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ECONOMETRIC ANALYSIS OF THE ENERGY SAVINGS PERFORMANCES OF THE ITALIAN PLASTIC MANUFACTURING SECTOR.

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Index

Introduction…………………………………………………………………………………....8

1 European framework on Energy efficiency: The energy audits. …………………………….10

1.1 Energy efficiency.

1.2 Energy efficiency in productive activities: barriers and drivers of energy efficiency interventions….13

1.3 Energy Efficiency First: The European Regulatory Framework……………………………………...16

1.4 Energy Efficiency in Italy: Incentive mechanism……………………………………………………..20

1.5 The Italian Directive on Energy Efficiency: The Energy Audit……………………………………...23

2 The 2019 Energy Audits: The potential for energy efficiency in Italy. ……………………….…28

2.1 The energy Audit of the second mandatory period. ………………………………..……………28

2.2 Interventions carried out and Identified: the potential for energy savings. …………………………...30

3 Statistical Analysis of Plastic Articles Manufacturing……………………………………………..36

3.1 The plastic articles manufacturing sector. …………………………………..……………………...36

3.2 Energy Audits of the plastic articles manufacturing sector……………………………………….....41

3.2.2 Analysis of energy consumption.…………………………………………………………..........42

3.3 Analysis of Identified Interventions and Potential Energy Savings. ………………………………….44

3.4 Intra-sectoral Comparison of Identified Interventions and Potential Savings…………………………56

4 Econometric approaches for the analysis of Energy Saving performances. ……………………..68

4.1 Energy Efficiency Sectorial Studies: literature review………………………………………………...68

4.2 The Data. …………………………………..…………………………………..…………………74

4.3 The Methodological approach………………………………..……………………………………..76

4.3.1 The selected models and the response variables………….………………………………………76

4.3.2 The predictors …………..………………………………………..…………………………….78

4.3.3 Criterion for the selection of the models…………..…………………………….………………81
4.3.4 Correlation among predictors…………..……………………………………………………82
4.3.4 The white certificate variable…………..………………………………………………...84

5 Estimation Results. …………..…………………………………………..…………………......…85

5.1. Econometric models without the *white certificate* variable…………..……………………………......85

5.1.1 The Ols and logistic models for all the intervention areas excluding Production from renewables and Cogeneration/Trigeneration.………..…………………..………………...85

5.1.2 The Ols model for the areas Production from Renewable sources and Cogeneration/Trigeneration……………………………………………………………….91

5.2 Econometric models with the *white certificate* variable…………..…………………………….….93

5.2.1 The Ols and logistic models for all the intervention areas excluding Production from renewables and Cogeneration/Trigeneration.……… ………..………………………..…93

5.3 Future research directions……….......………........………..........………......……………….....................97

Conclusions…………..…………………………………………..………………………………..…..100
Bibliography And Sitography…………….…………………..……………………………......................103

Appendix 1: Tested Models……………………………………..………………………………..106
Appendix 3: The R scripts…………………………………………………………………………109

List of tables and Figures

Table 1 : Summary of incentives mechanism for energy efficiency and the sectors of applicability……..21

Table 2: Summary of the identified, implemented interventions and associated final savings, broken down by ATECO code…………………………………………………………………31

Table 3: Summary of the identified, implemented interventions and associated primary savings, broken down by ATECO code……………………………………………………………….32

Table 4: Summary of the identified interventions organized by Intervention Areas………………………34

Table 5: Summary of Main activities organized by sector and energy vectors…………………………..…38

Table 6: Main indicators of the ATECO sector Manufacturing of plastic materials………………………..40

Table 7: Summary of productivity indicators in the ATECO 22.00.00 sector…………….……….…………41

Table 8: Summary of the composition of energy consumption carriers……………….…………………..42

Table 9: Summary of identified interventions and related energy savings organized by their belonging area……………………………………………………………………………………..45

Table 10: Summary of investments and energy savings relative to the different Areas of interventions…..47

Table 11: Summary of Investments and cost-effectiveness relative to Cogeneration/Trigeneration and Production from Renewable Sources………………………………………..………….50

Table 12: Summary of investments and cost-effectiveness relative to all Intervention Areas excluding Cogeneration/Trigeneration and Production from Renewable Sources……….…….50

Table 13: Regional distribution of the identified intervention and the investments levels…………………54

Table 14: Regional distribution of the achievable energy savings………………………………………….55

Table 15: Comparison of Interventions, Investment levels, Energy Consumption and Savings for the three ATECO sectors………..…………………………………………………………56

Table 16: Summary of interventions, energy savings and cost effectiveness related to the ATECO code 21.22.00……………………………………………………………………...57

Table 17: Summary of the descriptive statistics for the ATECO code 21.22.00………………………….58

Table 18: Summary of interventions, energy savings and cost effectiveness related to the ATECO code 22.22.00……………………………………..……………………………....59

Table 19: Summary of descriptive statistics pertaining the sector 22.22.00…..…………………………...61

Table 20: Summary of interventions, savings and cost effectiveness related to the ATECO code 22.29………………………………………………………………………….....................62

Table 21: Summary of descriptive statistics pertaining the sector 22.29.00……………………………….63

Table 22: Summary of the prevalent econometric methodologies utilized

for analyzing energy efficiency barriers and drivers…………………………………………………..…72
Table 23: Description of the variables included in the models, where the ticks
represent their inclusion or not in the models………………………...……..…………...79
Table 24: Summary of the constructed N-1 dummy for intervention areas (Final consumption)………...80
Table 25: Description of the construction of the variable
WHITE CERTIFICATE for "all the other areas". ……………………………..….…………..84
Table 26: Estimation results of the pooled OLS and the logistic regression for the
all the other areas of interventions"………………………………………...….…………..86
Table 27: Estimation results of the pooled OLS for the areas production from renewables and
Cogeneration/Trigeneration..………………………………………………...….…………..91
Table 28: Estimation results of the pooled OLS and the logistic regression introducing
white certificate (all the other intervention areas)……………………………………………94
Table 29: Estimation results of the logistic regression introducing white certificates
and removing all the interventions areas dummies.…………………………………..………97

Figure 1: Greenhouse gas emission by economic activity……………………………………………..…..11
Figure 2: Co2 emissions related to the products with the highest carbon dioxide footprint…..…………....12
Figure 3: Average Energy efficiency index weighted by the energy consumption of
the respective sector……………………………………………………………………….....18
Figure 4: European Green Deal crucial aspects……………………………………………………….....19
Figure 5: Evolution of energy savings achievable through incentive mechanisms………………………..22
Figure 6: Summary example of the proposed interventions and the information requested……………....27
Figure 7: Distribution of audits submitted in 2019 in relation to the ATECO sector they belong to……..29
Figure 8: Distribution of audits submitted in 2019 pertaining to SECTOR C in relation to
the 2-digit ATECO code………………………………………………………….………...30
Figure 9: Regional distribution of received energy audit in the second obligation period………………...35
Figure 10 : Composition of the Businesses Energy Scheme..………….……………….……………...….37
Figure 11: Regional distribution of primary energy consumption.…………….…………….……………43
Figure 12: Regional distribution of final energy consumption..…………….……………….……………43
Figure 13: breakdown of interventions for the ATECO sector 22 on the basis of the
AREA to which they belong..………………………..…….…………….………………44
Figure 14: Breakdown of energy achievable savings from Production from Renewables

and Cogeneration/Trigeneration Area……………………………………………………...49
Figure 15:Breakdown of energy achievable savings from all the other intervention Areas………………49
Figure 18: Comparison of investment levels and cost-effectiveness with reference to
selected areas of interventions. ………………….……………………………………..51
Figure 17 :Cost-effectiveness levels of investment referring to all the Areas
excluding Production from Renewables and Cogeneration/Trigeneration……………………..51
Figure 18: Bubble chart of intervention areas in relation to their investment levels
and payback periods………………………………….…………………………………..52
Figure 19 : Achievable Savings organized for the Payback Periods of the related Investments
(Production from Renewables and Cogeneration/Trigeneration values are excluded)………...53
Figure 20: Regional distribution of the identified intervention for the ATECO
sectors 22.21,22.22 and 22.29……………………………….……………………………54
Figure 21: Cumulate Achievable Savings referring to all the other areas organized
by payback period classes 22.21.00………………………………….………………..…63
Figure 22 : Cumulate Achievable Savings referring to all the other areas organized
by payback period classes 22.22.00………………………………….………………..…64
Figure 23 : Cumulate Achievable Savings referring to all the other areas organized
by payback period classes 22.29.00….……………………………….………………..…64
Figure 24: Breakdown of savings pertaining Production from renewable
sources and Cogeneration/Trigeneration ATECO 22.22, 22.21 and 22.29. ….……………..…..…65
Figure 25: Breakdown of savings pertaining All the Areas excluding Production from renewable sources
and Cogeneration/Trigeneration ATECO 22.22, 22.21 and 22.29.…..…………………………..65
Figure 26: Regional distribution of intervention for ATECO 22.21..….……………………………..…67
Figure 27: Regional distribution of intervention for ATECO 22.22..….……………………………..…67
Figure 28: Regional distribution of intervention for ATECO 22.29..….……………………………...67
Figure 29 :Comparison of the histogram of energy saving performance with the histogram of its logarithm
(All the other areas)……………………………………………………………………..…78
Figure 30: Comparison of the histogram of energy saving performance with the histogram of its logarithm
(Production from Renewables and Cogeneration/Trigeneration).…………………………..…..78
Figure 31: Comparison of the histogram of Investment levels with the histogram of its logarithm………80

Introduction.

The current European political context sees numerous challenges impacting the stability of the macro-economic framework of the member countries, such as the urgent need to address the growing uncertainties regarding the reliability and costs of energy flows whilst maintaining political strategies in line with the objectives of reducing greenhouse gas emissions.

The concept of energy efficiency thus becomes central in the pursuit of the ecological transition, and companies are central participants in the pursuit of this path; However, the literature on the subject shows that there are several attributes of energy efficiency measures (EEMs) capable of hindering their actual adoption, e.g. factors related to the economic dimensions of the investments required to introduce them, all the way also the founding traits of the company itself, its culture, specific production processes as well as elements of the political-economic and legislative context that are capable of having the same effect on EMMs or conversely able to stimulate their adoption.

One of the most relevant tools capable of spurring the aforementioned adoption is the energy audit, i.e. a systematic evaluation of energy uses from their point of entry to their final uses, thus enabling the analysis of the energy flows of a production activity, their handling and the pinpointing/quantification of energy saving opportunities within the company, for these purposes, this tool is increasingly evolving in the eurozone and we are not only witnessing the implementation of specific legal obligations for certain obliged parties, but we are also observing a growing interest on the part of the production sectors as it favors the reduction of costs incurred by energy flows and thus leads to higher levels of economic efficiency.

In Italy, ENEA plays the starring role in the field of energy audits, being acknowledged by legislation as the body responsible for setting up, maintaining and updating a database for audits, for carrying out controls to ascertain the compliance of audits with legal requirements, and for drawing up a comprehensive report on the diagnostic activities performed and the ensuing results.

The study in this regard benefits from the abundance of data held by ENEA and deepens the information on the energy audits received by this entity, regarding the EEMs that can be implemented, in 2018 from the manufacturing sector of the production of plastic and rubber articles (ATECO codes 22.21.00, 22.22.00, 22.29. 09), in particular, the work is part of a narrow strand of literature that uses econometric models for the individuation of those factors inherent to the companies, the context and the efficiency measures capable of impeding an upward path for energy efficiency. In detail, linear probability models and linear regression models with fixed effects will be used for the evaluation of the savings performance (considering simultaneously the achievable energy savings and the consumption carried out) of the production sites subject to compulsory diagnosis in the sector.

1) European framework on Energy efficiency: The energy audits

1.1) Energy Efficiency

The concept of *energy efficiency*, although it finds multiple definitions in the literature, has its roots in the basic economic principle whereby efficiency is measured as the ratio between the value and/or quantity of the means employed and that of the output obtained, therefore this concept is used as a tool to assess the use of energy resources in the various end uses and as a means of regulating consumption itself, the debate surrounding the promotion of interventions aimed at improving energy efficiency has been fueled in recent years by multiple concerns regarding the evolution of the energy-intensive sector and anthropogenic climate impacts.

In recounting the evolution of the mentioned concept, it is necessary to take a first step toward understanding the reasons underlying the current relevance of energy efficiency by starting with considerations regarding the future of energy uses.

In the *World Energy Outlook* realized by the International Energy Agency for 2022, projections regarding global energy demand confirm its future increases, despite the supply crisis in energy flows generated by current geopolitical tensions and economic contractions caused by the COVID-19 pandemic, estimates regarding the demand show a scenario similar to the 2019 projections, in detail the *Stated Policy Scenario* built on the basis of the announced and currently in effect policies on a global scale, shows that energy demand in this decade is set to increase by 1 percent annually, indeed although industrialized countries, through soaring electrification and the incremental commitments to improve the energy efficiency of different end uses, see a curtailment of consumption, the demographic and productive sectors expansion expected in Emerging Economies and Developing Countries will cause a net increase of it.

This trend induces two main reasons for concern, on the one hand from the volatility of energy prices arise growing pressures on the energy-intensive sector in terms of stability of supply and on national economies in terms of affordability of essential and auxiliary energy services, pushing the most vulnerable segments of the population towards conditions of energy poverty, secondly, such levels of consumption are associated with equally high levels of anthropogenic greenhouse gas emissions which call for their regulation in order to limit rising temperatures and the advance of climate change.

Turning our gaze to the European Union, similar apprehensions have prompted central institutional bodies to promote the principle of *energy efficiency first* in a way to enhance energy security and meet the undertaken international mitigation commitments, looking at the data provided by Eurostat, the amount of energy worn by households and productive activities in 2019 consisted of **62.6** million TeraJouls, a quarter of this consumption emerged from the needs of households to cope with the necessities of daily life, such as heating for buildings, while the needs of productive activities account for three-quarters of net domestic energy consumption.

