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Impact of Energy Monitoring and Management Systems on the Implementation and Planning of Energy Performance Improved Actions: An Empirical Analysis Based on Energy Audits in Italy

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Abstract: The implementation of monitoring tools and energy management systems (EnMSs) supports companies in their long-term energy efficiency strategies, and they are essential to analyse the effectiveness of energy performance improvement actions (EPIAs). The first fundamental step towards increasing energy efficiency is the development of energy audits (EAs). EAs provide comprehensive information about the energy usage in a specific facility, identifying and quantifying cost-effective EPIAs. The crucial role of these tools in clean energy transition is remarked by the European Energy Efficiency Directive (EED), which promotes the implementation of EAs and EnMS programmes. The purpose of this work is to better understand the link between EnMSs (specifically ISO 50001) and EAs in the EED Article 8 implementation in two industrial and two tertiary sectors in Italy. Moreover, the impact of company size, energy monitoring systems, and EnMSs on planned and/or implemented EPIAs is analysed. Our findings show that, albeit the complexity of the variables involved in energy efficiency gap, the "energy savings/company" and "EPIA/site" ratios are higher in enterprises with an EnMS and monitoring system. Thus, a correct energy audit must always be accompanied by a specific monitoring plan if it is to be effective and useful to the company decision maker.

Keywords: energy audits (EAs); energy management systems; energy performance improved actions (EPIAs); energy efficiency; manufacturing industry; tertiary sector

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1. Introduction

The Energy Efficiency Directive 2012/27/EU (EED) [1] (and the 2018/2002 directive amendment [2]) is one of the pillars of European legislation on energy. It is the regulatory framework to help the EU reach its energy efficiency targets (an increase of 20% by 2020 and $\geq$32.5% by 2030, relative to 1990 levels), and it is composed of a balanced collection of binding measures and recommendations. EED Article 8 is fully devoted to the promotion of cost-effective high-quality energy audits and the implementation of energy management systems. These are two crucial tools to evaluate the existing energy consumption, to identify all the opportunities to save energy, and to implement a continuous improvement on energy efficiency in the industry and in enterprises. The development of energy audits is the first step towards overcoming the main barriers to implementing energy efficiency actions [3].

The Italian government transposed the EED in 2014 and 2020 (by enacting Legislative Decrees 102/2014 and 73/2020, respectively), extending the obligation (from 5 December 2015) of carrying out mandatory energy audits at least every 4 years not only in large companies but also in a specific group of energy-intensive enterprises (mostly SMEs).

The Italian definition of large enterprise is a business organization that has more than 250 employees and has either an annual turnover exceeding EUR 50 million and/or

an annual balance sheet total exceeding EUR 43 million. The size of the company is calculated, taking into consideration the activities of all the sites of the core company and partner/linked enterprises within the Italian territory. Other companies obliged to carry out energy audits are the energy-intensive enterprises (in Italian, "*Energivori*") subjected to tax relief in part of the purchased electricity and registered in the list of the Environmental Energy Services Fund (CSEA, a government agency on electricity). These companies present large energy consumptions (in absolute terms and relative to their internal costs), and they must be part of some specific industrial sectors (mainly Annexes 3 and 5 of EU Guidelines 2014/C 200/01 [4]). Enterprises that do not comply with the mandatory energy audits are subject to administrative and monetary penalties.

According to Article 8 of Italian Legislative Decree 102/2014, ENEA manages the Italian energy audit programme, including data gathering and subsequent sectorial analysis [5]. From the beginning of the programme (2015), ENEA has managed more than 25,000 EAs. The present work is focused on data gathered in relation to the first year of the second compliance cycle (2018). On 31 December 2019, 6434 enterprises were submitted to 11,172 energy audits of their production sites. Most of the EAs were related to the manufacturing sector (53%) with particular importance to the plastic (8%), iron and steel (9%), food (6%), textile (3%), and paper (2%) industries. More than 14% of the EAs were from the trade sector. In the second cycle, compliance cycle was observed in that more than 70% of the audits collected by ENEA presented data of energy consumption from specific monitoring systems.

The purpose of this research analysis is to evaluate the impact of energy monitoring systems and energy management systems on a company's propensity to plan and/or implement energy efficiency measures. In order to achieve this objective, energy audits in four different sectors in Italy were analysed to better understand the possible existing link between energy management and monitoring systems and mandatory energy audits in the EED Article 8 implementation. Moreover, it is important to note that Italian legislation includes the development of energy monitoring systems or plans and the implementation of energy performance improvement actions (EPIAs) according to the energy audits submitted to the national database. The identified sectors for analysis are two manufacturing industries and two branches of the tertiary sector, in order to provide us with insights from two different perspectives.

Previous related research focused on the problem of potential savings due to the implementation of EnMSs, but they were not linked to EAs. Commonly, the data used in research are based on voluntary surveys. Hence, the main novelty of our work is the high quality and amount of data analysed: more than 1600 EAs from more than 700 companies, including more than 1000 implemented and 4000 planned EPIAs. Moreover, specific data and analysis of small and medium enterprises are scarce. Finally, to the best of our knowledge, there is no empirical evidence of the impact of monitoring systems on the effective implementation of EPIAs. Hence, this work is an empirical demonstration of the impact of the promotion of EAs and EnMSs as a crucial part of energy efficiency policies.

2. Context

Energy audits (in Article 2 of EED, energy audit is defined as "*a systematic procedure with the purpose of obtaining adequate knowledge of the existing energy consumption profile of a building or group of buildings, an industrial or commercial operation or installation or a private or public service, identifying and quantifying cost-effective energy savings opportunities, and reporting the findings*" [1]) are the first step towards increasing energy efficiency within a firm and implementing an EnMS, such as ISO 50001. Energy-saving strategies cannot be implemented without having detailed and regular energy consumption data of a facility. Starting from the energy audit programmes, many studies, as analysed by Schleich et al. [6], refer to the residential sector, and only a few refer to enterprises. A recent study carried out by the EIB remarks that, for SMEs, the probability of investing in energy efficiency actions

is 1.5 times greater for enterprises with an energy audit compared with those without one [7].

An energy management system (in Article 2 of EED, an energy management system is defined as "*a set of interrelated or interacting elements of a plan which sets an energy efficiency objective and a strategy to achieve that objective*" [1]) helps an enterprise build a structured process for monitoring its energy consumption and improve its internal efficiency through EPIAs. The adoption of an energy management system can lead to a reduction in energy consumption [8], gains in industrial productivity, and improvements in global enterprise performance, in addition to several other cobenefits positively affecting the overall company competitiveness [9,10]. Energy management is intrinsically connected to economic and environmental issues, but it could also lay the foundations of a comprehensive management system, which includes not only energy efficiency but also quality and environmental management, occupational safety and health, and other risk components [11,12]. However, instead of the multiple benefits of the adoption of energy efficiency strategies, there are multiple barriers involved in the energy efficiency gap that limit the implementation of EnMSs or EPIAs [13–15], or the adoption of the EnMSs in companies with implemented environmental management systems (EMSs) [16].

Regarding ISO 50001, Fiedler and Mircea, in their analysis [17], mentioned that cost saving is probably the key driver for most organizations adopting EnMSs and that certification may be useful for a company strategy and image. Fuchs et al. [18] conducted an analysis of the identification of drivers, benefits, and challenges of ISO 50001 through case study contents. The result was that the biggest motivations for ISO 50001 certification are: existing values and goals, cost savings, environmental sustainability concerns, government incentives or regulations, and gaining competitive advantage via visibility. These results are aligned with those of other works [19] and the 2015 AFNOR European survey "International survey energy management practices in ISO 50001-certified organizations". Another interesting analysis of the effectiveness of the ISO 50001 implementation shows a detailed framework analysis of gaps and potential improvements in order to boost the deployment of EnMSs [20].

McKane et al. [21], through the ISO 50001 Impacts Methodology, speculate both energy and nonenergy benefits. According to their analysis, considering a scenario by 2030 with 50% of the global enterprises under ISO 50001 management, the cumulative savings could reach nearly USD 700 billion, 105 EJ of primary energy, and 6.500 million tons of avoided CO_2 equivalent emissions.

An analysis based on a German energy audit national database [22] indicates that energy-intensive enterprises tend to prioritize energy efficiency projects compared with less energy-intensive ones. In terms of company size, larger companies are inclined to implement more energy efficiency measures than smaller ones. Similar empirical results were observed in Sweden [23] and Latvia [24]. Fleiter et al. [25] conclude that their result identifies high initial investment costs as the main barrier to the adoption of energy efficiency measures. Therefore, to accelerate the adoption of those measures, energy audit programmes should be supported by financing schemes. Moreover, they found evidence that higher satisfaction through energy audits increases the predisposition to implement suggested energy efficiency measures.

