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Original scientific paper

DEVELOPMENT OF THE ENERGY MANAGEMENT INFORMATIVE SYSTEM

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A b s t r a c t: The Industrial Revolution initiates an era of mass production and industrialization of cities that provides all the comforts of modern living, and thus the unconscious pollution of the planet, climate change and global warming. According to the Goddard Institute of Space Studies (GISS) of the National Aeronautics and Space Agency, the depths in the ozone layer and the increased carbon dioxide emissions in the air are responsible for increasing the surface temperature of the Earth by 1 °C in the last 100 years. As temperature rises on the Earth, we face an increase of sea level levels, a change in precipitation on a regional scale, frequent extremes in temperatures like heat waves, droughts, floods and snowstorms. The warming is felt more on the land surface than in the sea waters, while the most significant is the Arctic, where glaciers are starting to disintegrate, and this can lead to the eradication of some species of flora and fauna. For the human, global warming will lead to the challenge of providing food and leaving populated areas close to flooded areas. Many countries support the climate change convention and contribute to reducing the impact of GTC with climate engineering, with global warming being stopped before reaching 2 °C compared to the period before industrialization. By implementing a system for managing energy and renewable energy sources, it will contribute to the rational utilization of energy and energy sources and the formation of a sustainable society that will affect in future reduction of carbon dioxide emissions in the atmosphere.

Key words: EnMS – energy management system; self-sustaining facilities; management of processes; energy efficiency; EMIS – energy management informative system

РАЗВОЈ НА ИНФОРМАЦИСКИ СИСТЕМ ЗА УПРАВУВАЊЕ СО ЕНЕРГИЈАТА

А п с т р а к т: Со индустриската револуција започнува ерата на масовно производство и индустријализација на градовите, што ги овозможува сите удобности на модерното живеење, а со тоа и несвесно загадување на планетата, климатските промени и засилување на ефектот на стаклена градина. Според Институтот Годард за вселенски истражувања на НАСА, за зголемување на температурата на површината на Земјата за 1°С во последните 100 години се одговорни дупките во озонската обвивка и зголемената емисија на јаглероден диоксид во воздухот. Со зголемување на температурата на Земјата се соочуваме и со пораснување на нивото на водите во морињата, промена во врнежите и сушните периоди на регионално ниво, фреквентни екстреми во температурите како топлотни бранови, суши, поплави и снежни бури. Затоплувањето се чувствува повеќе на копнената површина отколку во морињата, а најзначајно е на Арктикот каде глечерите полека се топат, а тоа може да доведе до исчезнување на некои видови флора и фауна. За човечката раса глобалното затоплување ќе доведе до предизвик за обезбедување храна и до напуштање населени места блиску поплавните подрачја. Многу земји ја поддржуваат конвенцијата за климатски промени и со климатски инженеринг го даваат својот придонес за намалување на ефектот на стаклена градина, со што глобалното затоплување ќе биде стопирано пред да достигне 2°С во споредба со прединдустрискиот период. Со имплементирање на системите за менаџирање со енергенси и обновливи извори на енергија ќе се придонесе за рационално искористување на енергијата и енергенсите и формирање на одржливо општество, што пак во иднина ќе влијае врз намалување на емисијата на јаглероден диоксид во атмосферата.

Клучни зборови: EnMS– систем за менаџирање со енергенси; самоодржливи објекти; управување со процеси; енергетска ефикасност; EMIS – информативен систем за менаџирање со енергенси

1. INTRODUCTION

Advancement in technology used in everyday life for transportation and manufacturing leads to rapid increasment in energy consumption. Natural supplies of high calorie coal are reduced day by day. The life on this planet is not self-sustainable to support the burden of modern society, and in order not to affect the quality of this lifestyle, it is urgent to rationalize the usage of energy. This means saving energy for production by implementing Energy Management Systems (EnMS), as well as controlling energy consumption in real time.

EnMS will not only save energy for production, but also will make the consumer more independent from the supplier of energy and continuous fluctuations and increasment on the market prices.

When building new production plants or buildings it is essential to incorporate energy strategy and efficiency predictions for future energy use. In the existing buildings and industry plants it is important to make adjustments to incorporate energy efficient methodologies by making investments and process optimization that will lead to better use of energy.

The making of EnMS, the implementatiot and successful maintenance is complicated process that needs intradisciplinary professionals and experts in process automation and machine engineering, as well as sales and marketing.

2. LITERATURE REVIEW

As relatively new software tool, EnMS has high research potential in the development and in improving companies' performance and productivity [1, 2, 3, 6, 9]. In the improvement of overall company business strategies, EnMS uses informations and innovation integration for lowering the footprint in carbon trust of the company.

Base of this concept is **energy management**, that is elaborated in numerous books, reports and researches [3, 11, 12].

According to the many surveys, enough data have been collected that can be analyzed with few error options, leading to reliable sources of the structure and benefits of the EnMS energy management system. For the purpose of developing the model / prototype of the EnMS system, a manual [4, 10, 13] for managing energy is used as a reliable source that informs about the analysis, the technical and economic aspects of the heating and air conditioning systems, the control systems and automation, lighting, air quality control, energy maintenance, control over the procurement of energy sources, as well as for the procedure for measurement and verification of energy savings [4, 6, 10, 13].

The researchers generally agree on the benefits EnMS can provide. There are two types of energy management systems. The first type is EMIS information system for energy management monitors and monitors energy consumption in a defined unit (hourly, daily, monthly, etc.) [14, 15, 16] and exports reports and analyses regarding energy consumption. The second type, EnMS the energy management system continuously monitors consumption and allows for real-time corrective measures that will affect consumption [17, 18, 19].