Tthe energy flows worn and their projected augment do not engender concerns only in relation to the production capacity of the energy sector, in fact, the complex picture is broadened when considering the inferable changes in greenhouse gas levels, looking at the productive activities of EU member countries, Eurostat reports the supply of electricity, gas, steam and air conditioning among the most polluting activities (**21%** of total greenhouse gases emitted), followed by the extraction sector and manufacturing, anyway the time series of these values shows a significant decrease occurred in the last decade, are **496** million the tons of CO_2 saved between 2008 and 2020 (**41%** of the total), consumption activities on the other hand make up three quarters of the Union's ecological footprint, in particular statistics on household, government and capital goods consumption for gross fixed capital formation (such as buildings, plant and machinery etc.) show that energy products have the highest carbon footprint, in 2019 about **1.6** tons of CO_2 per capita was emitted directly by households through the combustion of fossil fuels and indirectly, along the production chains of final goods consumed or capital goods were **5.2** the tons of CO_2 per capita released in the atmosphere.

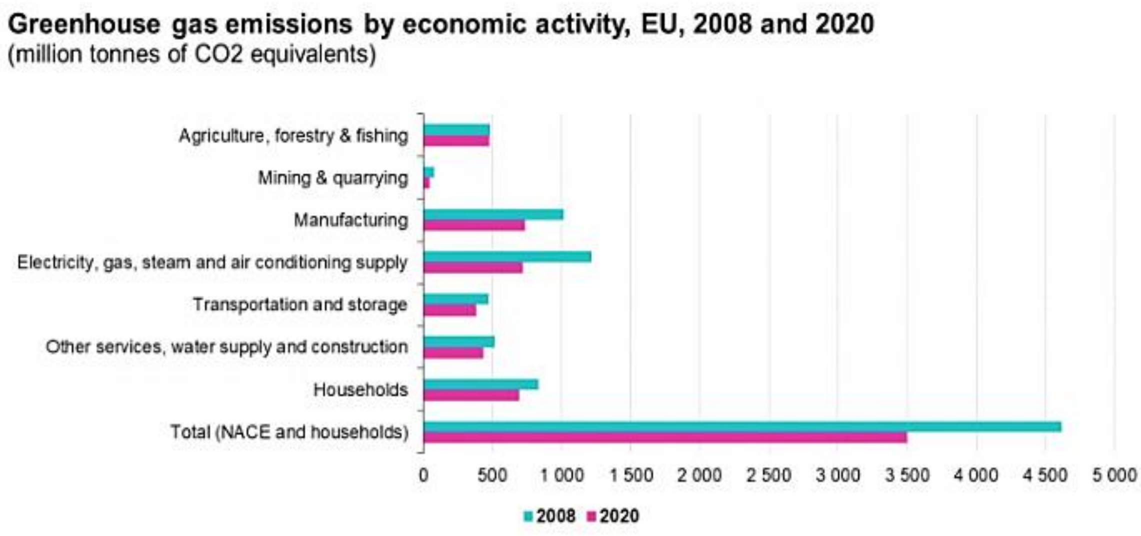

Figure 1: Greenhouse gas emission by economic activity.

Source: Eurostat

The combination of these data leads us to an inevitable conclusion, taking into account the significance assumed by the greenhouse gas levels generated by the production and consumption activities of energy flows, although EU-27 efforts to promote energy efficiency and an soaring role of production from renewable sources have led to remarkable changes over time in the same as well as in absolute levels of consumption, the urgencies related to mitigation commitments and more generally to the fight against climate change require sustained and incremental efforts that increasingly see involved businesses and households.

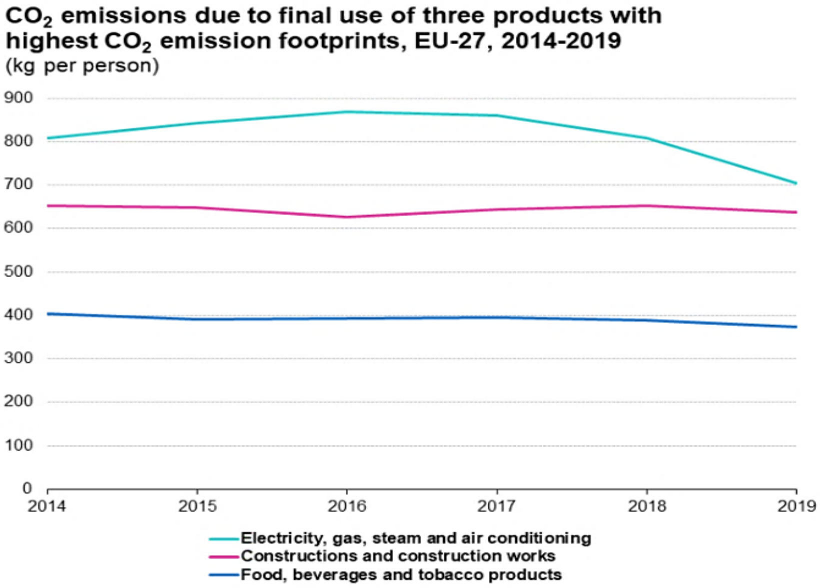

Figure 2: Co2 emissions related to the products with the highest carbon dioxide footprints.

Source: Eurostat

From the preceding information, could be inferred that the reduction of energy consumption required for the production of certain outputs able to pervade multiple economic sectors is an essential pillar for the resilience of the energy sector, functional for its emancipation from imports of energy flows, energy price fluctuations, and central to the fight against energy poverty, on the other hand, it is affirmed as a necessary means for the reduction of anthropogenic greenhouse gas emissions from various final energy consumption and consequently instrumental in meeting the commitment to "limit temperature increase well below 2 degrees Celsius, while efforts are pursued to limit the increase to **1.5** degrees" undertaken by many countries ratifying the *Paris Agreement*, for these reasons multiple supranational bodies, governments and energy-related entities in recent decades have amplified efforts to promote energy efficiencies to increase efficiency in the use of energy carriers.

1.2) Energy efficiency in productive activities: barriers and drivers of energy efficiency interventions.

Turning our focus to the role of businesses, one of the pathways to be undertaken inescapably for the reduction of emissions generated by production activities consists in the adoption of energy efficiency interventions, these measures and their actualization depend strictly on the technological trajectories observable in a given national context, all the way these interventions may or may not concern technological advances, for example they may consist in a behavioral modification assumed by the staff with the purpose of improving the control of energy consumption, such as in the replacement of equipment at the end of its life cycle, as a consequence the ability of the aforementioned EEMs (energy efficiency measures) to affect the level of emission depends strictly on the measure itself.

Interventions may assume a more or less complex nature, energy savings may be generated by the replacement of lighting apparatus as well by the introduction of extensive installations such as a trigeneration plant capable of generating electricity and at the same time, through heat recovery, to provide thermal and cooling energy, moreover, in connection to their complexity EEMs are not exclusively functional to the respect of social commitments and reduction of environmental impacts of companies, indeed they represent at the same time an opportunity to decrement the weight assumed by the costs of energy consumption on the total costs faced, with a consequent reduction of waste through better management of production sites and resources, however, although these benefits may be essential to stimulate the competitiveness of companies and production sectors, the adoption of these measures does not seem to assume rapidity parallel to the emphasis surrounding them.

The relevant literature to explain the insufficient adoption of *energy efficiency measures* (EEMs), despite their convenience, focuses on identifying the barriers faced by firms, in detail barriers are defined *as element (external and behavioral) that inhibit investment in energy efficient technologies* (Reddy, 2013[1]), the categorization of which has stimulated many empirical studies on the subject, the different contributions of the literature allow four main types of barriers to be identified, respectively as *non-market economic failure*, *market economic failure*, *organizational* and *behavioral type*, these are further subdivided into different sub-categories that vary according to the different framework considered.

Martin[2] and his colleagues for example suggest to distinguishing measures that employ cross-cutting technologies from those that employ technologies pertaining to specific processes, explaining how the reluctance to introduce the former is lower as they are related to broader uses, at the same time the risk factors associated with such interventions seem to play an important role in shaping resistance to adoption,

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[1] *Barriers and drivers to energy efficiency – A new taxonomical approach*
Reddy 2013.
[2] *Anatomy of a paradox: Management practices, organizational structure and energy efficiency*
Martin, Muûls, de Preux and J. Wagner

and the different perception of the same risk leads to the observation of very heterogeneous behavior among firms, for example, De Beer (1998)[3] points out that the propensity of manufacturing operations to introduce certain interventions turns out to be correlated with the degree of change they introduce, radical changes imply risks capable of undermining the propensity toward efficiency, a similar effect is evident in the case of measures capable of affecting production processes central to the firms activities, these lead to increased fears of possible disruptions in production and thus disincentivize the willingness of corporate decision makers; finally, very complex innovations for which the formation of specific knowledge in the field is necessary encounter equal resistances (Kemp and Volpi, 2008[4]; Tornatzky and Klein, 1982[5]).

Multiple studies, on the other hand, emphasize the centrality of economic-financial elements in the decision-making processes concerning energy conservation measures, in particular having access to the necessary capital turns out to be one of the main impediment, felt particularly by small and medium-sized companies (de Groot et al., 2001[6]; Rohdin et al., 2007[7]; Thollander et al., 2007, Trianni and Cagno, 2012[8]), Anderson and Newell (2004) substantiate how the expenditure initially incurred by companies and the related payback period are negatively correlated with the rate of EEMs adoption, while in while increases in the level of energy prices appear to be effective long-term stimuli for the introduction of the measures by creating the urgency to rationalize the resources used, this study also shows how economic incentives are particularly effective in the short term as they break down resistance originating from the costs of implementation, in any case the financial measures considered do not explain everything, indeed the analysis shows that by holding these factors constant some interventions find higher levels of adoption than others, suggesting that there may be many benefits and risks that these financial measures do not capture.

From the aforementioned studies it can be deduced how the specific characteristics of a given intervention can be highly relevant elements for decision making, in this regard Tobias Fleiter, Simon Hirzel and Ernst Worrell[9] identify three macro-areas for defining these characteristics, the first concerns the relative benefit of the measure itself, which in turn includes financial aspects such as expected economic returns as well as noneconomic benefits such as those related to the decrease in environmental damages, the second area instead looks at the technical context of the intervention and thus at all the elements characterizing the type of EEM such as its magnitude and lifetime, finally, the authors stress the role of the information context,

[3] *Potential for industrial energy-efficiency.*
De beer 1998.
[4] *The diffusion of clean technologies: A review with suggestions for future diffusion analysis*
Kemp and Volpi 2008
[5] *Innovation Characteristics and Innovation-Adoption-Implementation: A Meta-analysis of findings*
Tornatzky and Roberts 1982.
[6] *Energy saving by firms: decision-making, barriers and policies*
De Groot, Verhoef and Nijkamp 2001.
[7] *Energy policies for increased industrial energy efficiency: Evaluation of a local energy programme for manufacturing SMEs*
Thollander, Danestig and Rohdin 2007.
[8] *Dealing with barriers to energy efficiency and SMEs: Some empirical evidences*
Cagno and Trianni 2012.
[9] *The characteristics of energy-efficiency measures – a neglected dimension*
Fleiter, Hirzel and Worrell 2012.

referring in particular to the sectoral applicability of the intervention, also its diffusion and the knowledge deemed necessary.

From this categorization it is clear that these specificities can in turn take on different relevance depending on the characteristics of the company considered and the market in which it operates, different sizes, more or less competitive markets, the organizational and knowledge management model adopted etc. are all traits that can interact with the specifics of the intervention, expanding or reducing existing barriers (Cagno, Trianni et al. 2012).

Finally, among the most frequently found reasons for insufficient adoption we find the perception of the intervention itself, i.e., the priority assigned to it in relation to the business strategy adopted and thus compared to other possible investments and patterns, Cooremans[10] et al,. suggest that whether a EEM is perceived as strategic depends not only on the characteristics of the same but to an even greater extent on the culture and priorities of the company, following this reasoning it is not only the expected profits that drive intervention decisions but also the weight given to nonenergy benefits, a weight that varies in relation to the economic, legislative and social context in which companies operate and therefore can be shaped, to this end the role of financial, governmental and nongovernmental institutions in promoting energy efficiency in different production sectors and/or end uses and in guiding financial markets in that direction is evident.

Cagno and Trianni demonstrate the above-mentioned role by means of an analysis of factors capable of stimulating the adoption of conservation measures, the authors in particular defined the drivers as elements facilitating the adoption of both *"energy-efficient technologies and practices"*, their perspective includes drivers promoting energy-efficient culture and awareness rather than simply economic features, anyway their findings confirm the weight assumed by financial factors associated with the convenience of investment, however, any imbalances between the financial costs and the benefits of the latter lend themselves to correction by means of targeted policies for example consisting of subsidies and incentives (external economic factors), the second category found concerns regulatory tools distinguishable between internal, such as voluntary agreements undertaken by companies, and external, such as specific obligations and constraints imposed on companies, including those relating to the implementation of audits concerning energy consumption, these obligations along with the use of information tools, such as labels relating to the energy efficiency of products, and the necessary professional training, increase the efforts put in place by production activities and the ease with which these are undertaken, these element are also capable of stimulating their knowledge regarding the energy conditions of the production site in question and awareness concerning energy conservation spaces.

[10] *Energy management: A key driver of energy-efficiency investment?*
Cooremans and Schönenberger 2019.

Thollander and Ottosson [11]suggested instead three groups of drivers, the first include *market-related* driving forces, the authors stressed how for instance the threat of a sudden increase in energy prices can stimulate a rush to adopt efficiency measures, the second category refers to current and *potential energy policies* and the latter organizational and behavioral factors inherent to the firms such the perceived strategic relevance of a “green image”.

Considering these findings and jointly the complexity of the barriers to energy efficiency as well as their interaction with foundational elements of the enterprise it is clear that, in order to correct market failures capable of hindering the realization of the benefits from energy efficiency, institutional efforts must assume a complementary character by acting on different fronts.

1.3) Energy Efficiency First: The European Regulatory Framework.

The fundamental bodies of the European Union have been showing a deep awareness of the benefits and urgencies associated with energy efficiency for several years now, identifying the moderation of energy demand as a crucial dimension of the *European Energy Strategy*, according to the text of Directive 2012/27/EU, is an inescapable tool whose advances along the entire energy chain, including energy generation, transmission, distribution and end-use would generate benefits directly attributable to the lifestyles of the European population such as those related to the environment air quality and public health, but also positive impacts related to the energy security of the member countries by reducing their dependence on energy imports from outside the Union, as a result, energy costs for households and businesses would be reduced helping to alleviate energy poverty, stimulate business competitiveness and the dynamics of labor markets, the effects would thus permeate the entire economy of the member countries enabling them to achieve the ambitious mitigation goals of the EU-27 and the consolidation of the stability and resilience of the energy sector.

