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Assessment of the benefits of implementing the EMS system on the example of a container glass industry

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Abstract

The paper describes the glass manufacturing process, the process areas and their energy intensity. The implementation of an energy management system, its operation and participation in the decision-making chain as well as benefits from implementation are also described. The use of regression as a numerical technique for determining energy consumption is presented with reference to the historical experience of the glassworks and its developed trends on the example of gas consumption in the melting process in the glass furnace. The paper compared the deviation of actual energy consumption in the glass melting process to that calculated from linear regression variables for data before and after the implementation of the energy management system. The study confirmed the sensibility of implementing the described managing system. Constant observation and response to factors affecting the running process allows for its stabilization and optimization.

Keywords: Glass industry, Industry, Energy Efficiency, Energy Management System, Linear Regression

1. Introduction

Nowadays, climate policy sets a target for industry to reduce emissions to the environment. At the same time energy production is based mostly on non-renewable energy resources that are getting more expensive progressively. Therefore, a major challenge in many industries is to reduce electricity, fuels, water and raw materials consumption, as well as corresponding costs, which constitute strategic actions for cost savings and sustainability in industries.

Energy efficiency (EE) has for many years been seen as one of the key strategies for improving the economic results of industry, as well as for reducing industrial emissions. These days, EE is also considered important in the context of climate change and global CO2 emissions. Changing energy management by implementing an organization- or department-wide energy management program are the most successful and cost-effective ways to bring about energy efficiency improvements [1].

This is also supported by the fact that the implementation of such a system is included in the Industrial Emissions Directive Best Available Techniques (BAT) Reference Document [2]. In this respect, an energy management system (EMS) is a method allowing operators of installations to address environmental issues in a systematic and demonstrable way. EMSs are most effective and efficient where they form an inherent part of the overall management and operation of an installation [2].

Thus, the primary opportunity to improve energy efficiency in companies is to implement an Energy Management System (EMS). It is software to monitor utilities consumption in real time (e.g., electricity, gas, compressed air, water and more). Such a system also allows for the development of knowledge about the process based on historical data and for the conclusions about the consumption of energy media for production conditions and for the creation of best practices.

United Nations Industrial Development Organization published Practical Guide for Implementing an Energy Management System which aims to increase companies' understanding of Energy Management Systems to enable them to take effective measures to implement energy management, thereby improving their energy performance, productivity, and environmental sustainability [3].

Optimal energy consumption results not only from the need to reduce production costs. The globally applicable ISO 50001 standard is the international standard for efficient energy management in the economy, including manufacturing companies. Depending on the size of a company and its targets, top management may choose to create an energy management that works on energy-related tasks on a continuous basis. This team has an ongoing responsibility to adequately support energy management. It must provide the necessary resources for energy management. Therefore, the mentioned system for energy management fits into such a company policy in all respects [4].

Therefore, it is worthwhile to study and implement further systems to optimize processes, reduce energy consumption and environmental impact. While at the same time raising its industrial relevance and competitiveness.

The main aim of the article is to describe the production process of container glass with the specification of its energy intensity in different areas of the process, and to present the implementation of the Energy Management System (EMS), its operation and participation in the decision-making chain and the benefits of its implementation. This article describes also an example of a method to predict energy consumption in the process of glass melting in furnaces by using Energy Management System along with the database and with participation of energy manager and glass melting specialists.

2. Container glass production process areas description and utilities consumption

The main process line, schematically shown in Figure 1, is generally similar for all installations of the entire container glass sector and consists of:

- Glass batch plant for storage and mixing of batch,
- Glass furnaces with charging tanks,
- Production lines including:
- Forehearths,
- Forming glass machines,
- Bottle annealing and coating lines;
- Quality control,
- Packaging plants,
- Finished product warehouses.

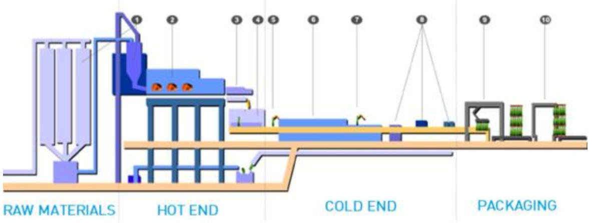


Figure 1: The process of manufacturing quality container glass; 1- batch preparation, 2 – melting, 3 – glass conditioning, 4 – forming, 5 - hot end coating, 6 – annealing, 7 – cold end coating, 8 – inspection, 9 – palletizing, 10 – shrink wrapping [5]

Container glass is a colorless sodium-calcium-silicate glass or one that is appropriately colored - usually brown (amber) or green.

In the glass batch plant, a batch is prepared which, together with cullet, is fed through a charging tank and feed pocket into the furnace where it is melted. After clarification and thermal stabilization, the molten glass flows from the furnace along a forehearth to a gathering bowl (spout) at the end. From the bottom of the gathering bowl, one to four parallel streams of glass are formed through appropriately sized orifices. These glass streams, modulated by a mechanical plunger system, are cut into accurate lengths by a shear mechanism to form primitive, sausage shaped, glass gobs. The complete system for forming the gobs is termed the feeder mechanism. Gobs are cut simultaneously from the parallel glass streams and are formed simultaneously in parallel mounds on the forming machine. These are termed single, double, triple, or quadruple gob machines, the latter being adapted to high-volume productions of smaller containers. Container glass furnaces feed two or more such forming machines, each via a dedicated forehearth [6].