3. MODEL OF THE ENERGY MANAGEMENT SYSTEM

In the sphere of innovation, the energy management system is one of the leading trends of the 21st century. Every facility, company and industry that strives to protect the environment and reduce greenhouse gas emissions as well as energy and energy savings will inevitably implement such a system. Energy Management System (EnMS) allows the planning and management of energy at hourly level [7], with each information coming to the top management of the company in the form of reports.

For successful implementation of the EnMS system for reducing consumption, it is first necessary to create an energy efficiency policy that will be supported by all employees. Next, it is necessary to determine the limits in which the company can influence the consumption of energy and energy sources. It implies whether all production units are locally compact or have production plants in different locations.

Subsequently, it is necessary to identify the main consumers of energy and energy sources. In each plant, one can determine which are the main consumers such as electricity, oxygen, compressed air, water and other energy sources, and each of those consumers should be placed on the optimization list [5, 8].

In order to achieve the desired energy and energy savings, a constant review of the results and actions taken in the production process is required. Minor improvements in the production process itself lead to major changes that are almost always in the direction of savings in materials, energy and energy sources, and thus increased profits of the company.

With proper knowledge of the production it is necessary to perform optimization of the process and the plants. This is not a simple job at all. Care should be taken not to disturb the quality of the finished product. It is necessary for the sector for commerce and procurement in the future to strive for energy efficient parts for which only the purchase price will not be important, but also to include calculations for energy consumption and ongoing maintenance. If in the part of purchases focuses only on an initially lower cost of an energy-inefficient system, over time it will be spent much more than if an energy-efficient part or device would be purchased which would be an investment that would soon be repaid taking the energy price who consumes it.

In order to see the results of the EnMS system for energy management, it is necessary to constantly check the energy and energy consumption and to review the possibilities for continuous improvement.

3.1. *Creating a model*

For the conceptualization of a model for energy and energy management, it is necessary to set control metering devices for measurements of the consumption of electricity at the measuring points that provide data on consumption and on which further calculation of the payment is made. Each of the measuring devices is required to provide data on active energy, reactive energy, maximum power and power factor as characteristics of the electrical energy transmission system [21].

Appropriate exits of the measuring devices are collected in a device called a concentrator, which serves as a collector of output impulses from the measuring devices. The collected impulses are converted into digital data that connect to the internal database through a computer network and are transferred to the company's main computer center, that is to the central computer servers. Different networking principles for control metering devices, the concentrator and the computer server are shown in Figure 1.

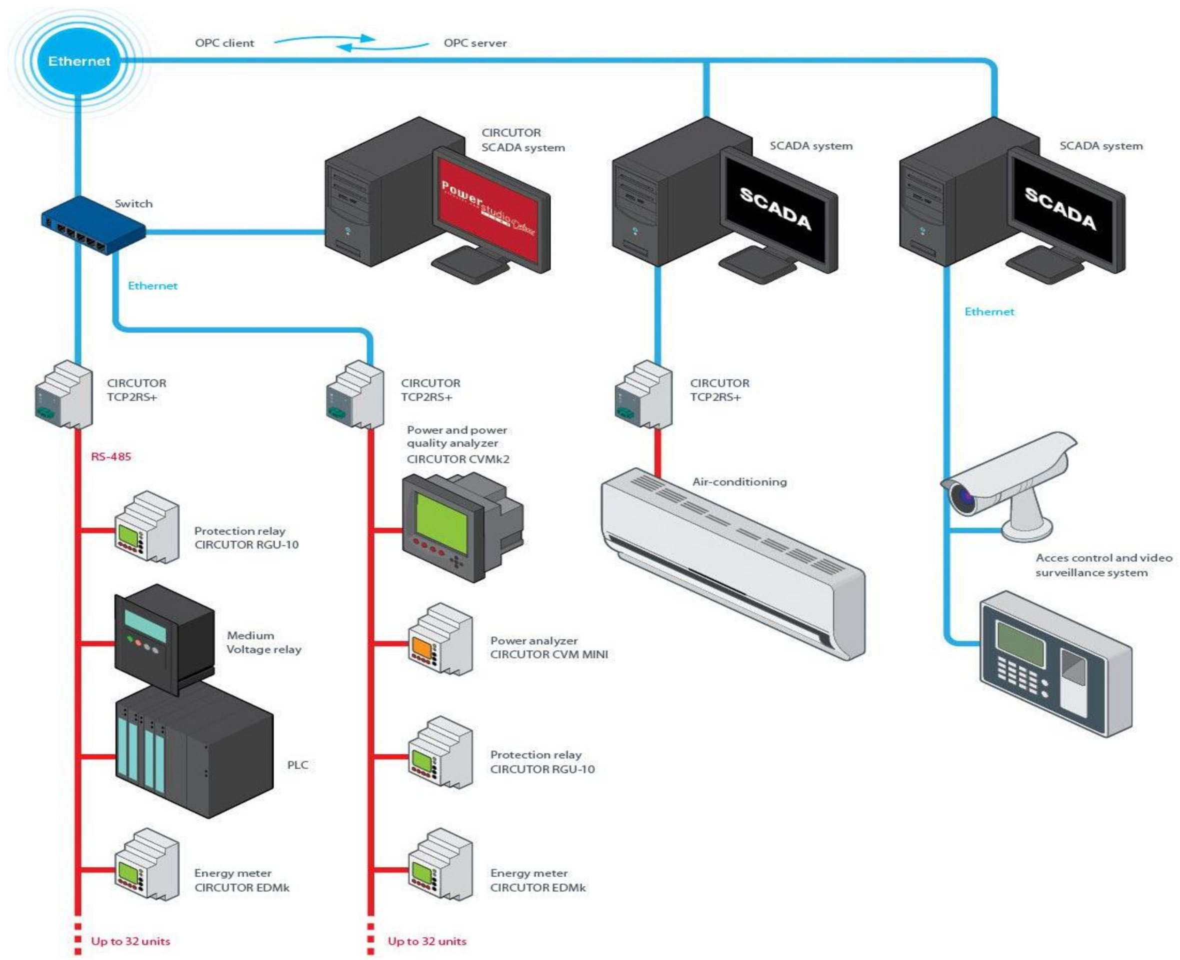

Fig. 1. An example of a network connection to an energy management model EnMS with SCADA [21]

In the case where the measuring devices are at a great distance from the computer server, data computer servers connected to a WLAN / GPRS modem must be set up for remote reading of the values of the measuring devices.