Italy is the third country in the world with the highest number of certifications in 2016 [26]. The main motivations for companies to implement an EnMS are, first, to increase competitiveness and, second, to reduce energy and costs [27]. Based on ENEA's analysis of the first obligation period data (started in December 2015) in the plastic sector, a relevant share of proposed interventions referred to ISO 50001 and monitoring systems (15% of 1051). A possible explanation for this relevant share is that the claimed payback time is lower than 2 years. This interesting payback period is confirmed in the energy audits presented for the ceramic sector, where on the same energy audit campaigns show an average payback lower than 1.5 years. A further confirmation of low payback periods for ISO 50001 is found in the FIRE-CEI-CTI survey carried out in 2016, where 70% of the

participants declared a payback time lower than 3 years for ISO 50001 EnMSs and a return of investments in line with their expectations in 85% of the cases [28]. A report carried out by Accredia showed that the reason for certification is business strategy for 74% of the interviews, while only 10% is mainly for cost reduction [29].

3. Materials and Methods

From the preliminary analysis of the EED Article 8 implementation in the second obligation period (started in December 2019), the overall percentage of ISO 50001 sites amounted to 9% (about 1050 sites) of the total number of sites accomplishing their Article 8 obligation, while the overall percentage of sites with an installed energy monitoring system amounted to 70%. The number of certified ISO 50001 companies that presented EAs was 358, with 27% of them being SMEs [30].

The ISO 50001 EnMS standard includes the implementation of a monitoring system. However, it is important to note that the number of monitored sites is sensibly higher than the number of sites with certified EnMSs. Hence, the impact of both variables was analysed separately: the installation of an energy monitoring system only and the implementation of an EnMS (in particular, ISO 50001).

Implemented and identified EPIAs were analysed under companies that were ISO 50001 certified and had a monitoring system and were SMEs. It is important to note that the Italian manufacturing sector is dominated by SMEs [31]; therefore, class size was included in the analysis.

Additionally, a focus on *general EPIAs* was carried out. *General EPIAs* include capacitation of energy management, implementation of energy management systems, monitoring of energy consumption, extension and improvement of current management and/or monitoring systems, and other actions not strictly related to the production process or technical EE measures. The impact of the presence of an energy monitoring system on planned and/or implemented energy efficiency measures and on the corresponding savings was analysed.

A descriptive statistical analysis was developed based on both qualitative (number and type of EPIAs) and quantitative (energy impact of EPIAs) information. The database informing such analysis consists of all the implemented and identified EPIAs reported in the EAs uploaded until December 2019 on the website managed by ENEA (https://audit102.enea.it/) (reference database update 17 May 2020). It is worth specifying that each EA should include information on implemented and identified EPIAs, but this is not always the case. Moreover, information characterizing EPIAs could be incomplete, for example, regarding investment costs and achieved or expected energy savings.

Seven 4-digit NACEs were examined, covering 4 different sectors:

- Banks: K64.19—other monetary intermediation;
- Retail: G47.11—retail sale in nonspecialised stores (hyper- and supermarkets);
- Ceramics: C23.31—manufacture of ceramic tiles and flags and C23.32—manufacture of bricks, tiles, and construction products in baked clay;
- Plastics: C22.22—manufacture of plastic packing goods and C22.29—manufacture of other plastic products.

The analysed sectors were chosen based on their relevance in terms of both energy consumption and ISO 50001-certified companies. The energy audits in the sample reflected the number of obliged parties according to Article 8 of EED, which clearly differs by NACE sector. The two manufacturing sectors were dominated by SMEs, whereas the tertiary sectors were dominated by large companies. Consistently, in the tertiary sector a higher number of sites belonging to the same company were observed than in the industrial sector. An overview of the companies and energy audits analysed is presented in Figure 1.

Different NACE sectors have different patterns when looking at the share of total final energy consumption of companies that have an ISO 50001 certification and a monitoring system and that are defined as SMEs (Figure 2, which shows the share of SMEs, companies with a monitoring system and ISO 50001 certification in the final energy consumption of

audited companies in 2019). In absolute value, the final energy consumption was relatively lower in the tertiary sector than in the manufacturing sector. In the tertiary sector, retail had a higher final energy consumption than banks, consuming 171 and 57 ktoe, respectively. In manufacturing, the total final energy consumption of the two NACE codes examined in the ceramic sector was double the consumption of the two NACE codes in the plastic sector (1100 vs. 577 ktoe).

The analysis of both implemented EPIAs (EPIAs, starting from here) and planned EPIAs covers, in addition to general EPIAs, also measures in technical intervention categories, such as pressure systems, heat recovery systems and thermal plants, inverters and other electrical machines and installations, transport, heating and cooling, and building envelope [32]. Measures in the categories of cogeneration and trigeneration and production from renewable sources were excluded from the analysis since they are associated with savings of primary energy [33].

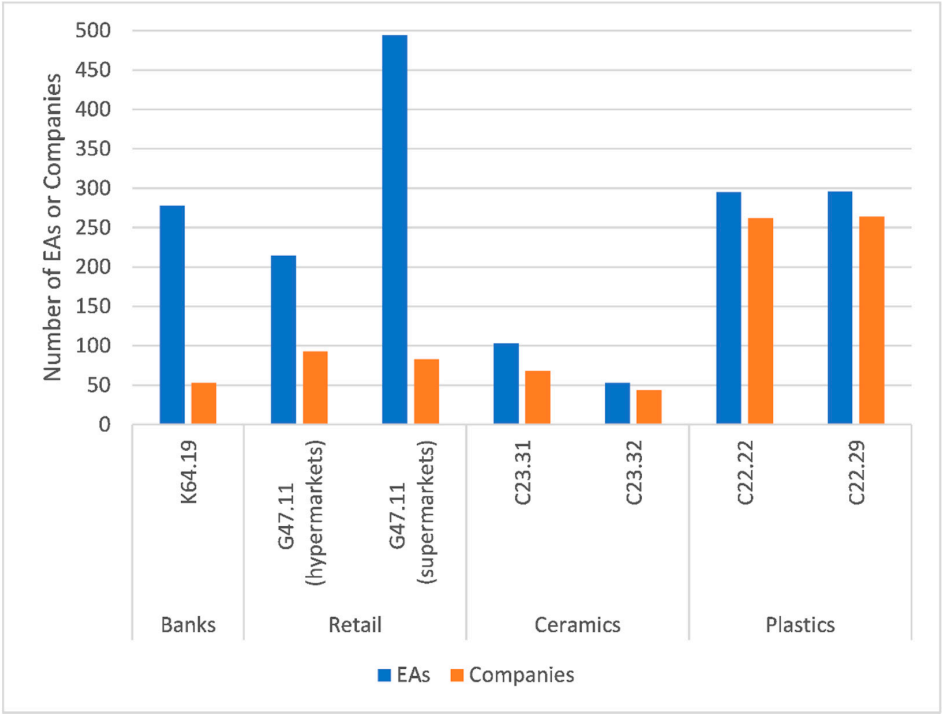

Figure 1. Number of EAs and companies by NACE code.

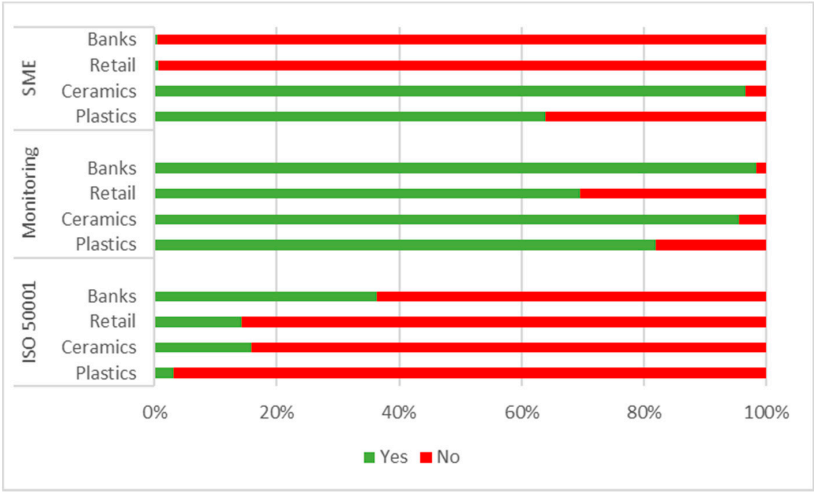

Figure 2. Share of the total final energy consumption by category.

In different NACE sectors, the number of EPIAs in enterprises that have an ISO 50001 certification and a monitoring system and are defined as SMEs is shown in Figure 3. The highest number of EPIAs was observed in plastics, with 558 implemented energy efficiency measures, followed by ceramics (218) and retail, with slightly lower numbers of measures (193). Banks had the lowest number of EPIAs (83). Clearly, this pattern is influenced by the number of EAs by sector; nevertheless, the number of EPIAs per site or per company could show different patterns by sector, as will be further investigated based on the indicators presented in next section. Regarding the total number of EPIAs, the share of measures reporting information on achieved energy savings was 53%, and this share varied by NACE sector, with retail having the highest share (85%). Figure 3 also shows the number of sites and companies that have an ISO 50001 certification and a monitoring system and are defined as SMEs: as anticipated, SMEs were absent in retail and very few in banks, so they were excluded from the analysis.