In 2007, the European Council conclusions emphasized the need to achieve the **20%** energy efficiency target by the 2020 horizon, a path was therefore embarked upon to promote the role of efficiency measures, which was continued through the issuance in 2012 of the European Energy Efficiency Directive 2012/27/EU (EED) with the aim of regulating the matter in a timely manner and introducing additional stimulus mechanisms.

In order to capture the full potential for energy savings that exists it is necessary to embrace an integrated approach reflected in the request for the Member States to set "*national energy efficiency targets expressed through national action plans to be published every three years*", in addition, National institutional bodies are called upon to define and promote financing tools or tax incentives that lead to the application as to the

[11] *Energy management practices in Swedish energy-intensive industries*
Thollander and Ottosson 2010.

identification of energy-efficient technologies or techniques concerning buildings, transport and industrial production processes, the committee also suggests the definition of a system of price regulation in order to make them indicative of the path to follow in terms of reducing energy consumption without threatening the affordability and so the access to the services themselves, consequently it imposed multiple binding measures to "*support Member States in achieving their energy consumption reduction targets*", establishing legally binding rules for end users and energy suppliers.

Considering the functional relevance of decreasing energy consumption, the content of such regulatory instruments was later expanded under the *Clean Energy for All Europeans package* enacted in 2018, which introduced the **New Energy Efficiency Directive** (2018/2002/EU), the instrument shows renewed reduction ambitions by requiring the commitment of Member Countries to develop detailed measures to decrease annual energy consumption by an average of **4.4**% and overall by at least **32.5** %.by 2030, renewed attention was given to local and regional governments in the development the design, execution and evaluation of planned measures in an attempt to better "*remove barriers in the market and overcome market failures that impede efficiency in the supply and use of energy*".

In order to stimulate the scenario concerning the current condition of the achieved and obtainable levels of energy efficiency, the Article 8 of EED individuates and imposes nationally implemented obligation schemes, this scheme must requires energy companies to achieve energy conservation of less than 1% per annum of annual sales to final consumers, thereby reducing carbon emissions and cutting energy bills, more precisely, the UE regulatory bodies calls on the Member States to set up, on the basis of objective and non-discriminatory criteria, specific obligations pertaining the amount of energy savings required of each obligated party, to be identified in terms of either final or primary energy consumption, consequently rise the need to implement systems of measurement, control and verification concerning at least a representative sample of the obliged sectors or parties, expressed as a percentage statistically significant of the aforementioned sample, with particular attention to be paid towards energy related or energy-intensive sectors, more precisely, this measurement focuses on level and quality of the energy efficiency improvement interventions implemented by the obligated parties and it must be carried out independently of them, appealing to third authorized parties or institutional authorities , anyway to the countries is left discretion about the obligation regime to be instituted even if specification of it are individuated in the document.

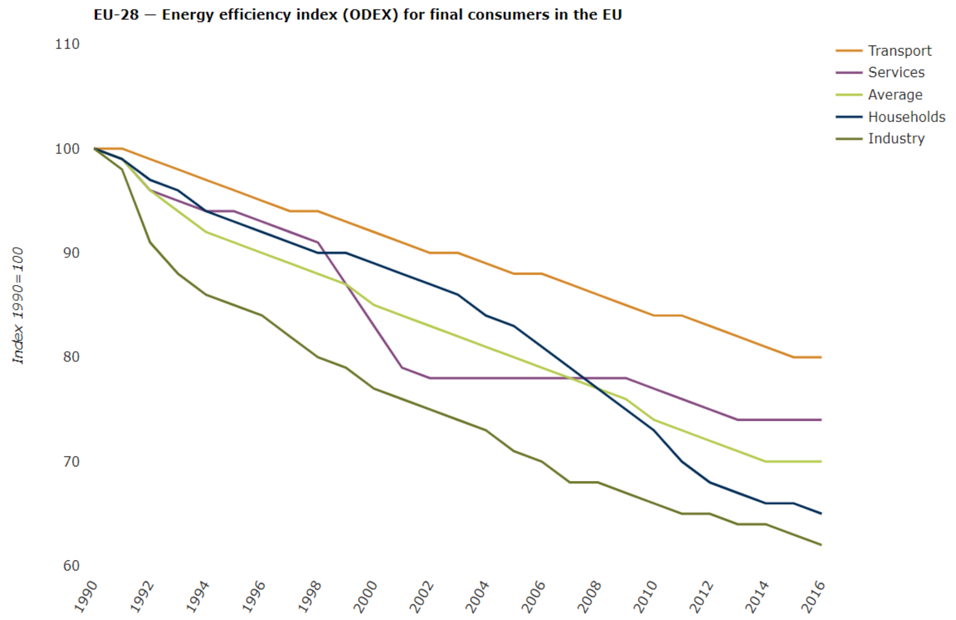

Figure 3: Average Energy efficiency index weighted by the energy consumption of the respective sector.

Source: EEA

Although this chain of regulatory tools represented a significant change in the overall regulatory framework related to the European Energy Strategy and led to significant progress, achieving climate neutrality, which is essential to counter the progression of climate change and its disastrous consequences requires a systematic increase of National commitments as well as related progress, the 2020 progress report on the Energy Efficiency Directive indicated that the Nations were able to meet their 2020 efficiency targets only as a consequence of anomalous combination the of Covid-19 related contractions of the economies and rise in the temperature characterizing the winter season, the awareness of increased effort needed has been formally institutionalized through the adoption of the *European Green Deal* and the package designed to implement it, the latter of which proposes and augment the "*targets for reducing primary and final energy consumption by 2030 up to **39%** and **36%**, respectively*", consistent with the advance of mitigation efforts and thus with the decision of the European Council to endorse a binding Union target of a net domestic reduction of at least **55%** in greenhouse gas emissions by 2030 compared to 1990, the document also includes measures whose purpose is to alleviate energy poverty by requiring countries to accord "*priority to vulnerable customers*" and by setting specific obligations to conduct energy audits especially for large energy consumers.

Closely related to large volumes of consumption there are large areas characterized by energy-saving potential, these latter according to the directive remain high in all sectors, but there is an intricate and complex challenge pertaining sectors essential to the economies of Member countries, such the transports, responsible for more than **30%** of final energy consumption, and the buildings, in light of Union's building stock which the **75%** of it showing poor energy performance, however, the higher level of ambition requires greater promotion of cost-effective energy efficiency measures in all in all areas of the energy system and in all economically relevant sectors.

Figure 4: European Green Deal crucial aspects.

Source: European Commission

The aforementioned package also engrave on the article 8 of the Directive 2012/27/EU pertaining the provisions about energy saving obligations (ESOs) modifying them; for the period 2021-2030 the values of such obligation are currently set at **0.8%** per annum and are required to grow significantly and almost double, actually their values would reach **1.5%**, under the revision of the 55 fit package, between 2024 and 2030, what is more is the necessity, underlined by the document, to include measures that capable to address energy poverty for vulnerable segment of consumers in the obligation schemes.

The growing European ambitions have assumed the character of growing obligations and commitments for the Member countries and consequently for their productive and residential activities in relation to the quantity and quality of energy vectors consumed, especially as regards the creation of efficient technological trajectories which show cost effectiveness and easy dissemination, jointly the regulatory framework introduces specific and incremental protections for consumers in order to avoid repercussions on them caused by the ecological transition undertaken by the sectors and the related energy improvements and the transformation of the energy sector itself, albeit with large differences, expressed through national plans, the member countries have over time outlined and perfected best practice mechanisms aimed at regulating and promoting energy efficiency improvements as evidenced by the progress achieved.

In the period 1990-2016, the energy efficiency of the end-use sectors improved by **30%** (EU-28) at an average rate of **1.4%** per year, these advances have been led by the industrial sector (**1.8%** per year) and households (**1.6%** per year) although the latter have seen subsequent variations or more precisely a rebound effect due to the purchase of more and more spacious homes, anyway despite such accomplishments the path towards achieving a holistic approach requires further efforts whose future trajectories could see local authorities and households even more involved.

1.4) Energy Efficiency in Italy: Incentive mechanism.

Italy pursues in line with European commitments a path to improve the country's energy security, environmental protection and accessibility of energy services by engraving their costs, recognizing the benefits associated with energy efficiency therefore identifying its strategic and crucial role through the Legislative Decree No. 102 of 2014 on Energy Efficiency which "*establishes a framework of measures for the promotion and improvement of energy efficiency that contribute to the achievement of the national energy savings target indicated in Article 3 and that contribute to the implementation of the European principle that puts energy efficiency first"*, in detail, it envisage a national obligation to save **20 Mtoe** per year of primary energy, equivalent to **15.5 Mtoe** per annum of final energy through mechanisms and tools outlined by the Legislative decree itself.

For what concern these latter, as stressed by the Italian Action Plan for Energy Efficiency, Italy mainly recurs to the White Certificates based obligation scheme, flanked in addition by other support tools for energy efficiency enhancement measures such as tax deductions for the energy requalification of buildings and the Thermal Count which incentivizes interventions to increase energy efficiency and thermal energy production from renewable sources for small-scale plants, these measures however see separate sectoral applications, finally, among the horizontal policies mentioned in the decree there are Energy Audits capable of stimulating a conscious management of energy consumption within production activities while identifying realizable efficiency measures and mechanisms for their concretization, breaking down some of the barriers associated with the adoption of these measures not necessarily related to economic-financial factors (See Chapter 1.2).

Over the years the evolutions undergone by commitments in the European Union legislative framework in terms of mitigation and energy security have necessarily required a modification of the Italian national objectives and the strengthening of the policy set concerning energy efficiency, the motivations behind these modifications are evident from the *National Integrated Plan for Energy and Climate* (PNIEC) issued in 2020, the document emphasizes the undertaken mix of fiscal, economic, regulatory and programmatic instruments, predominantly tailored to identified sectors of intervention and types of energy end-users as well the identified specific targets, it is decomposed into the various dimensions characterizing the *European Energy Strategy* and for what concern the information relating to the evolution of anthropogenic greenhouse gasses emission levels, with reference to the decarbonization of the economy as a primary objective, it suggest the heavy incidence of energy use in the generation of emissions, which in 2016 represented **81%** of the total, while the remaining quotas derived from non-energy sources, essentially connected to industrial processes, agriculture and waste, Italy, in line with the European regulatory body, for years has been putting in place efforts to reduce the aforementioned levels through the Emission Trading System accompanied by specifically outlined reduction obligations efforts for sectors not included in the ETS, more precisely for the latter it envisages a reduction target of **33%** of emissions compared to 2005 levels, such framework aimed at achieving a full decarbonization of the economy by 2025 has consequently identified a greater weight of policies assumed as stimuli to achieve improved energy efficiency trajectories.

		Sectors				Energy poverty
TYPOLOGY OF THE MEASURE	**MEASURE**	*Residential*	*Industry*	*Transport*	*Tertiary*	
Obligation scheme	**White certificate**		☑	☑	☑	
Alternative Measure	**Tax deductions**	☑			☑	☑
	Thermal Count				☑	☑
	Energy Efficiency National Fund	☑		☑	☑	☑
	Piano impresa 4.0		☑	☑	☑	
	PREPAC				☑	
	Cohesion Policies	☑	☑	☑	☑	☑
	Information and training plan	☑		☑	☑	
	Vehicle fleet renewal			☑		
	Commodity modal shift			☑		

Table 1: Summary of incentives mechanism for energy efficiency and the sectors of applicability.

Source: PNIEC

In relation to the path taken on energy efficiency, the above plan underlines the renewed objectives for the national economy, consisting of a **43%** reduction in primary energy consumption and a **39.7%** reduction in final energy, to be achieved by 2030 compared with the 2007 baseline scenario, in absolute values, primary and final energy consumption in this decade will reach values of **125.1** Mtoe and **103.8** Mtoe respectively, these results imply the generation of annual energy savings equivalent to **0.927** Mtoe to be originated in the period 2021-2030 through new interventions and technological trajectories, with special attention to be paid to the buildings and transport sector, however, considering the significance of direct and indirect energy consumption and the resulting greenhouse gas emissions associated with industry, although the efficiency potential detected is lower than in other economic sectors, the document identifies parallelly specific targets and policy measures for industrial activities, more precisely, the sector is called upon to achieve energy use reduction of about **1.0 Mtoe**, the policies to provide the necessary incentive with industrial sectoral application consist of *White Certificates*, introduced with the ministerial decree of 20 July 2004, which came into operation in 2006, to oblige electricity and gas distributors with more than 50,000 customers to save pre-set quantities of energy each year, in detail, they consist in tradable certification savings achieved in energy end-uses through projects aimed at increase energy efficiency, anyway, important modifications have succeeded over the years with the aim of simplifying and encouraging the use of the mechanism (one certificate is equivalent to saving one Ton of Oil Equivalent), a second central incentive tool for industry is found in the *Business Plan 4.0* which will generate cumulative savings by 2030 equal to **2.8 Mtoe** of final energy through the introduction of a new tax credit for expenses incurred as an investment in new capital goods including intangible assets instrumental to the technological transformation highlighted by Industry 4.0 model and finally the policy set see a range of investments that can be financed through the mechanisms sures and obligation schemes currently in force in the country.