The creation of a model for energy management can be created in 4 phases [21, 22]:

1. In the first phase of the development of the model, ideas are generated from all employees covering this issue.
2. Then, the second phase of the concept modeling, which focuses on the research of the current state, possibilities for implementation of the envisaged system, is followed, and the ideas for innovations from different aspects are considered.
3. In the third phase, a completely new one can be developed, or existing computer software can be adapted to enable the existing measurement devices to be connected, or new metering devices can be installed in pre-selected key sites that have significant energy and energy consumption.
4. The fourth and final phase of the model provides for a correct nomination of the basic energy and energy consumption and monitoring the consumption of energy and energy sources for the current hour. To this end it is necessary to set monitors for supervision in all production facilities and to train persons who will further monitor the consumption of energy and energy sources directly from the monitor display and will react in real time according to the prescribed operating instructions and protocols of the company.

In order to begin with the concept of EnMS, it is necessary to know and select the significant consumers and which energy sources they use. It is necessary to place on the incoming energy sources measuring devices that will read the consumption in real time in accordance with the rules for the energy and energy sources at the energy market.

After the installation of the measuring devices, the software development phase is adapted for the needs of the dynamic process in all production plants in the company. The software allows to monitor the consumption of all energy sources that are connected in the energy and energy sources management system EnMS.

Each system is unique and tailored according to the production process and no single universal EnMS system can be made.

4. OPERATIONAL USE OF THE DEVELOPED MODEL FOR ENERGY MANAGEMENT

Real-time energy management is a modern technology that transforms the way of utilizing and supplying energy by continuously collecting data on consumption and tracking past performances. These data are analyzed using the methodology for calculation of energy consumption and as a result, optimization of propulsion consumption is obtained [20].

Sensors, measuring devices, protocols and other equipment that provides data in the system database (Figure 2), which then through analyses and other services shows the performance of the object in real time. As an output, the system can issue a recommendation to improve performance in real time, resulting in lower operating and service costs and the ability to limit consumption and maintain productivity [22].

Fig. 2. An example of connecting the energy management system EnMS [22]

4.1. *Methodology for calculation of energy savings*

The first step of calculation energy savings is collection of data from the quantity of final product produced and the energy used for its production. The report is generated from the company's information system (ERP). For the input parameters in the regression analysis used for the formation of an energy model, is the energy consumption of all machinery of the production process. As input are taken into consideration product specifications that affect consumption such as [22]: production activities, weather conditions, winter and summer regime of lighting and some routine variables that are measurable as shown in Table 1.

Table 1

Results of the calculation of energy consumption with mathematical regression model [22]

(K0)	(K1)	(K2)	(K3)	(K4)	(K5)	(K6)	(K7)	(K8)	(K9)	(K10)	(K11)
	Production units	Energy (MWh)	Predicted consumption (MWh)	EnPI	Actual savings (MWh)	Sum of actual savings (MWh)	Target (MWh)	Target savings (MWh)	Cum sum of target savings (MWh)	Price €	Savings €
Jan-15	20.200	850.320					0				
Feb-15	20.469	801.359									
Mar-15	20.737	806.434									
Apr-15	21.006	811.509									
May-15	21.274	816.583									
Jun-15	21.543	821.658									
Jul-15	21.811	826.733									
Aug-15	22.080	831.807									
Sep-15	22.349	836.882									
Oct-15	22.617	841.957									
Nov-15	22.886	847.031									
Dec-15	21.543	852.106				0			0		
Jan-16	23.423	813.250	815.189	0,03	-1.939	-1.939	809.184	-6.005	-6.005	406.625	-9.695
Feb-16	23.691	800.370	812.270	0,03	-11.900	-13.838	796.368	-15.901	-21.907	400.185	-59.498
Mar-16	23.960	808.340	809.350	0,03	-1.010	-14.849	804.298	-5.052	-26.958	404.170	-5.050
Apr-16	24.229	806.100	806.431	0,03	-331	-15.179	802.070	-4.361	-31.320	403.050	-1.653
May-16	24.497	802.111	803.511	0,03	-1.400	-16.579	798.100	-5.411	-36.730	401.056	-7.001
Jun-16	24.766	797.592	800.592	0,03	-3.000	-19.579	793.604	-6.988	-43.718	398.796	-14.999
Jul-16	25.034	787.622	797.672	0,03	-10.050	-29.630	783.684	-13.988	-57.707	393.811	-50.252
Aug-16	25.303	784.833	794.753	0,03	-9.920	-39.550	780.909	-13.844	-71.551	392.417	-49.600
Sep-16	25.571	780.340	791.834	0,03	-11.494	-51.043	776.438	-15.395	-86.946	390.170	-57.468
Oct-16	25.840	760.914	788.914	0,03	-28.000	-79.043	757.109	-31.805	-118.751	380.457	-140.000
Nov-16	26.109	765.955	785.995	0,03	-20.040	-99.083	762.125	-23.869	-142.620	382.978	-100.198
Dec-16	26.000	698.150	787.175	0,03	-89.025	-188.108	694.659	-92.516	-235.136	349.075	-445.124
Jan-17	26.000	786.756	787.175	0,03	-418	-188.526	782.823	-4.352	-239.488	393.378	-2.092
Feb-17	26.914	780.775	777.236	0,03	3.539	-184.987	776.871	-365	-239.853	390.388	17.693
Mar-17	27.183	774.794	774.317	0,04	477	-184.511	770.920	-3.397	-83.921	387.397	2.384
Apr-17	27.451	768.812	771.398	0,04	-2.585	-187.096	764.968	-6.429	-98.075	384.406	-12.926
May-17	27.720	762.831	768.478	0,04	-5.647	-192.743	759.017	-9.461	-112.229	381.415	-28.236
Jun-17	27.989	756.850	765.559	0,04	-8.709	-201.452	753.065	-12.493	-126.382	378.425	-43.545
Jul-17	28.257	750.868	762.639	0,04	-11.771	-213.223	747.114	-15.525	-140.536	375.434	-58.855
Aug-17	28.526	744.887	759.720	0,04	-14.833	-228.056	741.162	-18.557	-154.690	372.443	-74.165
Sep-17	28.794	738.905	756.800	0,04	-17.895	-245.951	735.211	-21.589	-225.951	369.453	-89.475
Oct-17	27.720	732.924	768.478	0,04	-35.554	-281.505	729.259	-39.219	-261.505	366.462	-177.770
Nov-17	24.720	726.943	801.089	0,03	-74.146	-355.651	723.308	-77.781	-350.620	363.471	-370.730
Dec-17	25.720	726.943	802.069	0,03	-75.126	-430.777	723.308	-78.761	-420.777	363.471	-375.631
Jan-18	29.869		745.123						average	384.539	**-2.153.887**
Feb-18	30.137		742.203								
Mar-18	30.406		739.284								
Apr-18	30.674		736.364								
May-18	30.943		733.445								
Jun-18	31.211		730.526								
Jul-18	31.480		727.606								
Aug-18	31.749		724.687								
Sep-18	32.017		721.767								
Oct-18	32.286		718.848								
Nov-18	32.554		715.928								
Dec-18	32.823		713.009								

