Evaluation of Energy Efficiency in Final Uses: a new Energy Audit Approach in the Italian SMEs

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Abstract

The technological revolution of the last two centuries has radically changed human life and has led to a progressive increase of energy requirements. Nowadays all stakeholders agree on the necessity to change the consumption trends, not through the reduction of the energy final uses (that would lead to a drop in the standards of living), but rather through the optimization of the same uses and the control of the wasted energy.

In Italy potential energy saving is remarkable especially in the Small and Medium Enterprises where management of energy is often overlooked.

In this work a new framework for energy audits is proposed: this energetic diagnosis can lead to good results in a short time and it is particularly effective for the SMEs context where there is often the problem of information lack. The proposed approach is based on the comparison between the old equipments used both in the processes and in the auxiliary services and the best available technologies (BATs) on the market. This analysis allows to find inefficiencies and to propose improvements which permit to the enterprise a significant reduction of the energy bills and the environmental impact.

Keywords: Energy Efficiency, Energy Saving, Final Uses, Energy Audit, Best Available Technologies (BATs).

1. Introduction

Energy is the lifeblood of today’s economy. Any threat to the availability of this resource can endanger local or even global prosperity. Furthermore, the world’s thirst for energy is growing. Especially the highly dynamic emerging economies are set to account for a significant share of this global increase. Consumption trends all over the world are impressive and lead us to face the problem of the sustainability of our system, where 85% of primary energy requirements is still satisfied by fossil fuels. Facing this scenario, it is legitimate that all stakeholders are taking part in the debate over where this energy is going to come from.

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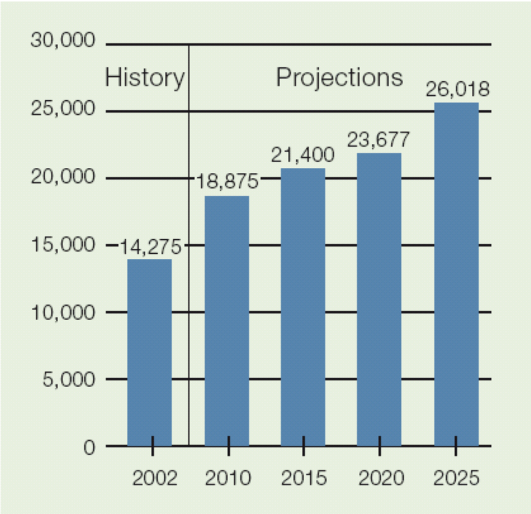

Fig. 1: World net electricity consumption in billion kWh, 2002-2025. Source: IEA.

Relying on the traditional sources alone can not be the solution. Most stakeholders think that the best answer to the increase of world's requirements of energy can be a mix of different solutions: nuclear, coal used in different ways, CO_2 sequestration, bio-fuels, wind, solar and ocean energy, taxation and certificates introduced as incentives for change, etc. The passage to a balanced mix of energy sources can not be considered around the corner and it will require a lot of time.

In this context energy efficiency is a good alternative that can deliver a fast solution and at the same time being economically viable. Using less energy for the same tasks has the same effect on the global energy balance as the introduction of other alternative energies. While both roads have to be taken, an increase of the efficiency of existing infrastructure can now be realized and, rather than leading to higher overall costs, the necessary investments are recoverable through operational economies.

Italy, with its consumption of approximately 0.32 tons of oil equivalent (TOE) for 1,000 dollars of the Gross Domestic Product and with CO_2-emissions of 7.7 tons per year for person [1], can be considered an energetically virtuous country. However its potential energy saving is remarkable.

Table 1. Italian final consumptions for sector and sources in 2005. Source: [1].

	Consumption (MTOE)	**Oil**	**Gas**	**Solid fuels**	**Electricity**
Transportation	44	97%	0.70%	-	2%
Industry	41	19%	41%	11%	29%
Residential sector	30	16%	60%	-	20%
Tertiary sector	16	10%	49%	-	41%
Other	15				
Total	146				

Recently the Italian government has introduced to Brussels a national action plan on the energy efficiency [2] with the measures already predisposed and those that are in order to be prepared to catch up the objective established by the European Directive 2006/32: 9.6% of energy saving within 2016. Through the adoption of this plan, the Italian government wants to obtain the following results:

- from the residential sector (buildings and equipments) savings for 16,998 GWh/year by 2010 and 56,830 GWh/year by 2016;
- from the tertiary sector (efficient heating, conditioning and lighting systems) 8,130 GWh/year by 2010 and 24,700 GWh/year by 2016;
- from the industry (efficient electric motors and variable speed drives, co-generation, etc) 7,040 GWh/year by 2010 and 21,537 GWh/year by 2016;
- from the transportation (introduction of the limit of emissions of 140 grams of CO_2/km for the vehicles sold from 2009) 3,490 GWh/year by 2010 and 23,260 GWh/year by 2016.