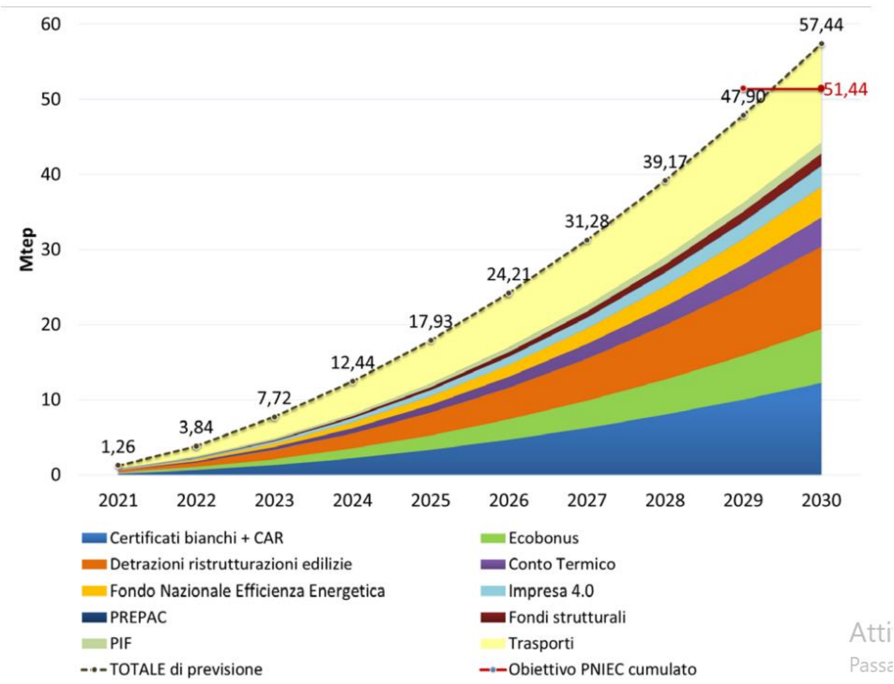

Figure 5: Evolution of energy savings achievable through incentive mechanisms

Source: PNIEC

1.5) The Italian Directive on Energy Efficiency: The Energy Audit

Within the wide range of tools identified by the decree in order to support the achievement of national objectives relating to energy efficiency we find *Energy Audits*, which becomes the most qualified tool for *analyzing the energy flows of a production activity and their management, presenting itself as a systematic evaluation of energy uses from their point of entry up to their final uses, able consequently to track and quantify energy saving opportunities,* so that if on the one hand it constitutes a means of acquiring the information necessary to paint a picture of energy consumption and its uses in the various functional areas of production activities, on the other hand it supports companies in acquiring greater awareness of their own consumption as well as of achievable savings in energy, economic terms and with reference to carbon dioxide emissions.

Article 8 (Legislative Decree. 102/2014) identifies as subjects obliged to carry out energy Audit, at their production sites, Large Enterprises and Energy-intensive Enterprises, excluding, however, from the burden Large Enterprises with a total annual energy consumption of less than 50 toe (this consumption is evaluated considering all relevant sites) and all public administrations reported in the ISTAT lists, in addition, the document titles Italian National Energy Efficiency Agency (ENEA) as the entity in charge of establishing and managing a database of enterprises subject to audit, entrusting it with the task of carrying out controls to ascertain the conformity of the audits with legal requirements and compiling a summary report on the overall diagnostic activities carried out and the results achieved.

Thanks to the introduction of standard **EN 16247.1** "Energy Audit- General Requirements" and subsequent regulatory tools, the methodology for obtaining a good quality energy audit of a production site as well as its characteristics and necessary requirements has been punctually defined, the standard paints the way of organizing and conducting the audit by specifying the professional requirements of the person in charge, i.e. the Energy Auditor, to collect "*the necessary and useful information to understand the production process, the sources of energy and raw materials supply, the way the production site/plant is managed in terms of energy, economics and work organization"* , the figure of the Auditor assumes therefore central relevance that by carrying out the analysis in the field allows to reduce any resistance to adoption caused by the need to develop specific knowledge regarding the management of energy vectors and potential interventions, the standard also details the methodology of analysis of the data collected and the criteria for the compilation and presentation of reports and documents relevant to the findings of the energy audit, pointing out the content.

For the purpose of fulfilling the obligation under Decree 102/2014, subjects undergoing the Audit are required to upload the relevant documentation on the ENEA portal, this currently consists of three documents whose contents have been meticulously defined in an attempt to provide support to companies for increasing their awareness regarding the actual effort undertaken for the regulation of energy consumption and regarding possible improvement interventions as well as the costs and benefits associated with them.

- The first document concerns the *Clusterization file* including the list of production sites associated with a specific company and their total consumption, this tool is necessary because, in order for the audit realization to be smooth, companies consisting of *n* sites all under a single P.IVA, the group of companies that present a single consolidated balance sheet and in addition the group of associated or affiliated companies, have the possibility to perform the energy audit only on a significant group of their sites according to percentages defined on the basis of different consumption classes depending on the production sector considered, all the way for the identification of obligated and excluded subjects it is stated necessary the calculation of total consumption summarized in the file.
- The second fundamental component of the necessary documentation consists of the real core of the audit i.e. the *Final Report*, the document gathers all the essential information to paint the complete picture of the founding features of the enterprise, as the production processes and the products made, it also punctuates the methodology used to conduct the audit and provides a summary of energy consumption and its breakdown in the different functional areas, resorting for the realization of such a breakdown, to punctual energy models, the auditor is also called upon to introduce in the report an analysis of current performance conducted by resorting to the use of specific performance indices concerning existing best practices in the various energy uses, finally, the document contains a section suitable to describe the interventions already put in place and one regarding the opportunities for improvement identified during the field activity.

The Audit Report thus contains a range of information of particular importance for the purposes of sectoral analysis of energy consumption and efficiency measures; in detail, the ENEA guidelines require it to be composed of the following sections:

1) NOTE ON WHO DRAWED THE ENERGY AUDIT: showing the data of the person who carried out the audit, so it is necessary to specify whether the person is external or internal to the company, his or her professional qualification and relevant certification (EGE or ESCo).

2) GENERAL DATA OF THE COMPANY.

3) DATA OF THE PRODUCTION SITE FOR WHICH THE AUDIT IS MADE.

4) THE REFERENCE PERIOD OF THE AUDIT.

5) THE UNITS OF MEASUREMENT ADOPTED WITHIN THE AUDIT.

6) ENERGY CONSUMPTION: both total energy consumption and energy consumption for individual energy vectors must be included; also including any self-produced and self-consumed energy flows.

7) RAW MATERIALS USED IN PRODUCTION PROCESSES.

8) PRODUCTION PROCESS DESCRIPTION: description of the production process, flowchart with energy vectors involved, including description of each step shown on the diagram.

9) DESCRIPTION OF FINISHED PRODUCTS: semi-finished products coming out of the production cycle shall also be included in the report, in addition, for each type of product, the annual quantity produced in comparable units shall be provided.

10) REFERENCE ENERGY INDICATORS: the document should include reference indicators for the process under consideration that can be found in literature, IPPC, trade associations, etc. (for each give detailed references of sources, including year of publication).

11) INFORMATION ON DATA COLLECTION METHOD: continuous measurements, measurements over a short period, data derived from calculations.

12) DESCRIPTION OF IMPLEMENTATION OF MONITORING STRATEGY: describe the tree of meters and their types. All instrumentation should be listed and related technical information, degree of uncertainty, and calibration schedule to which it is subjected should be provided.

13) ENERGY MODELS: the electrical, thermal and, if applicable, related to any other energy carrier model should be detailed.

14) CALCULATION OF ENERGY INDICATORS: definition and comparison with reference ones.

15) INTERVENTIONS CARRIED OUT IN THE PAST: the most important interventions already carried out should be described.

16) INDIVIDUATION OF POSSIBLE INTERVENTIONS: a detailed technical description of the intervention itself and of the equipment on which it is intended to intervene should be provided for each intervention, envisaging the implementation of a measurement plan with the aim of verifying the energy savings that will be achieved.

17) **SUMMARY TABLE OF IDENTIFIED INTERVENTIONS**: for each significant intervention, sorted according to NPV/I, indicate the following data:

- ☑ Investment (I)
- ☑ Cash flow (FC)
- ☑ Savings
- ☑ Payback Period (TR)
- ☑ IRR
- ☑ NPV
- ☑ NPV/I

- Finally, the third and last essential document consists of a *Summary file* regarding energy consumption and its breakdown into the different functional areas, calculations regarding the Global Energy Indicators are also given.

Returning to the core of the Audit, *the section on identified efficiency measures* plays a central role, namely the function *of promoting and stimulating their adoption*, in fact, the guidelines pertaining to the realization of the report require specifying *the technical-economic feasibility of the measures* through an analytical description of the intervention in relation to its uses and from an analysis reporting the level of costs faced by the company and the resulting thermal and electrical savings achievable, economic indicators such as *Payback Period, Net Present Value* and *cash flows* must be reported as foundational elements of business decisions, on the basis of these indicators and information it is therefore possible to select the investment more in line with the company's decision-making dynamics, both in terms of initial expenditure and expected benefits as well as in technical terms, the auditor is also called upon to point out the priority assigned to the measure and the possible existence of regulatory tools for its promotion such as incentives and subsidies, the aforementioned informational framework can finally be used with the aim of analyzing the distance between the efforts materialized in the conservation interventions introduced and the efficiency potential existing at the site as well as the origin of resistance to adoption.

The identified interventions serve *the function of tracking existing energy-efficient conservation spaces*, these can be distinguished according to four different macro-categories:

- **Alternative fuels assessment**: consisting of identifying the most appropriate fuels for efficient energy conversion.

- **Energy conversion systems:** i.e., opportunities for improving the conversion efficiency of plant components through, for example, optimal coupling of heat exchangers, reduction of excess air in combustion etc.

- **Power distribution**: thus, the opportunities for efficiencies in transformers, cables, switchgear, and possible power factor improvement in electrical and chilled water systems, water cooling, compressed air, etc.

- **Energy used by processes**: often this is the main location where to find improvement opportunities by going to evaluate through the analysis of the process itself possible recoveries and integrations.

Tabella 78: Riassunto degli interventi di riqualificazione individuati e ordinati per indice VAN/I decrescenti

Rank	Intervento	Risparmio elettrico stimato [MWh/anno]	Risparmio el. perc. sul consumo totale [%]	Risparmio di gas naturale stimato [MWh/anno]	Risparmio di gas naturale perc. sul consumo totale [%]	Risparmio economico stimato [€/anno]	Costo di investimento stimato [€]	Incentivi ottenibili	VAN/I	TR	VAN €
1	Certificazione ISO 50001:2018	156	1,0%	744	1,0%	43.200	20.000	-	**4,47**	**0,5**	89.391
2	Piattaforma di monitoraggio	-		730-1.470	1-2%	22.000-44.000[13]	45.000	-	**3,51**	**1,4**	157.900
3	Aria compressa: individuazione e riduzione delle perdite	87	0,6%		-	11.700	6.000	-	**1,82**	**0,5**	10.896
4	Impianto cogenerazione	12.350	79,4%	4.362	5,9%	733.000	2.000.000	TEE	**1,38**	**2,7**	2.765.719
5	Motori IE4 e Inverter	293	1,9%		-	39.500	114.000	TEE	**1,05**	**2,9**	119.193
6	Installazione di un impianto FV	3.089	19,8%			353.300	2.240.000	FER 1	**0,82**	**6,3**	1.831.518
7	Sistema di destratificazione			1.222	1,6%	30.600	203.100	-	**0,16**	**5,7**	27.748
8	Ottimizzazione sistema di rifasamento					2.100	Da definire	-	**Da definire**	**Da definire**	Da definire
	TOTALE	**15.974**	**100%**	**7.434**	**10%**	**1.246.700**	**4.628.100[14]**				

Figure 6: Summary example of the proposed interventions and the information requested.

To conclude, energy audit are today the fundamental unit for the definition of the framework of energy flows of the different ATECO sectors and crucial tool for the removal of some of the barriers regarding the very introduction of the measures, all the way different difficulties' faced by ENEA experts to promote the dissemination and homogenization of the audits in the different production sectors as well as to improve its analysis, all way the effectiveness of the same within the boundaries of the company in the long term is guaranteed through the request for the definition "of the implementation of a permanent monitoring plan" of the trend of energy consumption in the main activities, general and auxiliary services of a given production site, this would allow to maintain an efficient management of supplies to assess the variation of the same in relation to any changes in the balance between the functional areas and / or within them.

2) The 2019 Energy Audits: The potential for energy efficiency in Italy.

2.1) The energy Audit of the second mandatory period.

At the end of 2019, the energy audit sent to ENEA, in fulfillment of the obligation related to the second round of audit occurred four years after the first, exceeded **11,000** units from **6,434** enterprises, **3,695** of these declared themselves as Large Enterprises while **3,109** declared themselves as Energy-Efficient Enterprises (of these latter 2,314 declared themselves to be exclusively energy-intensive enterprises, while **795** turn out to be both Large Enterprises and Energy-intensive Enterprises), all the way the number of companies involved in the implementation of energy audits increases if we consider the enterprises included in the clustering tools uploaded to the portal in the case of multi-site enterprises, in fact, in total there are **634** enterprise groups that have uploaded clustering, totaling **3,132** affiliated enterprises, the use of the latter tool has led to a substantial simplification of the work done by multiple production activities with a consequent reduction (by about 5 thousand units) of the audit received compared to 2015.

The work carried out by ENEA on the analysis of the documentation uploaded to the official portal has made it possible to highlight the different incidence assumed by the economic sectors on the total of the audit themselves, the strength ratios characterizing the second cycle are in line with the findings of the previous one, approximately **53%** of the audit (**5,919**) in fact come from the Manufacturing sector (sector C) followed by Wholesale and Retail Trade (G) from which derive **1,561** audits (**14 percent of the total**) and Transport and Storage (H) with **687** audit, while ATECO codes related to the tertiary sector such as Financial and Insurance Activities (K), Real Estate Activities (L) and Health and Civil Assistance Services (Q) collectively figure as about **6 percent** of the total audits received.

The following figure (7) summarizes the breakdown of the audit according to the 2-digit and 6-digit ATECO codes, the number of companies (P.IVA) that sent documentation for each individual ATECO sector and the ratio of audit sent to companies are also shown, these data are able to provide us with an immediate informative picture regarding the involvement of companies in fulfilling the obligations related to the energy audit carried out.