Table 1 shows the calculated energy savings results using the regression model in the time frame for which the analysis is performed. In Table 1, 2015 is taken as the base year through which the implementation of EnMS takes place. The next two years, 2016 and 2017, are the years on which the mathematical model is formed, and the predictions are made on the basis of the planned production for 2018.

The first column (K1) represents the unit value of the final product expressed in pieces, tons, liters, depending on how the company calculates the final product, while the second column (K2) represents the amount of electricity in MWh consumed in the production.

The predicted energy consumption (K3) is the output of the regression analysis that is the sum of the intersection with the coefficients multiplied by the corresponding input parameter, as shown in the third column (K3), and represents the frame in which the consumption should vary. Calculated values of predicted consumption are shown in column 3 (K3) and together with the energy consumed (K2) construct the graph shown in Figure 4.

The fourth column (K4) in Table 1 represents the energy performance coefficient, which gives the percentage of the expected consumption versus realized consumption. The fifth column (K5) represents the real savings from the regression model and the consumed energy where it can be noted how much MWh are saved monthly. The sixth column (K6) represents a cumulative amount of savings over the period.

Target savings (K8) derrives from the mathematical regression model and shows how much MWh should be spend monthly according to the planned production, in order to achieve the desired savings, that in this case is 3% savings already calculated in the results.

The last columns represent the savings expressed in a monetary unit, that is to say the cost of the energy in euros (K10) and the monthly saving of MWh expressed in euros (K11).

The difference between the anticipated (K3) and the realized consumption (K2) is discussed further with the team and the reasons for the specific deviations are analyzed.

The actual savings column (K5) represents the difference from the planned consumption (K3) according to the mathematical model and the actual consumption (K2) according to the measured values. The purpose of the formed model is to produce a monthly target-savings (K8) of a certain percentage (in the model of Table 1 it is 3%), which should be regulary checked during production. This percentage is not fixed and is part of the company's energy saving policies and can vary on annual basis. To change the target savings (K8), the calculated formula changes the predicted percentage and automatically generates the monthly targeted savings that needs to be achieved.

The last two columns (K10) and (K11) show the monthly price of electricity expressed in euros for a large industrial consumer.

According to the energy strategy, the company sets annual target savings that needs to be achieved. According to target consumption (K7) and savings (K8), the long-term goals in line with the energy policy are followed, the potential targets and investments for energy savings in the next year are updated and action plans are being set up. Company policy should aim at energy efficient maintenance of significant energy users through maintenance training, monitoring of critical operating parameters, plan for effectively planned maintenance and employee awareness of their impact on the energy consumption on each significant user.

4.2. *Use of the developed model*

The first step of the monitoring the energy usage is completed with the implementation of the EnMS system. The next step is managing energy, which means real time monitoring and managing consumtion of each siginificant energy user.

Every company needs to know the significant energy users and the type of energy they use in the production process, since the initial optimization starts with them. The other less significant consumers have a lower priority in the process of introducing energy efficiency principles [22]. For example, in a large manufacturing industry, it is insignificant if the lighting in the halls is completely replaced with efficient solutions, if the motors or boilers are inefficient, while in office facilities, lighting is an important factor.

With the formulated regressive model for each consumer, a consumption plan for the next year can be determined and calculated whether the plant is energy efficient despite of the production. From the results obtained with the conducted mathematical regression analysis and from the developed models of energy performance, a plan for consumption for the next period can be formed. For future energy consumption forecasts according to the planned production quantity, energy managers can choose to set the target so it will achieve the best performance of the previous year or choose a fixed savings of a certain percentage. In the case of fixed savings (K9), the percentage is entered in the creation of the model and consumption is required to follow the trend of the model. In case when the consumption (K3) is less than (K8), energy savings are made which in the real case are shown in (K9), and in case the actual consumption (K2) is above the trend of the model, the plant consumes more than planned, there is a loss of energy and in that case where it is necessary to intervene, which means corrective action needs to be taken.