The forming process is carried out in two stages. The initial forming of the blank may be made either by pressing with a plunger, or by blowing with compressed air, depending on the type of container. The final moulding operation is always by blowing to obtain the finished hollow shape. The formed containers are presented for post-forming production stages on a continuous conveyor.

Rapid cooling of the containers on the outside surface creates high differential stresses in the glass and consequent fragility. To eliminate this, the containers are passed through a continuous annealing oven (lehr), where they are reheated to 550 ˚C then cooled under controlled conditions to prevent further stresses being set up. Lehrs are heated by gas or electricity but once brought to the operating temperature, the heat from the incoming containers provides most of the heating energy. Once sufficiently cooled, all containers are inspected automatically with automatic rejection for out-of-tolerance and other quality concerns. To prevent damage between containers and to enable them to slide through guide systems without damage, lubricating treatments can be applied to the product at the cold end of the annealing lehr. After inspection, the product is assembled onto pallets either in cartons or in bulk and packed, and stored before shipment to a customer [7].

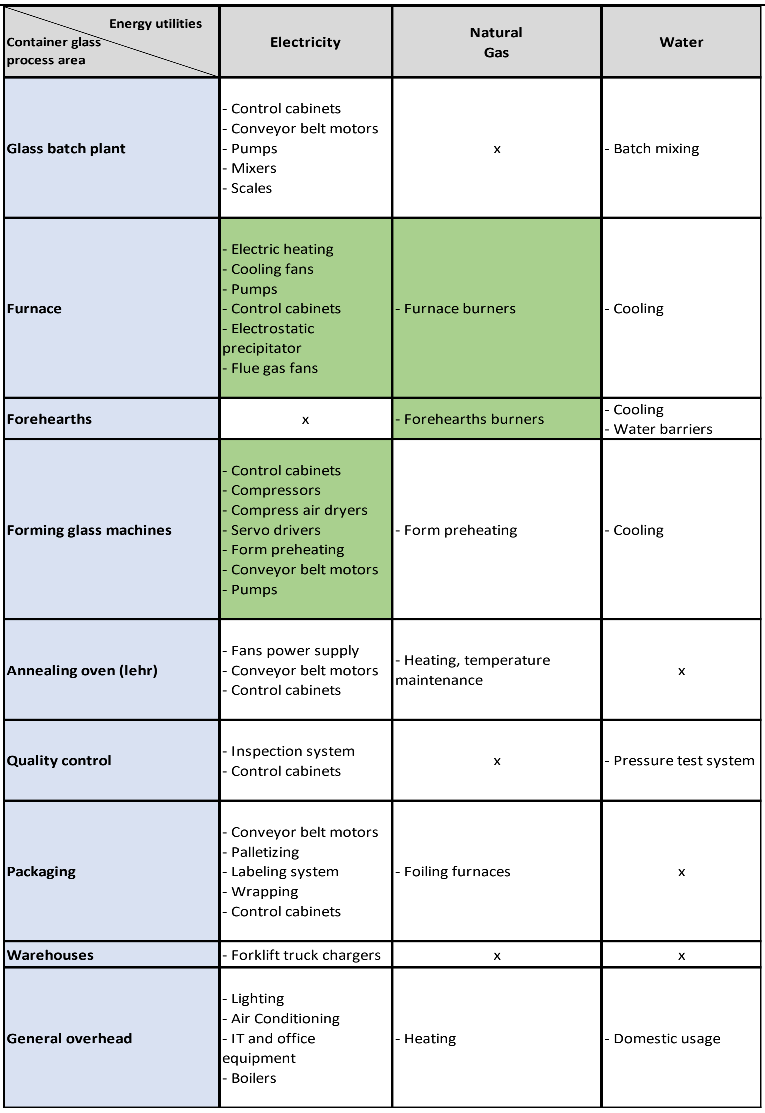
Production of container glass is continuous: glass baths operate continuously (with only minor repairs) for up to 12 years, after which they are rebuilt. Glass manufacturing is a high-volume process during which large quantities of substances are turned into commercial products, with large amounts of non-renewable resources and energy consumed in the process. Table 1 presents the main energy receivers in each area of container glass production. Green marked cells represent production areas that consume 60% of total electricity consumption and 80-90% of natural gas consumption as determined by historical data, industry experience and reports generated by the Energy Management System.

3. Implementing Energy Management System

Energy management systems are systems that combine the ability to collect and process large amounts of information from production areas, perform analysis on it, and use models, collected data, and knowledge to represent complex decision-making problems. An exemplary interface of such a system is shown in Figure 2.

Inherent in such a system is knowledge base and artificial intelligence tools along with quantitative processing software and meters, sensors, and metrics.

This is a mature technology available at an affordable price that provides real-time information on individual utility consumption parameters of plant equipment components. The information from analyzers is interesting not only because of the measurement of consumption, but also due to the parameters related to the actual working conditions of equipment and installations, which also reveal premature failures or unusual behavior of machines [1].



