

Proposal of an Energy Management Maturity Model to assess the progress achieved through mandatory energy audit application in the EU Energy Efficiency Directive context

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Abstract: In the European scene, the promotion of energy efficiency is a key element of the community’s strategic effort. Among the binding measures established by the Energy Efficiency Directive of 2012 to foster this vision, the requirement for large companies to conduct energy audits with a four-years frequency was one of the most notable. Thus, following the receipt of the second round of energy audits reports, in December 2019, a new "photograph" of the energy situation of Italian companies has been made available. This presents the possibility, previously unavailable, of being able to compare the two situations reported in 2015 and 2019 in order to evaluate how the legislative obligation, and in particular the tool represented by mandatory energy audits, influenced the development of energy efficiency in the country. In order to do so, in collaboration with the Italian National Agency for Energy, a project has started with the objective to develop tools and methodologies necessary to evaluate in more detail the evolution that has taken place in the four years since 2015. In the present paper, a Maturity Model to assess the degree of progress achieved in the last four years in a company's energy management is presented. The model, realized after a comprehensive assessment of the scientific literature on this theme, comprises 5 maturity levels and 6 dimensions to cover all relevant aspects of energy management. The evaluation of the maturity level of the organization is achieved through a guided self-assessment conducted with a questionnaire of 48 questions. Moreover, through the use of the maturity model, an evaluation of the examined organization’s weaknesses and strengths is provided. In the next years, the model will be applied to a significant selection of Italian organizations in energy-intensive industrial sectors.

Keywords: Energy audit; Energy management; Maturity Model, Energy Efficiency Directive; Energy efficiency

1. Introduction

Following the publication of Legislative Decree no. 102/2014 that, implementing the European Directive 2012/27/EU on energy efficiency, set the obligation for large enterprises and enterprises with high energy consumption to undergo an energy audit every four years, thousands of companies in Italy have performed, sometimes for the first time, an energy audit of their site.

In December 2019, four years after the first obligation expired, new energy audits reports for companies still interested by the legal obligation were received, thus presenting the possibility, previously unavailable, of being able to compare the two situations reported in 2015 and 2019 in order to evaluate how the mandatory energy audits have influenced the development of energy efficiency in the country. In order to do so, in collaboration with the Italian National Agency for Energy, a three-year research project, of which this paper contains the description of the results of the first year, has started. The ultimate goal of the project is to achieve greater insight about the current situation and the evolution

undergone in the past four years by companies subjected to the legislative obligation and to analyse energy audits in relation to the dissemination of good practices in the energy management.

In the present paper, a Maturity Model designed to assess the degree of progress achieved in the last four years in a company's energy management is presented. The structure of the paper is as follows: Section 2 describes the background on maturity models, both in general terms and in reference to their use for energy efficiency assessment; in Section 3 the definition of the maturity model is outlined; Section 4 describes the results of its experimental application and Section 5 concludes the paper, describing the future steps of the work.

2. Background

2.1 Maturity Models

The concept of corporate maturity was conceived in 1979 by Philip Crosby in the work titled “Quality is free” (Crosby, 1979) with the purpose of providing a tool for

corporate management to measure, and therefore control, the degree of quality management in the organization. The instrument proposed was the “Quality Management Maturity Grid (QMMG)”. Subsequent to its first formulation, the concept of maturity has evolved over time thanks to the interest from both academics and practitioners. Nowadays, the sectors in which maturity models are applied have broadened, from project management to security management, to sustainability (Introna et al., 2014). For example, a literature review published in 2012 identified 237 articles regarding the research on maturity models, covering more than 20 different domains (Wendler, 2012).

A clear definition of a maturity model is provided by Becker, Knackstedt, & Pöppelbuß in 2009 (Becker et al., 2009): “A maturity model consists of a sequence of maturity levels for a class of objects. It represents an anticipated, desired, or typical evolution path of these objects shaped as discrete stages”. Therefore, a maturity model is used to represent an evolutionary path for certain entities that may be represented by organizations or processes (Becker et al., 2009; Mettler et al., 2010).

Maturity models are also tools suitable for the knowledge transfer process, since they can define a specific improvement path based on an assessment of the current conditions and their comparison with relevant best practices (Benedetti et al., 2019). They can often be configured in self-assessment mode, thus allowing professionals and organizations to identify key areas for improvement and the actions to be taken.