The total energy saving that is wanted to be obtained is equal, therefore, to 35,658 GWh/year by 2010 (3%) and to 126,327 GWh/year by 2016 (9,6%).

Especially in industry, there are great opportunities to reduce the energy consumptions with positive effects on the competitiveness of the companies beyond the ones on the environment. In Italy industrial sector is based on a system of small and medium enterprises (SMEs) in which energy management is relegated to a secondary function behind raw material, human resources, productivity, quality and safety. The significance of energy is too often dismissed because it is seen as a specialized field outside the core business of the organization.

This paper deals with the potential energy saving in industry and the measures that can be implemented to reduce energy consumptions. It introduces also a versatile instrument (particularly useful to the SMEs) to find inefficiencies and to propose improvements: the energy audit.

2. Energy saving opportunities in industry: the best available technologies

Technologies that save energy or improve efficiency are becoming more widespread. The term “Best Available Technologies” (BATs) refers to the technologies that, when compared to other ones that are used in a similar process or in the same auxiliary services, produce superior results consuming less energy. The BATs usually present higher prices than traditional ones but the necessary investments are characterized by short payback periods and are recoverable through operational economies.

In industry it is possible to obtain great energy savings through the application of the BATs both on the processes and the auxiliary services. The interventions on the processes are generally very complicated because of the peculiarity of the activities of the different enterprises. Moreover improvements are often limited because the processes are already optimized and the equipments used are new and efficient. On the contrary great margins of improvement are usually found in the auxiliary service equipments: fans, air compressors, pumps, HVAC systems (heating, ventilation and air conditioning), refrigerators, conveyors and lighting systems. The consumptions of the auxiliary services are often underestimated from the management especially in the

SMEs. Electric motor driven systems account for 74% of electricity consumption in Italian industry [3] and the auxiliary services are responsible for a good part of this consumption; this is the reason for which the following interventions are priority:

- application of Energy-Efficient Motors (EEMs);
- application of Variable Speed Drives (VSDs);
- improvement of the efficiency of the final use devices (fans, air compressors, pumps, etc).

There are multiple reasons that explain why profitable energy saving measures are not put into practice by the management of the SMEs:

- motor systems electricity consumption is "invisible" to the management;
- electricity consumption in general, and motor systems consumption in particular, is usually treated as a general overhead item in company analytical accounting schemes: thus reducing this cost item is not the responsibility of any particular manager;
- measures to optimise the cost of equipment purchases, such as competitive bidding procedures, rarely take into account long term operating costs due to electricity consumption even if they are approximately the 98.4% of the life cycle costs of a motor (Fig. 2);
- EEMs require higher initial investment so they are not even proposed by suppliers in competitive bidding procedures;
- responsibility for potential optimisation measures is largely diffused among several management functions: production, maintenance, purchasing and finance; it is difficult to get high-level management agreement, cutting across departmental responsibilities, on a low priority item such as electricity consumption.

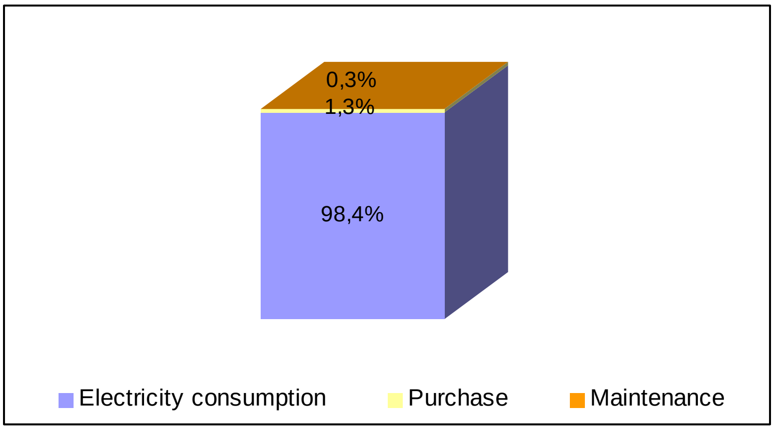

Fig. 2. Life cycle costs of an electric motor. Source: [3].

