The impact of an energy efficiency action plan for an energy-intensive SME in Romania – a case study

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***Abstract*— This paper presents a methodology for evaluating the targeted energy saving potential in a SME that has been developed and validated in the framework of the H2020 SMEmPower Efficiency project, based on a Monitoring & Targeting tool, with the goal of assisting in overcoming the barriers that are limiting the adoption of energy efficiency measures in the SMEs sector, mainly addressing informational and organizational issues. As a case study, the approach was used in a SME operating in Romania's building construction industry. Once the company's energy profile was designed, the Monitoring & Targeting tool simulation resulted in a number of energy savings and CO2 emission reduction targets. These targets were the basis for a set of specific energy efficiency (technical and organizational) measures suited to the company's requirements.**

Keywords—energy efficiency, SMEs, energy scan, non-energy benefits

I. INTRODUCTION

One of the key strategies for cutting CO_2 emissions from industrial energy use is Energy Efficiency (EE). It is clear that reducing industrial sector energy end-use is important from both society and business perspective. The two most crucial ways to increase EE in the industry have been identified as implementing energy-efficient technologies and concentrating on energy management procedures [1], [2].

Worldwide, Small and Medium-sized Enterprises (SMEs) represent around 99% of all businesses [3], and according to Eurostat, the share of SMEs in the EU Member States and the UK is about 99.8%. According to the Organisation for Economic Cooperation and Development (OECD), small and medium-sized enterprises are autonomous businesses with a number of employees that do not go over a set threshold. The European Union defines SMEs as autonomous organizations with fewer than 250 employees, a turnover of less than €50 million, or total assets worth less than €43 million, as mentioned in Title I of the Annex to European Commission Recommendation 2003/361 from May 6, 2003 [4].

Although SMEs individual energy use is frequently not large, an IEA report estimates that their cumulative consumption accounts for more than 13% of all worldwide energy use. Therefore, it is evident that there is a substantial opportunity for this industry to reduce energy use by implementing EE measures, which the same study estimates to be up to 30% [3]. In this context, implementing EE measures in SMEs is a pressing issue with significant development potential, which could have a significant positive impact on the achievement of both global and European climate targets. Even while SMEs are seen as an important factor toward a sustainable energy transition, their predicted potential for EE is not always realized. Due to the SMEs' resistance to adopting EE measures, there is a difference between the predicted potential and the actual energy performance status in this sector [5]. According to the European Commission, in the SME sector, "the situation is not good because nearly two-thirds of SMEs operating in the European Union do not have any strategies or tools for energy saving and energy management." [6].

The aspects that contribute to the ineffective implementation of these measures are referred to in the literature as EE measure implementation barriers [7]. The three categories of barriers that are frequently mentioned as being most important in SMEs' incapacity to adopt EE measures are organizational, informational, and economic barriers.

Economic issues are thought to be the biggest obstacle to the deployment of EE initiatives in SMEs [8]. The issue that is most usually addressed is the lack of funding [6], [9-12]. This must be considered in addition to the high expenses, low returns and significant risks of such an investment, as well as the challenging or impossible access to external funds [13], [14].

The informational barriers are categorized into three groups: the lack of information, the expense of getting information, and the clarity of the information [14], [15]. These three factors contribute to the lack of knowledge about the funding options, the real costs and benefits of implementing EE measures, the potential effects that their implementation may have on the company's products and/or processes, and the lack of technical expertise among employees in using new technologies.

The implementation of EE measures must take into consideration also the organizational perspective [11], [16], [17]. The fact that most SMEs do not have appropriately qualified employees who may be given energy management responsibilities contributes to the lack of time, prioritizing of other things more pressing to the company, and decreased awareness regarding the need for energy monitoring.

This paper presents a methodology for assessing the targeted energy saving potential in a SME that has been designed and tested in the framework of the practical action dimension in the H2020 SMEmPower Efficiency project, based on a Monitoring & Targeting (M&T) tool. Its goal is to help in removing the barriers to the adoption of EE measures in the SME sector, with a focus on informational and organizational issues. Applying this approach can make it easier to get past some of the obstacles mentioned in the literature – the lack of energy consumption monitoring, the complexity of the decision-making process, and the poor understanding of the true costs and benefits related to the implementation of EE

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actions in the SMEs sector. The paper provides also a case study using the methodology described above, consisting of an energy assessment carried out within a SME in Romania, which is operating in the manufacturing sector. A number of EE actions were suggested in order to enhance the company's energy performance based on the potential energy savings calculated using the M&T tool.