Moreover, maturity models can be defined by different levels (or stages) of maturity and by several structuring dimensions. The dimensions give a systematic representation of the field of interest and should be defined so that they are distinct and representative of all aspects of the activity/process for which the maturity is being evaluated (Fraser et al., 2002). The maturity models can, therefore, be one-dimensional, multi-dimensional or even hierarchical through the use of subdimensions (Lahrman and Marx, 2010).

Finally, the main features common to all maturity models are as follows (Introna et al., 2014):

- **Model structure** – It can be “continuous” or “in stages”. For models in stages, each level of maturity is considered as the basis for the next level. In continuous models, the approach to improvement is based on the development of processes’ capacities and is ongoing and flexible. (Fraser et al., 2002; Lahrman and Marx, 2010; Introna, 2010).
- **Methodology of analysis** – It refers to the manner used to evaluate the organization’s maturity.
- **Reference to international standards** – It can be beneficial for an organization that already has applied an international standard to choose to use a maturity model that is based on the same

standard but in contrast, other organizations could benefit more from using a maturity model not tailored to a specific standard.

- **Mode of assessment** – It refers to the operational procedures used to conduct the evaluation. Most of the models are characterized by the presence of questionnaires with closed questions or grids. The number of questions is a compromise between a thorough evaluation and the aim to appeal even less structured and less experienced organizations. Moreover, the possibility of self-assessment is an effective way to allow even less aware organizations to obtain an overall assessment of their maturity.
- **Results of the assessment** – It refers to the differences in terms of results provided. They may vary according to the degree of detail of the assessment (e.g. a simple number or a more structured report). Very often the results of the assessments are supported by graphical tools to better convey the concept.
- **Guide to improvement** – It refers to the presence of specific directions for improvement. In some models, these indications are absent, in others they are easily deductible or are made explicit and organized in a structured way in order to identify an improvement plan for the organization.

2.2 Maturity Models for Energy Efficiency

In order to achieve the objective of defining a maturity model suitable for the specific purpose of evaluating how the dissemination of best practices in energy management has evolved in companies submitted to mandatory energy audits, it was fundamental to first evaluate the state of the art of the maturity models in this field. In energy management, in fact, there have been several attempts to build models to assess the maturity of organizations.

The bibliographic research has been led on Scopus (<https://www.scopus.com/>) and the keywords used to search titles, abstracts and keywords were “energy” AND “maturity model” OR “maturity assessment”.

From this first research a total of 114 documents were identified. The analysis of abstracts and titles led to the identification of 12 relevant documents among them. Afterwards, a supplementary cross-reference analysis of these 12 documents resulted in the definition of a final sample of 19 documents, then analyzed.

Table 1 summarizes the main features of the models examined referring to model structure, methodology of analysis, reference to international standards (in particular to the standard ISO 50001 for energy management systems), mode of assessment, results of the assessment and guide to improvement.

