UDC 697.9

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SCHEME FOR PROMOTING INDUSTRIAL ENERGY EFFICIENCY – PINE PROJECT RESULTS

Досліджено основні фактори, що впливають на процедуру енергоаудиту, та описано заходи щодо підвищення енергоефективності на малих і середніх підприємствах (МСП), забезпечуючи пропозиції для енергетичної політики підприємств. Наш аналіз грунтується на вибірці з 280 малих і середніх підприємств з 7 європейських країн, які брали участь у міжнародному проекті з промислової енергоефективності. Думки, отримані під час енергетичних аудитів, зведено у 8 основних висновків: 1) енергоаудит є цінним для малого і середнього бізнесу, але 2) не є життєздатним варіантом для консалтингової компанії на комерційній основі. Основними складовими при проведенні енергетичного аудиту є 3) відсутність даних про фактичне споживання енергії; 4) інформаційні бар'єри і 5) інші м'які чинники, – такі, як очікування і попередній досвід; 6) економічні чинники є значними бар'єрами для підвищення енергоефективності. Серед заходів щодо підвищення енергоефективності 7) поведінка та контроль є ключовими факторами. І, нарешті, 8) відповідний метод для енергоаудиту є ключем до успіху.

Ключові слова: енергозбереження, енергоефективність промисловості, енергоаудит, малі та середні підприємства; бар'єри енергоефективності; лінійна регресія.

This paper investigates the main factors influencing an energy auditing procedure, leading to the adoption of energy efficiency measures by small and medium-sized enterprises (SMEs), providing suggestions both for enterprises and energy policy makers. Our analysis is based on a sample of 280 SMEs from 7 European countries which participated in an international project (PInE) devoted to industrial energy efficiency. Opinions learned during the energy audits are summarized in 8 key findings: (1) Energy Audits are a valuable activity for SMEs, yet (2) not a viable option for consultancy on a commercial basis. The main difficulties in carrying out an energy audit are (3) lack of data on energy consumption, (4) information barriers and (5) other soft factors such as expectations and previous experience. Economic factors (6) are significant barriers to energy efficiency. Among the energy efficiency measures (7) behaviour and control are key factors. Finally (8) an appropriate method for energy auditing is key to success.

Key words: Energy Conservation, Industrial Energy Efficiency, Energy Audit, Small and Medium-sized Enterprises; Energy Efficiency Barriers; Linear Regression

Introduction. Energy Efficiency is one of the highlighted objectives in the European strategy for a smart, sustainable and inclusive growth. The industrial sector has a major role in energy efficiency, esspecially improving energy efficiency in small and medium-sized enterprises (SMEs) plays a crucial role, since SMEs represent a high share of energy consumption. A wide range of cost-effective energy efficiency measures are available [1–3], but remain unimplemented due to several energy efficiency barriers as described in literature by Sorrell et al. [4] and further developed by Cagno et al. [5].

Methodology. This study is based on the data collected within the project PInE (Promoting Industrial Energy Efficiency) carried out by a consortium led by AREA Science Park and composed of 14

partners in 7 European countries (Italy, Austria, Spain, Slovakia, Romania, Bulgaria and Cyprus), aimed to increase energy efficiency in SMEs. PInE activities are based on the idea that professional energy audits can help SMEs to overcome the main barriers (information, behaviour and financial barriers) and implement cost-effective energy efficiency measures (EEM).

The first phase of the project involved 280 SMEs for the **preliminary auditing** to identify the energy use of SMEs and identify potential for action and willingness to implement the EEM on their premises. The second phase involved the 140 SMEs with the highest energy saving potential in a **full energy audit**, conducted by professional technical experts onsite to gain insight into short and long-term energy consumption patterns in processes and infrastructure and identify EEMs. The energy audit is carried out according to the steps described in Table 1.