Settore ATECO		ATECO 2	N. ATECO 6	Diagnosi	P.IVA	Diagnosi/P.IVA
A	AGRICOLTURA, SILVICOLTURA E PESCA	01 - 03	53	75	39	1,92
B	ESTRAZIONE DI MINERALI DA CAVE E MINIERE	05 - 09	17	53	31	1,71
C	ATTIVITÀ MANIFATTURIERE	10 - 33	417	5.916	4.453	1,33
D	FORNITURA DI ENERGIA ELETTRICA, GAS, VAPORE E ARIA CONDIZIONATA	35	8	318	106	3,00
E	FORNITURA DI ACQUA; RETI FOGNARIE, ATTIVITÀ DI GESTIONE DEI RIFIUTI E RISANAMENTO	36 - 39	14	576	243	2,37
F	COSTRUZIONI	41 - 43	35	176	89	1,98
G	COMMERCIO ALL'INGROSSO E AL DETTAGLIO; RIPARAZIONE DI AUTOVEICOLI E MOTOCICLI	45 - 47	290	1.561	466	3,35
H	TRASPORTO E MAGAZZINAGGIO	49 - 53	40	687	267	2,57
I	ATTIVITÀ DEI SERVIZI DI ALLOGGIO E DI RISTORAZIONE	55 - 56	21	214	70	3,06
J	SERVIZI DI INFORMAZIONE E COMUNICAZIONE	58 - 63	36	383	96	3,99
K	ATTIVITÀ FINANZIARIE E ASSICURATIVE	64 - 66	39	368	109	3,38
L	ATTIVITA' IMMOBILIARI	68	5	78	38	2,05
M	ATTIVITÀ PROFESSIONALI, SCIENTIFICHE E TECNICHE	69 - 75	50	133	81	1,64
N	NOLEGGIO, AGENZIE DI VIAGGIO, SERVIZI DI SUPPORTO ALLE IMPRESE	77 - 82	55	150	81	1,85
O	AMMINISTRAZIONE PUBBLICA E DIFESA; ASSICURAZIONE SOCIALE OBBLIGATORIA	84	22	2	1	2,00
P	ISTRUZIONE	85	20	3	3	1,00
Q	SANITA' E ASSISTENZA SOCIALE	86 - 88	28	226	115	1,97
R	ATTIVITÀ ARTISTICHE, SPORTIVE, DI INTRATTENIMENTO E DIVERTIMENTO	90 - 93	31	70	33	2,12
S	ALTRE ATTIVITÀ DI SERVIZI	94 - 96	42	36	16	2,25
T	ATTIVITÀ DI FAMIGLIE E CONVIVENZE COME DATORI DI LAVORO PER PERSONALE DOMESTICO; PRODUZIONE DI BENI E SERVIZI INDIFFERENZIATI PER USO PROPRIO DA PARTE DI FAMIGLIE E CONVIVENZE	97 - 98	3	0	0	0,00
U	ORGANIZZAZIONI ED ORGANISMI EXTRATERRITORIALI	99	1	0	0	0,00
	NON ASSEGNATE			147	97	1,52
	TOTALE		1.227	**11.172**	**6.434**	**1,74**

Figure 7: Distribution of audits submitted in 2019 in relation to the ATECO sector they belong to.

Source : ENEA

Looking more closely at the Manufacturing sector, in light of its own potential in terms of contributing to the achievement of national energy efficiency goals, we find the relevance of the sectors afferent to metallurgy and nonmetallic mineral processing (**ATECO codes 23 and 24**), both of which in fact represent **9.0%** of the audits delivered to ENEA, equally central is the observed numerosity of the audit afferent to the production activities engaged in the manufacture of plastics and rubber (ATECO code 22) and the productions associated with the manufacture of metal products (ATECO code 25) from which derive **8.1**% and **5.4%,** respectively, of the total audit submitted.

	DIVISIONE ATECO (Codice a 2 cifre)	Diagnosi	P.IVA	Diagnosi/P.IVA
10	INDUSTRIE ALIMENTARI	726	524	1,39
11	INDUSTRIA DELLE BEVANDE	95	68	1,40
12	INDUSTRIA DEL TABACCO	5	3	1,67
13	INDUSTRIE TESSILI	350	301	1,16
14	CONFEZIONE DI ARTICOLI DI ABBIGLIAMENTO; CONFEZIONE DI ARTICOLI IN PELLE E PELLICCIA	95	59	1,61
15	FABBRICAZIONE DI ARTICOLI IN PELLE E SIMILI	84	60	1,40
16	INDUSTRIA DEL LEGNO E DEI PRODOTTI IN LEGNO E SUGHERO (ESCLUSI I MOBILI); FABBRICAZIONE DI ARTICOLI IN PAGLIA E MATERIALI DA INTRECCIO	69	58	1,19
17	FABBRICAZIONE DI CARTA E DI PRODOTTI DI CARTA	231	161	1,43
18	STAMPA E RIPRODUZIONE DI SUPPORTI REGISTRATI	66	52	1,27
19	FABBRICAZIONE DI COKE E PRODOTTI DERIVANTI DALLA RAFFINAZIONE DEL PETROLIO	45	26	1,73
20	FABBRICAZIONE DI PRODOTTI CHIMICI	404	294	1,37
21	FABBRICAZIONE DI PRODOTTI FARMACEUTICI DI BASE E DI PREPARATI FARMACEUTICI	160	108	1,48
22	FABBRICAZIONE DI ARTICOLI IN GOMMA E MATERIE PLASTICHE	903	765	1,18
23	FABBRICAZIONE DI ALTRI PRODOTTI DELLA LAVORAZIONE DI MINERALI NON METALLIFERI	508	345	1,47
24	METALLURGIA	505	414	1,22
25	FABBRICAZIONE DI PRODOTTI IN METALLO (ESCLUSI MACCHINARI E ATTREZZATURE)	598	460	1,30
26	FABBRICAZIONE DI COMPUTER E PRODOTTI DI ELETTRONICA E OTTICA; APPARECCHI ELETTROMEDICALI, APPARECCHI DI MISURAZIONE E DI OROLOGI	95	70	1,36
27	FABBRICAZIONE DI APPARECCHIATURE ELETTRICHE ED APPARECCHIATURE PER USO DOMESTICO NON ELETTRICHE	169	113	1,50
28	FABBRICAZIONE DI MACCHINARI ED APPARECCHIATURE NCA	448	332	1,35
29	FABBRICAZIONE DI AUTOVEICOLI, RIMORCHI E SEMIRIMORCHI	147	98	1,50
30	FABBRICAZIONE DI ALTRI MEZZI DI TRASPORTO	71	34	2,09
31	FABBRICAZIONE DI MOBILI	63	50	1,26
32	ALTRE INDUSTRIE MANIFATTURIERE	54	42	1,29
33	RIPARAZIONE, MANUTENZIONE ED INSTALLAZIONE DI MACCHINE ED APPARECCHIATURE	25	16	1,56
	TOTALE	5.916	4.453	1,33

Figure 8: Distribution of audits submitted in 2019 pertaining to SECTOR C in relation to the 2-digit ATECO code.

Source: ENEA

2.2) Interventions carried out and Identified: the potential for energy savings

Based on the information contained in the Audits submitted in 2019, there are **7,265** interventions already carried out by **2,370** enterprises compared to **30,953** interventions identified through the different stages of energy audit, referring to **5,845** companies, this difference suggests the existence of a wide margin for improvement in terms of energy efficiency and identifies a maximum threshold, taking into account that not all interventions will actually be carried out, deepening the analysis we discover how some sectors more than others seem to be the source of such potential, for example the Manufacturing sector (C) as well as Public Administration and Defense and Mandatory Social Insurance (O) and the sector pertaining to Education (P).

Regarding Manufacturing Activities, in detail, it is necessary to emphasize the weight assumed, in terms of interventions found in the Audits, by *the manufacture of rubber and plastic articles* which accounts for **10%** of the total with **3,049** interventions, followed by the Food Industries with **7.8%** (**2,567** interventions) and finally by the Manufacture of Metal products (excluding machinery and equipment) and Metallurgy with respectively **7.0%** (**2,139** interventions) and **5.5**% (**1,688** interventions), respectively, of the total of EEMs identified thanks to the audits carried out.

The following tables shows the interventions carried out and identified broken down according to the ATECO code of the sector they belong to, the realizable and concretized savings are also display, note that **table 3** refers to energy saving values associated to *Production from Renewables and Cogeneration/Trigeneration* areas of intervention while **table 2** to intervention areas non involving auto-generation of energy carriers so including: *Air Conditioning; Aspiration; Building Envelope; Thermal Power Plant/ Thermal Recovery; Compressed Air; Electrical Systems; Electric Motors/Inverters; General; Interventions on Distribution Networks; Lighting; Process Cooling; Production Lines; Refurbishment; Other and Transportation.*

	ATECO SECTORS	REALIZED INTERVENTIONS	IDENTIFIED INTERVENTION	ANNUAL SAVINSG REALIZED INTERVENTIONS (TOE)	ANNUAL SAVINGS IDENTIFIED INTERVENTIONS (TOE)
A	AGRICULTURE, FORESTRY AND FISHING	40	155	447,6	1,264.6
B	EXTRACTION OF MINERALS FROM QUARRIES AND MINES	9	109	11,298.6	11,971.7
C	MANUFACTURING ACTIVITIES	5,255	16,661	375,970.8	933,967.9
D	SUPPLY OF ELECTRICITY, GAS, STEAM AND AIR CONDITIONING	165	377	33,193.4	239,369.6
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND SANITATION ACTIVITIES	170	1,023	2,898.7	23,644.9
F	CONSTRUCTION	41	251	619	5,211.5
G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES	449	3,151	3,111.2	21,187.6
H	TRANSPORTATION AND STORAGE	241	1,256	41,143.6	145,759.1
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	97	434	328.6	8,015.4
J	INFORMATION AND COMMUNICATION SERVICES	239	589	2,985.5	7,198.1
K	FINANCIAL AND INSURANCE ACTIVITIES	88	776	454.1	257,750.4
L	REAL ESTATE ACTIVITIES	21	153	62.1	1,966
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES	35	222	432	3,250.3
N	RENTAL, TRAVEL AGENCIES, BUSINESS SUPPORT SERVICES	22	198	111.4	1,707.1
O	PUBLIC ADMINISTRATION AND DEFENSE; COMPULSORY SOCIAL INSURANCE	0	10	0	0
P	EDUCATION	0	15	0	102.6
Q	HEALTH AND SOCIAL WORK	66	405	687.2	10,242.5
R	ARTS, SPORTS, ENTERTAINMENT AND RECREATION ACTIVITIES	11	92	59,3	1,453.1

S	**OTHER SERVICE ACTIVITIES**	7	73	11.8	682.3
	TOTALE	6,956	25,940	473,814.1	1,674,645.2

Table 2: Summary of the identified, implemented interventions and associated final savings, broken down by ATECO code.

	ATECO SECTORS	**REALIZED INTERVENTIONS**	**IDENTIFIED INTERVENTION**	**ANNUAL SAVINSG REALIZED INTERVENTIONS (TOE)**	**ANNUAL SAVINGS IDENTIFIED INTERVENTIONS (TOE)**
A	**AGRICULTURE, FORESTRY AND FISHING**	4	31	432,8	3,284.7
B	**EXTRACTION OF MINERALS FROM QUARRIES AND MINES**	1	12	972.2	526.6
C	**MANUFACTURING ACTIVITIES**	293	3,019	174,579.4	762,294.5
D	**SUPPLY OF ELECTRICITY, GAS, STEAM AND AIR CONDITIONING**	11	56	45.6	13,963.7
E	**WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND SANITATION ACTIVITIES**	36	174	3,394	8,650.7
F	**CONSTRUCTION**	3	25	1,828	547.6
G	**WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES**	11	523	236.5	17,369.7
H	**TRANSPORTATION AND STORAGE**	11	238	4,222.2	15,240.7
I	**ACCOMMODATION AND FOOD SERVICE ACTIVITIES**	6	97	41.4	5,623.9
J	**INFORMATION AND COMMUNICATION SERVICES**	1	68	12.7	10,986.7
K	**FINANCIAL AND INSURANCE ACTIVITIES**	2	61	4.7	913.5
L	**REAL ESTATE ACTIVITIES**	3	25	23.2	1,477.2
M	**PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES**	1	30	5.6	1,735.5
N	**RENTAL, TRAVEL AGENCIES, BUSINESS SUPPORT SERVICES**	0	21	0	582.2
O	**PUBLIC ADMINISTRATION AND DEFENSE; COMPULSORY SOCIAL INSURANCE**	0	0	0	0
P	**EDUCATION**	0	2	0	32.7
Q	**HEALTH AND SOCIAL WORK**	12	128	4,554.7	10,798.5
R	**ARTS, SPORTS, ENTERTAINMENT AND RECREATION ACTIVITIES**	0	20	0	648
S	**OTHER SERVICE ACTIVITIES**	1	17	0	1,244.8
	TOTALE	396	4,547	190,892.1	855,921.3

Table 3: Summary of the identified, implemented interventions and associated primary savings, broken down by ATECO code.

The final energy savings realized through the interventions already put in place is around **474 ktoe/year** and primary energy savings are about **191 ktoe/year**, these latter refers to the saving associated with interventions in the *Cogeneration/Trigeneration* and *Renewable Energy Production* categories, looking at the identified interventions, if implemented, would be associated with final energy savings of about **1.675 Mtoe/year** which when disaggregated shows values of electricity savings corresponding to **23%** of the total while those pertaining to thermal energy, fuel and other savings constitute **13%, 4%** and **60%** respectively, through an intra-sectoral comparison it is clear that this decomposition of savings strictly depends on the processes and specificities characterizing the productive activities and production sites, indeed there are important distances among, but also within, the ATECO sectors, concerning the Areas of Intervention most associated with potential conservation, differences that determine the types of savings that can be concretized, for example, from the data, a higher share of interventions related to *Lighting* (**28%**) and *Air Conditioning* (**13%**) is observed in the Trade sector (G) than for Manufacturing Activities (**18%** and **4%** of total measures, respectively).

The information regarding investments pertaining to EEMs allows us to unearth dissimilarities between sectors regarding the classes of *payback period* (PBP) characterizing the investments themselves, looking at the sector with the largest number of interventions identified, manufacturing, for example, we find a prevalence of investments associated with the third class of PBP , i.e., between 3 and 5 years, which accounts for **24%** of the identified interventions, intra-sector specificities are also noted here, within it (C) for example, code 24 is characterized by a high share of energy savings associated with interventions with a payback time of 1 year or less (**57**% of the total), compared with shares of about **20%** in codes 22 and 23.

The analysis of data relevant to the economic feasibility of interventions also makes it possible to assess the levels of cumulative energy savings associated with the different classes of return on investment, the **12,040** interventions characterized by a payback period of up to three years (**15%** of the total investments) assume particular incidence on the achievable savings, representing **53%** of them, against a total investment of **615** million euros, considering additionally the interventions with a return time of up to 5 years (**6,689**) would reach almost 60% of the total savings against an investment of **1,1 billion** euros (**70%** of the total).

The following table shows the interventions carried out and identified with reference to their respective areas as defined by the ENEA guidelines.