The paper is structured as follows: in section I the actual context of EE in the SMEs sector is presented, with a focus on the barriers identified in the literature as factors that are hindering the implementation of EE measures in this sector. The second section describes the methods and tools that were used. In section III a case study consisting of an energy assessment conducted within a SME was presented, together with the EE action plan proposed considering the needs identified within the company. In the same section, the estimated technical performances of the proposed solutions are presented along with the non-energy benefits. The conclusions of the conducted energy assessment are discussed in the final section.

II. Methodology

In order to analyse the current state of EE in European small and medium-sized firms, the work started with a review of relevant studies in the literature, and concentrated on the key obstacles to EE implementation in this sector.

Based on this review findings a SME EE evaluation methodology was developed and proposed to identify the energy savings potential and the suitable EE and local RES generation solutions at the level of a particular SME. To better understand the proposed SME evaluation and analysis methodology in the third section of the paper showcased how the authors applied this methodology to a SME from Romania presented as a demonstration and validation case study.

The methodology starts with an energy evaluation, a brief energy scan of the analysed SME. Description of the technological process, aggregation of the company's key consumers, and general corporate information are all presented. The energy profile of the company is described based on a critical study of the energy consumption statistics, related costs, and greenhouse gas emissions, all correlated with the production data in the SME. Further, a M&T tool could be used to estimate the company's potential for improving its EE by setting a number of targets for potential energy savings as well as corresponding cost savings and CO2 emission reductions.

Based on the potential for energy consumption reduction identified in the company several EE specific measures could be proposed and technically assessed, focusing not only on energy savings, but also considering a series of non-energy benefits.

A. Applied Monitoring & Targeting tool

The M&T tool aims to set EE specific goals by using energy management data based on the principles of "monitoring" and "targeting". The term "monitoring" refers to the process of gathering information about energy usage in order to create a consumption model, which may then be used to develop, put into action, and assess energy management strategies to achieve targeted energy savings.

The tool provides advise on the amount of energy used or anticipated to be used in a given period of time by displaying energy consumption patterns graphically and offering the possibility to recognize time intervals where consumption deviates from expected or typical values. [18].

B. Energy efficiency action plan

The final step of the proposed SME evaluation and analysis methodology should be a dedicated energy efficiency plan consisting of a series of EE-specific technical and financial solutions proposed, together with a package of organisational measures for improving the EE in the company, considering the potential of energy consumption and CO2 emissions reduction estimated within the M&T simulation.

III. Case study

A. General information

The company that has been chosen for the case study is from the construction sector, having the NACE code 41.20 – construction of residential and non-residential buildings. More specifically, the main activity of the company is the production of prefabricated reinforced and prestressed concrete elements including the provision of the related services that raising the structure requires. The production is based on nine lines dedicated to each element that the company produces, such as prestressed beams, linear lights elements, floor elements, and bridge beams.

The casting space consists of the production lines equipped with two overhead cranes. The elements produced here are evacuated when they reach the stripping resistance in the warehouse for the finished products. From the finished good, the products are loaded into trucks and transported to construction sites. On the site, they are installed according to the requirements of the beneficiary. Overall, the company offers the following services: design, production, logistics, and assembly.

The turnover of the company decreased between 2019 and 2020 from 26 million Euros to 18 million Euros due to the effect of the COVID-19 pandemic.

The company is operating its activity in five buildings out of which three are dedicated for production lines, one for storing and one is an administrative building. The facilities do not have an Energy Performance Certificate (EPC).

Regarding the energy management of the company, this does not have an assigned or employed energy manager, does not have an EE strategy for the next three years and the last energy audit in the company was carried out more than five years ago.

The electricity demand of the company is due to various consumers such as equipment from the technological process, lighting, compressors, ventilation, pumps, drives, electrical heating, air conditioning, and office appliances. Thermal energy is used for the production process, heating, and for domestic hot water preparation. In the following section, the monthly and multiannual energy consumption and cost are presented, along with the correlation with the production through specific consumptions.

B. Energy profile and analysis

Considering the main activity of the company, the consumers involved in the technology process require a high energy demand. The energy intensity of the company is characterized by high electrical and thermal energy consumption. The energy profile in 2020 reached a level of 628 MWh electrical energy consumption and 1,288 MWh thermal energy consumption in form of methane gas. The monthly electrical energy – Fig.1 reached the peak level in the months of January and February, in both analysed years, 2019 and 2020 respectively.