Table 1

Energy Audit Steps according to PINE methodology

Preliminary contact	Provide the company with information about the energy audit: scope, procedure, data, expectations
Collecting data	Collect basic data on a data collection sheet: electricity consumption, heat consumption on a monthly basis, rated power and hours of operation of main equipment, operational practises and technical status of the equipment
Discussion of the data	Discussion on data: mayor equipment, benchmarking, interpretation of load curves, identification of parasitic loads, operational practises, efficiency
Company visit	Visit the company, inspecting the main processes, equipment, utilities and buildings, taking key performance data, recording good housekeeping options and technical options, and measurements
Analysis and Report	Analyse the existing energy performance situation and prepare a Report including data, interpretation, benchmarking, list of EEM including technical and financial feasibility analysis of options
Discussion and Action Plan	Discuss the Report with company representatives and agree on an implementation plan
Monitoring	Record consumption data and calculate product specific indicators (heat and electricity) at regular intervals
Implementation	Provide technical support, coaching and monitoring during the implementation of the EEMs.

The final implementation phase extends for several months after the report has been handed to the company, in order to provide support for the SMEs in overcoming technical, economical and organizational issues that could support the implementation of the EEMs.

The EEMs takes into account in the energy audit are mainly *cross-cutting technologies*, such as compressed air (leakages, optimized pressure level, control of compressors), lighting (control, bulbs), motors (size, control), boilers (return of condensate, pressure level, air/fuel ratio, size, control, preheating of combustion air and/or feed water), cogeneration, energy recovery (from hot waste water from washing, to preheat fresh water, from hot exhaust air, to preheat air or product). Organizational and behavioural issues are tackled as well, such as avoiding parasitic loads (equipment running idle, works planning, automatic control, assigning of responsibilities and definition of procedures with set points, monitoring and controlling of actual consumption. Monitoring energy consumption, although it is not commonly listed among EEMs, has been included as a common EEM, as explained in Opinion Learned 3.

Partial results. The sample of 280 SMEs considered in the study represents a wide range of sectors and company size, with an average primary energy consumption of 724 toe (varying from 159 toe in Cyprus to 1951 toe in Bulgaria), as shown in Table 2.

Table 2

SMEs included in the sample

Country	SMEs	Energy consumption - fuel [MWh]	Energy Consumption - Electricity [MWh]	Primary Energy [toe]	GHG Emissions [tCO2]	Primary Energy per SME [toe]	GHG Emissions per SME [tCO2]
Romania	40	665.161	83.268	78.021	155.346	1.951	3.884
Bulgaria	40	161.288	110.368	41.463	122.972	1.037	3.074
Spain	40	100.393	77.377	27.978	57.652	699	1.441
Austria	40	116.427	44.869	21.230	62.733	531	1.568
Italy	40	65.809	47.505	17.536	34.195	438	855
Slovakia	40	38.118	27.000	10.028	13.343	251	334
Cyprus	40	8.493	22.512	6.359	17.497	159	437
TOTAL	280	1.155.689	412.898	202.614	463.739		
					AVERAGE	724	1.656

Opinions learned during the energy audits are summarized in 8 key findings, discussed in the following paragraphs. On a general perspective (1) energy audits are a valuable activity for SMEs, yet (2) not a viable option for consultancy on a commercial basis. The main difficulties in carrying out an energy audit are mainly due to some barriers, namely (3) a remarkable lack of data on energy consumption, (4) lack of expertise in energy management within the company and (5) other soft factors such as excessive expectations and previous negative experience. Economic factors (6) such as expectation of high profitability or limited use of available incentives, are significant barriers to energy efficiency. Among the EEMs (7) behaviour and control provide a relevant impact and are easily implemented due to low investment required. Finally (8) an appropriate method for energy auditing is key to success.

Opinion Learned 1: Actual and perceived value of Energy Audits for SMEs. An energy audit is a complex activity requiring an investment of company resources (cost of the audit as well as time of management and employees), leading to investments in energy efficiency that, finally, bring value to the company in the medium and long term. In an SME the perceived value (or expected) of the audit – when the SME decides whether to start the audit or not - can be very different from the actual value delivered at the end of the process.

The perceived value of an energy audit is underestimated in SMEs due to the following reasons:

– Energy audit requires technical skills on energy efficient technology that is out of the core business of the company, therefore there is rarely qualified dedicated staff. The key decision makers and do not believe that an external consultant can identify any improvement which the staff would not have identified before.