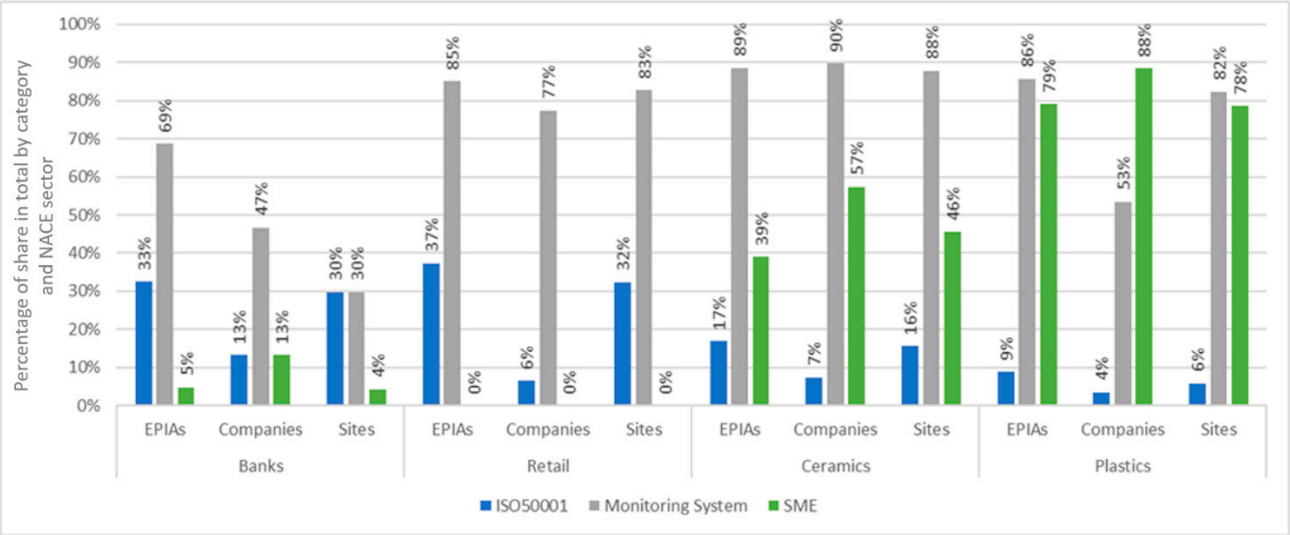

Figure 3. Share in total EPIAs by category.

In the following section, several indicators will be proposed, computing them also for general EPIAs (when available information allows):

- Number of EPIAs per site: it refers to all interventions, as well as those with no saving or investment information available.
- Energy saving per site or per company: it refers to final energy saving, and it is computed excluding sites without saving information.
- Saving: it is computed as the share of saving in total energy consumption of the relevant NACE code. Since the indicator includes only the available information on EPIA reporting savings, it represents a lower threshold for both achieved savings (EPIAs) and potential savings (identified EPIAs). In the second case, the potential nature of savings should be highlighted; namely, they are not likely to be achieved in full since companies would implement only part of the identified EPIAs and in different periods. These potential savings are not presented in this work, but they are employed in the calculation of the average cost effectiveness of the identified EPIAs.
- Investment per site: it is computed by excluding sites without investment information.
- Average cost effectiveness: it is computed as the average of the ratio between investment and saving calculated for each EPIA and identified EPIA, and it refers only to EPIAs including both figures. Such indicator is aimed at representing the cost of saving a toe of final energy and then the effectiveness of different NACE sectors in investing in energy efficiency.

- PBT: it represents simple payback time computed as the ratio between investment cost and energy saving expressed in economic terms. Such information is available only for identified EPIAs.

Payback time and cost effectiveness information does not include information on the effect of Italian incentive schemes on energy efficiency, such as tax deduction scheme for energy renovation, white certificates or regional funds, and tax relief for energy-intensive enterprises. Such incentive mechanisms are likely to have an impact on investment costs, each one in a different way, and then on both examined indicators. Access to each incentive scheme is likely to differ greatly by NACE sector due to different factors represented, for example, by the profile of energy consumption and the company dimension. Banks represent the NACE sector where heating and cooling and building envelope are the prevailing areas of intervention, and therefore, access to the tax deduction scheme is likely to be most relevant. This would pave the way to several insights in terms of investing behaviour and access to existing incentive mechanisms, but these are outside the scope of the present work.

The energy consumption and savings, the quality of data extracted from the energy audits, and the main economic indicators from implemented and planned EPIAs and *general* EPIAs are statistically analysed in Appendix A. Due to the variability of the terms of technology and the size of the EPIAs, the mean values of economic indicators are presented, but they are analysed qualitatively.

4. Results and Discussion

4.1. Ceramics and Plastics

The two manufacturing sectors evaluated in this study (plastic and ceramic) present some important insights in terms of EPIA distribution among the different categories analysed (ISO 50001-certified sites, sites with energy monitoring systems, and size class). As shown in Figures 1 and 2, the EA sample analysed from the plastic sector is dominated by small- and medium-sized enterprises in terms of both share of total final energy consumption and share of total EPIAs. In the ceramic sector, on the other hand, similar numbers of large and small enterprises operate, but the energy consumption share of large companies for the presented EAs is about 80%.

Around 40% of plastic manufacturing sites reported the implementation of any kind of EPIAs in the last 4 years, while this percentage reached 57% for the ceramic manufacturing sites. Thus, the implementation potential of EPIAs was still high in both sectors. The average number of EAs for plastic companies was 1.1 EAs, while it was 1.4 for ceramic companies. However, it is important to note that this number increased to 1.3 for plastic companies and 2.8 for ceramic companies if ISO 50001 certified.

Table 1 presents the impact of *general EPIAs* and the investment in plastic and ceramic manufacturing sites. Plastic and ceramic showed a similar distribution of EPIAs per site (2.35 and 2.42) and a ratio for "*general/total*" EPIAs (15% and 13%). In both cases, the ISO 50001-certified and monitored sites presented a higher degree of implementation of EPIAs per site compared with the sites without EnMSs or monitoring systems.

The number of implemented general EPIAs was very low for both sectors, and for ceramics, it was not possible to evaluate the related cost effectiveness for lack of information.

In Figure 4, energy savings per site, EPIAs, and companies in the plastic sector are presented. It is clear that the global energy savings (% compared with the total sector consumption in EAs) were higher in companies with ISO 50001 certification and monitoring systems compared with companies without these systems. Therefore, the use of EnMSs at the corporate level seemed to effectively increase energy savings. This effect was not observed if savings were evaluated at the site or EPIA level for ISO 50001-certified companies.

Table 1. Plastic and ceramic sector implemented EPIAs.

	IMPLEMENTED EPIAs	General EPIAs (%)	EPIAs per Site (#)	General EPIAs per Site (#)	General EPIA Savings (toe/site)	General EPIA Cost Effectiveness (EUR/toe)	Investment per Site (EUR)
22—Plastics	**ISO 50001**	6%	3.50	0.17	n.a	n.a.	675,910
	Not ISO 50001	16%	2.28	0.30	n.a.	n.a.	355,375
	Monitoring	16%	2.45	0.30	1.50	9956	456,916
	Not Monitoring	8%	1.90	0.18	0.94	n.a.	253,641
	Large Enterprise	12%	2.29	0.17	0.46	n.a.	497,732
	SME	15%	2.37	0.32	2.15	7387	376,688
	Total	**15%**	**2.35**	**0.28**	**1.41**	**7847**	**369,088**
23—Ceramics	**ISO 50001**	14%	2.64	0.36	n.a.	n.a.	733,731
	Not ISO 50001	13%	2.38	0.32	n.a.	n.a.	399,433
	Monitoring	11%	2.44	0.27	n.a.	n.a.	513,983
	Not Monitoring	32%	2.27	0.73	n.a.	n.a.	126,500
	Large Enterprise	14%	2.71	0.39	n.a.	n.a.	640,374
	SME	12%	2.07	0.24	n.a.	n.a.	221,288
	Total	**13%**	**2.42**	**0.32**	**n.a.**	**n.a.**	**466,292**

Similar trends for ISO 50001 companies were observed in ceramics, as shown in Figure 5. The number of sites without a monitoring system and including savings data was very low, and for this reason, it was not possible to evaluate properly the effect of the monitoring system on savings.

A comparison of cost effectiveness for the different categories analysed is reported in Figure 6. The average cost effectiveness of the implemented EPIAs in the analysed ISO 50001-certified plastic manufacturing site was higher than that of the noncertified sites, implying a worst performance in the former. This was mainly due to the fact that most of the interventions carried out in certified sites related to the replacement of process machinery (press, compressors, etc.) for which the main benefit lies in improving process productivity rather than energy efficiency. On the contrary, the average cost effectiveness for ISO 50001-certified ceramic manufacturing sites was lower than that for noncertified sites, showing a better performance in the former. In these sites, the most common interventions were related to the substitution or revamping of process machineries, installation of more efficient pumps and compressors, reduction of leaks, and energy consumption in intake ducts.