Therefore because of these problems the BATs are often not applied in SMEs and remarkable savings are not obtained. For example an energy-efficient motor reduces energy losses up to 40%: this means that in the case of a 15 kW motor with high operating hours (e.g. 6,000 hours per year), it is possible to save about 4 MWh per year or more than 450 € of the electricity bill (at 0.12 €/kWh). The higher purchase cost of an

EEM can be recovered in a short time; moreover EEMs are characterized by materials of good quality that normally increase also the lifetime of the motor.

Since 1999 CEMEP (European Committee of Manufacturers of Electrical Machines and Power Electronics) and the European Commission have defined a scheme to designate energy efficiency classes for low voltage AC motors. This scheme is an important element of the European efforts to improve energy efficiency in industry; through it OEMs and motor end-users can themselves decide, on the basis of easy to read information, whether currently used standard motors can be replaced by improved or high efficiency motors. Three classes of efficiency levels are defined by two levels of efficiency per output and number of poles and designed EFF3, EFF2 and EFF1; these labels appear on motor rating plates.

Also variable speed drives can allow remarkable energy savings [4]. In particular VSD technology applied to traditional devices like fans, pumps and air compressors with speed regulation through load losses can reduce significantly energy consumptions in the industrial plants. In many cases the investments are characterized by payback periods inferior to one year and sometimes the savings can be also of 50%, contributing to an important cut of the electricity bills. For example traditional compressor systems can not precisely track the variation of compressed air demand from the process: airflow is usually regulated by a valve control that modulates between open and close positions, being the compressor operated constantly at its initial pressure setting. When it is required the compressor works at partial loads, this method results very inefficient because the machine operates at higher pressure than necessary.

In opposition VSD technology consists of a more dynamic internal compressor controller that allows compressors to produce the exact amount of air at the required pressure, by varying the speed of the compressor drive motor, and so minimizing energy consumption. The control software also enables the compressor to be taken completely off-line when it is not needed, thus getting remarkable savings during idle periods.

These are only some of the examples of the application of the BATs in industry: other effective energy saving measures can be put into practice on the lighting system (that is responsible of about 4% of the electricity consumption in industrial plants). The most convenient interventions on these systems are the following:

- utilization of higher efficiency lamps (fluorescent lamps);
- utilization of higher efficiency ballasts (electronic ballasts);
- reduction of the illumination to minimum necessary levels;
- utilization of the daylight whenever possible instead of artificial light;
- cleaning of the lamps and reflectors;
- turning off lights when not needed;
- addition of area lighting switches;
- installation of timers on light switches in little used areas;
- use of separate switches on perimeter lighting which may be turned off when natural light is available;
- use of photocell controls;
- installation of occupancy sensors.

In some cases through these measures the energy requirements of lighting systems can be reduced of 30 - 35% with investments characterized by payback periods inferior to 4 years.

3. Energy audit

The top management of the SMEs usually underestimates the energy wasted by old equipments used both in the processes and in the auxiliary services. Moreover the managers of these organizations consider energy as a specialized field outside the core business and often do not know the remarkable potential of the application of the BATs. Because of this, it is important to define an instrument based on a rigorous protocol to conduct energy assessment in the SMEs finalized to propose and implement energy efficiency measures: the energy audit. Examples of the success of this instrument can be found also in literature [5], [6].

The energy audit is undertaken with the aim of providing a description of the company's global energy situation, quantifying possible energy savings and defining the measures needed to achieve such savings. In the SMEs there are not the competences to execute these diagnosis and the energy audit has to be conducted by people external to the organization which are specialized in this field: the energy auditors.

To ensure a high quality service, the auditor has to respect the following rules:

- be attentive to the industrial needs of the enterprise;
- create a communicative relationship with the top management;
- make a very accurate data collection;
- act professionally while establishing the energy balance and its follow-up;
- quantify as accurately as possible the potential energy savings;
- specify the costs that the interventions incur;
- provide to the top management all the information necessary to take the successive decisions.