INTERVENTION AREAS	N° REALIZED INTERVENTIONS	%	N° IDENTIFIED INTERVENTIONS	%
AIR CONDITIONING	608	8.3%	2,305	7.6%
ASPIRATION	84	1.1%	454	1.5%
BUILDING ENVELOPE	1,243	16.9%	2,461	8.1%
COGENERATION/TRIGENERATION	201	2.8%	1,087	3.6%
COMPRESSED AIR	747	10.2%	3,413	11.2%
ELECTRIC MOTORS/INVERTERS	195	2.7%	3,460	11.3%
ELECTRICAL INSTALLATIONS	284	3.9%	2,576	8.4%
GENERAL (Monitoring, organization, training, ISO 50001)	1,099	14.9%	4,602	15.1%
INTERVENTIONS ON DISTRIBUTION NETWORKS	106	1.4%	428	1.4%
LIGHTING	1,909	26.0%	6,134	20.1%
OTHER	68	0.9%	374	1.2%
PROCESS COOLING	170	2.3%	447	1.5%
PRODUCTION FROM RENEWABLE SOURCES	15	0.2%	41	0.1%
PRODUCTION LINES	120	1.6%	852	2.8%
REFURBISHMENT	11	0.1%	41	0.1%
THERMAL POWER PLANT/THERMAL RECOVERY	424	5.8%	1.479	4.9%
TRANSPORTATION	68	0.9%	333	1.1%
TOTAL	7,352		30,487	

Table 4: Summary of the identified interventions organized by Intervention Areas.

Source: ENEA

The findings related to the second period of obligation, allow outlining the possible role of the different economic sectors in terms of reducing energy consumption and the resulting environmental impacts, providing information on the path to be followed for their implementation, most of the identified interventions consist of replacements of existing inefficient equipment, for example, measures related to the replacement of lighting systems account for **20.1%** of the total, the audits enable corporate decision-makers to acquire the necessary knowledge for the concretization of such replacements as well as to increase their awareness of the most complex production processes and of the possible implementable interventions, in particular the potential found in the manufacturing sector opens the door for further intra-sectoral analysis and insights, this document will scrutinize in detail the ATECO 22 code, relating to the manufacture of plastic articles, in the light of the weight assumed by this in terms of interventions found and potential energy conservation highlighted by the data received.

Finally in order to have a comparative tool for the understanding of the subsequent results of the analysis regarding the plastics sector, it is relevant to offer a picture of the regional distribution of the audits received for the second period of obligation, the following graph made by ENEA (figure 9) shows a clear concentration in the northern regions of the country, for example, the largest number of audits received came from Lombardy, anyway, this is not surprising when we take into account the spatial distribution of the industries in Italy, lower values are found in the central regions and in addition these decrease approaching the southern part of the peninsula, although there are some relevant exceptions.

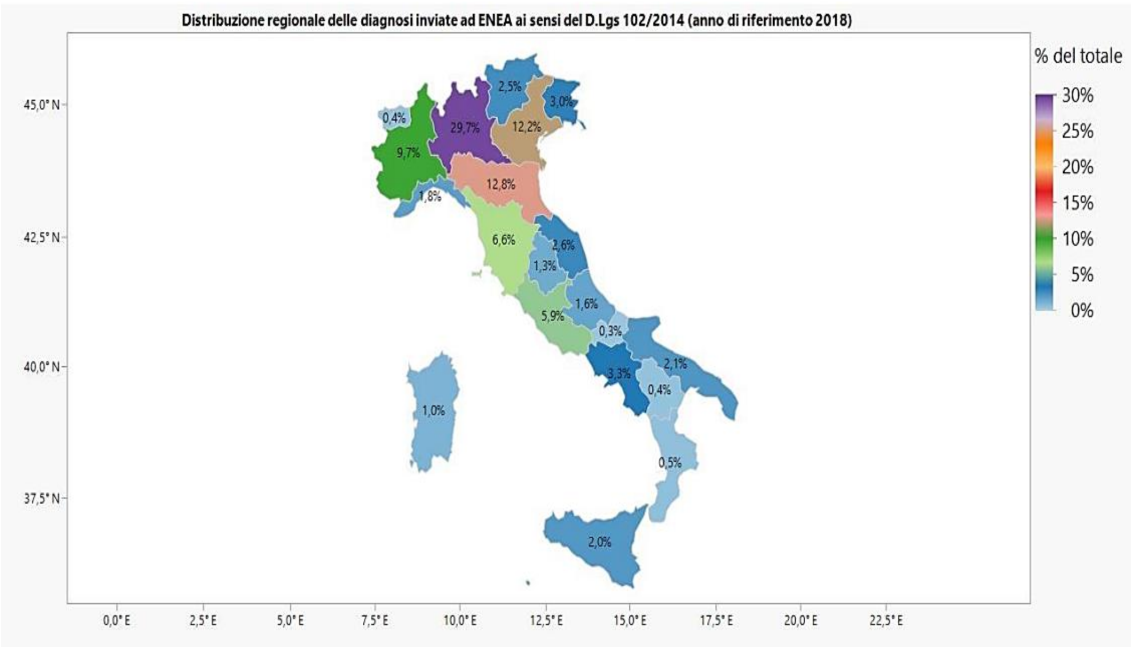

Figure 9: Regional distribution of received energy audit in the second obligation period.

3) Statistical Analysis of Manufactures of Plastic Articles.

3.1) The plastic articles manufacturing sector.

In Italy, the ATECO sector 22.22.00 Manufacture of articles of plastics is divided into four different subcategories:

- *22.21.00 Manufacture of plastic plates, sheets, tubes and profiles;*
- *22.22.00 Manufacture of plastic packaging;*
- *22.23.00 Manufacture of plastic articles for construction purposes;*
- *22.29.09 Manufacture of other articles of plastics nca.*

Following the previous findings regarding the efficiency potential of the Manufacturing sector and more specifically that of the manufacture of plastic articles this study focuses on the ATECO codes 22.21.00, 22.22.00 and 22.29.09, precisely this section analyzes their energy consumption levels, the interventions identified and the savings associated with them in order to provide a general picture of the energy conservation space achievable by the sector, in the next section (Chapter 4) the determinants of these savings will instead be investigated.

The production of plastic products shows itself to be a particularly complex sector also in relation to the large number of polymers that can be processed as raw materials, such as polyvinyl chloride, by means of intricate and consequential processes such substances can generate a varied range of products with very different mechanical and commodity characteristics, molding and extrusion techniques are established as the prevailing or traditional ones but the sector in question shows a continuous evolution towards new processing methods

According to the guidelines defined by ENEA, the sectors of the manufacture of plastic and/or rubber articles are characterized by a well-defined energy scheme, by the latter is *meant the form assumed by the description of the uses of each energy carrier within specific boundaries within the object of the energy diagnosis*, more precisely, for the generality of production activities the company energy structure consists of four levels:

- **Level "A"** (LA) is characterized by the description of the data characterizing the company and its commodity scope and includes the identification of the set of energy carriers supplied externally and not subject to internal transformation within the company itself
- **Level "B"** (LB) is the extreme summary point of the energy structure related to each carrier, so each specific energy carrier is referred to as "Vj" with j varying from 1 to n, where n is the number of energy flows used.
- **Level "C"** (LC) is characterized by the subdivision of each individual vector under consideration into the following macro areas detailed below:

- ❖ *Main Activities: in this description should be included all the activities related to the articulation of production or that characterize the service provided.*
- ❖ *Auxiliary Services:* This macro area is typically including a *compressor room, a thermal power plant, a refrigeration plant, a heat pump plant, a power plant* and *other.*
- ❖ *General Service:* This macro area typically involves *lighting, air conditioning, the offices, CED* and *other*.

- ➢ **Level "D"** (LD) is the part that identifies the structure of the use of each energy carrier within the functional areas, so it actually constitutes the set of areas that allow to characterize the business reality in a detailed and structured way.

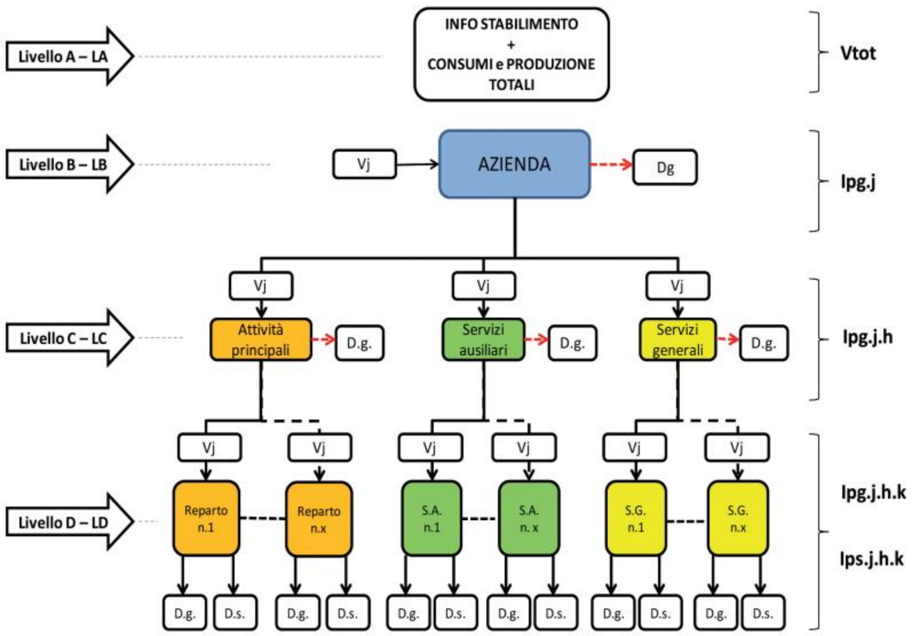

Figure 10 : Composition of the Businesses Energy Scheme.

Clearly, the sectors covered by the study see a similar schematization characterizing General and Auxiliary services while identifying specific Main Activities outlining the different production processes generated by the companies of these sectors, consequently it is also considered necessary to further distinguish between the processing of plastics materials and rubber processing, the following table (5) shows the list of the aforementioned activities by the sector and energetic vector they belong to.

	PLASTIC PROCESSING MAIN ACTIVITIES	RUBBER PROCESSING MAIN ACTIVITIES
Electricity	Blow molding	Cutting/Assembly
	Blown film extrusion	Calendering
	Coumpunding	Compression molding
	Compression molding	Cryogenic pre-curing processes
	Cast film extrusion	Drawing/Extrusion
	Extrusion blow molding	Die cutting
	Profile extrusion	Fabric rubberizing/reinforcement
	Pipe extrusion	Injection molding
	Rotational molding	Mixing
	Thermoforming	Post vulcanization
	Packaging	Post process processing
	Other (to be specified)	Vulcanization by methods other than molding
Natural gas	Other (to be specified)	Vulcanization by molding
	Other (to be specified)	Vulcanization by methods other than molding
Fuel	Other (to be specified)	Other (to be specified)

Table 5: Summary of Main activities organized by sector and energy vectors.

The analysis conducted by ENEA in collaboration with Federazione Gomma Plastica[12] has also allowed the identification of the most relevant and used processes of plastic transformation which consist of the following:

-Extrusion Of Granulates: it consists in bringing the material to a viscous fluid state so that it can be pushed continuously through an opening having a given shape, furthermore the main function of the extruder is to create a pressure on the material which must be pushed through the extrusion head in the molten state.

- Film blow Extrusion: is characterized by the presence of an annular extrusion head with a vertical axis, the melt is pushed out of the die and stretched upward by means of a calender located high above the bubble and at same time air is blown into the bubble, which has the dual function of cooling the polymer and determining the useful width of the film and the stretching ratio.

-Cast Film Extrusion: similar to that of a sheet, the difference being that the product thickness is very small, Cooling is achieved by passing the molten film fresh from the die over water-cooled rolls (chill rolls) that cause it to freeze rapidly, multilayer films can also be obtained through the use of multiple extruders

[12] Plastic Rubber Federation, formed in 2005 by Assogomma and Unionplast, is now one of the most important sector federations of Confindustria

that converge the streams on a single head. Cast films are of high quality, both as optical (appearance, gloss, transparency) and dimensional characteristics.

- Injection Molding: with this technique, perfectly finished plastic parts can be produced; the plastic material is homogeneously melted by an extruder and rapidly injected into a mold, keeping it under pressure during the compacting phase so that shrinkage and deformation due to material cooling are minimized.

- Stretch-blow: mostly are containers the final goods produced with this technique, the process involves extruding a tube vertically, then introducing it into an open mold allowing a few inches to come out, the mold closes, the bottom and upper neck weld due to the high temperature of the material, and inside the cavity (in the tube) pressurized air is fed in causing the material to adhere to the walls of the mold, which cools it down giving it the necessary shape.

- Thermoforming: With this process, molded parts can be obtained from a semi-finished product on a reel or in sheets or plates, with reduced equipment costs, it lends itself both to high-speed production of disposable items as well as for large elements of household appliances, textiles, and many other items used in packaging, moreover, in some cases the thermoforming machine is combined with a sheet extrusion plant, which thus saves much of the heat required to bring that sheet from room temperature to thermoforming temperature.

With regard to the transformation of materials into rubber instead, the following processes are highlighted in relation to their relevance:

- **Mixing**: this technique has the purpose of making the elastomer soft and plastic, lowering its molecular weight, so that it is easier to incorporate the additives and fillers, in the mixing stage, which takes place inside a closed mixer called BANBURY, the polymers are added with mineral oils, carbon black, mineral fillers and with various chemicals such as vulcanizers, stabilizers, rheological additives, additives that increase resistance to oxidizing agents, resistance to ultraviolet, etc.
- **Injection molding:** is an industrial manufacturing process in which a rubbery material is melted (plasticized) and injected at high pressure inside a closed mold, which is opened after the part solidifies.
- **Calendering:** makes it possible to produce sheets of rubber material or profiles, processing is carried out in machines (calenders) consisting of rollers with parallel axes, having adjustable spacing, and rotating at low speed, the uncured rubber compound in its pasty state is passed between pairs of rollers to obtain sheets or plates of the desired thickness.
- **Drawing**: is a forming process that induces a change in the shape of the raw starting material through plastic deformation due to the action of forces impressed by equipment and dies.
- **Post-curing**: this is generally carried out in an oven and is the post-molding heat treatment to which the gaskets are subjected in order to remove residual stresses, complete any vulcanization, achieve the required final dimensions, and improve the characteristics of the rubber.