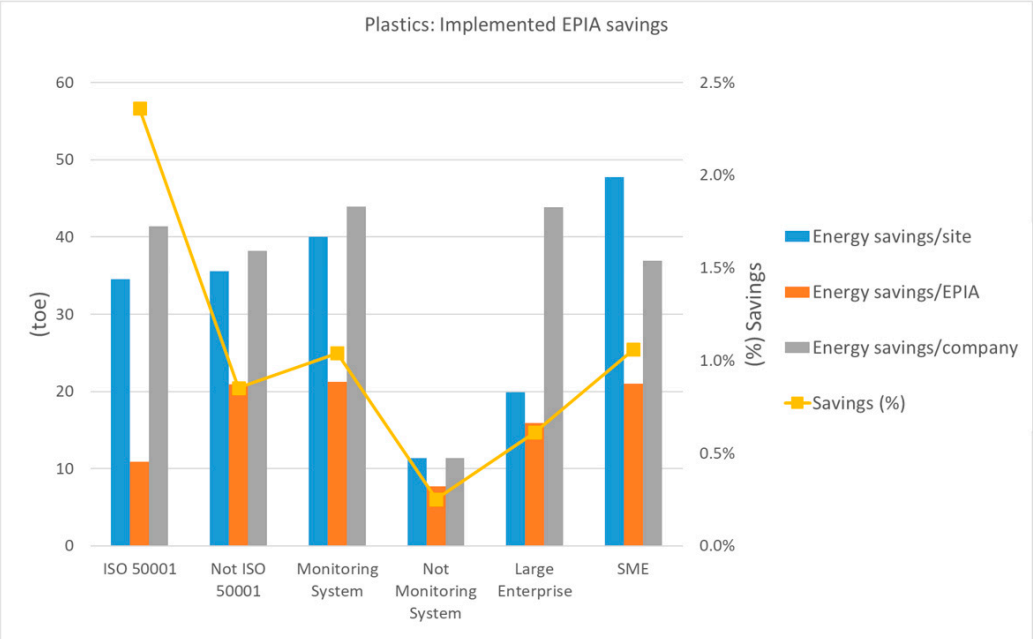

Figure 4. Plastics: implemented EPIA savings.

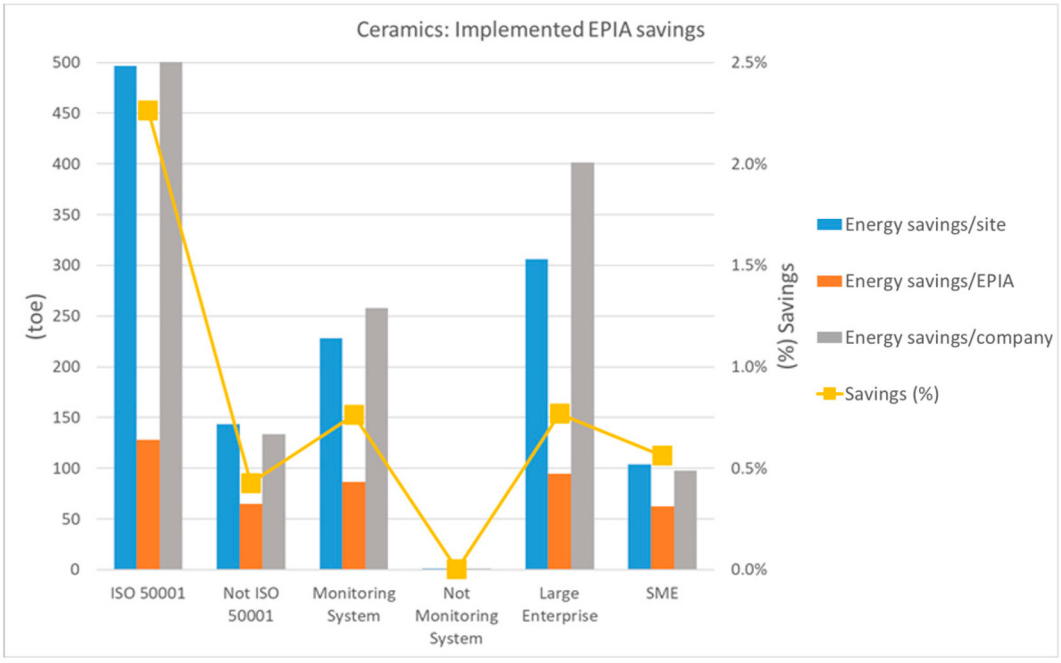

Figure 5. Ceramics: implemented EPIA savings.

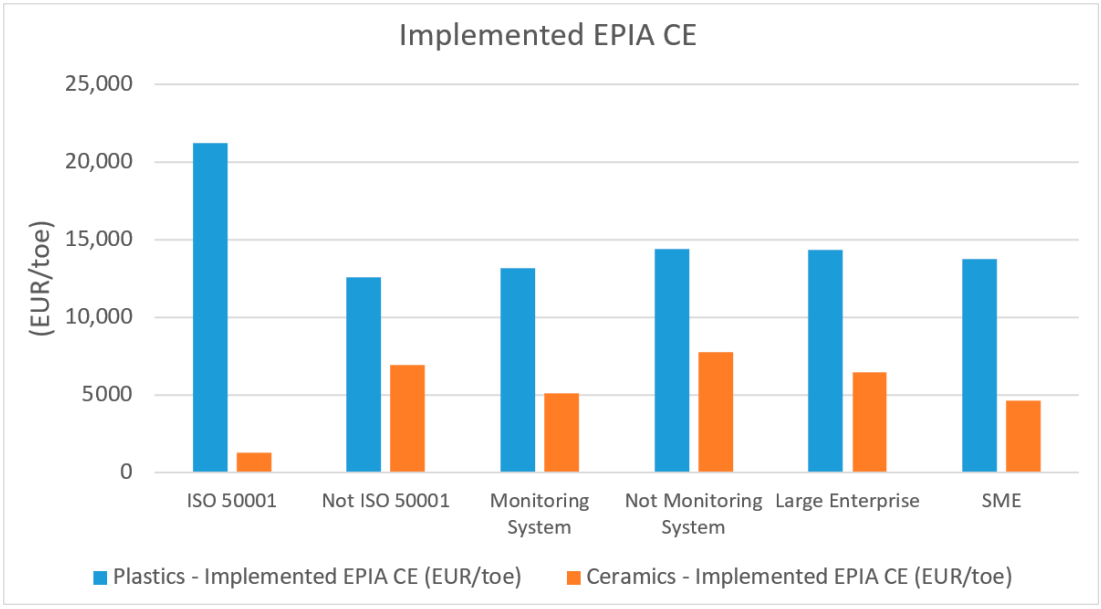

Figure 6. Implemented EPIA cost effectiveness (plastics and ceramics).

The main results of the analysis of the planned EPIAs for the plastic and ceramic sectors are shown in Table 2. A total of 2145 EPIAs were identified (excluding the integration of RES, 283 EPIAs, and CHP, 121 EPIAs), of which 17.7% were *general EPIAs* (mainly implementation of monitoring systems, EnMSs, and capacity training).

In the plastic sector, it seemed that in *general EPIAs* planned under ISO 50001, monitored and large enterprise sites presented lower CE, probably due to better understanding of energy savings and EE investments. On the contrary, CE for global EPIAs was higher for ISO 50001 and monitored sites due to the major share of process-related interventions (substitution of process machineries) planned in these sites. In ceramic sites with global EPIAs planned under ISO 50001, monitored and large enterprise sites presented lower CEs.

About 40% of the interventions in ISO 50001 sites were related to lighting, while general interventions were not considered. In ceramic production sites not subjected to monitoring, interventions on the lighting system prevailed (about 28%), while in the monitored sites, there was a prevalence of interventions concerning lighting (about 21%) and also compressed air (20%) and electric motors (18%).

Table 2. Plastic and ceramic sector planned EPIAs.

	PLANNED EPIAs	Companies (#)	Sites (#)	EPIAs (#)	General EPIAs (#)	EPIA Cost Effectiveness (EUR/toe)	General EPIA Cost Effectiveness (EUR/toe)	EPIA PBT (y)	General EPIA PBT (y)
22—PLASTICS	**ISO 50001**	17	22	57	7	8294	2804	4.0	1.8
	Not ISO 50001	470	513	1594	301	5929	3476	4.1	3.4
	Monitoring	329	371	1147	198	6438	3146	3.8	3.2
	Not Monitoring	158	164	504	110	5679	3739	4.4	3.7
	Large Enterprise	73	94	252	31	5417	1839	3.8	1.9
	SME	414	441	1399	277	6116	3657	4.1	3.5
	Total	**487**	**535**	**1651**	**308**	**6011**	**3303**	**4.1**	**3.3**
23—CERAMICS	**ISO 50001**	3	11	14	0	4699	n.a.	9.0	n.a.
	Not ISO 50001	101	131	480	72	5399	3691	3.9	2.2
	Monitoring	84	119	414	62	5245	3963	4.0	2.2
	Not Monitoring	20	23	80	10	6307	1859	4.4	2.0
	Large Enterprise	30	65	247	42	5153	5700	3.8	2.4
	SME	74	77	247	30	5640	2242	4.3	2.0
	Total	**104**	**142**	**494**	**72**	**5374**	**3691**	**4.1**	**2.2**

4.2. Banks and Retail

The two tertiary sectors evaluated (retail and banks) presented some important differences compared with the manufacturing ones. First, these sectors are dominated by large enterprises. The number of SMEs that presented EAs was very low (<5%), and the number of sites with implemented or planned EPIAs was lower than 2%. Hence, the analysis of class size in the tertiary sector was considered negligible. Second, these sectors are characterized by the clustering of multiple sites (supermarkets/hypermarkets and bank offices) with relatively low consumptions (240 and 200 toe/site for retail and banks, respectively). Therefore, the relative weight of *general EPIAs* induced a great impact in the different sites. Third, only a partial analysis of the results could be performed in these sectors due to missing information (specifically the savings of EPIAs in ISO 50001 banks). The impact of missing information on clusters of big companies was difficult to comprehensively analyse.