During this analysis, the auditor looks at the existing situation and considers all the main energy consumption points. So as to determine the level of intervention, a prior visit to the site is necessary. The auditor collects the expectations, needs and constraints of his industrial contacts so that he can both decide the aim of the diagnosis and its scope. If necessary, the auditor can modify his analysis in line with the peculiarities of the industrial site. In such a case, he explains the reasons to his contacts clearly and he also mentions them in the report. The identification and quantification of energy saving sources is undertaken on the basis of energy consumption data which have to be sufficiently accurate and representative. When such data are either unavailable, incomplete or inaccurate, specific measurement campaigns have to be carried out.

The energy audit can be divided into three different phases:

1. preliminary analysis (Fig. 3);
2. detailed analysis (Fig. 4);
3. proposal of improvement solutions (Fig. 5).

In the first phase an energy diagnosis is conducted on the basis of the evaluation of the data collected on the site through analysis of documentation, site visits and interviews. The results of this diagnosis allow:

- a preliminary assessment of the energy balance of the site;
- the comparison of the energy performance between the equipments used both in the processes and in the auxiliary services and the BATs on the market;
- an initial assessment of the potential energy saving sources.

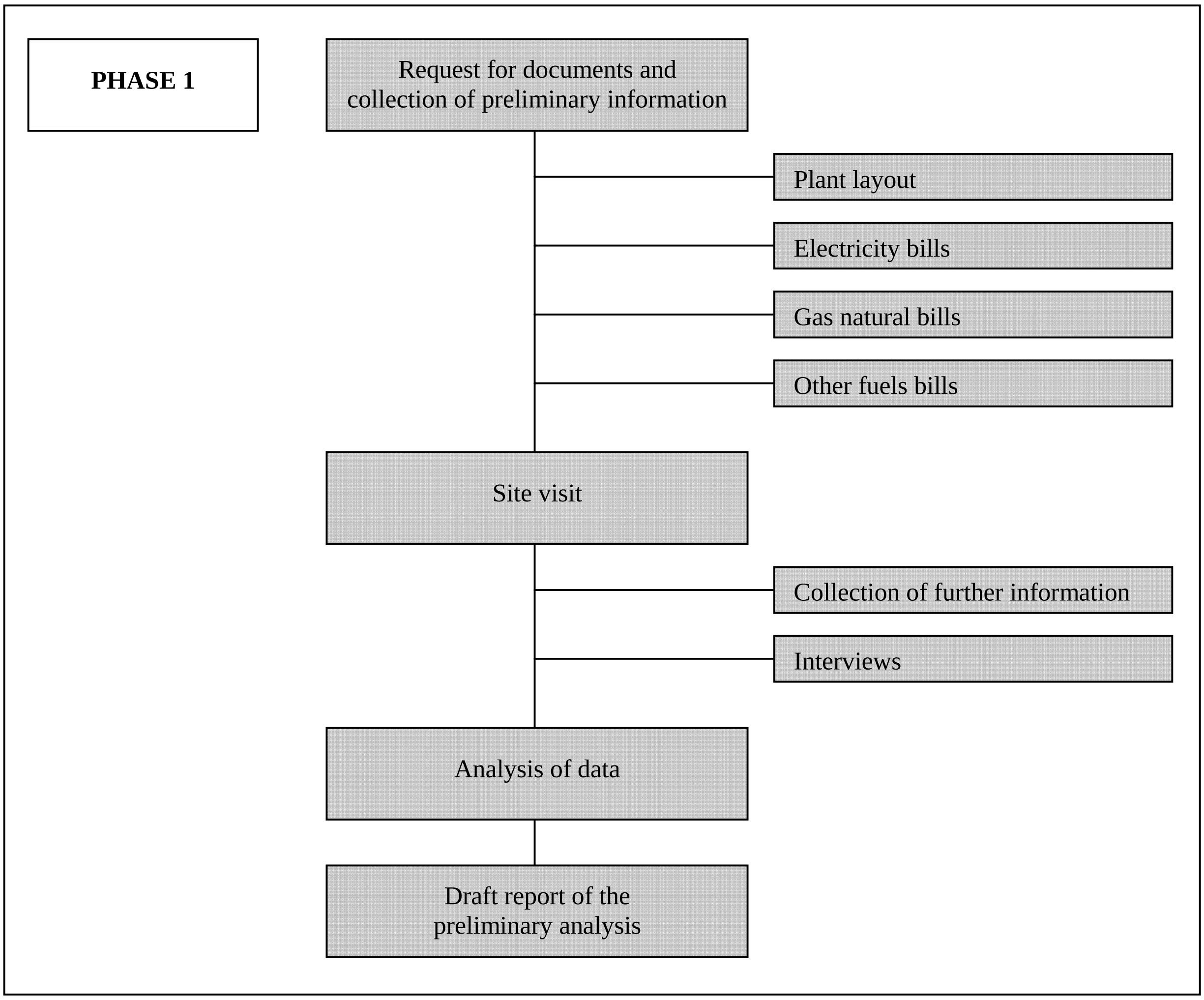

Fig. 3. Phase 1: preliminary analysis.