The sector also shows itself to be remarkably dynamic with regard to sustainable trajectories, *La Federazione Gomma Plastica* declares itself to be active in the fostering of new processes and methodologies of plastic and rubber material processing based on the principle of circularity and eco-design, this ecological transition is sought through the use of materials with lower environmental impact, for example we observe an increasing use of rubber materials of natural origin and annealed plastics, a transition chased also through the production processes themselves, in the rubber sector, in fact, there are conventional material recovery mechanisms (regeneration and devulcanization of waste materials with consequent reuse of the powder in rubber articles and/or in other uses) as well as new recycling opportunities given by pyrolysis, as far as plastics processing is concerned, on the other hand, it is particularly important to highlight Italy's performance as one of the most virtuous countries in Europe in terms of the share of plastic waste transformed into secondary raw materials, which is becoming increasingly significant.

Turning our gaze on the economic magnitude of this industrial branch, In Italy in 2019 the plastic and rubber processing sectors involved almost **10.000** enterprises with more than **175.000** employees, the companies involved show increasing level of profitability whit an dependence on import higher than their contribution on exports, the sector also shows a clear concentration of production activities in the northern regions of the peninsula accounting for more than half of the total, anyway the cited stylized facts of the sectors involved refers to a period antecedent to the economic contractions caused by the Covid-19 pandemic which, taken together with the current energy crisis hampering productions, make the future of the sector uncertain, also due to the possible future progression of taxation on plastics (currently applied only to single-use products), other relevant economic indicators related to the sector are shown in Table 6.

INDICATORS	***2018***	***2019***
NUMBER OF ENTERPRISES	9,730	9,655
NUMBER OF EMPLOYEES	178,558	179,989
ADDED VALUE (% of total manufacturing)	30.6	31.1
NUMBER OF NEW ENTERPRISES	319	332
ENERGY INTENSITY RELATIVE TO VALUE ADDED	2.81	3.82
GROSS PROFITABILITY (%)	38.4	39.2
EXPORTS (% of turnover)	34.2	34.2
INTENSITY OF IMPORT (Imports of goods and services / intermediate consumption) (%)	39.0	37.8
INVESTMENT IN ENVIRONMENTAL PROTECTION (% of gross fixed capital formation)	1.1	0.7

Table 6: Main indicators of the ATECO sector Manufacturing of plastic materials.

Source: Istat.

3.2) Energy Audits of the plastic articles manufacturing sector.

The Audit received by ENEA for the three ATECO codes object of the study are **684** delivered by more than **600** companies, through a combined analysis of the data resulting from the audits and those available thanks to the database AIDA (Computerized analysis of Italian companies) it is possible to evaluate the incidence of plastic factories subject to mandatory energy Audit within the Italian production landscape, in particular, the information pertaining the productivity are available for about **400** of the companies subject to the obligation, the latter employ **35,527** individuals for an average *revenue per employee* that reaches **370.664 €** while total sales exceed **11 Million**, the sector also shows a turnover rate of invested capital equal to **1.14** interpretable as an efficient ability of the companies involved to achieve high levels of revenue by rationally employing the available resources, such information pertaining to the productivity and composition of the companies considered provide additional value to the analysis itself confirming the need for a thorough investigation of a productive branch so relevant both in the national economic context and in the achievement of national energy efficiency goals.

INDICATOR	
NUMBER OF EMPLOYEES	35,527
AVERAGE REVENUE PER CAPITA	370,664.06 €
TURNOVER RATE OF INVESTED CAPITAL	1.14
TOTAL SALES REVENUE	11,840,233.14 €
AVERAGE DEBT RATIO	5.18

Table 7: Summary of productivity indicators in the ATECO 22 sector.

Source: AIDA

3.2.2) Analysis of energy consumption.

The data concerning the energy carriers consumed by companies in the sector subject to audit obligation showed a primary energy consumption exceeding **1 Mtoe (1,007,917**) while the final energy consumption is around **752,065 toe**, this distinction is necessary because the interventions considered refer to different energy conversion processes. interventions associated with production from renewable sources and trigeneration and cogeneration plants allow self-production of flows at the same time as a reduction in consumption caused by the greater efficiency of the supply itself, for these purposes in this section and in the subsequent ones the consumption and savings electricity associated with these areas will be considered separately, anyway independently from the consumption flows considered, final or primary, electric carriers constitute the majority of the energy uses of the production activities, symptom of an increasing electrification of the entire production system, the thermal consumption on the other hand is around **88,531** tons of oil equivalent while that related to gas is **235,517 toe.**

CONSUMPTIONS	**Levels found expressed in toe**
PRIMARY CONSUMPTION	1007,916.57
FINAL CONSUMPTION	752,064.8
GAS	235,517.16
THERMAL	288,530.97

Table 8: Summary of the composition of energy consumption carriers.

The territorial distribution of energy consumption levels reflects the current Italian production context characterized by the concentration of production activities in the northern part of the Peninsula, in particular, Figures 11 and 12 illustrate the regional distribution of the most relevant percentage consumption, i.e., primary and final consumption, in both scenarios high levels of use are highlighted in the regions of *Lombardy*, *Piedmont*, *Emilia Romagna* and *Veneto*, although the region of *Campania* with regard to primary consumption and *Basilicata* with regard to final consumption demonstrate higher than average values for the southern territories of the Nation (average values of **29,911** and **19,017 toe**), representing an exception, however, it is necessary to point out that this breakdown was made in the absence of data from the Calabria and Val d'Aosta regions for which there are no audit received.

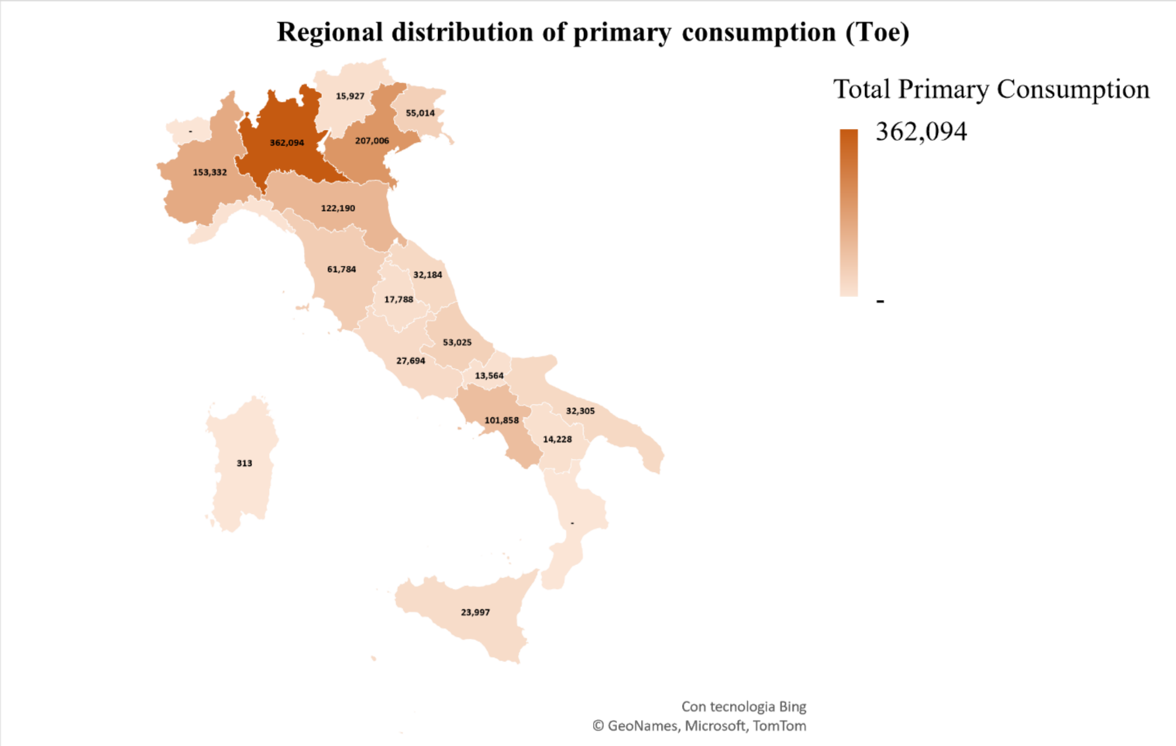

Figure 11: Regional distribution of primary energy consumption.

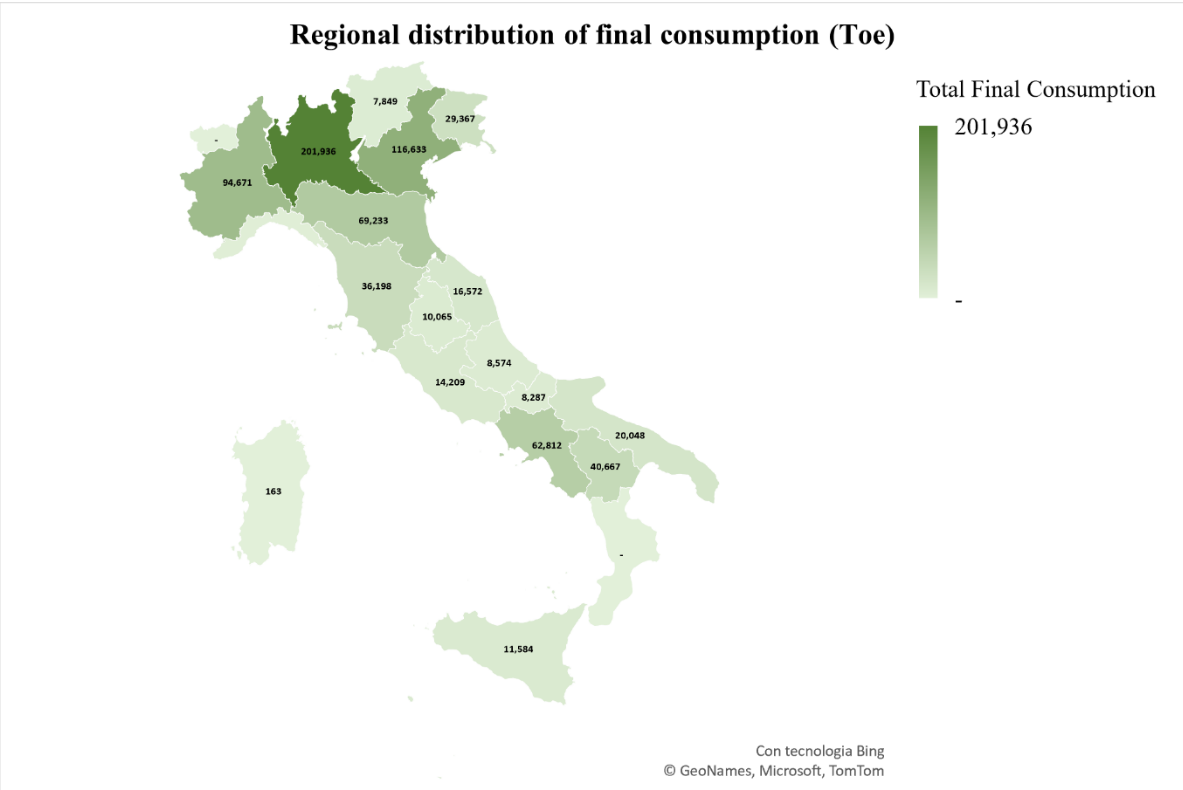

Figure 12: Regional distribution of final energy consumption.

3.3) Analysis of Identified Interventions and Potential Energy Savings.

The interventions identified from the audits received by ENEA in 2019 are in total **2,608** of which:

- **650** are related to sector 22.21.00 *Manufacture of plastic plates, sheets, tubes and profiles*
- **932** are the measures associated with ATECO code 22.22*.00 Manufacture of plastic packaging;*
- **1,025** those associated with sector 22.29.09 *Manufacture of articles of plastics nca.*

The sector considered are the equivalent of NACE C22.1.1, C22.2.2 and C22.2.9.

With regard to the sample analyzed is formed of a predominance of energy-intensive small and medium-sized enterprises of which a good portion identify as multi-site, moreover it is, for the purposes of the analysis, of paramount importance to remark the extreme heterogeneity of the audits presented reflected in the information and economic analysis contained, the starting database therefore showed the urgent need to validate and clean the data, the subsequent information must therefore be understood taking into account the fact that they mirror the quality of the audits received.

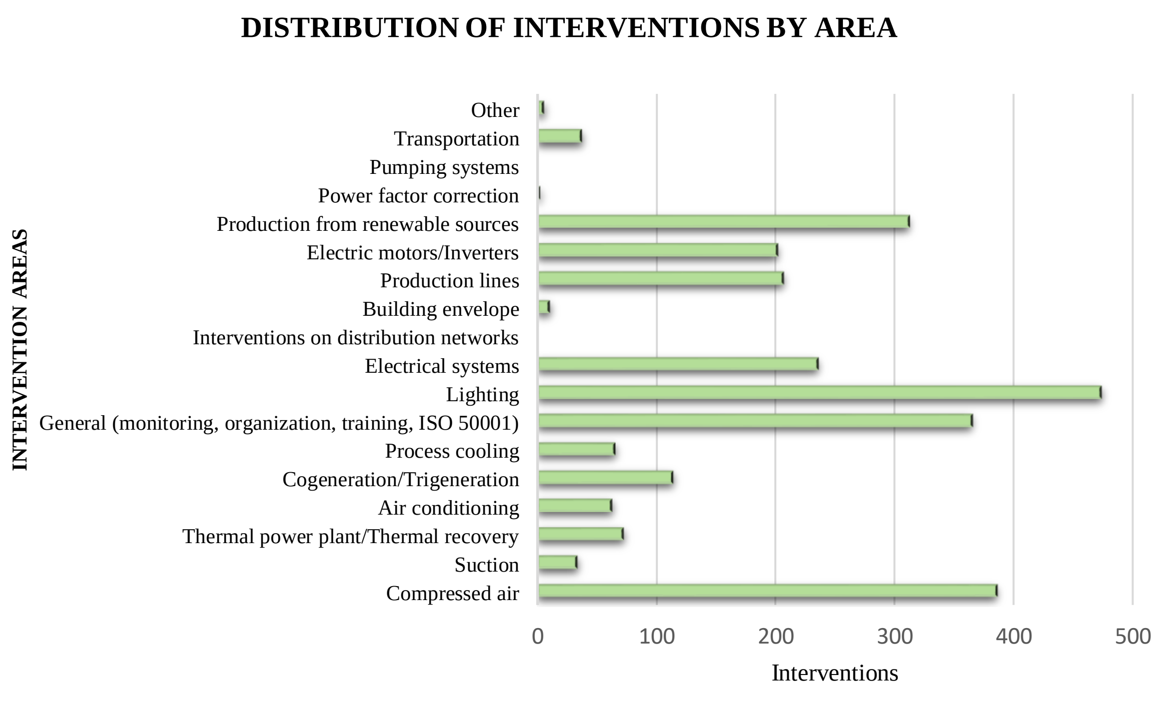

Figure 13: breakdown of interventions for the ATECO sector 22 on the basis of the AREA to which they belong.