Energy utilities Container glass process area	Electricity	Natural Gas	Water
Glass batch plant	- Control cabinets - Conveyor belt motors - Pumps - Mixers - Scales	x	- Batch mixing
Furnace	- Electric heating - Cooling fans - Pumps - Control cabinets - Electrostatic precipitator - Flue gas fans	- Furnace burners	- Cooling
Forehearths	x	- Forehearths burners	- Cooling - Water barriers
Forming glass machines	- Control cabinets - Compressors - Compress air dryers - Servo drivers - Form preheating - Conveyor belt motors - Pumps	- Form preheating	- Cooling
Annealing oven (lehr)	- Fans power supply - Conveyor belt motors - Control cabinets	- Heating, temperature maintenance	x
Quality control	- Inspection system - Control cabinets	x	- Pressure test system
Packaging	- Conveyor belt motors - Palletizing - Labeling system - Wrapping - Control cabinets	- Foiling furnaces	x
Warehouses	- Forklift truck chargers	x	x
General overhead	- Lighting - Air Conditioning - IT and office equipment - Boilers	- Heating	- Domestic usage

Figure 2: Main energy receivers in each area of container glass production.

A tool, Energy Management System, configured in this way supports the work of managers, engineers, specialists and operators at an expert level. The database is one of the most important sources of information about the running process and supports its management. Information collected by the system on reliability, maintainability and energy consumption of equipment can be a key element in the decision-making process.

The management system receives important information for predicting anomalous situations, which significantly reduces the number of unplanned downtimes, as well as costs resulting from the continuous malfunction of equipment, especially energy expenses. This shared knowledge also significantly increases plant safety, both from an environmental and industrial perspective. Energy indicators, alone or in combination with other parameters specific to an operation or a process, provide information on energy consumption as well as machine malfunctions, helping to detect possible machine failures at an early stage [8].

Figure 2: The Energy Management System exemplary user interface

Energy Management System can be used for benchmarking and controlling of the company energy consumption. Benchmarking plays a significant role in managing of key media and tracking the performed activities.

The system can present consumption per areas or departments, production line and per production like order, item, quantity, which helps in calculation of real production costs. EMS aims at complete control over the use and cost of utilities in the factory. Counters, alarms and controlling dashboards give the user the opportunity to manage the utilities as well as all facilities, areas of the plant - from the production floor to offices. Correlation with production data allows for full analysis and transparency of the actual production costs. Active monitoring supports detection of leaks and waste of utilities that can be easily missed and just as easily fixed. Such a system also allows for the development of knowledge about the process based on historical data and for the conclusions about the consumption of energy media for production conditions and for the creation of best practices. Energy efficiency programs like EMS with regular feedback could have the best results, even by saving only small amounts of energy at one time, taken continuously over longer period, can have a much greater effect than more costly technological improvements.

4. Example of energy usage prediction in a glass factory

By implementing an Energy Management System, a glass factory can collect utility consumption data on servers from all areas of production. Moreover, the system enables comparative analysis of data and determination of whether all machines are consuming the required amount of energy. The EMS isolates the modes of operation of the equipment, individually evaluates the level of consumption and indicates optimization opportunities. Generation of energy consumption reports and access to database allows us to calculate the amount of energy that is needed to produce a product, in glass factory's case – melted glass.

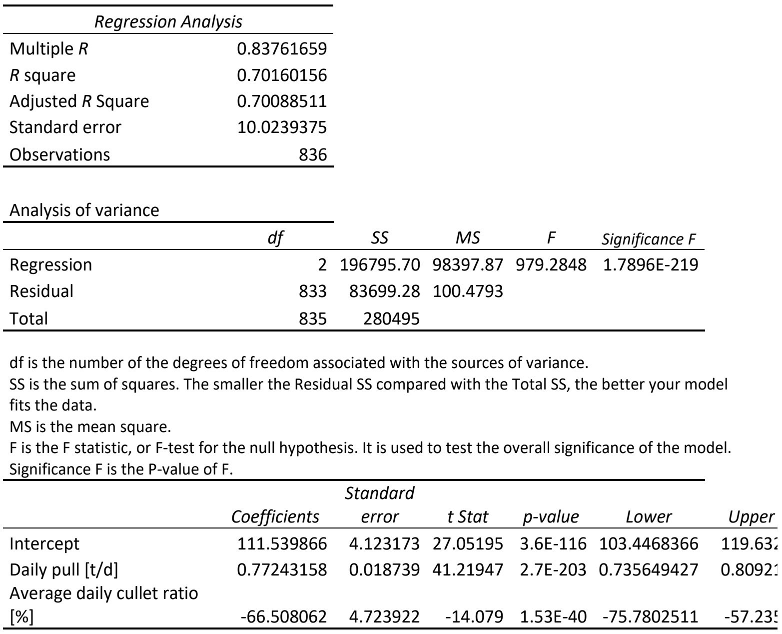
EMS provides constant tracking of the consumption of energy utilities in real time, during the process. By combining this capability with employee experience and data from melting process collected since beginning of the furnace campaign, such as pull rate, cullet share, temperatures level, natural gas, and electricity consumption, it is possible to begin to predict the energy intensity of the process depending on the prevailing conditions. The described method is Multiple Linear Regression Analysis (MLRA). It was used at glassworks in the glass melting department because it is a reliable technique for predicting future values based on a previously available dataset that defines the independent variables that affects the energy consumption in the glass melting process, and MLRA is a simple statistical tool for melting specialists. With one of the most used tools for calculations, MS Excel with the Data Analysis add-in, employers can generate a regression equation in which the dependent variable is written in terms of the independent variables. The general MLR equation is as follows:

$$y = A + b_1x_1 + b_2x_2 + \cdots + b_\mathrm{n}x_\mathrm{n} \quad (1)$$

where y denotes calculated energy consumption, constant A is an intercept (the point where the function crosses the y-axis in the regression equation) and x1, x2 are pull rate and cullet share (table 3 and 4), with respectively b1, b2 being the coefficients for both from the regression equation (table 1). In more complex analyses and predictions, more variables are added [9].