In the second phase the preliminary analysis is extended through an additional collection of data which are then elaborated to quantify the actual energy needs of the site and to describe possible improvements. The elaboration of data is based on measurements, calculations, estimates, simulations and the analysis of the relationship between calculations and actual data.

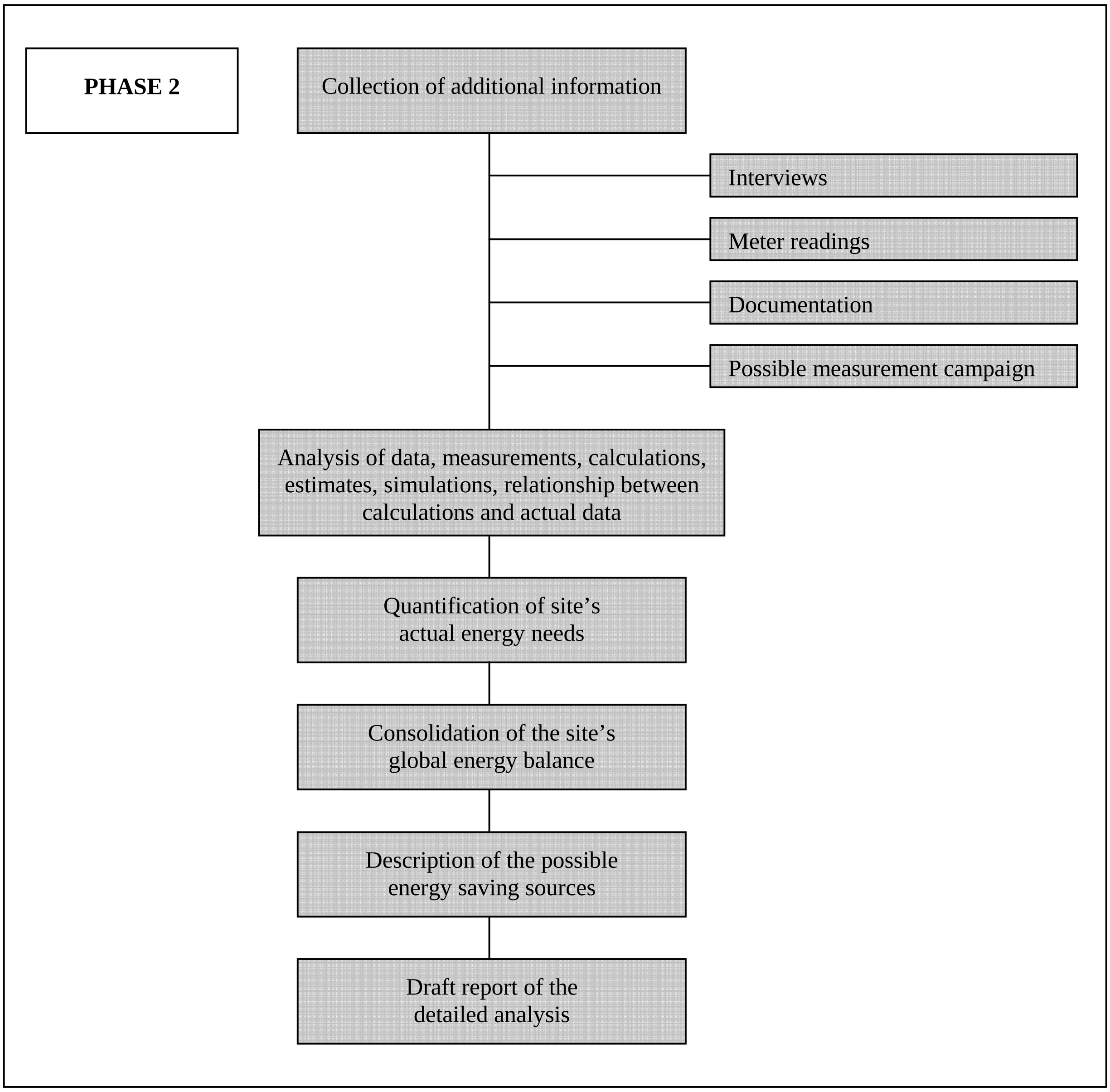

Fig. 4. Phase 2: detailed analysis.

