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Energy Audit of an Enterprise for Powder Coating and Blasting Details

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Abstract: An energy audit of an enterprise for powder coating and blasting details was carried out. The production process in an enterprise was examined. A description of technological processes and technological equipment was made. Primary information regarding energy costs incurred in an enterprise for three year period was collected and analyzed. The baseline for energy consumption, depending on the energy consumption in an enterprise for the considered period of the survey was determined. Specific energy costs of an enterprise before and after energy saving measures was calculated and compared. Energy-saving measures, object of investment intention, were presented. Energy and non-energy cost savings from the applied energy saving measures were analyzed. The increase in productivity and competitiveness of the enterprise as a result of the proposed energy-saving measures was shown. On this basis an economic and ecological assessment of the proposed energy-saving measures was carried out. Energy savings in an enterprise are presented as saved energy in kWh/year and as saved carbon emissions in tons of CO_2/year.

Keywords: Technology, Energy engineering, Energy efficiency

Introduction

To mandatory energy efficiency audit in accordance with regulation act in Bulgaria are: large enterprises for the production of goods, large service providers, industrial systems whose annual energy consumption is over 3000 MWh (AYEP, 2016a, 2016b). Small and medium-sized enterprises most often have lower annual energy consumption than the above-mentioned value. Their competitiveness on the European market depends on the following three factors:

- high quality of the produced product;
- low energy costs in production;
- good working conditions for workers.

In addition to improving quality of their products, enterprises strive to achieve European requirements of product quality (Baev et al.,2015; Kaloyanov et al, 2020; Ivanov et al., 2021; Kamburova et al., 2017; Iliev et al., 2013). This allows them to implement quality standards in their production and to sell their products on the European market. The product produced must be manufactured in such a way that during its production minimal CO_2 emissions are released into the environment. Furthermore, for an enterprise to be competitive, the specific energy costs of the enterprise per unit of output product must be as low as possible.This includes energy-saving measures in:

- implementation of highly efficient boilers burning fuels emitting low levels of carbon dioxide;
- implementation of energy-efficient technological equipment in the technological scheme of the enterprise - machines and devices with low consumption of electrical and thermal energy;
- implementation of equipment operating with renewable energy sources - photovoltaic systems, solar systems for hot water, heat pumps, etc.

- implementation of equipment that utilizes waste heat in enterprise - ventilation recuperation systems, heat pumps, etc.
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The use of highly energy-efficient equipment also has an additional beneficial effect - a significant reduction in operating costs in the enterprise, related to maintenance and repair activities of technological and auxiliary equipment. The direct losses of the enterprise due to unforeseen interruptions of the production process are also reduced. It is important for owners to have real-time information about all costs in the enterprise. In terms of energy costs, this is achieved by introducing energy management and monitoring systems into production. By introducing this type of system, a reduction in energy costs in the enterprise is guaranteed due to the absence of long periods in which the equipment in the enterprise will operate in an inefficient mode. The presence of an energy management and monitoring system is a mandatory condition for the enterprise to implement a certain European quality standards, which will open up new markets for the sale of its products. In addition to the presence of energy management and monitoring systems, low energy costs in the enterprise are also guaranteed by conducting periodic training for personnel. These trainings discuss guidelines for reducing energy costs, which are mandatory for those working in the enterprise.

The increase in the production capacity of the enterprise after the introduction of energy-saving measures should not lead to a deterioration in working conditions for its workers. The implemented technological equipment should have a high degree of automation, which will lead to the possibility of the operator to perform more activities. In order to increase the productivity of labor activities, the worker should also be provided with good working conditions such as:

- optimal air temperature in work premises;
- optimal amount of fresh air in work premises;
- optimal lighting in work premises;
- provision of hot water for sanitary and hygienic needs, etc.

Assessment of the need and effectiveness of energy-saving measures in an enterprise is carried out with the help of energy audit (Rasheva, 2011; Thuman & Younger, 2008; Turner, 1997; Capeheart, et al.,2012; Doty,2016).