Table 1 shows the summary output of the multiple linear regression equation generation in MS Excel for glass melting depending on the pull rate and cullet share (x1, x2) used in calculation of the energy consumption forecast.

Table 1: The summary output of multiple linear regression equation generation in MS Excel Data Analysis add-in.



Regression Analysis	
Multiple *R*	0.83761659
R square	0.70160156
Adjusted *R* Square	0.70088511
Standard error	10.0239375
Observations	836

Analysis of variance

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	196795.70	98397.87	979.2848	1.7896E-219
Residual	833	83699.28	100.4793		
Total	835	280495			

df is the number of the degrees of freedom associated with the sources of variance.
SS is the sum of squares. The smaller the Residual SS compared with the Total SS, the better your model fits the data.
MS is the mean square.
F is the F statistic, or F-test for the null hypothesis. It is used to test the overall significance of the model.
Significance F is the P-value of F.

	Coefficients	*Standard error*	*t Stat*	*p-value*	*Lower*	*Upper*
Intercept	111.539866	4.123173	27.05195	3.6E-116	103.4468366	119.63
Daily pull [t/d]	0.77243158	0.018739	41.21947	2.7E-203	0.735649427	0.8092
Average daily cullet ratio [%]	-66.508062	4.723922	-14.079	1.53E-40	-75.7802511	-57.23

To verify the meaningfulness of implementing an energy utility management system and using multiple linear regression analysis to predict the energy intensity of glass melting in a glass furnace, historical data from glass melting operation logs were compared with data collected in the system's databases. For both these sets of data graph was drawn with the real energy consumption and the consumption calculated from multiple linear regression. The numerical values to represent this comparison were the results of calculating the relative error and average energy consumption for melting a ton of glass.

Relative error was calculated for the difference between real and calculated from MLR equation (number 1) furnace energy consumption in the glass melting process (equation 2).

$$Relative\ error = \frac{Real\ Energy\ Consumption - Calculated\ Energy\ Consumption}{Real\ Energy\ Consumption} \cdot 100\% \qquad (2)$$

The averages of relative error for the difference between real and calculated furnace energy consumption in the glass melting process and each researched time was calculated in accordance with equation 3.

$$Average\ energy\ consumption\ per\ glass\ tonne = \frac{\sum Relative\ errors}{Number\ of\ samples\ [days]} \qquad (3)$$

The averages energy consumption per ton of melted glass, calculated based on the eq. (4), for the years before and after the implementation of EMS was also examined and compared with each other.

$$Average\ energy\ consumption\ per\ glass\ tonne = \frac{\sum \frac{Daily\ pull\ [t]}{Real\ Energy\ Consumption\ [MWh]}}{Number\ of\ samples\ [days]} \qquad (4)$$

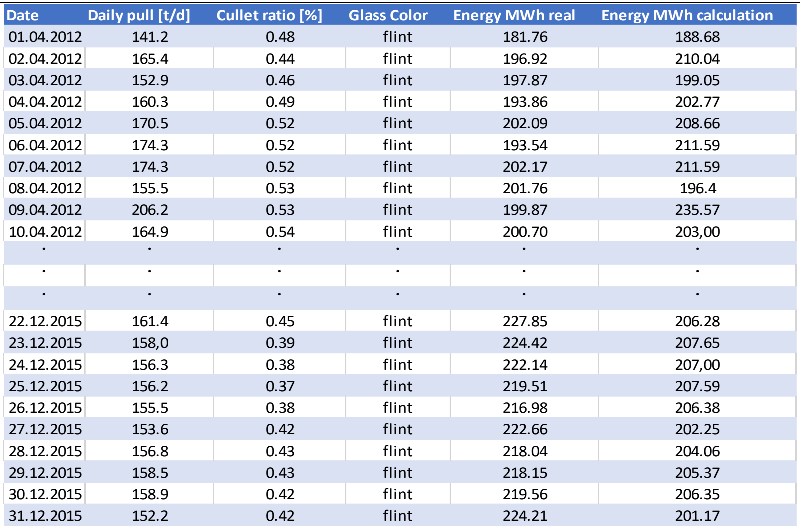
5. Results

The analyzed data comes from a furnace in a real glass plant that is more than a decade old, and which mainly melts flint glass. The study did not include days when the glass mass was discolored in the furnace. Data from the years before and after the implementation of the energy management system were compared. Such a comparison made it possible to clearly examine the impact of implementing the Energy Management System and using Multiple Linear Regression Analysis to forecast energy consumption during glass melting process.