– The concept of Energy Audit is biased due to previous experience in “energy audits” focused on a single commercial solution (e.g. selling a new piece of equipment, a new material or solution) instead of analysing the whole production process to identify the best opportunities for energy efficiency. It may happen, for example, that an "energy audit" is focused only on the compressed air system, concluding that the best action is to buy a new compressor, overlooking options as reducing air pressure, turn off idle equipment and use a smaller compressor.

Furthermore some SMEs focus only on the core production processes that allow no trade-off between cost and product quality, overlooking the large potential improvement in energy efficiency that can be achieved in cross cutting technologies.

In our sample of 280 SMEs the actual value is often higher than perceived value, leading to cost-effective savings (ranging from 5 % to 15 %) with a payback time from 0,5 years to 5 years.

Opinion Learned 2: Business model for Energy Audits in SMEs. Energy audits are a common market activity for consultants and ESCOs in large, energy intensive companies, but SMEs are not a valuable market for such activities, mainly because of the barriers mentioned above and because investments are too small.

A relevant opportunity to define a new business model for energy audits in SMEs is set by the "Energy Efficiency Directive" (Directive 2012/27/EU) entered into force in December 2012 will be implemented by the European Member States by June 2014, binding large companies to a regular energy audits once every 4 years and boosting energy audits in SMEs by means of public support programmes. Once this new regulatory framework is adopted at national level SMEs will have access to an audit scheme and will be more likely to have a correct perception of the value an energy audit can bring.

Consultants can anyway need some criteria to identify SMEs that offer a good potential for profitable energy audits using the following:

- energy consumption exceeding 1GWh (electricity) and 2GWh (fuels)
- energy intensity (i.e. Cost of energy / Annual turnover) > 2 %
- Specific issues such as waste heat, oversized or obsolete equipment.

Opinion Learned 3: Lack of data on energy consumption. A remarkable lack of data on energy consumption is common to all 280 companies in our sample. The main sources of information on energy consumption is the data available through the energy bills, while the common effort to reduce energy cost is limited to negotiations on prices.

Measurements taken during the company visit add important information, but are not sufficient to establish a complete overview of energy consumption. Thermography proved to be useful to identify on energy wastes or possible sources or heat recovery (see fig. 1).

Fig. 1. Thermography of a ventilation system. The two electric motors are the same size and the same nominal load but the surface temperatures are very different: a warning sign of possible energy waste

An energy monitoring system is certainly the best solution for a SME and it should include submeters an key equipment, reading and processing of energy data, use of production related specific consumption indicators, periodic monitoring and controlling, evaluation of load curves. Analysis should include energy consumption of infrastructure (buildings) and utilities (water treatment, air supply, vacuum generation, air handling, lighting, etc.).

When a comprehensive energy monitoring system is not available (as it is often the case in SMEs) an in-depth analysis of monthly data can provide some additional information by analysing load curves on a daily or hourly basis (e.g. during weekends, nights or holidays) to identify base loads. Linear Regression on data available from general meters (e.g. monthly readings of electricity and gas meters) can provide

further insights on the influence of production and external temperature on energy consumption (see fig. 2) be analysed by means of Linear Regression.