The third phase provides the identification of the energy saving measures and the quantification of the cost reduction and the investments necessary with their relative payback periods. Then the priority of the interventions is defined and a final detailed report is provided to the top management which has to decide on the implementation of the energy saving measures.

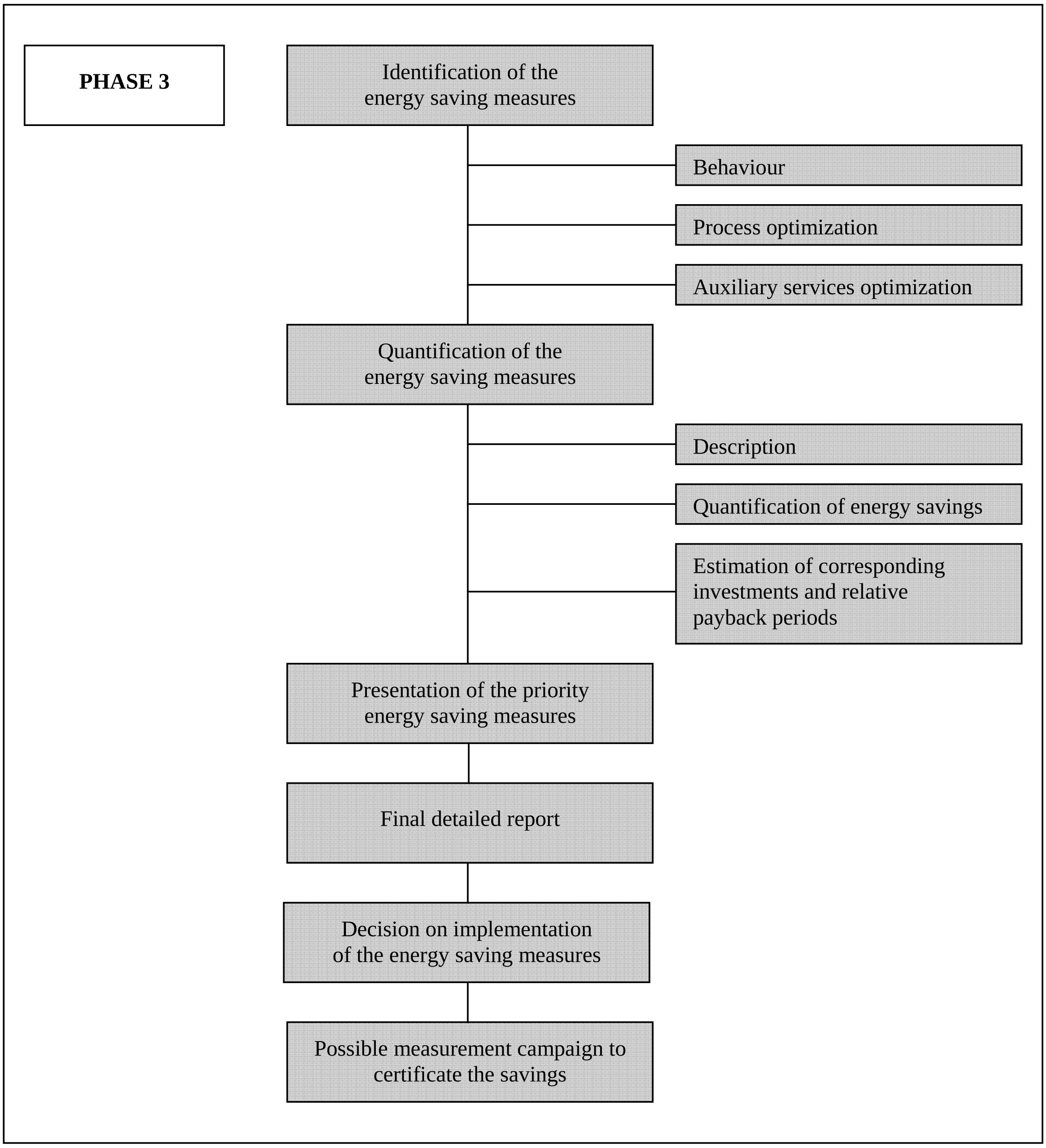

Fig. 5. Phase 3: proposal of improvement solutions.