Only 18% of the sites reported the implementation of any kind of EPIAs in the last 4 years. Thus, the implementation potential of EPIAs was enormous in both sectors. Each retail company presented 4 EAs; meanwhile, each banking company had 5.2 EAs. However, it is important to note that this number increased to 11.6 and 20 EAs/company if there was ISO 50001 certification. Table 3 presents the impact of *general EPIAs* and the investment in tertiary sectors. Retail and banks showed a similar distribution of EPIAs per site (1.5 and 1.8) and a ratio for "*general/total*" EPIAs (37% and 31%). In both cases, the certified and monitored sites presented a higher degree of implementation of EPIAs per site compared with the sites without EnMSs or monitoring systems. However, the detailed distribution by EnMS and monitoring was very different. On the one hand, in the retail sector, the number of EPIAs per site was stable (between 1.3 and 1.7), and the *general EPIAs* were concentrated in the ISO and monitored sites. On the other hand, in banks there was a high variability in the number of EPIAs per site (from 1 to 4.1), and it was not possible to identify specific trends due to general EPIAs.

Table 3. Retail and bank sector implemented EPIAs.

	IMPLEMENTED EPIAs	General EPIAs (%)	EPIAs per Site (#)	General EPIAs per Site (#)	General EPIA Savings (toe/site)	General EPIA Cost Effectiveness (EUR/toe)	Investment per Site (EUR)
47—RETAIL	**ISO 50001**	81%	1.7	1.3	3.8	5791	19,653
	Not ISO 50001	12%	1.3	0.2	0.6	5926	142,402
	Monitoring	44%	1.5	0.7	2.1	5804	80,533
	Not Monitoring	0%	1.3	0	n.a.	n.a.	83,501
	Large Enterprise	37%	1.5	0.5	1.8	5804	81,819
	SME	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Total	**37%**	**1.5**	**0.5**	**1.8**	**5804**	**81,819**
64—BANKS	**ISO 50001**	19%	1.9	0.4	n.a	n.a	5016
	Not ISO 50001	38%	1.7	0.6	7.0	4640	34,270
	Monitoring	32%	4.1	1.3	10.0	5225	31,119
	Not Monitoring	31%	1	0.2	1.5	3982	34,537
	Large Enterprise	32%	1.8	0.6	7.5	4292	35,966
	SME	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Total	**31%**	**1.8**	**0.6**	**7.0**	**4640**	**32,690**

The lower cost effectiveness seemed to indicate that the EPIAs were implemented more efficiently in sites with energy management systems (in the retail sector). Moreover, the general EPIAs presented higher savings per site under ISO 50001 and monitoring systems. However, due to lack of information, these trends must be subsequently studied in other tertiary sectors.

It is worth noting that investments were strongly different between retail (81 k€/site) and banks (33 k€/site). Practically half of energy consumption in supermarkets was due to refrigeration [34]. Hence, a high number of technical EPIAs were related to the increase in efficiency of these systems and presented a relatively high cost compared with other technical EPIAs [35]. In banks, EPIAs were mainly related to non-residential uses of buildings (lighting, HVAC, and electric and electronic systems) in common with the retail sector [36,37]. The lower investment in ISO 50001 sites compared with noncertified sites could be explained by the clustering of the sites. Four certified companies reported 32% of sites with implemented EPIAs; hence, the relatively low investment by site was compensated by a high investment policy of ISO 50001 enterprises.

In Figure 7 are presented the energy savings per site, EPIAs, and companies in the retail sector. It is clear that the energy savings were higher in companies with ISO 50001 certification (110 toe/Co.) and with monitoring systems (97 toe/Co.) compared with companies without these systems (64 and 31 toe/Co., respectively). Therefore, the use of EnMSs at the corporate level seemed to effectively increase energy savings. This effect was not observed when savings were evaluated at the site or EPIA level. The global savings (compared with the total sector consumption) due to ISO 50001 or not due to ISO sites were very similar (0.9% and 1%). However, the impact on the use of a monitoring system significantly affected global saving, being that the sites monitored were responsible for at least more than 1.1% savings on global consumption, meanwhile nonmonitored systems had close to 0.6%.

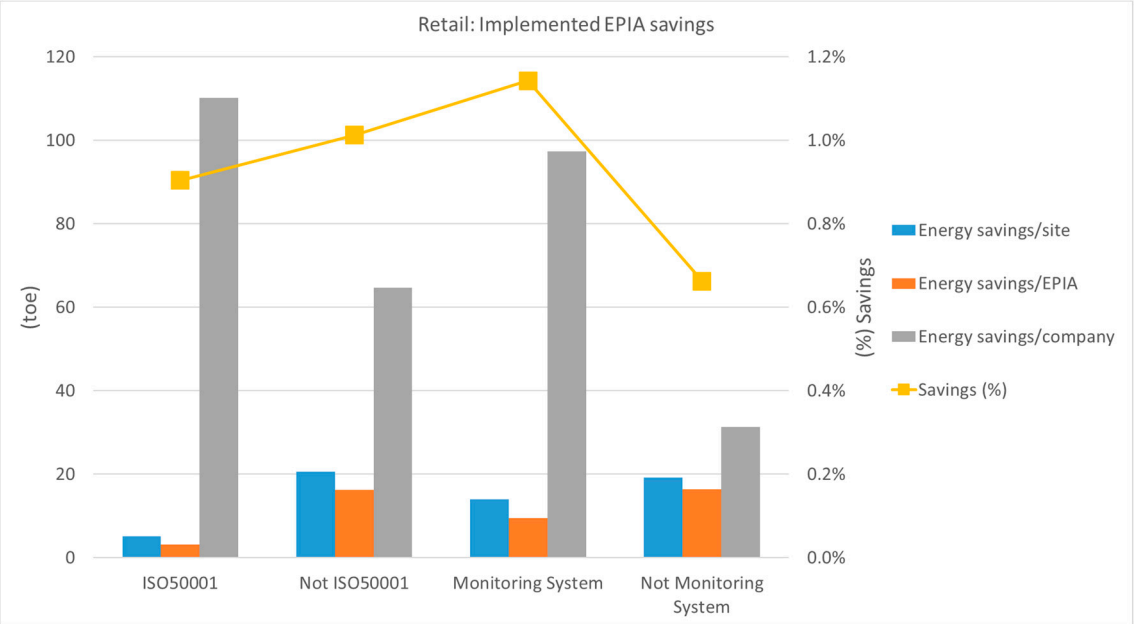

Figure 7. Retail: implemented EPIA savings.

The crucial impact of monitoring systems on energy savings was increased in the bank sector. The savings per site, EPIA, company, and globally were at least sensibly higher in monitored banks (21.7 toe, 13.4 toe, 86.9 toe, and 0.67%, respectively) compared with the nonmonitored ones (1.8 toe, 1.5 toe, 8.1 toe, and 0.33%) (see Figure 8). Unfortunately, the missing information on savings did not allow us to extend this study to ISO 50001 companies in the banking sector.