The savings resulting from Table 1 columns (K6) and (K9) are shown in the following graph (Figure 3) from which it can be concluded that to a certain point the amount of target savings (K9) (shown in red trend line) and the amount of the actual savings (K6) (shown by the blue trend line) are followed by which period the efficiency of the plant increases and the actual savings exceed the planned savings [22].

The graph shown in Figure 3 refers to the savings shown in Table 1. The time period is two years, i.e. 24 months, from 2016 to 2017 [22].

According to the data from Table 1, for the specific mathematical regression model and analysis of the consumed energy according to the production, it can be noted that the return on the initial investment for a period of 6 months. As an initial investment, the data from Table 1 and the cost of energy with EnMS were taken.

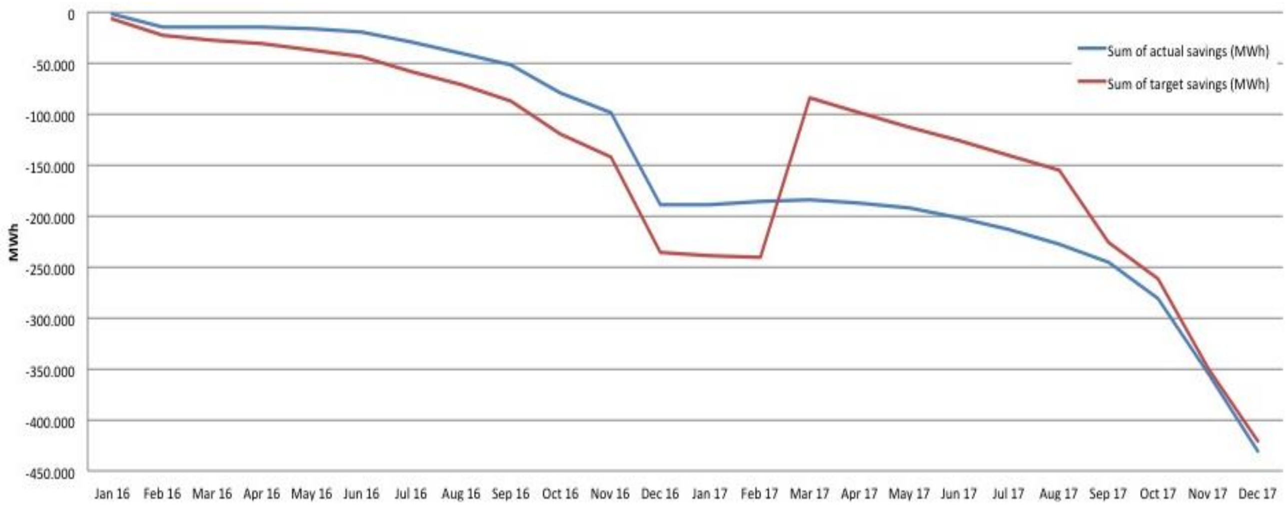

Fig. 3. Graphic representation of the savings achieved with EnMS [22]

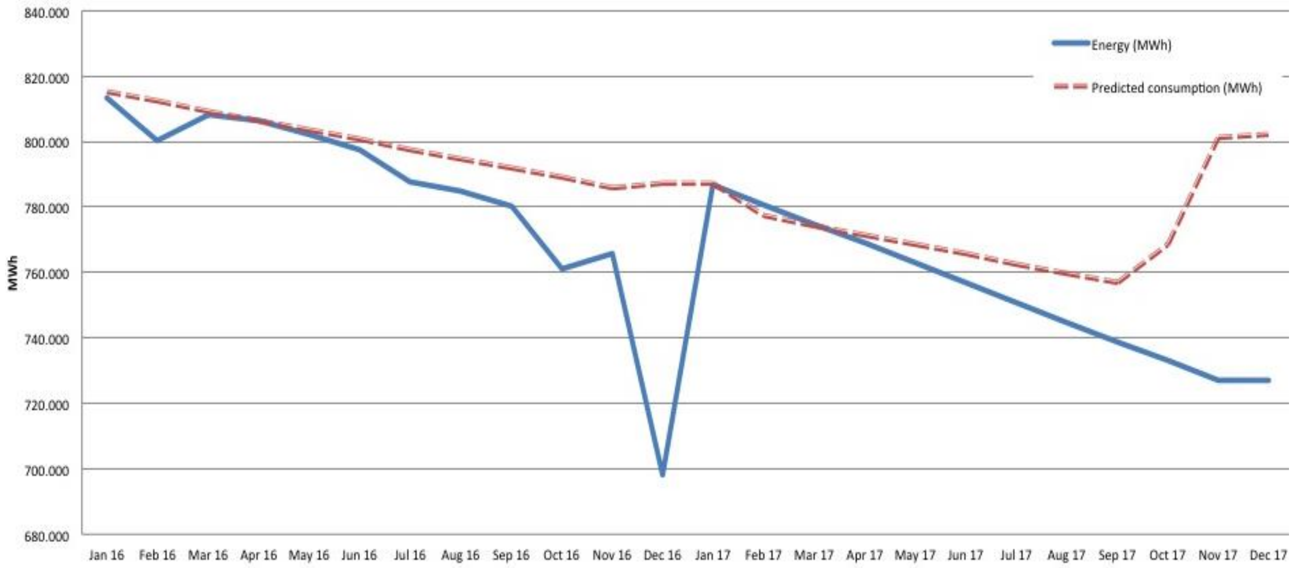

Fig. 4. Regressive models of calculation of consumption and future prediction [22]

On the basis of the obtained results from Table 1 and the calculated consumption (K3), the regressive models shown in Figure 4 are formed, where the dashed line (shown in red) represents the predicted energy consumption (K3), while the full trend line (shown by blue color) represents the actual consumption (K2). From the analysis of the results and the graph, it can be noted that by January 2017 the real consumption is lower than planned, which means that everything is in accordance with the energy policy, the promoted energy practices and procedures of the company are satisfied.