Table 1. Summary of the main features of the maturity models examined

REF.	MODEL STRUCTURE	METHODOLOGY OF ANALYSIS	REFERENCE TO INTERNATIONAL STANDARDS	MODE OF ASSESSMENT	RESULTS OF THE ASSESSMENT	GUIDE TO IMPROVEMENT
(Carbon Trust, 2011)	In stages: 5 levels	Identification of practices conducted for each dimension	No	Self-assessment not guided	Partial evaluation of the level of maturity achieved in each area	No
(Carbon Trust, 2011)	Continuous	Identification of practices conducted for each dimension	No	Self-guided assessment (questionnaire with 50 questions)	Evaluation of the development (%) of each area	No
(ENERGY STAR Guidelines for Energy Management, n.d.)	In stages: 3 levels	Identification of practices conducted for each dimension	No	Self-assessment not guided	Partial evaluation of the level of maturity achieved in each area	Energy Star guidelines and references are provided for further consultations.
(O’Sullivan, 2012)	In stages: 5 levels	Identification of practices conducted for each dimension	ISO 50001	Self-guided assessment (questionnaire with 63 questions)	Partial evaluation of the level of maturity achieved in each area	No
(Ngai et al., 2013)	In stages: 5 levels	Identification of practices to lead to change from one to another level of maturity	No	Assessment on the field and workshops	Global rating	The moderator of the workshop leads the company in the analysis of practices to improve.
(Introna et al., 2014)	In stages: 5 levels, but the dimensions are defined by levels and evaluated in a continuous manner. (Hybrid)	Identification of practices conducted for each dimension	Compliant but not based on ISO 50001	Self-guided assessment (questionnaire with 40 questions)	Evaluation of the overall maturity, assessment of the percentage coverage of all dimensions and all levels	Final report that contains a detailed guide to the improvement based on rules of development.
(Benedetti et al., 2019)	In stages: 5 levels, but the dimensions are defined by levels and evaluated in a continuous manner. (Hybrid)	Identification of practices conducted for each dimension	Compliant but not based on ISO 50001	Self-guided assessment (questionnaire with 34 questions)	Evaluation of the overall maturity, assessment of the percentage coverage of all dimensions and all levels	Final report that contains a detailed guide to the improvement based on rules of development.
(Curry et al., 2012, 2013)	In stages: 5 levels	Identification of key objectives for each dimension	No	Online survey supported by interviews	Partial evaluation of the level of maturity achieved in each area	No
(Antunes et al., 2014)	In stages: 5 levels	Identification of practices to lead to change from one to another level of maturity	ISO 50001	N/D	N/D	No
(Jovanović and Filipović, 2016)	In stages: 5 levels	Identification of practices conducted for each dimension	ISO 50001	Self-guided assessment (questionnaire with 21 questions)	Partial evaluation of the level of maturity achieved in each area	No
(Yucel and Halis, 2016)	In stages: 5 levels	Identification of practices conducted for each dimension	ISO 50001	N/D	Global rating	No
(Prashar, 2017)	In stages: 5 levels	Identification of practices conducted for each dimension	ISO 50001	Self-guided assessment (questionnaire with 19 questions), supported by interviews.	Evaluation of the overall maturity, evaluation of the development of every dimension	Gap analysis for the identification of areas of improvement.
(Qiang and Jiang, 2009)	In stages: 5 levels	Identification of practices conducted for each dimension	No	Interviews	Global rating	No

(EDF Climate Corps, 2015)	In stages: 5 levels	Identification of practices conducted for each dimension	No	Self-guided assessment (questionnaire with 16 questions)	Partial evaluation of the level of maturity achieved in each area	No
(Finnerty, Sterling, Coakley, and Keane, 2017; Finnerty, Sterling, Coakley, Contreras, et al., 2017; Finnerty et al., 2015)	In stages: 5 levels	Identification of practices conducted for each dimension	Compliant to Plan-Do-Check-Act	Self-guided assessment (questionnaire divided into 3 sections)	Evaluation of the overall maturity, evaluation of the development of every dimension (at site level and overall organization), performance evaluation based on market benchmarks (incorporating the previous model)	Roadmap to guide the continuous improvement
(Çoban and Onar, 2020)	In stages: 5 levels (fuzzy)	Identification of practices conducted for each dimension	Compliant to Plan-Do-Check-Act	Self-guided assessment (questionnaire divided into 3 sections)	Similar to the previous model	Roadmap to guide the continuous improvement

3. Definition of the Maturity Model

3.1 Maturity Models Description

After the analysis of the existing maturity models, it was possible to evaluate the features most suitable for the definition of the specific maturity model. In particular, the definition of the maturity model followed these methodological steps: definition of the structure of the model, definition of analysis methodology and definition of assessment procedures.

The most common structure found for the models examined is the staged one, which has been evaluated as the most suitable to allow to carry out an assessment of the evolution of maturity in the energy management of companies and to perform future correlation analysis taking into account the evolution of the energy performance indicators of the organizations to deepen the assessment. It was decided to use 5 levels, number most common in the existing models, as a good compromise between the need for differentiation and the ease in the recognition of the actual behaviours:

1. Level 1 – Elementary;
2. Level 2 – Occasional;
3. Level 3 – Project-based;

4. Level 4 – Management;
5. Level 5 – Optimized.

In the case of model in stages it is necessary to establish the operational mode to assess within the companies the achievement of different maturity levels (e.g. whether to reference to dimensions, targets or processes such as the processes of ISO 50001).