In the current energy audit of the enterprise for powder coating and blasting details, the following are proposed:

- energy-saving measures related to the implementation of highly efficient technological equipment;
- energy-saving measures to improve working conditions in the enterprise - temperature, amount of fresh air and lighting of work premises;
- energy-saving measures related to real-time monitoring of electricity consumption in the enterprise.

Method

The object of the present energy efficiency audit of an industrial system is a machine enterprise in Bulgaria. The enterprise provides services related to powder coating and blasting metal details. The following technological processes in process are carried out:

- manual degreasing and drilling on details;
- hooking of detail on a rail track;
- applying a powder coating to detail;
- detail calcination in furnace;
- detail cooling;
- detail packaging.

Detailed energy analysis of the enterprises includes:

- collection of primary information on the energy costs of the enterprise for a period of 3 consecutive years and analysis in order to determine the potential for energy savings;
- determination of a reference year, on the basis of which the baseline of energy consumption of the enterprise is determined;
- determination of specific energy consumption depending on the production in the enterprise;

- determining the amount of energy savings as saved energy and as saved carbon emissions to the environment.

Results and Discussion

In Table 1 are shown data on installed electrical power of the facilities in the enterprise.

Table 1. Installed electrical power of the facilities in the enterprise

Name	Value	Power, kW	Total power, kW
Main technological equipment			
Electrical furnace	1	75.00	75.00
Electrical furnace	1	45.00	45.00
Powder gun	3	0.00	0.00
Auxiliary technological equipment			
Screw type compressor for compressed air, working pressure 8 atm	1	7.50	7.50
Refrigeration air dryer	1	0.41	0.41
Screw type compressor for compressed air, working pressure 6 atm	1	4.50	4.50
Groundwater pump	1	2.00	2.00
Water deionization installation	1	0.25	0.25
Lighting	16	0.054	0.86
Heating devices (Others)	2	6.00	12.00
Hot water tank	1	3.00	3.00
Total usable power			150.52

The main problems in the production process are two and they are:

- Low degree of automation of the available basic facilities involved in the technological process;
- Impossibility of fulfilling the requirements of the European Union regarding the quality of the coatings of the metal parts.

In Table 2 are shown data for annual consumption of electrical energy in enterprise for 2021, 2022 and 2023 year.

Table 2. Annual consumption of electrical energy in enterprise for 2021, 2022 and 2023 year

Year	2021	2022	2023
Month	kWh	kWh	kWh
January	19056	18654	19882
February	19724	18964	18885
March	18879	19542	20158
April	18645	18999	20004
May	19120	18563	19532
June	18774	19004	19556
July	19005	17642	18658
August	18507	19112	19957
September	17597	17209	17888
October	19649	20266	21422
November	20544	20333	20741
December	19056	18854	19357
Total	228556	227142	236040

Data in table show that annual consumption of electrical energy in enterprise is higher for 2023 year.. This is why this year was chosen as a reference year for energy audit. On Figure 1 are shown correlation between used energy in enterprise and number of manufactured unit, which is specified in square meters.