In the second month of 2017, it can be noted that consumption is greater than anticipated, which can be influenced by several factors and it is necessary to consider that month specifically and directed to the quality of operations. On the basis of this principle, consumption prediction can be performed when the planned quantity of product units is known for a certain period of time [22].

5. COMPARATIVE ANALYSIS OF THE RESULTS OBTAINED WITH THE DEVELOPED MODEL

The energy management system is a significant investment. While there is an opportunity for the company to directly implement ready-made solutions for EnMS, but it can also develop and adapt software. Given the quantities produced on the final product, the price for transmission, distribution and balancing of the energy can be rounded up to a monthly savings of around 10%. This entails a return on investment in less than a year [22].

With operational control in the production process and taking into account the minimum investment for the energy management system, depending on the dynamics of the production process, in some industries, the investment for EnMS can also be paid for a shorter period of operational operation. If the user spends an average of 40 MWh (shown in Table 2, column (K2)) with an appropriate day ahead nomination of energy, one can significantly affect the cost per MWh. By nominating an upper limit on consumption in moments when the stock exchange of energy is more expensive than the price of the trader or the nomination of the lower limit of consumption in the period when the price of the stock exchange is significantly lower than the trader, there are large variations in the cost of production for the final product.

For industries that are dominant electricity consumers, this model represents a negligible investment leading to large energy savings. A key role in the success of the EnMS model is the system for predicting the consumption or expertise of the team working with the nomination. The members of the team should be adequately familiar with the production process and the dynamics of foreign exchange markets for the electricity market, because any wrong forecast and estimate is a loss, and any good prediction leads to a reduction in the unit cost price and the competitiveness of the company's market [22].

Table 2 gives the energy consumed for the current hour (K2), the announced energy (K3) and (K4) and an example of the prices of electricity from the stock exchange in two days (K5) and (K6) for the analysis of 46th week of the year. From the data in Table 2, it can be concluded that one precisely predicted day is enough to pay off the investment of the EnMS system in relation to the received cost of consuming the consumed electricity [22].

For medium and small consumers, it may be necessary to have a longer period of time to see the positive effects and savings from such an advanced model of EnMS for monitoring and managing the consumption of energy.

Depending on the variations in the price of the stock exchange at the hourly level as shown in Table 2, fewer can be announced, and a larger amount of energy is taken. In that case, when the price of the free market is lower than the trader, a reduction in the cost per unit of MWh is taken. With the EnMS model in these days, more than 50% of the energy cost can be saved. But there are days when the price of electricity on the market is greater than the one offered by the trader. In those days it is necessary to announce the upper limit of consumption and take a minimum amount of energy from the free market.

Table 2 shows the data for each hour of consumed energy (K1), standard consumption (K2) and an example of two announcements of the energy supply from a trader (K3) and (K4). The price offered by the merchant is fixed for each day of the month, while the price of electricity on the free market varies at hourly level. Without an EnMS monitoring system (Table 2, Columns (K8) and (K9)), daily nominations will be a significant challenge.

Total expressed energy consumed (K2) which is taken to calculate one day is approximately 900 MWh. For fixed power consumption at a given hour, different amounts of energy (K3) and (K4) can be nominated, which will give different values in the formation of the final energy price shown in the columns (K8) and (K10). The same applies to the columns (K9) and (K11) for a different value of the free market price (K7), which on that day is significantly higher than the price of the trader. Without the EnMS model, there is a significant difference in the value of the funds spent with respect to the use of the EnMS model (Table 2, columns (K10) and (K11)).

It is significant that using the EnMS model saves the company's financial resources (Table 2, Columns (K9) and (K11)) and when the team has a poor forecast or announcement (K4).

T a b l e 2

Overview of the nomination of consumption with and without the energy management system EnMS [22]