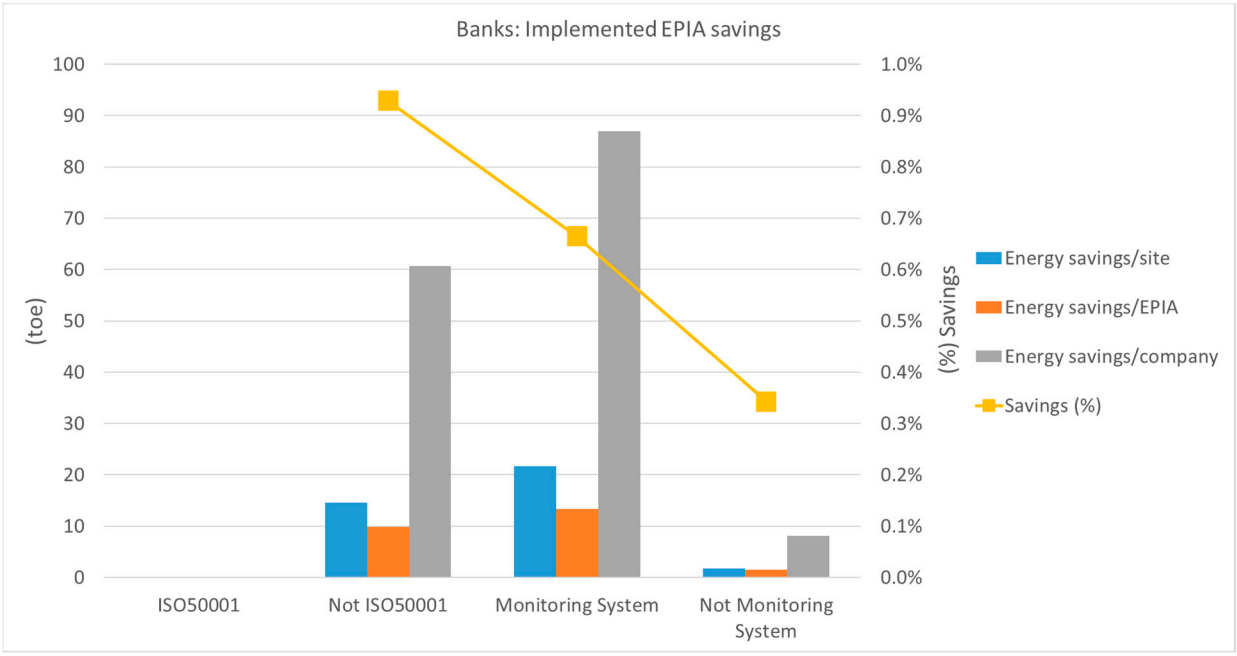

Figure 8. Banks: implemented EPIA savings.

In the tertiary sector, the EPIA cost effectiveness (EUR /toe) was aligned with the values observed in manufacturing (Figure 9). On the one hand, *general EPIAs* presented a lower CE than overall EPIAs. This means that the efficiency of the investment in *general EPIAs* was higher than in other measures. Hence, the promotion of these general practices

(also promoted by the use of EnMSs) seemed to be convenient despite its limited impact (2.7 toe/site). On the other hand, CE spanned from 4000 to 10,000 EUR/toe as a function of the kind of EPIAs. From a general point of view, the CE of the refrigeration measures were higher for HVAC (medium CE) or lighting (low CE mainly promoted by the implementation of LEDs).

An analysis of planned EPIAs was carried out (see Table 4). A total of 1854 EPIAs were identified (excluding the integration of RES, 220 EPIAs, and CHP, 15 EPIAs), of which 17.4% were *general EPIAs* (mainly implementation of monitoring systems, EnMSs, and capacity training).

The CE of the identified *general EPIAs* was lower than that of the global EPIAs. This trend was similar to the values observed in implemented EPIAs. From a general point of view, it seemed that the global and general EPIAs with an ISO 50001 certification or a monitoring system presented lower CE, probably due to a better understanding of energy savings and EE investments. However, the specific CE by sector should be analysed with caution because it diverged from implemented to planned EPIAs, while in implemented EPIAs, CE was aligned between the two sectors, in the case of planned EPIAs, bank CE doubled retail CE. In any case, this trend was coherent with the lower PBT observed in the retail sector due to the intervention in refrigeration processes.

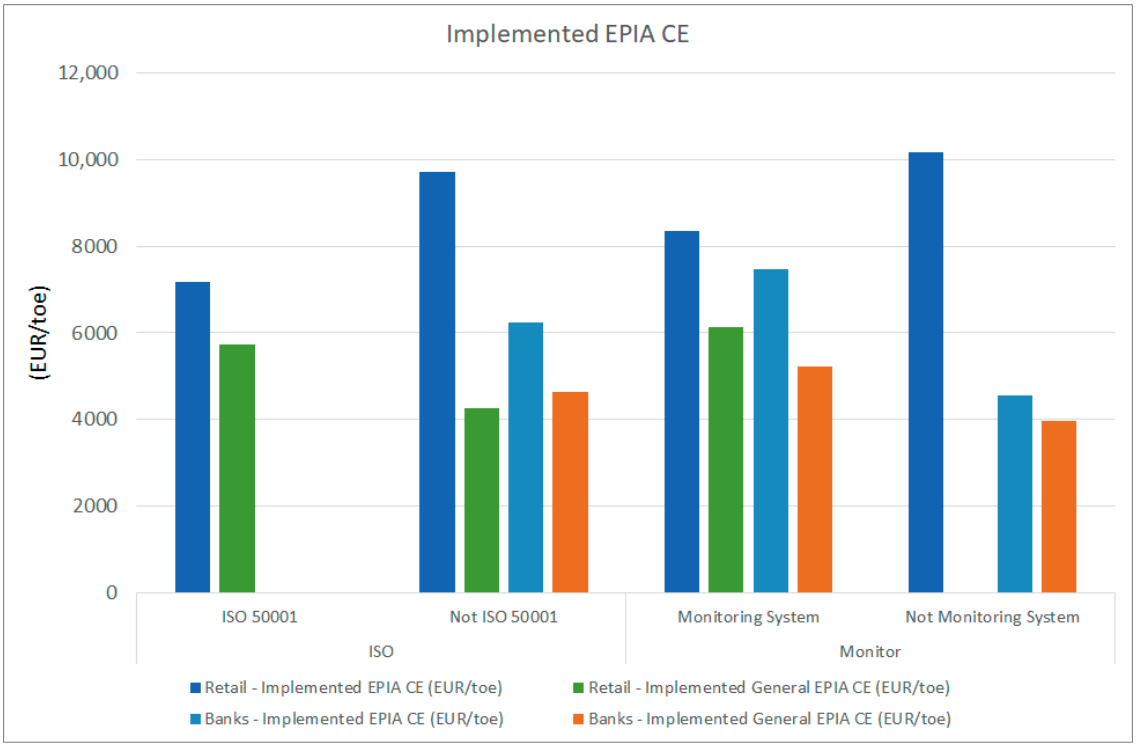

Figure 9. Implemented EPIA cost effectiveness (retail and banks).

Another interesting aspect was related to simple payback time (PBT). PBT was lower in *general EPIAs* than in overall EPIAs. This aspect was mainly due to the relatively low-risk investment associated with the general EE measurement [38]. Another important aspect was related to the lower PBT in the retail than in the banking sector. This fact can be due to several reasons. First, the technical refrigeration EPIAs (only in the retail sector) had a high impact on general site consumption, reducing the PBT. Second, the integration of energy-efficient technologies in supermarkets was usually incentivized by government legislation [39]. Third, banks' energy efficiency investments were supported by incentives related to non-residential buildings. These incentives were not considered in the EAs; therefore, PBT became longer [40].

However, the proposed EPIAs were not binding, and an analysis of the evolution of their execution should be carried out in order to increase the accuracy of this analysis. In any case, all the EAs were carried out by certified energy auditors and ESCOs; hence, all the information related to the proposed EPIAs was reasonable.

Table 4. Retail and bank sector planned EPIAs.

	PLANNED EPIAs	Companies (#)	Sites (#)	EPIAs (#)	General EPIAs (#)	EPIA Cost Effectiveness (EUR/toe)	General EPIA Cost Effectiveness (EUR/toe)	EPIA PBT (y)	General EPIA PBT (y)
47—RETAIL	ISO 50001	4	97	340	106	5474	3368	3.3	2.2
	Not ISO 50001	75	365	870	88	7782	5292	4.3	2.7
	Monitoring	42	334	882	169	7050	3968	3.8	2.4
	Not Monitoring	37	128	328	25	7280	5464	4.4	2.4
	Large Enterprise	75	457	1193	189	7072	3970	4.0	2.4
	SME	4	5	17	5	10,903	13,805	4.6	4.5
	Total	**79**	**462**	**1210**	**194**	**7111**	**4133**	**4.0**	**2.4**
64—BANKS	ISO 50001	2	40	123	36	18,478	6279	4.2	1.6
	Not ISO 50001	39	170	521	93	14,775	7318	8.8	4.9
	Monitoring	13	116	371	65	13,733	5875	7.2	3.8
	Not Monitoring	28	94	273	64	16,766	8023	9.1	5.0
	Large Enterprise	40	207	640	129	15,307	7256	8.1	4.5
	SME	1	3	4	0	1938	n.a.	1.9	n.a.
	Total	**41**	**210**	**644**	**129**	**15,201**	**7256**	**8.0**	**4.5**

4.3. Synthesis

The information presented can be summarized in a qualitative way in the following table, which includes information on both implemented and planned EPIAs: in Figure 10, green cells indicate that companies that are ISO 50001 certified and have a monitoring system or are defined as SMEs have better performance for each of the examined indicators; red cells, opposite results; and orange cells, mixed results.