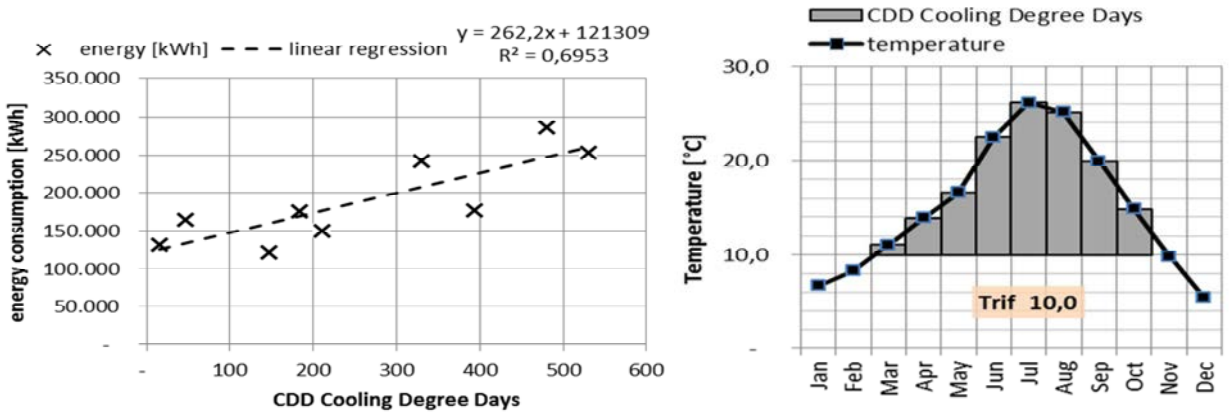

Fig. 2. An example of linear regression on monthly electricity consumption. A company consumes electricity for the production line and different cooling processes but does not have measures of such consumption. Linear Regression analysis indicates a weak correlation (R^2 = 69 %) between energy consumption and CDD (Cooling Degree Days) and suggests that there are also other relevant factors to be taken into account

Linear regression proved to be a powerful tool to overcome the lack of energy consumption data, providing a clear insight on energy use within the company, therefore a good basis to identify priorities for EEMs. Furthermore, a linear regression analysis should always be used to assess reduction in energy consumption due to reduced production.

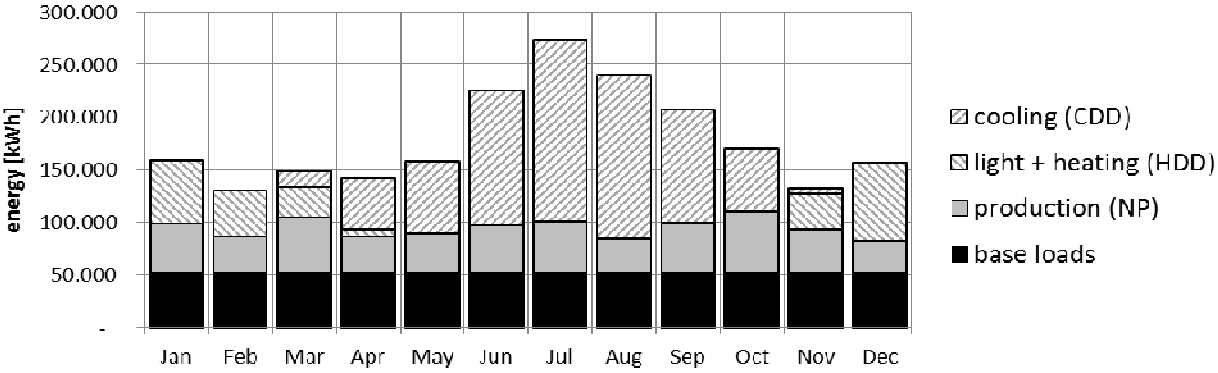

Fig. 3. Estimating energy consumption of key processes using multiple linear regression analysis. Multiple Linear Regression improves the accuracy and provides further insight. In the example above, three variables (NP, number of pieces produces, HDD, Heating Degree Days and CDD) proved to be significant predictors of energy consumption according to T-test (confidence interval 5 %, R^2 = 78 %). Regression coefficients can then be used to estimate the distribution of the energy consumption of the production line (NP) and cooling processes (CDD), even without detailed measurements of their actual energy consumption

Opinion Learned 4: operational barriers to energy efficiency.

Operational barriers to energy efficiency, as described by [5], are a major issue in SMEs included in our study, specifically:

– **Lack of internal technical skills:** None of SMEs in our sample have appointed an energy manager or have a specific procedure / policy for energy efficiency, therefore there is not an appropriate support for decisions regarding energy efficiency. Many companies depend fully on their suppliers and do not have the capacity to understand their equipment and the connection of operational practises to energy consumption in detail themselves.

– **Scarce information** regarding energy efficiency technologies and economic incentives (i.e. information is not available to relevant decision makers, or it is available in a general form, not tailored to the company needs).

– **Lack of personnel awareness:** personnel awareness is notoriously an important factor in several programs based on continuous improvement such as *quality* management and *lean management*. Raising awareness on energy efficiency in issues may boost energy efficiency, since personnel working in the production line knows the details of the production process and can provide useful information on small (or large) energy waste, help identify actions to lean improvements and acquire new - more efficient – habits.