(K0)	(K1)	(K2)	(K3)	(K4)	(K5)	(K6)	(K7)	(K8)	(K9)	(K10)	(K11)
	Production units	Energy (MWh)	Predicted consumption (MWh)	EnPI	Actual savings (MWh)	Sum of actual savings (MWh)	Target consumption (MWh)	Target savings (MWh)	Sum of target savings (MWh)	Price €	Savings €
Jan 16	23.423	813.250	815.189	0,03	-1.939	-1.939	809.184	-6.005	-6.005	406.625	-9.695
Feb 16	23.691	800.370	812.270	0,03	-11.900	-13.838	796.368	-15.901	-21.907	400.185	-59.498
Mar 16	23.960	808.340	809.350	0,03	-1.010	-14.849	804.298	-5.052	-26.958	404.170	-5.050
Apr 16	24.229	806.100	806.431	0,03	-331	-15.179	802.070	-4.361	-31.320	403.050	-1.653
May 16	24.497	802.111	803.511	0,03	-1.400	-16.579	798.100	-5.411	-36.730	401.056	-7.001
Jun 16	24.766	797.592	800.592	0,03	-3.000	-19.579	793.604	-6.988	-43.718	398.796	-14.999
Jul 16	25.034	787.622	797.672	0,03	-10.050	-29.630	783.684	-13.988	-57.707	393.811	-50.252
Aug 16	25.303	784.833	794.753	0,03	-9.920	-39.550	780.909	-13.844	-71.551	392.417	-49.600
Sep 16	25.571	780.340	791.834	0,03	-11.494	-51.043	776.438	-15.395	-86.946	390.170	-57.468
Oct 16	25.840	760.914	788.914	0,03	-28.000	-79.043	757.109	-31.805	-118.751	380.457	-140.000
Nov 16	26.109	765.955	785.995	0,03	-20.040	-99.083	762.125	-23.869	-142.620	382.978	-100.198
Dec 16	26.000	698.150	787.175	0,03	-89.025	-188.108	694.659	-92.516	-235.136	349.075	-445.124
Jan 17	26.000	786.756	787.175	0,03	-418	-188.526	782.823	-4.352	-239.488	393.378	-2.092
Feb 17	26.914	780.775	777.236	0,03	3.539	-184.987	776.871	-365	-239.853	390.388	17.693
Mar 17	27.183	774.794	774.317	0,04	477	-184.511	770.920	-3.397	-83.921	387.397	2.384
Apr 17	27.451	768.812	771.398	0,04	-2.585	-187.096	764.968	-6.429	-98.075	384.406	-12.926
May 17	27.720	762.831	768.478	0,04	-5.647	-192.743	759.017	-9.461	-112.229	381.415	-28.236
Jun 17	27.989	756.850	765.559	0,04	-8.709	-201.452	753.065	-12.493	-126.382	378.425	-43.545
Jul 17	28.257	750.868	762.639	0,04	-11.771	-213.223	747.114	-15.525	-140.536	375.434	-58.855
Aug 17	28.526	744.887	759.720	0,04	-14.833	-228.056	741.162	-18.557	-154.690	372.443	-74.165
Sep 17	28.794	738.905	756.800	0,04	-17.895	-245.951	735.211	-21.589	-225.951	369.453	-89.475
Oct 17	27.720	732.924	768.478	0,04	-35.554	-281.505	729.259	-39.219	-261.505	366.462	-177.770
Nov 17	24.720	726.943	801.089	0,03	-74.146	-355.651	723.308	-77.781	-350.620	363.471	-370.730
Dec 17	25.720	726.943	802.069	0,03	-75.126	-430.777	723.308	-78.761	-420.777	363.471	-375.631
									Average	384.539	**-2.153.887**

Figure 5 shows a graphic representation of the price of electricity for hourly production of final product. It is significant to notice the variation in the price of energy for the same quantity of produced final product.

Figure 6 shows the quantity of nominated energy and real consumption of electricity hourly. The nominated energy is charged at the price given by the trader, while the remaining energy is taken from the market. In days when the price of energy from the stock is lower than that of the trader, it is desirable to nominate a smaller amount of energy, while in periods when the price of the trader is lower, it is desirable to nominate a greater amount of energy to reduce the cost of production of a unit product.

Figure 7 shows the difference in the cost price needed for the production of a unit product. For the production of a single product, the price may vary considerably. One influential factor is the price of electricity in the market for a certain hour, then the nomination, i.e, the amount of electricity that is taken from the trader and the rest from the market. The most important factor for increasing the savings of the company is the EnMS energy management system, which monitors the consumption in real time and can minimize the negative effects of the market prices. Without the developed model of EnMS, from Figure 7 it can be easily assessed and realized that the price of the product is twice as high.

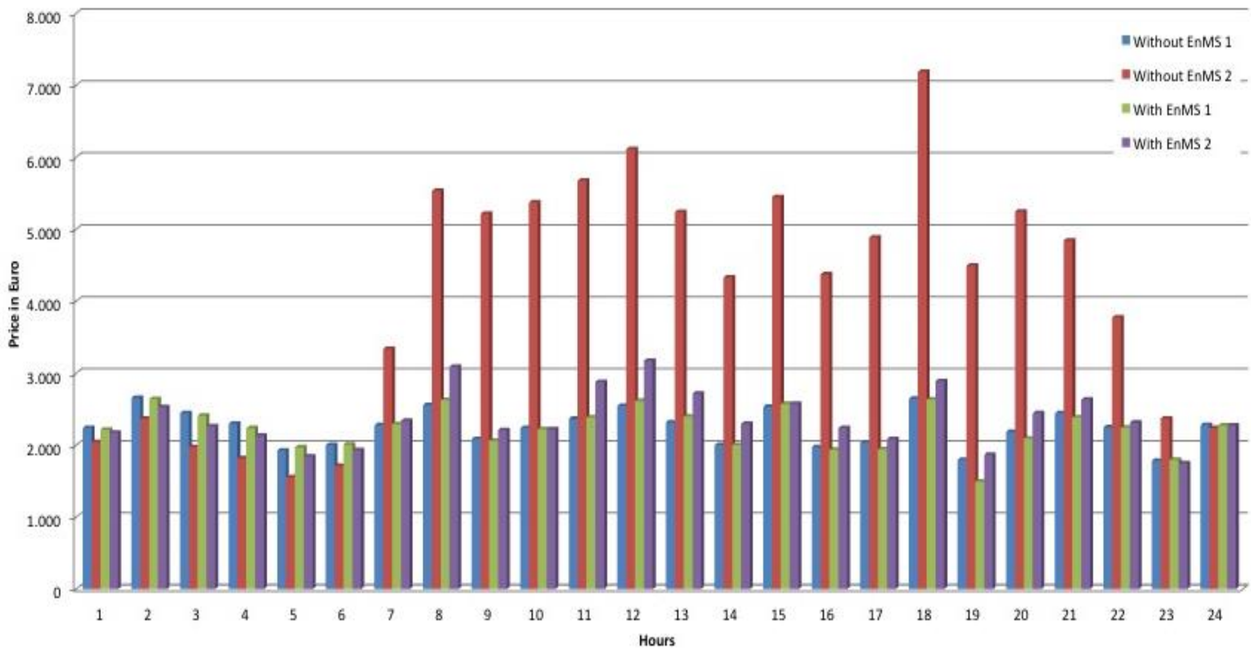

Fig. 5. Price for hourly production expressed in euros [22]