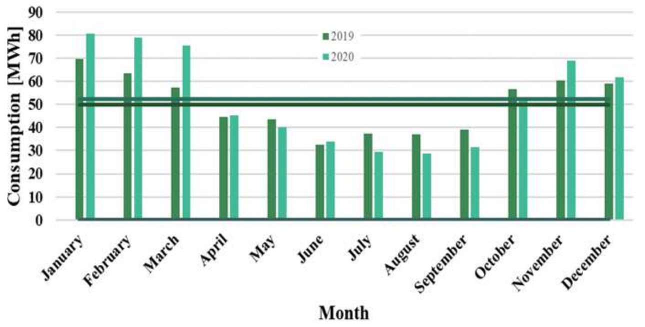

Fig. 1 Electrical energy consumption in 2020-2021

The company operates from Monday to Sunday between 8 AM and 8 PM, both in the hot and cold seasons. The daily hourly electrical energy consumption curve has a similar variation both for the warm and cold seasons, represented by the hourly load curve for July and December from Fig. 2.

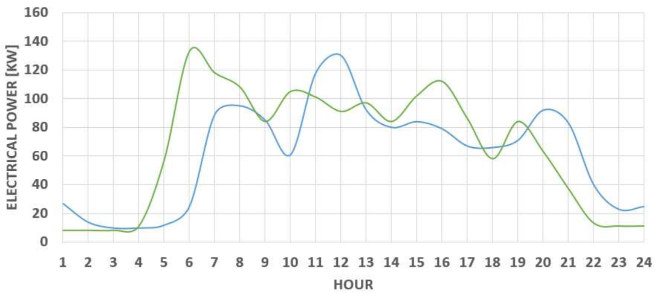

Fig. 2. Daily/hourly consumption curve

The trend of methane gas consumption presented in Fig. 3. is seasonal, with high values in cold months (December-March) and low values in summer (June-August). The heat demand is influenced by the variation of the temperature in the cold season, reflecting the fact that thermal consumption is less depending on the production capacity as on the monthly basis is approximately constant for the years 2019 and 2020.

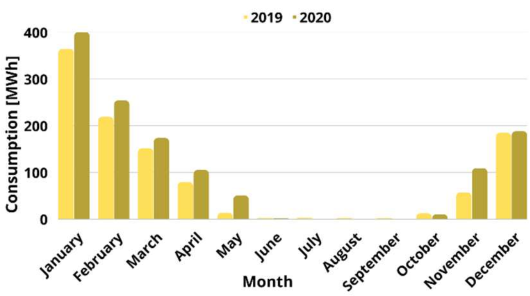

Fig. 3 Thermal energy consumption in 2019-2020

The company paid almost €100,000 for energy in 2019 and approximately €105,000 in 2020. The annual energy cost along with consumption for electrical energy and thermal energy is detailed in Table 1 and Table 2 respectively.

TABLE I. ELECTRICAL ENERGY CONSUMPTION AND COST IN 2019-2020

Year	2019	2020
Consumption [MWh]	601	628
Cost [Euro]	67,696	69,473

TABLE II. THERMAL ENERGY CONSUMPTION AND COST

Year	2019	2020
Consumption [MWh]	1,084	1,288
Cost [Euro]	32,052	36,015

Considering the utility costs paid by the company in 2020, the share is divided between electrical energy (59%), thermal energy (30%), and water consumption for the process (11%) represented also in Fig. 4.

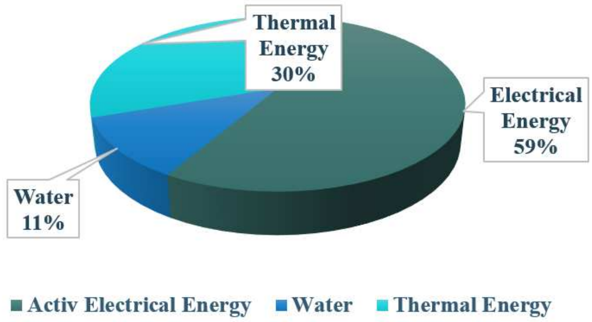

Fig. 4. Share of the utility cost for 2020

The CO_2 emission baseline of the company is shown in Table 3, highlighting the increase in the period 2019-2020.