– **Lack of managerial awareness**. Information on the use of energy within the company is often available in the form of monthly aggregate cost. The typical response to this type of information is to try to reduce the purchase price of electricity and fuels. Appropriate analysis of the data, with the creation of indicators (e.g. energy consumption per unit of product) may give the manager a better vision of energy consumption and potential improvement of efficiency. Monitoring & Targeting techniques may be very helpful in this respect.

The above barriers may be overcome only through a consistent "capacity building" process within the company, following the first Energy Audit.

Opinion Learned 5: Behavioural barriers

Behavioural barriers, as defined by [4], include several factors influencing decision making, such as expectations of the decision makers, credibility and trust of information sources, risk perception and play a key role for the success of an energy audit and subsequent adoption of energy efficiency measures by SMEs. The main factors are:

§ Expectations may be too high, i.e. some SMEs may expect a new technology making a huge leap forward in terms of efficiency, halving energy bills, with little or no investment and a negligible risk. This may happen only in few cases, such as replacement of old electric motors and pumps, replacement of conventional drying by microwave or infrared drying, replacement of conventional fans by backward bent fans.

§ On the opposite expectations may be very low due to previous experiences of energy audits focused on selling a specific technology (as explained in Lesson Learned 1)

§ Poor knowledge of energy efficient technology, leading to an overestimation of the risks associated with the investment. Consequently SMEs may set a very high threshold for profitability of energy efficiency investments.

Opinion Learned 6: Economic barriers

Economic factors are significant barriers to energy efficiency, including lack of -or limited access to- capital to be devoted to energy efficiency investments, expectation of excessively high profitability and limited use of available incentives (despite financial support schemes for energy efficiency exist in all 7 countries involved in the project). Actual implementation of suggested EEMs depends on payback; a common requirement is that payback time is less than three years [3].

The SMEs in our sample showed a strong reluctance to use energy efficiency criteria – and its profitability – as the main reason for an investment. The main motivation for the investment has always been of a technical nature (e.g. replacement of obsolete machinery), using energy efficiency criteria as an added value. Investment criteria change among companies and sectors. SMEs in purely productive sectors are cost driven and expect high profitability (i.e. paybacks less than 1 year), while SMEs in heavy capital investment sectors may accept longer payback up to 3 years. Anyway finance is *not* the main issue: there are many other issues to overcome before you get to finance, as discussed in Opinions Learned 2, 3 and 4.

Opinion Learned 7: Low-Cost energy efficiency measures

There is a gold mine of options to save energy at little or no investment, mainly adopting "good housekeeping" measures, establish better behaviour and make good use of existing control systems.

Employees need to be informed and trained – setting rules, defining appropriate metrics and establishing new *habits*. Some commonly reported EEMs in our sample of 280 SMEs are setting the right pressure level in compressed air systems, setting the right temperature for process fluids, switching off equipment when it is not used (e.g. compressed air, heating, lighting) and separate heated areas using automatic opening doors or air barriers.

Opinion Learned 8: Method and quality of energy audit

An appropriate method for energy auditing is the key to success, since it allows to control costs (especially staff and travel costs), provide a high quality result and therefore build confidence, addressing some of the barriers cited above.

Support for implementation should be always included in the audit procedure, in order to allow for further information exchange (e.g. the SME may perceive the EEMs as "not feasible", therefore the auditor may help overcome barriers to the implementation of suggested EEM). Support should be technical and organisational (including suggestions where to put submeters, how to collect data, how to monitor and control), providing guidance on measurements (which parameters, how, provision of measuring equipment) and systematic top down analysis including visualization of energy flows as a basis to prioritize the areas for detailed analysis.

Conclusion. This study provided a survey of 8 key factors influencing an energy auditing procedure, leading the adoption of energy-efficiency measures by SMEs. Energy policy makers can use such information to define specific measures to promote energy efficiency, while energy auditors can follow the above mentioned hints to design more successful energy audit campaigns for SMEs.

Acknowledgements. This paper is based on the results of project PInE (Promoting Industrial Energy Efficiency), co-funded by the Intelligent Energy Europe program of the European Union. The sole responsibility for the content of this paper lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither the EASME nor the European Commission are responsible for any use that may be made of the information contained therein.

The Authors would like to thank all the project partners involved in PINE the project. Further information about the project is available on the website www.pineaudit.eu.

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