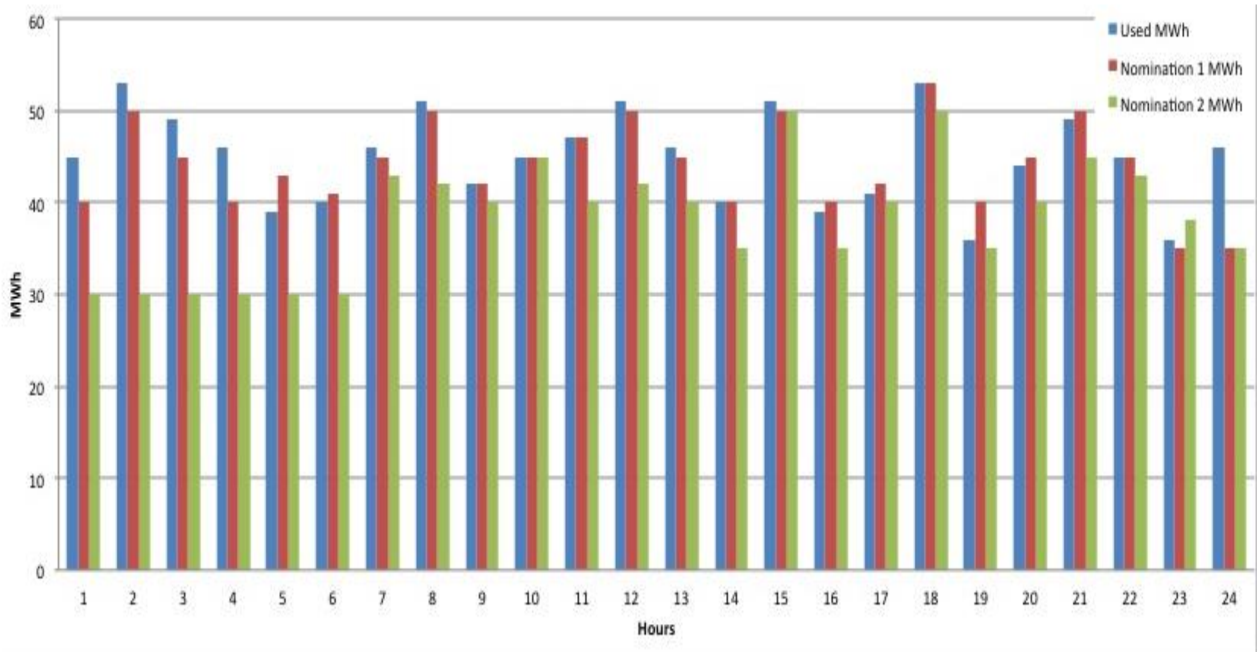

Fig. 6. The nominated and spent amount of energy expressed in MWh [22]

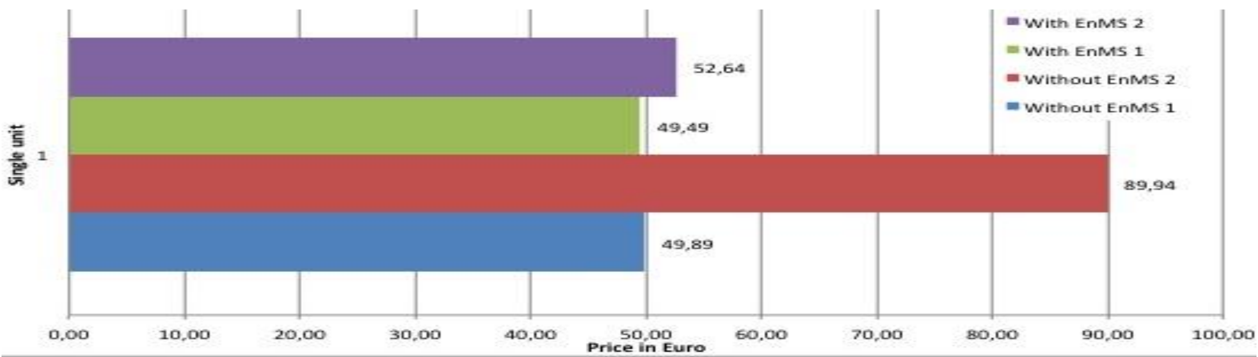

Fig. 7. Average price for energy on a daily basis [22]

6. CONCLUSION

With the implementation of the EnMS the company's competitiveness and sustainability on the market is advanced, new business benefits are opened, energy performance improves and systematic approach to consumption is introduced. The first savings can be seen through successfully performed operational control and investments. The most important benefit is the financial savings, but also the reduced emission of carbon gases in the air, thereby reducing the greenhouse effect that leads to global climate change. A key path to successful implementation of EnMS is the believe that a change can be made with the appropriate team and commitment from top management and through planning, monitoring and verification of the action plans for saving, which improves the energy performance of industrial facilities and opens new opportunities and challenges for saving.

It is necessary to see EnMS system as an continuous process, and not as a one-time project, which when it reaches the maximum savings, it will cease. Energy management is a cycle where there is always an opportunity for improvement that is not always visible, until the current period is compared to the beginning, in order to notice the inevitable success.

For the production of a single product, the price may vary considerably. One influential factor is the price on the market for a certain hour, then the nomination, thet is to say the amount of energy taken from the trader, and from the market. The most important factor for increasing the savings of the company is the EnMS energy management system, which monitors the consumption in real time and can minimize the negative effects of the market.

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