control of wort extract in the boiler enables to stop the boiling when the objective is reached.
4. Applying steam condensate recovery. At the brewery the vapors are used to boil the wort. The heat in the vapor condensate is recovered by producing hot water which is used to pre-heat the wort. In the mashing process, waste heat can be captured from the mash or from the hot water tank [3]. This heat can be used for either mashing or for other processes. Hot water of 95-98°C generated from heat recovery can be used to partially heat the mash thereby reducing steam or hot water generation requirements at the facility. The heat from the vapor is used to pre-heat the incoming wort, while the heat from the vapor condensate is used to produce hot water for cleaning or other applications in the brewery. Savings were estimated to be 3 % of steam consumption.
5. Flash pasteurization of beer instead of tunnel pasteurization reduce energy consumption. Flash pasteurization is used for in-line heat treatment of beer prior to filling the kegs [8]. Flash pasteurization rapidly heats the beer for a short period of time to a high temperature and then rapidly cools the product. As opposed to conventional tunnel pasteurization, flash pasteurization requires less space, steam, electricity and coolant. The optimum heat recovery is 94-96%, by plate systems Operation and maintenance cost estimates for flash pasteurization systems are 70% cheaper compered to tunnel pasteurizers.
6. As most breweries, “Stefani and Co” has a process integration system for recovery of waste heat from process, used for heating water. The site has an installed chiller capacity of 700kW

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(electric) applying ammonia as refrigerant. The majority of the site demand for thermal heat is below 80°C. Heat recovery from chillers could provide the site with approximately 1 000 kW of heat at 65°C which would reduce the costs for cooling water and gas correspondingly. The energy recovered could by used for CIP, keg wash, box wash and pasteurization.

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For a well run brewery optimal figures of electricity consumption are in the range of 7 - 12 kWh/hl. The site has a distribution of -5°C glycol system based on R22. The chillers have a capacity of 550kW electric and use a dry cooler as condenser which reduces the performance and increase the specific energy consumption. The electricity consumption of this system should be monitored with respect to Coefficient of Performance (COP) and "Stefani and Co" could consider applying a evaporative cooling tower or heat recovery system in order to improve the COP. The glycol chiller system is likely to be the largest single consumer for the site and the performance is thus important to monitor. The NH_3 chillers (160kW) apply an evaporative cooling tower and we recommend motoring of the COP as well. If the facility has the opportunity to use direct expansion of ammonia instead of glycol, operational costs will be reduced around 18% and also running costs will be lower.

The most important measures undertaken in the facility for electric energy conservation consist on:

1. Optimizing and better control of the processes.
2. Improving efficiency of equipment's through better production planning and non-stop running of equipment. Especially packaging lines and cooling plant which are the biggest consumers of the plant.
3. Lowering condensing temperature or use a higher evaporating temperature in the cooling plant. The increase of evaporating temperature with 1^0C reduce the electricity consumption for cooling plant with 3 %. Decrease of 1^0C (this is a function of outside conditions) reduce the electricity consumption for the cooling plant with about 2%.

Stefani has also two lines of ADS G62 PET blow moulding machines. Both machines are supplied with 40 barG compressed air from a SIAD Tempo 610 compressor (118 kW). Many suppliers of compressors offer after sales services where recovered air at e.g. 25bar can be returned to the compressors and thus reduce the specific electricity consumption. Similarly, the PET blow mould machines could be investigated for recovery of air at 25 bar for use as pre-blow (typically 17 bar) or for supply air to the air compressor.

Breweries also, require significant amounts of energy in the forms of heat and electricity for beer packaging. Energy intensity, or specific energy consumption, reflects the amount of energy required per unit of output or activity. The variation in intensities is partly influenced by the type of product being produced. For example, draught beer has much lower energy requirements than other types of beer since it is not tunnel pasteurized. Intensities will also vary depending on the amount of production.

Packaging line	Energy Intensity	Notes
Keg	32	Low value as result of high volume of production and no tunnel pasteurization
Bottle	212	High value. Small beer volume. Tunnel pasteurization. Washing bottle machine.
Can	100	Tunnel pasteurization.
PET	135	High value due to blowing machine for PET bottles.

Table 1. Energy intensity for packaging lines

In this paragraph we provide a summary of energy data's for the period 2015-2017, as well as references to technical literature. Energy efficiency is an important way to reduce production costs.

Parameter	2015	2017	Optimal interval
Total energy consumption in MJ/Hl	238.6	211.2	180 - 190
Heat in MJ/Hl	188	170	100 - 150
Electricity in kWh/hl	12	11.5	7 - 12
Percentage of energy on beer production cost	4.2%	3.8%	3 - 4%

Table 2. Comparison of energy values with reference values

Sector	2015	2017	Optimal interval
Packaging	4.59	3.89	1.5 -3.5
Refrigeration	4.48	3.75	3 - 4
Compressed air	1.35	1.31	0.8 – 1.1
Brewhouse	1.08	0.95	0.5 - 1
Lighting	0.81	0.76	0.5 – 0.6
Facility heating	0.65	0.65	< 0.6
Boiler	0.40	0.39	0.4 -0.5
Utilities	0.70	0.41	0.5 – 0.6

Table 3. Specific electric consumption in kWh/Hl beer produced compared to the reference values

Sector	2015	2017	Optimal interval
Brewhouse	120.5	105.0	65 - 100
Packaging	50.3	46.2	20 - 45
Facility heating	3.5	1.9	1 – 1.5
Utilities	13.8	11.2	10 - 15

Table 4. Specific thermal energy consumption in MJ/Hl beer produced compared to the reference values

3. CONCLUSIONS

While there are many issues at the brewery, there have been several years of continual improvement. Key issues highlighted by energy audit consist mainly on reduction of water use

throughout the process, control of energy leakages, optimization of equipment running, installation of proper measuring devices (water, electric energy) to take corrective and preventive actions properly, etc.

Process optimization and ensuring the most productive technology is in place are key to realizing energy savings in a plant's operation. Energy monitoring and process control systems play important role in energy management and in reducing energy use.

In the Brewing Industry, 80% of the energy used is for process heating. Consequently to effect savings in this area, processing methods must be changed while still maintaining product quality. The areas of action which will produce immediate results include: condensate return systems, recycling of cooling water, effective control of boiler efficiencies and the latest developments in electrical power consumption. Other possibilities considered are water and heat recovery in pasteurizers, flash pasteurization techniques, heat recovery from brewhouse and reduced wort boiling times.

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Although energy figures after undertaking saving and recovery measures started to drop they are still high compared to European breweries. Inherent inefficiencies of smaller scale operations cause high specific energy use relative to output as European breweries. Despite of this fact, there exists a variety of opportunities to reduce energy consumption while maintaining or enhancing the product quality and productivity of the plant.

Energy consumption from 5,2% of production beer cost, decreased at 4.7% in the end of this study. The efficient use of energy has become a major factor in the profitability of a brewery. Furthermore, the cost of energy is predicted to increase at an even greater rate in the future in Albania.

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