		IMPLEMENTED EPIAs							PLANNED EPIAs								
		EPIAs per Site (#)	General EPIAs per Site (#)	EPIA Savings (toe/site)	General EPIA Savings (toe/site)	EPIA Savings (%)	EPIA CE (EUR/toe)	General EPIA CE (EUR/toe)	EPIAs per Site (#)	General EPIAs per Site (#)	EPIA Savings (toe/site)	General EPIA Savings (toe/site)	EPIA Savings (%)	EPIA CE (EUR/toe)	General EPIA CE (EUR/toe)	EPIA PBT (y)	General EPIA PBT (y)
22- Plastics	ISO 50001				n.a.			n.a.									
	Monitoring System							n.a.									
	SME							n.a.									
23 - Ceramics	ISO 50001				n.a.			n.a.							n.a.		n.a.
	Monitoring System				n.a.			n.a.									
	SME				n.a.			n.a.									
47- Retail	ISO 50001																
	Monitoring System																
	SME	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
64 - Banks	ISO 50001	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.									
	Monitoring System		n.a.														
	SME	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Better performance for enterprises that are ISO 50001 certified, have a monitoring system, or are defined as SMEs
Mixed results on performance
Not better performance for enterprises that are ISO 50001 certified, have a monitoring system, or are defined as SMEs

Figure 10. Impact of EnMS, monitoring, and SME class in implemented and planned EPIAs.

The results should be analysed while keeping in mind the sector-specific characteristics highlighted in previous sections, such as higher share of SMEs in the plastic sector, in terms of both total energy consumption and total EPIAs, or high concentration of multi-site companies in the retail and bank sectors. The results were also affected by the distribution of implemented and planned EPIAs among different technology and intervention domains.

Looking at the implemented EPIAs, having a monitoring system and being ISO 50001 certified had a positive impact on the global number of EPIAs in all the examined sectors (except for banks, where there was no information available on ISO 50001-certified sites). In

all the sectors with available information (banks, retail, and plastics), having a monitoring system positively affected savings on total energy consumption and average savings from general EPIAs per site. In the two manufacturing sectors, monitoring systems also implied better cost effectiveness results.

Planned EPIAs showed mixed results when analysed in different sectors and by distinguishing by ISO 50001 certification, monitoring system, and class size. It should be considered that planned EPIAs were not binding and would deserve further analysis over time, in particular, relative to their implementation. The number of both global and general EPIAs had a slight tendency to be positively affected by having a monitoring system, which would require further investigation. The results seemed to be influenced by the specific intervention mix at the sectoral level, as described in previous sections. In general, monitoring systems seemed to have a positive impact on average savings when only general EPIAs were examined. To confirm this, the CE of general EPIAs was better in three out of the four sectors examined, and so was the average PBT of investments in general EPIAs. Finally, it is interesting to note that the average PBT was lower in all the analysed sectors for the monitoring system category.

5. Conclusions

In this work, the possible existing link between energy management and monitoring systems and energy audits in the EED Article 8 implementation in four different sectors in Italy was analysed. Additionally, an investigation on the impact of energy monitoring systems and an energy management system on planned and implemented energy performance improvement actions was developed.

The analysis showed that the manufacturing subsectors, plastics and ceramics, had a similar distribution of EPIAs per site (2.35 and 2.42) and a ratio for "*general/total*" EPIAs (15% and 13%). In both cases, the ISO 50001-certified and monitored sites presented a higher degree of implementation of EPIAs per site compared with the sites without EnMSs or monitoring systems. In the plastic sector, it was clear that the global energy savings (% compared with the total sector consumption in EAs) were higher in the companies with ISO 50001 certification and with monitoring systems compared with the companies without these systems. Therefore, the use of EnMSs at the corporate level seemed to effectively increase energy savings. This effect was not observed when savings were evaluated at the site or EPIA level for the ISO 50001-certified companies. Similar trends for the ISO 50001 companies were observed in the ceramic sector. The number of sites without a monitoring system and including savings data was very low, and for this reason, it was not possible to properly evaluate the effect of the monitoring system on savings.

The services subsectors, retail and banks, showed a similar distribution of EPIAs per site and a ratio for "*general/total*" EPIAs (37% and 31%). In both cases, the certified and monitored sites presented a higher degree of implementation of EPIAs per site compared with the sites without EnMSs or monitoring systems. However, a detailed distribution by EnMS and monitoring was very different. On the one hand, in the retail sector, the number of EPIAs per site was stable (between 1.3 and 1.7), and the *general EPIAs* were concentrated in the ISO and monitored sites. On the other hand, in banks there was a high variability in the number of EPIAs per site (from 1 to 4.1), and it was not possible to identify specific trends due to *general EPIAs*. Additionally, the bank sector is a clear example of the crucial importance of monitoring systems in the implementation of energy efficiency measurements. The savings per site, EPIA, company, and globally were at least sensibly higher in the monitored banks (21.7 toe, 13.4 toe, 86.9 toe, and 0.67%, respectively) compared with the nonmonitored ones.

The use of EnMSs effectively increased energy savings at the corporate level in all the sectors analysed. However, this trend was not fully corroborated at the site or EPIA level. Moreover, it was evident that the presence of a monitoring system was of fundamental importance for the implementation of EPIAs. All four sectors, in fact, had higher "energy savings/company" and "EPIA/site" ratios, where there were an EnMS and a monitoring

system. This shows that a correct energy audit must always be accompanied by a specific monitoring plan if it is to be effective and useful to the company decision maker.

The methodology and analysis developed from the four chosen sectors can also be replicated in other sectors, and it would be necessary to implement this analysis also to other productive sectors of the industry or the tertiary sector to effectively evaluate whether the conclusions reached by our analysis can also be extended to other economic sectors.

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Nomenclature

EA	energy audit
AFNOR	French Standardization Association
CE	cost effectiveness (EUR/toe saved)
CEI	Italian Electrotechnical Committee
CHP	combined heat and power, cogeneration
CSEA	Environmental Energy Services Fund (in Italian, Cassa per i servizi energetici e ambientali)
CTI	Italian Thermotechnical Committee
EC	European Commission
EE	energy efficiency
EED	European Energy Efficiency Directive
EIB	European Investment Bank
EMS	environmental management systems (e.g., ISO 14001)
ENEA	Italian National Agency for New Technologies, Energy, and Sustainable Economic Development
EnMS	energy management system
EPIA	energy performance improved action
ESCO	energy service company
FIRE	Italian Federation for Energy Efficiency (in Italian, Federazione Italiana per l'uso Razionale dell'Energia)
HVAC	heating, ventilation, and air-conditioning
ISO	International Organization for Standardization
ISO 50001	international standard on energy management systems
LE	large enterprise
LED	light-emitting diode
NACE	Statistical Classification of Economic Activities in the European Community
PBT	simple payback time (y)
RES	renewable energy source
SME	small and medium-sized enterprise
toe	tonne of oil equivalent (=41.868 GJ)

Appendix A. Statistical Analysis

Clean data used for the analysis are presented in this appendix. The main results and the hypothesis derived from this appendix are extensively detailed in the manuscript, and some of the data were not presented in the body of the manuscript to avoid duplicities. Some small variations in data between the appendix and the main sections of the manuscript can be observed due to rounding issues.

In Table A1 is presented the total number of sites (one for each EA) and companies. The final energy consumption and relative distribution are presented. It is possible to observe that the subsectors with very low relative consumption (<2%) were excluded from the analysis, and the sectors with low percentage weight (<10%) were cited in the main text. The implemented EPIA savings are presented as the % with respect to the overall consumptions (as presented in Figures 4, 5, 7, and 8). The importance of general EPIAs in terms of the number of savings and relative weight is highlighted. It is possible to see that the accumulate savings are similar in the sectors that provide these data.

In Table A2 are presented data available about the implemented and planned EPIAs. The "sites with EPIA data" term refers to EAs that have declared the implementation of EPIAs in the last 4 years and EAs that have identified improvement measures. Obviously, the number of "planned" EPIAs is higher due to the intrinsic definition of the EA. One of the aims of the audits is to identify EPIAs. The "EPIAs with savings data" term refers to effective information of energy savings in the EPIAs. There is a high variability in information regarding the effective savings of implemented EPIAs. There is a non-negligible amount of energy audits that specify the details of implemented EPIAs, but without declaring the savings obtained. These EAs vary from 15% to 53% and 11% to 86% for implemented EPIAs and general EPIAs in the different sectors. The quality of these data increases up to 80% in the planned EPIAs. However, these values are not binding estimations. Hence, the analysis of savings was qualitatively carried out in the manuscript.

In Tables A3 and A4 are presented the mean and standard deviation of the main economic indicators (CE and investments by site for implemented EPIAs and CE and PBT for planned EPIAs). It is possible to observe the high standard deviation in all the parameters. These values are reasonable due to the high variability of the EPIAs considered. Overall, EPIAs include measures that vary from the substitution of lighting with led (W scale) to the substitution of furnaces (at the MW scale) and technologies (active vs. passive, process related vs. auxiliary or services related). General EPIAs include capacitation in energy management, implementation of energy management systems, monitoring of energy consumption, extension and improvement of current management and/or monitoring systems, and other actions not strictly related to the production process or technical EE measures. Therefore, it is also strongly heterogeneous. Finally, investment depends on multiple economic (non-energy-related) aspects from the companies (that present a strong variable structure internally to each sector). Therefore, only the mean values of economic indicators are presented, but they are analysed qualitatively.

Table A1. Number of EAs and companies; energy final consumption and savings from EPIAs and general EPIAs.