Table 3 shows an extract of the production and utility consumption data and the calculated by regression energy consumption approximation from analyzed glass furnace before Energy Management System implementation. Table 4 shows the same data set but for the time after the implementation of EMS. The analyzed data are from the period from before (2012 to 2015) and after (2018-2020) the implementation of the system, the years in between were devoted to the full implementation of the EMS and the training of employees, the application of corrections. The data is in one-day resolution because before the system implementation, employees of the glass melting department reported energy consumption and other process indicators once a day, so it is easier to compare the data sets on a single day basis.

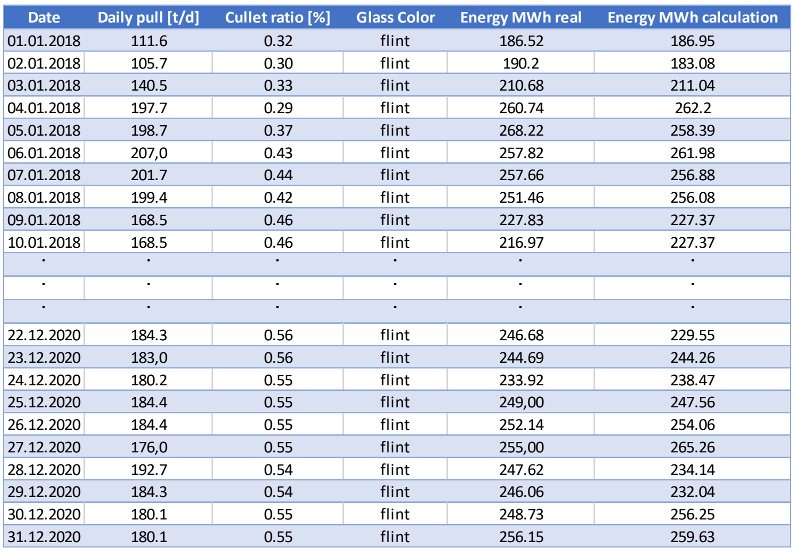
Characterization of the population must include the study of relationships between variables. Tackling overconsumption of energy cannot be limited to merely observing the level of energy during the processes taking place. Determining the nature of the energy intake of an energy carrier should include simultaneous monitoring of data that can have a significant impact on the variable under study. Proper classification of the process under study can help understand its nature. Diagrams, which have collected data on energy production and consumption over fixed periods of time, prove helpful at this stage of consideration [10].

Table 5 and 6 show an extract of the results of relative errors and energy consumption per ton of glass before and after Energy Management System implementation.



Date	Daily pull [t/d]	Cullet ratio [%]	Glass Color	Energy MWh real	Energy MWh calculation
01.04.2012	141.2	0.48	flint	181.76	188.68
02.04.2012	165.4	0.44	flint	196.92	210.04
03.04.2012	152.9	0.46	flint	197.87	199.05
04.04.2012	160.3	0.49	flint	193.86	202.77
05.04.2012	170.5	0.52	flint	202.09	208.66
06.04.2012	174.3	0.52	flint	193.54	211.59
07.04.2012	174.3	0.52	flint	202.17	211.59
08.04.2012	155.5	0.53	flint	201.76	196.4
09.04.2012	206.2	0.53	flint	199.87	235.57
10.04.2012	164.9	0.54	flint	200.70	203,00
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
22.12.2015	161.4	0.45	flint	227.85	206.28
23.12.2015	158,0	0.39	flint	224.42	207.65
24.12.2015	156.3	0.38	flint	222.14	207,00
25.12.2015	156.2	0.37	flint	219.51	207.59
26.12.2015	155.5	0.38	flint	216.98	206.38
27.12.2015	153.6	0.42	flint	222.66	202.25
28.12.2015	156.8	0.43	flint	218.04	204.06
29.12.2015	158.5	0.43	flint	218.15	205.37
30.12.2015	158.9	0.42	flint	219.56	206.35
31.12.2015	152.2	0.42	flint	224.21	201.17

Figure 3: Excerpt glass melting process data in a glass furnace before EMS implementation and energy consumption as the results of regression.



Date	Daily pull [t/d]	Cullet ratio [%]	Glass Color	Energy MWh real	Energy MWh calculation
01.01.2018	111.6	0.32	flint	186.52	186.95
02.01.2018	105.7	0.30	flint	190.2	183.08
03.01.2018	140.5	0.33	flint	210.68	211.04
04.01.2018	197.7	0.29	flint	260.74	262.2
05.01.2018	198.7	0.37	flint	268.22	258.39
06.01.2018	207,0	0.43	flint	257.82	261.98
07.01.2018	201.7	0.44	flint	257.66	256.88
08.01.2018	199.4	0.42	flint	251.46	256.08
09.01.2018	168.5	0.46	flint	227.83	227.37
10.01.2018	168.5	0.46	flint	216.97	227.37
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
22.12.2020	184.3	0.56	flint	246.68	229.55
23.12.2020	183,0	0.56	flint	244.69	244.26
24.12.2020	180.2	0.55	flint	233.92	238.47
25.12.2020	184.4	0.55	flint	249,00	247.56
26.12.2020	184.4	0.55	flint	252.14	254.06
27.12.2020	176,0	0.55	flint	255,00	265.26
28.12.2020	192.7	0.54	flint	247.62	234.14
29.12.2020	184.3	0.54	flint	246.06	232.04
30.12.2020	180.1	0.55	flint	248.73	256.25
31.12.2020	180.1	0.55	flint	256.15	259.63

Figure 4: Excerpt glass melting process data in a glass furnace after EMS implementation and energy consumption as the results of regression.