In the proposed model, key aspects of energy management within an organization have been defined and used to create 6 dimensions. Each level may contain aspects related to the different dimensions of maturity. Below, the 6 maturity dimensions identified are listed:

1. Strategic approach;
2. Awareness, knowledge and skills;
3. Methodological approach;
4. Organizational structure;
5. Energy performance management and Information System;
6. Best practices.

Table 2 presents an overview of how the 6 maturity dimensions evolve over the 5 levels of maturity inside the organization.

Table 2. Overview of the dimensions of the model along the 5 levels of maturity

LEVEL	DIMENSIONS OF MATURITY					
	Strategic approach	Awareness, knowledge and skills	Methodological approach	Organizational structure	Energy performance management and information system	Best practices
5	Optimized, addressed to continuous improvement	Optimized, continuous staff training	Optimized and in use	Optimized and in use	Optimized and in use	Optimized, constantly updated

4	Complete organization's strategic alignment	The staff has all the skills and knowledge needed to support an energy management system	Energy Management System in use	Perfected, stabilized and in use	Perfected, stabilized and in use	Systematic search and standardization of best practices for all the activities relevant for the energy performance
3	Significant progress (shared targets)	Significant progress	Approach to projects (through energy audits)	Organization projects	Standardized and in use	Dissemination of good practices as result of energy audits
2	Definition of energy policy	Basic	Identification of occasional opportunities of energy consumption reduction	Energy Manager nominated	Basic	Attention to best practices in purchasing
1	Inexistent	Inexistent	Inexistent	Inexistent	Inexistent	Inexistent

Refer to Appendix A for additional information about the model.

3.2 Assessment Methodology

The assessment method chosen for the proposed maturity model was the self-assessment guided through a questionnaire. The reasons for this are related to the intention to reduce the risk of misunderstandings due to personal interpretations that could skew the results of the assessment. Furthermore, since the aim of the project is to gather as much information as possible about the level of dissemination of good practices in Italian companies, this type of tool is better suited to be made available also on web platforms and thus to be carried out remotely.

For each level, a number of questions associated with each dimension has been identified, for a total of 48 questions:

- 12 questions for Level 2;
- 14 questions for Level 3;
- 15 questions for Level 4;
- 7 questions for Level 5.

Since the first level is an elementary stage, it is not associated with any questions. From level 2 to 5, questions are associated with a series of responses to characterize the specific level (the number of responses is equal to 4 for the first three levels, from second to fourth, while it is equal to 2 for the last level).

The organization that answers the questionnaire must choose the answer that better reflects their situation.

The answers are defined so that if an answer is true, also the previous ones are true. As a result, the score of each response can be calculated cumulatively.

In order to enable companies to assess how their approach to energy management has evolved in the four

years between 2015 and 2019, for each question two answers are given:

- The first one, representative of the situation prior to the conduction of the energy audit of 2015;
- The second one, representative of the situation after the conduction of the energy audit of 2019.

The presentation of the results is achieved through three indicators:

- The maturity index, a number between 1 and 5, which summarizes the overall level of maturity of the organization;
- The degree of coverage of the different levels;
- The development of maturity in different dimensions.

In accordance with the definition of the model, for every indicator two evaluations are made: the first representative of the situation prior to the conduction of the energy audit of 2015, the second representative of the situation after the conduction of the energy audit of 2019.

4.Application

In order to provide a first validation of the maturity model proposed, a case study has been tested experimentally. It represents the case of an organization without any experience prior to the first mandatory energy audit of 2015.

Afterwards, a measurement system was introduced for all relevant entities together with a first not systematic implementation of some relevant energy efficiency opportunities identified in the aforementioned energy audit (especially in regard to the modification of operational procedures to save energy).

The Maturity Index changed from 1.5 and 2.4, showing an improvement in the maturity of the organization in the four years. In order to understand the reasons behind this evolution, the other indicators have been examined.

Figure 1 shows the degree of coverage of the different maturity levels, from 0% to 100%. From the figure, it appears that the organization has been improving both Level 2 and Level 3, the lower levels, representing an overall consolidation of the basic energy management practices in the 4 years. It should be noted that in order to achieve a more stable performance, before any further improvement to the higher levels, Level 2 should be completed since it represents the most elementary aspects of the implementation of energy management, thus a lack of a solid foundation would be detrimental to the effective application of the more advanced practices linked to levels 4 and 5.