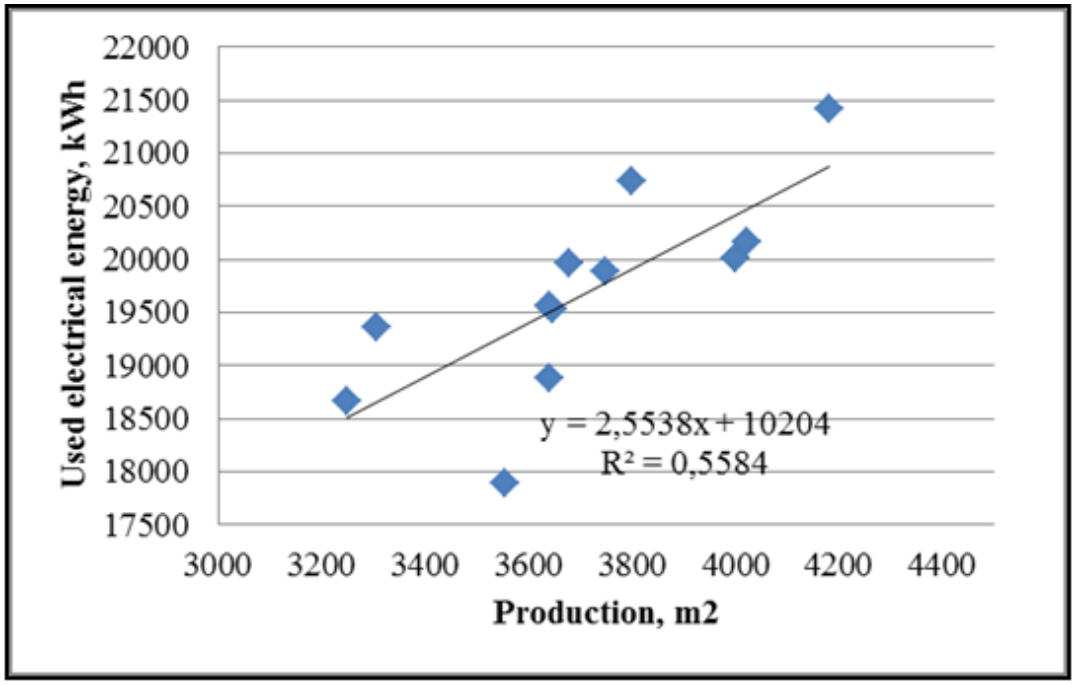

Figure 1. Correlation between used energy in enterprise and number of manufactured unit.

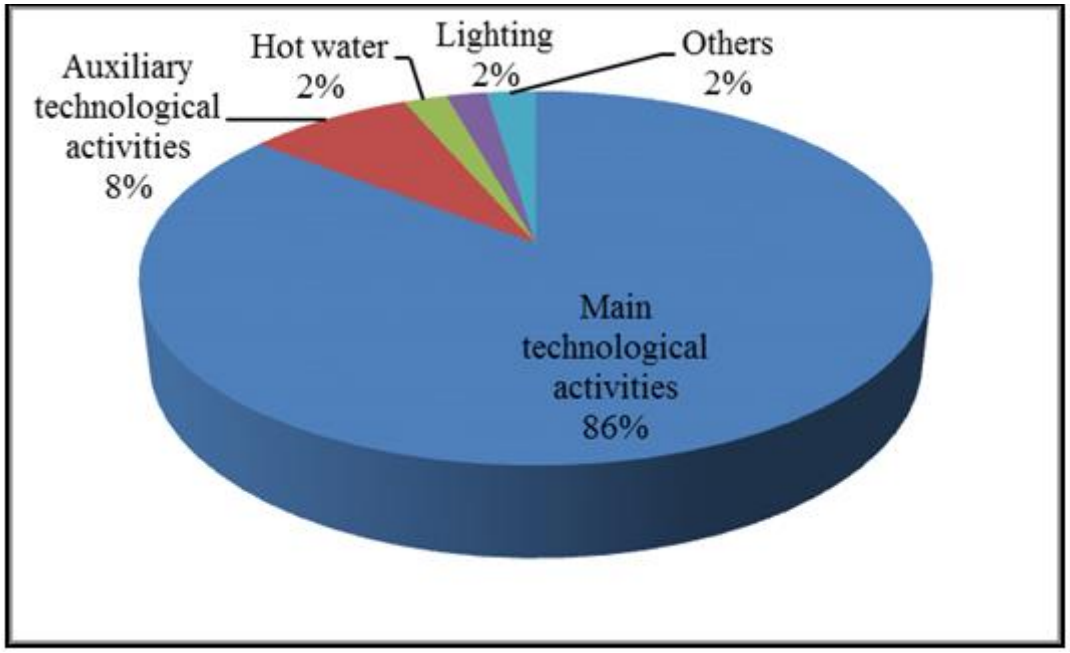

Figure 2. Percentage distribution of electrical energy for reference year

On Figure 2 is shown percentage distribution of electrical energy for reference year. The graph shows that there is a potential for saving energy in machines – main and auxiliary technology equipment. This requires optimization and replacement of facilities consuming electrical energy for production activity.