TABLE III. CO2 EMISSION BASELINE IN 2019-2020

CO2 emission baseline in 2019-2020 [tonnes eq. CO2]	
2019	***2020***
347	394

In terms of production, quantified in m^3, the monthly production data are presented in Table 4 for the period 2019-2020. It can be observed that the smallest quantity of final product is measured for the year 2020, due to the COVID-19 pandemic situation.

TABLE IV. PRODUCTION DATA IN 2019-2020

Month	**Production [m^3]**	
	2019	***2020***
January	3,573	2,746
February	3,615	3,789
March	3,869	4,374
April	3,661	2,705
May	4,596	3,315
June	3,699	3,855
July	4,556	2,940
August	4,574	3,022
September	4,681	3,545
October	4,925	3,526
November	3,613	3,002
December	1,558	1,529
TOTAL	46,920	38,348
AVERAGE	3,910	3,196

The multiannual specific electricity consumption is represented in Fig. 5. The average annual specific consumption for 2019 is quantified to 14.42 kWh/m^3 while for 2020 is 17.6 kWh/m^3, observing an increase of 23% due to the decrease of production by 18% in the analysed period due to the increase of electrical energy consumption of almost 4%.

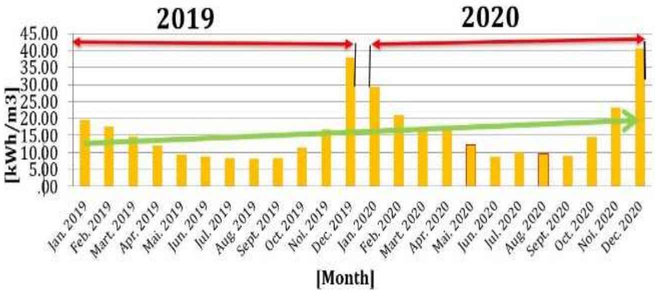

Fig. 5. Multiannual specific electricity consumption

IV. Results and Findings

A. Energy saving target

The electrical energy saving target of the SME has been assessed using the M&T tool as described in the methodology. Using linear regression, the potential estimated saving has been evaluated to be 72 MWh/year, reaching a target of 12% compared to the total real electrical consumption. The monthly energy saving potential is highlighted in Fig. 6, where the bar charts are showing the real consumption while the horizontal line represents the targeted consumption. It can be observed that the months with the higher energy potential are January and February.

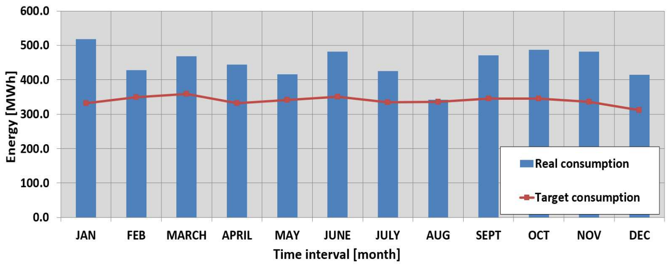

Fig. 6. Energy saving target within the M&T tool

B. Energy efficiency action plan

After the energy saving target definition, the following stage is represented by the proposed EE action plan with the scope of reducing the energy demand and introducing sustainable sources to the company with the main scope of gradually becoming energy independent from conventional sources. Along with the proposed measures, the financing options are also specified based on available national financial sources and on the company's willingness to invest from its own resources.

1) Building Energy Management System (BEMS)

Although being an energy-intensive consumer on the market, the SME does not monitor any consumption. The current database is only available from monthly bills which haven't been processed before the performed energy scan. In this context in which the company doesn't know where and how the energy is consumed, a Building Energy Management System (BEMS) is proposed. The system aims to monitor appliances within the buildings, but also the energy-intensive consumers from the technological process, along with the available energy sources.

2) Photovoltaic system

Considering the high electrical energy demand and the climatic characteristics of the site, including the solar radiation potential, and also the company's long-term strategy to become independent from the national grid, a photovoltaic system has been proposed for producing electrical energy for own consumption and selling the excess energy to the grid according to the national legislation. The solar energy potential of the area is about 1350 kWh/sqm/year. The proposed system has been simulated with Solar Edge, software dedicated to photovoltaic system design. The self-consumption and export potential share are the following:

Total production: 376 MWh, representing 100%.

Self-consumption: 266 MWh, representing 71%

Export: 110 MWh, representing 29%.