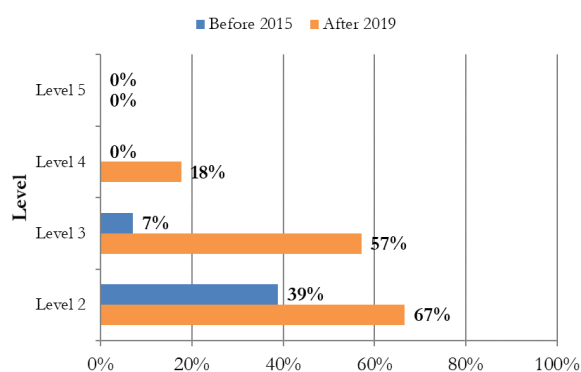


Figure 1. Degree of coverage of the different levels

Moreover, to define more clearly the areas affected by the improvement of the energy management in the organization, the third indicator, representing the development of maturity in different dimensions, can be examined (Figure 2).

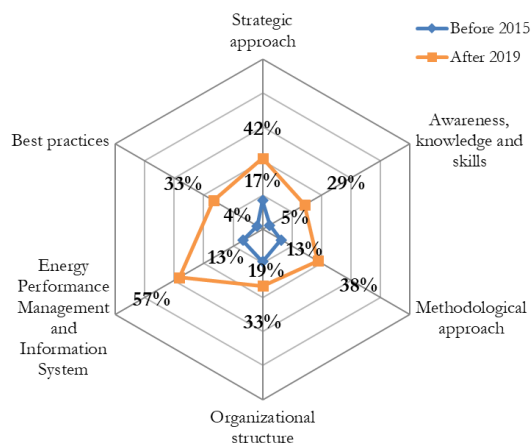


Figure 2. Development of maturity in the different dimension

Figure 2 shows that all 6 dimensions have been improved since the first mandatory energy audit. However, one dimension presents the biggest changes: “Energy performance management and Information System”. Indeed, the cause behind this relevant development is that in these 4 years the organization has invested in the

development of a measurement system. Energy data from the main users of the industrial plant are now collected and analyzed.

It is also interesting to highlight another relevant change. The development of the dimension “Best Practices”, which refers to the standardization and optimization of the activities and processes that have an impact on energy consumption in the organization, has changed from 4% to 33%. This result is consistent with the information obtained before the questionnaire. Indeed, after the first energy audit the organization has decided to focus its effort first on the energy efficiency opportunities that concern the modification of operational procedures, since they usually guarantee relevant benefits without the requirement of huge investments. It follows that to further improve its energy management the organization should focus primarily on the combined progress of the other 5 dimensions apart from the “Energy performance management and Information System”.

The use of the proposed Maturity Model allows to identify the progress occurred in the energy management performance of the organization, while also highlighting the areas and practices in which it would be more useful to focus further efforts by the organizations.

5. Conclusion

A maturity model able to assess the evolution achieved by an organization after the introduction of mandatory energy audit has been developed and presented in this paper. The model is the result of the first year of a project developed in collaboration with the Italian National Agency for Energy. The model, realized after a comprehensive assessment of the scientific literature on this theme, comprises 5 maturity levels and 6 dimensions to cover all relevant aspects of energy management and is implemented through a questionnaire of 48 questions. Three different indicators have been developed to support the maturity assessment, describing the maturity at different levels of detail.

A first experimentation of the model on a case study showed the ability to define the organization’s weaknesses, strengths and progress in the four years. This kind of tool would enable the comparison of the two situations reported in 2015 and 2019 and therefore it would enable the evaluation of how the mandatory energy audits have influenced the development of energy efficiency in the country.

In the next years, the model will be applied to a significant selection of Italian organizations in energy-intensive industrial sectors to assess their evolution after the implementation of Legislative Decree no. 102/2014, thus testing its general applicability and gathering feedbacks to further improve the tool.

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Appendix A. EXTENDED DESCRIPTION OF THE MATURITY MODEL

The Appendix is available at the following link: <https://www.dropbox.com/s/0de8v6kehmdhc4l/Appendix%20A.pdf?dl=0>