The approach to the energy audit described in this work is a dynamic approach (Fig. 6): the individuation of the inefficiencies and the proposals of improvement are based on a main database (DB1) sourced by other three databases:

- the database of the BATs (DB2);
- the database with the data of the consumptions and the efficiency indicators of the various industrial sectors (DB3);
- the database of the previous energy audits (DB4).

DB2 and DB3 have to be continually updated and allow respectively the individuation of the opportunities of improvement present in the market and a comparison with the energetic performances of the other enterprises in the same sector. DB4 is updated by the energy audits already conducted and allows a comparison with other case studies.

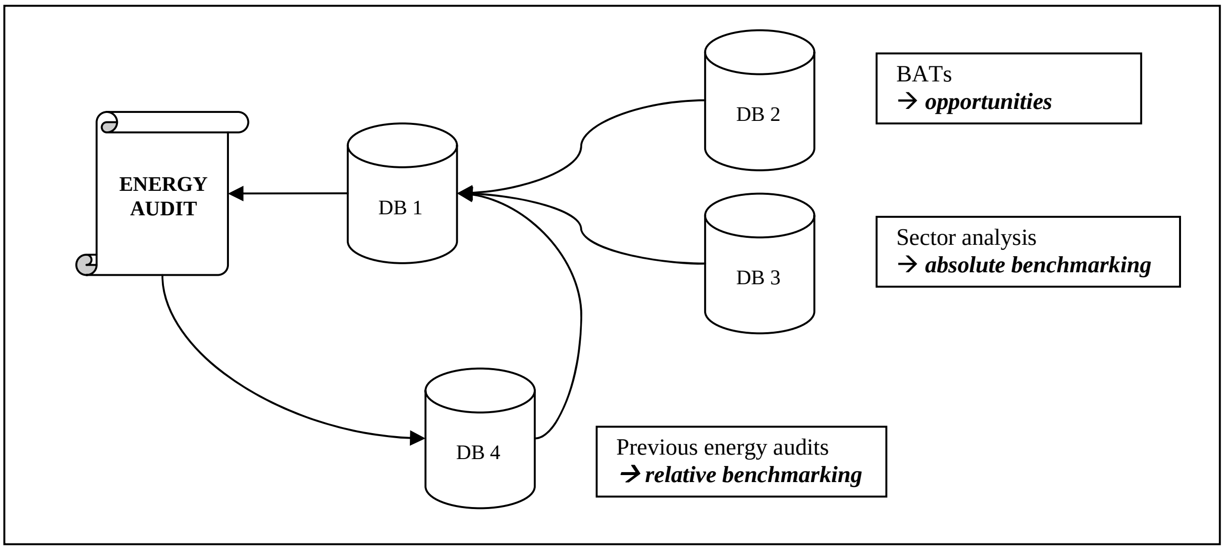

Fig. 6. The dynamic approach of the energy audit.

4. Conclusion

The implementation of such a structured energy audit offers numerous benefits to the enterprises including:

- improved energetic efficiency;
- reduced energy bills;
- reduced environmental impact;
- reduced maintenance costs;
- improvement of working conditions and safety;
- greater organizational involvement and competency concerning energy issues.

Moreover this approach can be particularly effective also in Italian SMEs context because it is adaptable to every kind of enterprise and situation (lack of information on the technical characteristics of the old equipments, no interlocutor with knowledge of management of energy, etc).

The main condition for the success of the energy audit proposed in this work is the commitment of the top management. Top management holds the decision making power and, if it is not convinced of the interventions benefits, it can determine the failure of the audit.

In addition to the evident and immediate benefits of the energy audit, there are also other success factors which can motivate the top management to implement energy efficiency measures:

- the need to gain competitiveness by reducing production costs;
- the increase of energy prices;
- the opportunity represented by the diffusion of new and more efficient technologies;
- new legislation and regulations that incentive energy saving interventions.

Due to these reasons, the top management should sustain and promote energy audits in its enterprise. With a well structured energy audit every company can obtain significant economical saving and reduce its environmental impact. When the benefits are known to the top management there is no reason to avoid the implementation of a serious energy diagnosis of the plants, but, often, the more difficult and critical step is the first one i.e. to decide to begin.

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