The enterprise intends to make the following investments:

- automated technology line for cataphoresis coating of steel details;
- replacement of old lighting fixtures with energy-efficient ones;
- recuperation ventilation system for the utilization of waste heat energy;
- energy consumption monitoring system.

In Table 3 are shown data on installed electrical power of facilities in enterprise after energy saving measures.

Table 3. Installed electrical power of facilities in enterprise after energy saving measures.

Name	Value	Power, kW	Total power, kW
Main technological equipment			
Electrical furnace	1	75.00	75.00
Electrical furnace	1	45.00	45.00
Powder gun	3	0.00	0.00
Line for cataphoresis coating	1	40.00	40.00
Auxiliary technological equipment			
Screw type compressor for compressed air, working pressure 8 atm	1	7.50	7.50
Refrigeration air dryer	1	0.41	0.41
Screw type compressor for compressed air, working pressure 6 atm	1	4.50	4.50
Groundwater pump	1	2.00	2.00
Water deionization installation	1	0.25	0.25
Lighting	16	0.04	0.64
Heating devices (Others)	2	6.00	12.00
Hot water tank	1	3.00	3.00
Recuperative ventilation installation	1	2.73	2.73
Energy consumption monitoring system		0	0
Total usable power			193.03

Data for the baseline of energy consumption in enterprise after energy saving measures are shown in a Table 4.

Table 4. Baseline of energy consumption in enterprise after energy saving measures

Name	Value	Unit of measure
Energy consumption automated technology line for cataphoretic coating – good practice	241580	kWh/year
Quantity produced before energy saving measures	57820.2	m^2/year
Energy consumption automated technology line for cataphoretic coating – new line	141480	kWh/year
Energy consumption old lighting fixtures	4636	kWh/year
Energy consumption new lighting fixtures	3709	kWh/year
Energy consumption heating installation changing room without recuperation system	3420	kWh/year
Energy consumption heating installation changing room with recuperation system	1519	kWh/year
Baseline energy consumption	249636	kWh/year
Energy consumption for related with measures activities after energy-saving measures	146708	kWh/year

The implementation of a new technology line for cataphoresis coating of steel details, new lighting fixtures, recuperation ventilation system and energy consumption monitoring system are accordingly marked as energy-saving measures ESM 1, ESM 2, ESM 3 and ESM 4. A comparison of specific costs before and after energy saving measures is shown in Table 5.

Table 5. Comparison of specific costs before and after energy saving measures

	Before ESM			After ESM			
	Energy consumption for related with measures activities	Produced output	Specific energy consumption	Corrected energy consumption for related with measures activities	Energy consumption for related with measures activities	Produced output	Specific energy consumption
	kWh/year	m^2/year	kWh/m^2	kWh/year	kWh/year	m^2/year	kWh/m^2
ESM 1	241580	57820.2	4.18	241580	141480	57820.2	2.45
ESM 2	4636	-	-	4636	3709	-	-
ESM 3	3420	-	-	3420	1519	-	-
ESM 4	-	-	-	-	-	-	-
Total:	249636	-	-	249636	146708	-	-

Energy savings in kWh on ESM 4 are calculated as 8% of total energy consumption for related with measure activities after energy saving measures (based on information of good practices for use energy management systems in practice). The share of enterprise's energy savings compared to the reference year has been determined in energy value (in kWh) and ecological equivalent (t CO_2/ year). The results are shown in Table 6.

Table 6. Energy savings

Energy saving measures	Energy carrier	Energy savings		Ecological equivalent
		kWh	%	t CO_2/ year
ESM 1	electricity	100100	41.44	146.5
ESM 2	electricity	927	20.00	0.8
ESM 3	electricity	1901	55.58	1.6
ESM 4	electricity	11737	8.00	9.6
Total	-	114665	45.93	158.5

Conclusion

With the introduction of energy-saving measures, additional benefits will be realized, as follows:

ESM 1 - with implementation of new automated technology line for cataphoresis coating of steel details degree of automation of production process and quality of production will increase, work errors will be reduced, conditions for greater flexibility in use of materials in production process will be created. This will enable implementation of an efficient production process, growth of manufactured product (up to 30 %), as well as meeting European requirements regarding quality of the applied coating and environmental protection. In addition, there will be an opportunity for highly qualified operators of the new line to perform additional activities;
ESM 2 – installation of new lighting fixtures will lead to reduction of electricity cost for lighting, as well as to an increase in quality of the working environment in enterprise;
ESM 3 - installation of new recuperation ventilation system will lead to reduction of electricity cost for heating, as well as to an increase in quality of the working environment in enterprise;
ESM 4 - with the implementation of energy consumption monitoring system degree of automation and competitiveness of enterprise will increase.

Upon implementation of energy-saving measures, the enterprise will realize an energy savings of 45.93% compared to the baseline of energy consumption, which is equal to an energy savings of 114665 kWh/ year with an ecological equivalent of 158.5 tons of CO_2 emissions saved.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in EPSTEM Journal belongs to the author.

Acknowledgements or Notes

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References

АУЕР. (2016a). *Ordinance № E-RD-04-03 of 4.05.2016 on admissible measures for implementation of energy savings in final consumption, ways of proving the achieved energy savings, requirements to methodologies for their evaluation and ways for their confirmation (In Bulgarian).* Retrieved from https://seea.government.bg/documents/NAREDBA_ERD043_ot_4052016_g_za_dopustimite_merki_za_osysestvqvane_na_energijni_spestqvaniq_v_krajnot.pdf

АУЕР. (2016b). *Ordinance № E-RD-04-05 of 8 September 2016 on determining energy consumption indicators, energy performance of enterprises, industrial systems and outdoor artificial lighting systems, as well as on determining conditions and procedure for conducting inspections for energy efficiency and preparation of energy savings assessment (in Bulgarian).* Retrieved from https://seea.government.bg/documents/Naredba%20ERD0405.pdf

Baev, D., Georgiev, Z., Manchev, P., Simeonov, K., Ivanova, D., Hristov, H., Canev, D., Haladzhova, R., Stankov, A. (2024, 16 October). *Manual on energy efficiency management in enterprises (in Bulgarian).* Retrieved from https://seea.government.bg/documents/narachnik.pdf

Capehart, B., Turner, W., & Kennedy, W. (2012). *Guide to energy management* (7 th ed.). The Fairmont Press.

Doty, S. (2016). *Commercial energy auditing reference handbook* (3rd ed.). The Fairmont Press.

Iliev, I., Kaloyanov, N., Gramatikov, P. Terziev, A., Pavlov, I., Stefanov, S., Sirakov, K., & Kamburova, V. (2024, 16 October). *Energy efficiency and energy management handbook.* Retrieved from https://www.exergia-max.com/sites/default/files/documents/EEEM_Handbook_ENG.pdf

Ivanov, K., Georgieva, N., Tasheva, S., & Gandova, V. (2021). Analysis of energy efficiency of an industrial system. *IOP Conference Series: Materials Science and Engineering, 103*1(1), 012080.

Kaloyanov, N., Kasabov, I., Bojkov, C., Matanov, N., Penkova, N., Vasilev, M., Cekov, R., Tomova, M., Djabarska, S., Markova, S., & Todorov, C. (2024, 16 October), *Methodological instructions for do a survey for energy efficiency and evaluation of industrial energy savings systems and enterprises (in Bulgarian)*. Retrieved from https://seea.government.bg/documents/metodicheski_ukazania.pdf

Kamburova, V., Iliev, I., Velikanov, M., Terziev, A., Ahmedov, A., & Iliev, K. (2017). Energy efficiency of large industrial enterprises. *Journal Energetika, 3*, 40-50.

Rasheva, V. (2011). *Energy technology analysis of industrial enterprise*. UHT Plovdiv: Academic publishing house of UHT - Plovdiv.

Thuman A., & Younger, W. (2008). *Handbook of energy audit*. The Fairmont Press.

Turner, W.(1997). *Energy management handbook* (3rd ed.). The Fairmont Press.

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