Figures 3 and 4 present a comparison of real energy consumption and that resulting from the MLRA calculation of energy consumption before and after EMS implementation.

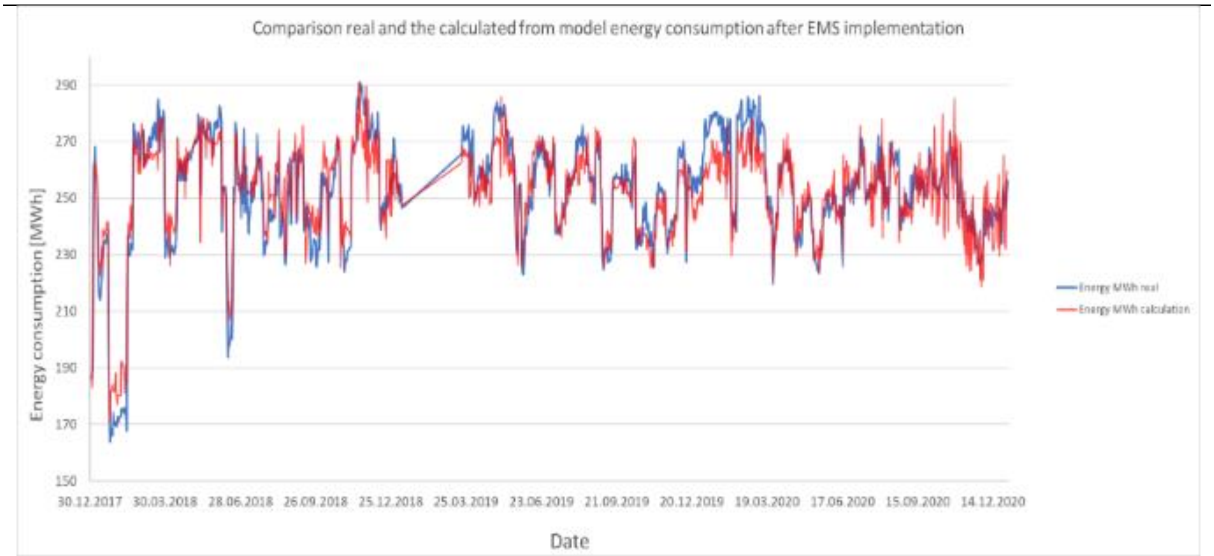


Figure 5. Comparison of real energy consumption and that resulting from the calculation before Energy Management System implementation.

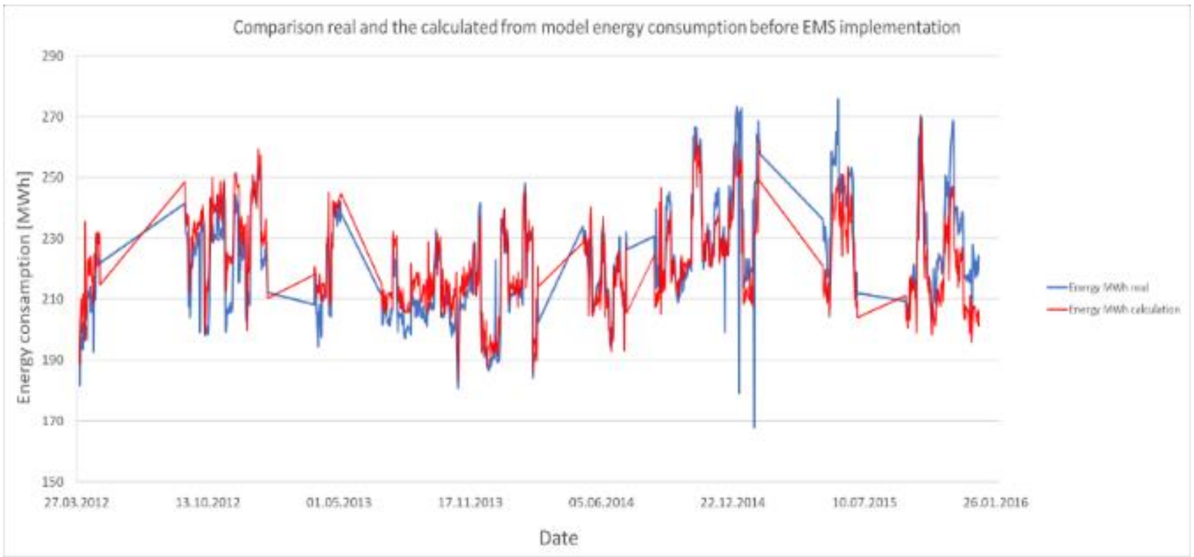


Figure 6. Comparison of real energy consumption and that resulting from the calculation after Energy Management System implementation.