				Final Energy Consumption		Implemented EPIA Energy Savings (% vs. Consumptions)		General EPIA Energy Savings (% vs. All EPIA Savings)	
		EAs	**Companies**	**(toe)**	**(%)**	**(toe)**	**(%)**	**(toe)**	**(%)**
22—PLASTICS	ISO 50001	22	17	17,545	3%	414	2.36%	-	0.00%
	Not ISO 50001	569	509	559,669	97%	4770	0.85%	-	0.00%
	Monitoring System	412	359	473,514	82%	4923	1.04%	185	3.76%
	Not Monitoring System	179	167	103,699	18%	261	0.25%	22	8.28%
	Large Enterprise	104	76	207,955	36%	1272	0.61%	29	2.31%
	SME	487	450	369,259	64%	3912	1.06%	176	4.50%
	Total	**591**	**526**	**577,214**	**100%**	**5184**	**0.90%**	**206**	**3.97%**
		EAs	**Companies**	**(toe)**	**(%)**	**(toe)**	**(%)**	**(toe)**	**(%)**
23—CERAMICS	ISO 50001	17	6	175,586	16%	3974	2.26%	-	0.00%
	Not ISO 50001	140	106	938,853	84%	4012	0.43%	-	0.00%
	Monitoring System	133	91	1,047,030	94%	7985	0.76%	-	0.00%
	Not Monitoring System	24	21	67,408	6%	1	0.00%	-	0.00%
	Large Enterprise	69	32	836,010	75%	6424	0.77%	-	0.00%
	SME	88	80	278,429	25%	1562	0.56%	-	0.00%
	Total	**157**	**112**	**1,114,438**	**100%**	**7986**	**0.72%**	**12**	**0.15%**
		EAs	**Companies**	**(toe)**	**(%)**	**(toe)**	**(%)**	**(toe)**	**(%)**
47—RETAIL	ISO 50001	105	9	24,376	14%	220	0.90%	164	74.60%
	Not ISO 50001	604	167	146,813	86%	1486	1.01%	43	2.92%
	Monitoring System	458	135	119,165	70%	1362	1.14%	208	15.26%
	Not Monitoring System	251	41	52,024	30%	345	0.66%	-	0.00%
	Large Enterprise	698	162	170,175	99%	1706	1.00%	208	12.18%
	SME	11	14	1014	1%	-	0.00%	-	-
	Total	**709**	**176**	**171,189**	**100%**	**1706**	**1.00%**	**208**	**12.18%**
		EAs	**Companies**	**(toe)**	**(%)**	**(toe)**	**(%)**	**(toe)**	**(%)**
64—BANKS	ISO 50001	40	2	17,838	31%	-	0.00%	-	-
	Not ISO 50001	238	51	39,208	69%	364	0.93%	175	47.92%
	Monitoring System	147	13	52,293	92%	348	0.67%	161	46.21%
	Not Monitoring System	131	40	4752	8%	16	0.34%	14	84.41%
	Large Enterprise	275	52	56,970	100%	361	0.63%	174	48.13%
	SME	3	1	76	0%	3	4.53%	1	26.22%
	Total	**278**	**53**	**57,046**	**100%**	**364**	**0.64%**	**175**	**47.92%**

Table A2. Analysis of data available on energy audits: sites, EPIAs, and general EPIAs with information on savings. Implemented and planned EPIAs.

		IMPLEMENTED						PLANNED					
		Sites with EPIA Data		EPIAs with Savings Data		General EPIAs with Savings Data		Sites with EPIA Data		EPIAs with Savings Data		General EPIAs with Savings Data	
		(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)
22—PLASTICS	ISO 50001	12	63.6%	49	77.6%	1	33.3%	22	100%	52	91.2%	5	71.4%
	Not ISO 50001	134	39.2%	509	44.8%	16	20.3%	513	90.2%	1426	89.5%	215	71.4%
	Monitoring System	123	47.3%	478	48.5%	17	22.4%	371	90.0%	1018	88.8%	137	69.2%
	Not Monitoring	23	23.5%	80	42.5%	0	0.0%	164	91.6%	460	91.3%	83	75.5%
	Large Cos	64	49.0%	117	68.4%	2	14.3%	94	90.4%	148	58.7%	24	77.4%
	SME	82	38.2%	441	42.2%	15	22.1%	441	90.6%	1330	95.1%	196	70.8%
	Total	**146**	**40.1%**	**558**	**47.7%**	**17**	**20.7%**	**535**	**90.5%**	**1478**	**89.5%**	**220**	**71.4%**
		Sites with EPIA Data		EPIAs with Savings Data		General EPIAs with Savings Data		Sites with EPIA Data		EPIAs with Savings Data		General EPIAs with Savings Data	
		(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)
23—CERAMICS	ISO 50001	8	82.4%	37	83.8%	0	0.0%	11	64.7%	14	100%	0	n.a.
	Not ISO 50001	28	54.3%	181	34.3%	4	16.7%	131	93.6%	401	83.5%	32	44.4%
	Monitoring System	35	59.4%	193	47.7%	4	19.0%	119	89.5%	346	83.6%	28	45.2%
	Not Monitoring	1	45.8%	25	4.0%	0	0.0%	23	95.8%	69	86.3%	4	40.0%
	Large Cos	21	71.0%	133	51.1%	2	10.5%	65	94.2%	196	79.4%	14	33.3%
	SME	15	46.6%	85	29.4%	2	20.0%	77	87.5%	219	88.7%	18	60.0%
	Total	**36**	**57.3%**	**218**	**42.7%**	**4**	**13.8%**	**142**	**90.4%**	**415**	**84.0%**	**32**	**44.4%**
		Sites with EPIA Data		EPIAs with Savings Data		General EPIAs with Savings Data		Sites with EPIA Data		EPIAs with Savings Data		General EPIAs with Savings Data	
		(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)
47—RETAIL	ISO 50001	43	41.0%	72	100%	58	100%	97	92.4%	339	99.7%	106	100%
	Not ISO 50001	90	14.9%	92	76.0%	6	42.9%	361	59.8%	864	99.3%	86	97.7%
	Monitoring System	110	24.0%	143	87.2%	64	88.9%	331	72.3%	881	99.9%	167	98.8%
	Not Monitoring	23	9.2%	21	72.4%	0	n.a.	127	50.6%	322	98.2%	25	100%
	Large Cos	133	19.1%	164	85.0%	64	88.9%	454	65.0%	1186	99.4%	188	99.5%
	SME	0	n.a	0	n.a	0	n.a.	4	36.4%	17	100%	4	80.0%
	Total	**133**	**18.8%**	**164**	**85.0%**	**64**	**88.9%**	**458**	**64.6%**	**1203**	**99.4%**	**192**	**99.0%**
		Sites with EPIA Data		EPIAS with Savings Data		General EPIAs with Savings Data		Sites with EPIA Data		EPIAS with Savings Data		General EPIAs with Savings Data	
		(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)
64—BANKS	ISO 50001	14	35.0%	0	0.0%	1	20.0%	37	92.5%	100	81.3%	21	58.3%
	Not ISO 50001	33	13.9%	37	66.1%	16	76.2%	154	64.7%	482	92.5%	83	89.2%
	Monitoring System	14	9.5%	26	45.6%	9	50.0%	98	66.7%	317	85.4%	45	69.2%
	Not Monitoring	33	25.2%	11	42.3%	8	100%	93	71.0%	265	97.1%	59	92.2%
	Large Cos	45	16.4%	33	41.8%	16	64.0%	188	68.4%	578	90.3%	104	80.6%
	SME	2	66.7%	4	100%	1	100%	3	100%	4	100%	0	n.a.
	Total	**47**	**16.9%**	**37**	**44.6%**	**17**	**65.4%**	**191**	**68.7%**	**582**	**90.4%**	**104**	**80.6%**

Table A3. Analysis of mean and standard deviation of CE and investments for implemented EPIAs.

	IMPLEMENTED EPIAs					
	EPIA CE (EUR/toe)		General EPIA CE (EUR/toe)		Investment per Site (EUR)	
	MEAN	SD	MEAN	SD	MEAN	SD
22—Plastics Total	14,254	24,468	8098	8392	370,991	664,765
23—Ceramics Total	6552	12,747	n.a.	n.a.	482,053	1,099,639
47—Retail Total	8584	6878	5804	4571	81,629	148,132
64—Banks Total	6238	8271	4640	7313	32,690	52,763

Table A4. Analysis of mean and standard deviation of CE and PBT for planned EPIAs.

	PLANNED EPIAs							
	EPIA CE (EUR/toe)		General EPIA CE (EUR/toe)		EPIA PBT (y)		General EPIA PBT (y)	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
22—Plastics Total	6028	9953	3277	4641	4.4	4.1	3.2	10.0
23—Ceramics Total	5355	6465	3692	4913	4.2	3.1	2.2	2.1
47—Retail Total	7111	8451	4133	3238	4.0	3.7	2.4	1.9
64—Banks Total	15,201	16,429	7256	4925	8.0	11.1	4.5	4.3

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