The proposed system consists of the following equipment:

760 PV modules with a total peak power of 315 kWp

10 inverters

The positioning of the system – Fig.7. is chosen in order to maximize the production for the whole year. Additional characteristics will be defined at the design phase of the project.

Fig. 7. Positioning of the photovoltaic system

Considering the available resources, the company is applying for a financial scheme dedicated only to SMEs for the implementation of photovoltaic systems and electric vehicle chargers. The program is aimed to finance SMEs for the installation of photovoltaic systems for the production of electricity with an installed capacity of between 27 kWp and 100 kWp required for their own consumption and the delivery of surplus into the National Energy System and 22kW electric vehicle charging stations. The maximum grant amount is €100,000. The difference is proposed to be covered by own resources or bank loan.

3) Organisational measures

In addition to the above-mentioned approach, a dedicated set of organizational measures were proposed, considering the current situation regarding energy culture within the company. The following list of measures has been proposed to enhance behavioural culture regarding EE for the management staff and employees:

Assessment of energy culture level by questionnaires and organisation of dedicated training and workshops for the top

management and also employees. Proposed topics: EE measures, carbon footprint, energy-draining habits;
Rewarding system for anyone who initiates EE initiatives within the company;
Acquisition of energy-efficient appliances in the offices;
Carrying out the necessary maintenance and cleaning work on energy-consuming equipment.

C. Technical performance and non-energy benefits

The performances of the implementation of all the proposed technical solutions were analysed from technical perspectives considering two situations: the individual implementation of each proposed measure and also the implementation of a package containing all the proposed solutions.
Through the assessment of the key performance indicators – energy saving, and CO2 emission reduction presented in Table 6, respectively, better technical feasibility can be deducted from the EE package reflected in the cumulative energy saving potential of 31 MWh/year and 266 MWh/year energy produced by renewable energy sources along with the total CO2 emission reduction of 263 tonnes of CO2 eq. per year and a cumulative cost saving reduction of €44,937/year.

TABLE V. ENERGY, EMISSION AND COST BENEFITS OF THE PROPOSED MEASURES

	Investment [Euro]	**Energy saving [MWh/year]**	**Cost saving [Euro]**	**CO2 emission reduction [tonnes eq. CO2/year]**
BEMS	200,000	31	4,712	7
PV system	190,000	266	40,222	115
TOTAL	390,000	297	44,934	122

Besides the energy-related and monetary benefits, the following non-energy benefits have been identified based on the proposed EE action plan:
Improved equipment performance;
Increased production reliability;
Reduced customer service costs due to better quality;
Reduced water consumption;
Reduced maintenance cost;
Air quality improvement of ambient air;
Reduction of health cost;
Increased installation safety;
Contribution to the company's vision and strategy.

V. CONCLUSIONS

Small and Medium-sized Enterprises (SMEs) have a significant potential to contribute to the European energy transition process, however, some obstacles may prevent the implementation of EE measures from being exploited. There isn't a clear-cut strategy that could improve SMEs' EE across the board, but several methods have been found to be successful.
In the context defined at the beginning of this paper, an energy scan conducted in a SME located in Romania has been presented as a case study, by applying methods and tools developed and tested in the framework of H2020 SMEmPower Efficiency project. The proposed methodology envisioned the general assessment of a SME, including the technological process, energy consumers, and building facilities, in order to formulate the energy profile of the company in terms of annual and monthly energy consumption and costs. As a result of the Monitoring & Targeting simulation, a potential electrical energy-saving of about 12% of the total real consumption has been estimated. The energy-saving targets set within the M&T process were further used as a starting point in designing a package of technical and organisational solutions for improving the EE of the company and also to increase the independence of the facility from the national grid. The technical assessment of the proposed solutions resulted in favouring the whole package over the individual implementation due to higher energy saving and CO2 emission reduction potential using renewable energy sources and advanced management systems. It is important to be mentioned that after the results were presented to the beneficiary company, the decisional factors consider the adoption of the proposed measures by applying them to different financial schemes available at the national level. In this regard, a follow-up of the energy assessment in the same SME, after the implementation of the technical solutions package would represent a significant future perspective for extending this research.
By improving the energy consumption monitorization within a SME and providing an overview of the benefits associated with the implementation of a series of proposed EE measures, from both energy saving and cost saving perspectives, the implementation of the given method and using M&T tool could therefore facilitate a smooth decision-making process when it comes to the adoption of EE specific measures in the SMEs sector.

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