Table 2: The results of relative errors and energy consumption per tonne of glass before Energy Management System implementation

Date	Energy per glass tonne [MWh/t]	Relative error [%]
01.04.2012	1.29	-3.81%
02.04.2012	1.19	-6.66%
03.04.2012	1.29	-0.59%
04.04.2012	1.21	-4.60%
05.04.2012	1.19	-3.25%
06.04.2012	1.11	-9.32%
07.04.2012	1.16	-4.66%
08.04.2012	1.30	2.65%
09.04.2012	0.97	-17.86%
10.04.2012	1.22	-1.15%
.	.	.
.	.	.
.	.	.
22.12.2015	1.41	9.47%
23.12.2015	1.42	7.47%
24.12.2015	1.42	6.82%
25.12.2015	1.41	5.43%
26.12.2015	1.40	4.88%
27.12.2015	1.45	9.17%
28.12.2015	1.39	6.41%
29.12.2015	1.38	5.86%
30.12.2015	1.38	6.02%
31.12.2015	1.47	10.27%

Table 3: The results of relative errors and energy consumption per tonne of glass after Energy Management System implementation

Date	Energy per glass tonne [MWh/t]	Relative error [%]
01.01.2018	1.67	-0.23%
02.01.2018	1.80	3.74%
03.01.2018	1.50	-0.17%
04.01.2018	1.32	-0.56%
05.01.2018	1.35	3.66%
06.01.2018	1.25	-1.61%
07.01.2018	1.28	0.30%
08.01.2018	1.26	-1.83%
09.01.2018	1.35	0.20%
10.01.2018	1.29	-4.80%
.	.	.
.	.	.
.	.	.
22.12.2020	1.34	6.94%
23.12.2020	1.34	0.18%
24.12.2020	1.30	-1.95%
25.12.2020	1.35	0.58%
26.12.2020	1.37	-0.76%
27.12.2020	1.45	-4.02%
28.12.2020	1.28	5.44%
29.12.2020	1.34	5.70%
30.12.2020	1.38	-3.03%
31.12.2020	1.42	-1.36%

The figures merely represent real energy consumption and that resulting from the calculation before and after Energy Management System implementation are not sufficient to compare energy consumption management (Figure 3 and 4). Therefore, Figures 5 and 6 summarize the calculated relative error for both energy consumption parameters and both time periods compared.

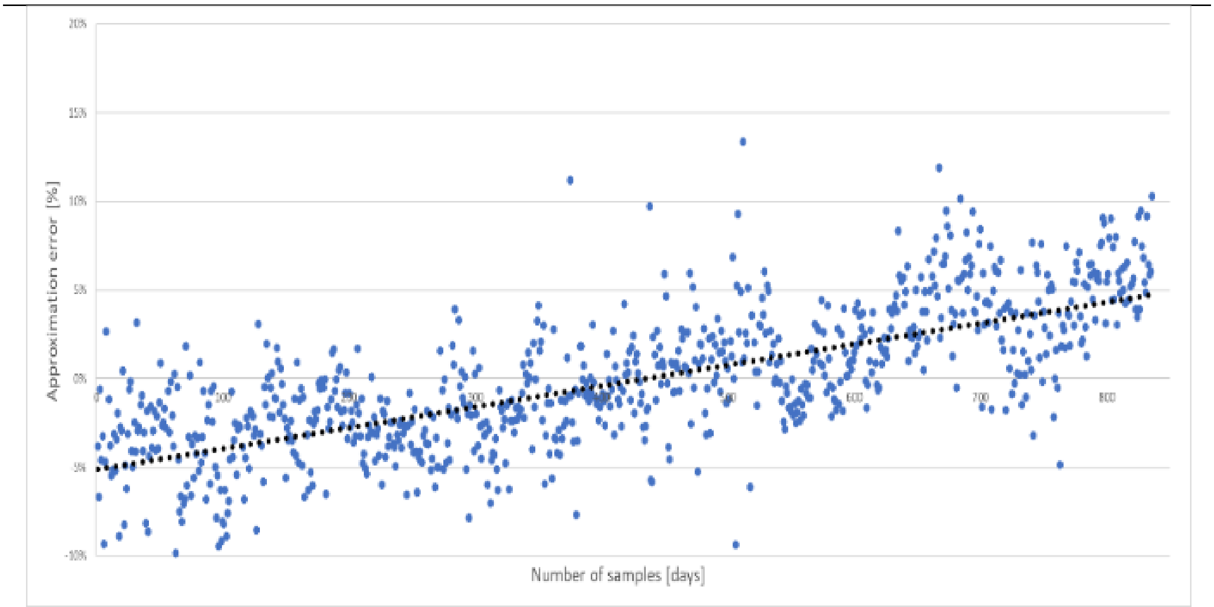


Figure 7. Energy consumption control relative error chart before EMS implementation

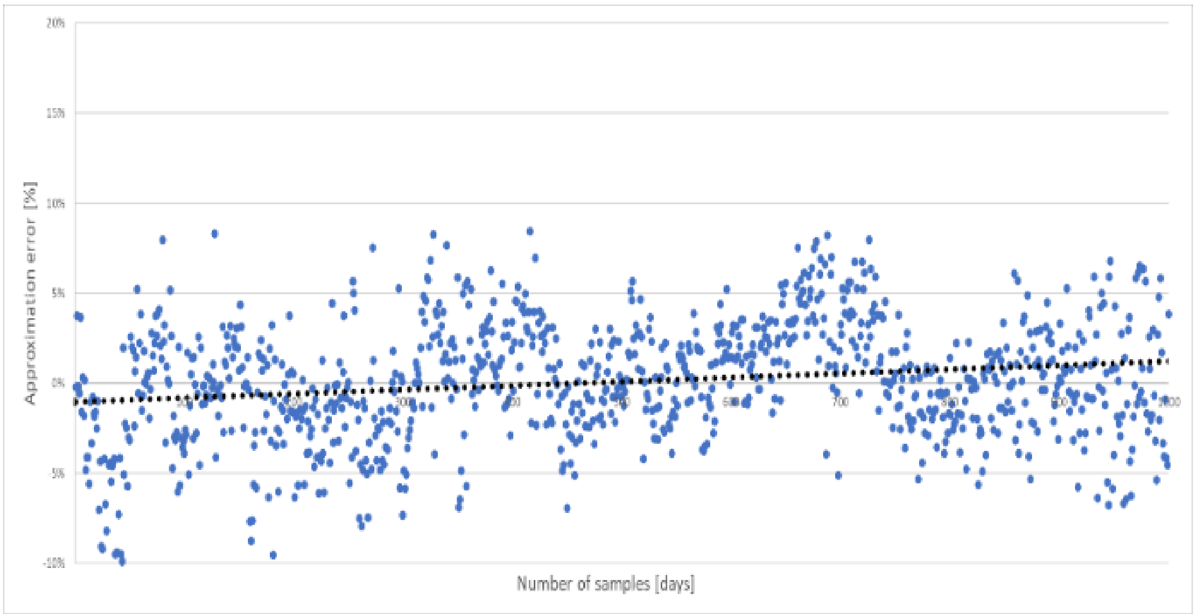


Figure 8. Energy consumption control relative error chart before EMS implementation

Table 4: represent final results of Energy Management System implementation as averages of relative error and averages of energy consumption per glass tonne, calculated according to equations 3 and 4.

	Average relative error [%]	Average energy per glass tonne [MWh/t]
Before EMS implementation	0.21	1.32

After EMS implementation	0.12	1.22

Analyses and calculations such as those presented in table 7 testify to improvements in the energy consumption of the ongoing glass melting process. The average relative error is lower for the data series collected after the implementation of the energy management system, this is a result of greater process control and smaller deviations in the daily consumption of energy utilities. The same conclusion can be drawn by comparing the average energy consumption per glass melted tonne, after the implementation of the system the ratio is lower.

6. Discussion

In the presented application of Multiple Linear Regression Analysis (MLRA) by the glass melting staff, each time the process parameters are changed, data is entered into a model which compares the current consumption with the predictive one. This allows for immediate decisions and the possibility of changes in the method of conducting glass melting process in the furnace.

What was proven by this study, which compared real energy consumption and that resulting from the calculation before and after Energy Management System implementation, shown in Figures 3 and 4, and was further verified by calculating and drawing the relative error of the two data sets (Figure 5 and 6). As could be observed, the trend line for the relative error for the compiled data after the implementation of the system (as presented in Figure 6) is significantly flatter, indicating smaller deviations between actual energy consumption and consumption that resulted from the MLRA model. This is also confirmed by the result in Table 7 comparing the average relative error before and after implementation of the EMS, where the average relative error is almost half lower for the post-implementation compilation. The same table also presents the results of the average energy use per ton of glass melting, which states an improvement in glass melting efficiency by an average of 8% after EMS implementation.

The example given is a simple solution to the use of data, knowledge, and system, but it does not fully describe the very large and complex issue of collecting and analyzing data and setting up a measurement and management system in a given exemplary glass factory. Improving energy efficiency in a glass factory is approached from several directions. The glassworks consume energy on equipment such as motors, pumps, compressors, etc. These important components require regular maintenance, good operation, and replacement when necessary. Therefore, a critical component of energy management at the plant is the effective control of the equipment that powers the plant's production processes [11].

As a result of EMS implementation, employees and the management department are provided with important information to anticipate anomalous situations, which significantly reduces unplanned downtime, as well as costs resulting from continued equipment malfunctions, particularly energy expenses. With this shared knowledge, plant safety can also be significantly improved, both from an environmental and industrial perspective [12].

7. Conclusion

Environmental protection is becoming an important issue for many companies and factories, both from the point of view of fulfilling legal regulations and promoting a "pro-environmental" corporate image. The Environmental Management System provides such planning and control of the implementation of activities that allows to reduce the level of threats to the natural environment, resulting from the operation of the company.

Process optimization and ensuring that the most productive technologies are in place are key to realizing energy saving in plant operation. Coordinating their efficiency and operation is necessary to ensure that energy savings are realized.

The purpose of this paper was to present issues concerning the establishment and management of an energy monitoring system as an advisory system. The use of energy monitoring and process control systems can play an important role in energy management and in reducing energy use. These may include sub-metering, monitoring, and control systems. By properly tracking the flow of utilities and the operation of energy equipment, they can reduce the time required to perform complex tasks, often improve product and data quality and consistency, optimize process operations, and improve production budgeting.

Analyses and calculations such as those presented in this article illustrate how energy and maintenance management systems can effectively contribute to the energy efficiency, safety, and reliability of plant operation, as well as its impact on the company's bottom line.

A successful energy management program begins with a strong organizational commitment to continuous energy efficiency improvement. This includes assigning supervisory and management responsibilities to an energy manager and establishing an energy policy. Steps and procedures are then put in place to evaluate performance through regular energy data reviews, technical assessments, and benchmarking. From this assessment, the organization can develop a baseline level of energy use and set targets for improvement. Performance targets help shape the development and implementation of the action plan.

8. References

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