In the subsequent table (table 9) are shown the breakdown of the EEM according to their Areas as classified by ENEA, expressed both in absolute and percentages values, are also shown the related potential energy savings, expressed in tons of oil equivalent, achievable through their implementation, in addition, two of the areas of interventions (Production from Renewable Sources and Cogeneration/Trigeneration) are reported separately in the light of the fact that this two include activities of auto-production of energy as a consequence the energy vector considered refers to primary energy consumption.

INTERVENTION AREAS	N° INTERVENTIONS	% INTERVENTIONS	SAVINGS (Toe) (FINAL ELECTRIC CONSUMPTION)
AIR CONDITIONING	63.0	2.41	886.47
BUILDING ENVELOPE	11	0.42	67.37
COMPRESSED AIR	386.0	14.81	2,065.011
ELECTRIC MOTORS/INVERTERS	202.0	7.75	1,255.47
ELECTRICAL SYSTEMS	236.0	9.05	2,618.22
GENERAL (Monitoring, organization, training, iso 50001)	365	14.00	2,648.64
INTERVENTIONS ON DISTRIBUTION NETWORKS	0	0	0
LIGHTING	474.0	18.18	3,129.31
POWER FACTOR CORRECTION	3	0.12	0
PROCESS COOLING	66.0	2.53	1,367.01
PRODUCTION LINES	207	7.94	3,158.855
PUMPING SYSTEMS	0	0	0
SUCTION	34.0	1.30	59.71
THERMAL POWER PLANT/THERMAL RECOVERY	73.0	2.80	3,260.29
TRANSPORTATION	38	1.46	162.23
OTHER	6	0.23	117.47

INTERVENTION AREAS	N° INTERVENTIONS	% INTERVENTIONS	SAVINGS (Toe) (Primary Electric Consumption)
PRODUCTION FROM RENEWABLE SOURCES	312	11.97	19,694.73
COGENERATION/TRIGENERATION	114	4.37	87,456.53

Table 9: Summary of identified interventions and related energy savings organized by their belonging area .

The reported values show the high numerosity of interventions concerning the lighting system constituting **18%** of the total, followed by interventions in the *General area* (**14%** of the total) and those concerning *Compressed Air* (**14.8%** of the total), slightly less numerous are instead the EEMs associated with *Production Lines* (**7.94%**) signaling the existence of the possibility for companies to review central production processes in order to increase their efficiency in the use of resources including energy vectors, the terminology of the above area should not mislead readers as these measures do not necessarily concern extensive operations, for example energy conservations in this area can be realized through the replacement of a used engine with another one with high energy efficiency, *Production from Renewable sources*, on the other hand, sees **312** interventions (**12%** of the total), many are the production sites that can introduce, in particular, photovoltaic panels designed to increase the company's independence from the purchase of energy flows, on the other hand, there are no interventions related to *Pumping Systems* and *Interventions on Distribution* lines all way the characteristics of many efficiency measures make them adaptable to different Areas, for example, the thermal recoveries that can be implemented through an improvement of equipment at *Compressed Air* would make such a modification suitable to be associated with the latter Area as well as with the Area related to Thermal Recoveries, which implies that the absence of such interventions does not necessarily lead to the conclusion that there are no identified interventions capable of affecting the aforementioned Areas.

INTERVENTION AREA	INVESTMENT €	SAVINGS(Toe) (FINAL ELECTRIC CONSUMPTION)	SAVINGS %	AVERAGE COST EFFECTIVENESS[13]
AIR CONDITIONING	3,451,800.40	886.47	0.69	5,998.50
BUILDING ENVELOPE	454,021.00	67.37	0.05	15,904.09
COMPRESSED AIR	5,204,331.71	2,065.01	1.61	3,441.10
ELECTRIC MOTORS/INVERTERS	7,271,315.00	1,255.47	0.98	4,880.08
ELECTRICAL SYSTEMS	13,979,374.70	2,618.22	2.05	7,162.38
GENERAL (Monitoring, organization, training, iso 50001)	5,531,932.00	2,648.64	2.07	2,947.77
INTERVENTIONS ON DISTRIBUTION NETWORKS	0	0	0	-
LIGHTING	13,252,232.86	3,129.31	2.45	6,223.35
POWER FACTOR CORRECTION	12,578.80	0	-	-
PROCESS COOLING	6,728,270.00	1,367.01	1.07	8,470.02
PRODUCTION LINES	32,757,091.21	3,158.85	2.47	12,131.67
PUMPING SYSTEMS	0	0	-	-
SUCTION	354,121.50	59.71	0.05	5,771.49
THERMAL POWER PLANT/THERMAL RECOVERY	6,140,802.00	3,260.29	2.55	5,259.27
TRANSPORTATION	1,059,540.00	162.23	0.13	15,128.68
OTHER	360,976.00	117.47	0.092	7,203.99
INTERVENTION AREAS	**INVESTMENT €**	**SAVINGS(Toe)** (Primary Electric Consumption)	**SAVINGS %**	**AVERAGE COST-EFFECTIVENESS**
PRODUCTION FROM RENEWABLE SOURCES	95,948,847	19,694.73	15.39	5,317.92
COGENERATION/TRIGENERATION	131,061,163	87,456.53	68.35	5,741.54

Table 10: Summary of investments and energy savings relative to the different Areas of interventions.

With regard to achievable savings, we observe from the data how the replacement of *lighting* equipment with neon and LED equipment, characterized by greater energy efficiency, is a widely identifiable and

[13] Cost effectiveness, defined as final or primary energy investment/savings

feasible intervention that would lead to the conservation of **3,129** toe, all the same, although this analysis recognizes its merits, it is necessary to emphasize how an emphasis of excessive magnitude placed on such interventions would prevent the delineation of more efficient technological trajectories pertaining to production processes, emphasis already supported by relatively low costs.

To the extent to which the concept of innovation expands to the introduction of new organizational forms[1] the *General area* is functional to provide for greater cognisance of the current and possible management of energy flows, by expanding the knowledge base the search for new rationalization mechanisms is invigorated, the **365** identified interventions pertinent to the introduction of organizational mechanism, control of energy flows, implementing ISO 50001 certification (General area) would allow to reduce consumption by **2,648 toe**, confirming the existence of a wide room for improvement achievable through more organized and careful management of energy carriers by staff.

The greatest source of savings is identified instead in the area pertaining to the installations *of Cogenerators* and *Trigenerators*, such installations have become in recent years the subject of in-depth study of European Union institutional bodies in relation to the search for new avenues for energy efficiency in buildings and in the industrial sphere, as they allow a combined and simultaneous production of electrical and thermal energy generating the rise of plant efficiency and the optimization of energy self-production, for these reasons this type of intervention is characterized by its criticality, wide scope, long lifespan and high payback time, consequently, such measures may face particular resistance to adoption, particularly exacerbated by current economic conditions and the high energy costs, however, the concretization of the above measures would lead to a reduction in consumption of **87,456** tons of oil equivalent equal to about **70%** of the total savings, against an equally important investment of **131,061,163**€ , similarly *Productions from Renewable meet* high levels of initial expenditure equivalent to **95,948,847 €** and longer payback times, accordingly the associated energy savings reach almost **20,000 toe** (**15.6%** of total savings) the latter measures offer essential benefits, not only from the point of view of reduced consumption, relative costs and productivity improvements, but also in terms of competitiveness and ability to meet companies' social and environmental commitments.

The expenditure incurred initially by companies is found to be one of the main obstacles to the implementation of the measures so it is relevant to analyze the relationship of the latter variable with the associated savings materializable, the two variables show a semi-parallel path characterized by a Pearson's linear correlation coefficient of **0.8**, the observations obtained from the audits also show, a concentration for low levels of investment and savings with an almost constant trend, overall the companies subject to energy audits against an investment of **323,568** euros, would be able to save energy flows equivalent to **126,151 toe**.

Through a decomposition of the primary achievable savings, as highlighted in Figure 14 , it can be seen that electricity flows not only encompass most of the consumption in the three ATECO sectors considered, but also outline their most significant savings potential; in fact, the totality of energy savings is given by the sum of electrical savings, which exceed half of the total (**64 percent**), followed by *thermal savings*, *fuel-related savings*, and *other savings* whose relative weight is **12%**, **0%,** and **24%** respectively, considering alternately the *final potential savings*, the weight assumed by the respective energy carriers does not changes, we thus find **17%** associated with other savings, **15%** to the thermal conservation and the **68%** to the electrical.

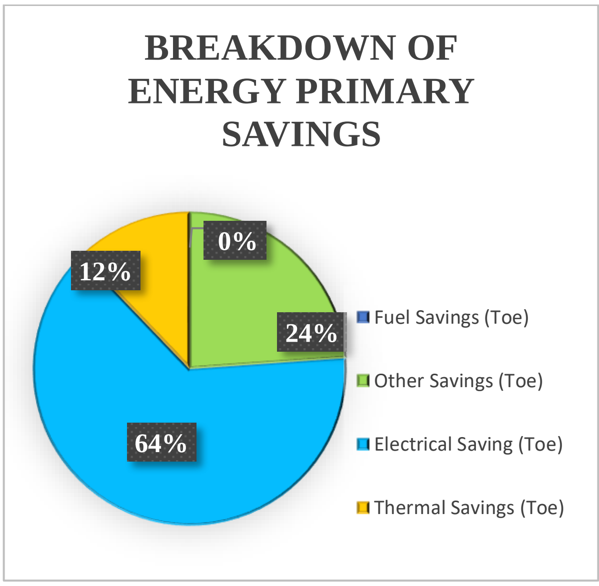

Figure 14: Breakdown of energy achievable savings from Production from Renewables and Cogeneration/Trigeneration Area.

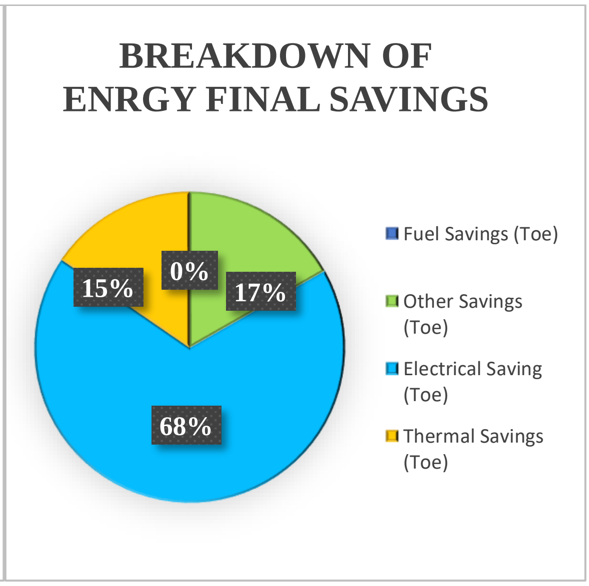

Figure 15: Breakdown of energy achievable savings from all the other intervention areas.

The values of the average cost-effectiveness ratio for each area of intervention mirror the specificities of the interventions themselves and the economic criticalities they represent; the Areas related to *Transportation*, *Electrical Systems* and *Production Lines* find the highest levels, flagging an excellent opportunity for energy consumption enhancement for the companies involved, we also find elevated amounts pertaining *Production from Renewables* sources signaling the weight assumed by their costs in relation to achievable savings as well as the potential of such measures concealed behind forms of energy self-production, whereas the lowest value is to be found in the *General Area*, anyway, it is imperative to emphasize how the latter outcome may derive from the actual complexity of evaluating the returns associated with such interventions, the graph 18 shows a comparison of the abovementioned levels for some of the areas considered of particular interest to businesses.

The following tables show, respectively, the levels of investment and average cost effectiveness referred to the Areas of intervention Production from Renewable Sources and Cogeneration/Trigeneration (Table 11) and all other Areas (Table 12) this distinction is deemed necessary because the magnitude of interventions typifying the former involve economic characteristics that are not comparable with those of interventions referred to other areas.

INTERVENTION AREA	INVESTMENT €	AVERAGE COST EFFECTIVENESS €
COGENERATION/TRIGENERATION	131,061,163	5,741.54
PRODUCTION FROM RENEWABLE SOURCES	95,948,847	5,317.92

Table 11: Summary of investments and cost-effectiveness relative to Cogeneration/Trigeneration and Production from Renewable Sources.

INTERVENTION AREA	INVESTMENT €	AVERAGE COST EFFECTIVENESS €
AIR CONDITIONING	3,451,800.40	5,998.50
BUILDING ENVELOPE	454,021.00	15,904.09
THERMAL POWER PLANT/THERMAL RECOVERY	6,140,802.00	5,259.26
COMPRESSED AIR	5,204,331.71	3,441.09
ELECTRIC MOTORS/INVERTERS	7,271,315.00	4,880.08
ELECTRICAL SYSTEMS	13,979,374.70	7,162.38
GENERAL (Monitoring, organization, training, ISO 50001)	5,531,932.00	2,947.77
INTERVENTIONS ON DISTRIBUTION NETWORKS	0	-
LIGHTING	13,252,232.86	6,223.35
PROCESS COOLING	6,728,270.00	8,470.02
PRODUCTION LINES	32,757,091.21	12,131.67
PUMPING SYSTEMS	0	-
REFURBISHMENT	12,578.80	-
SUCTION	354,121.50	5,771.49
TRANSPORTATION	1,059,540.00	15,128.68
OTHER	360,976.00	7,203.99

Table 12: Summary of investments and cost-effectiveness relative to all Intervention Areas excluding Cogeneration/Trigeneration and Production from Renewable Sources.

Figure 16 shows us a comparison of the levels of cost effectiveness and average investment among some of the areas whose interventions are particularly relevant to the day-to-day activities of businesses, it is highlighted in detail that electrical installations are associated with especially high level of investment compared to the respective cost-effectiveness levels.

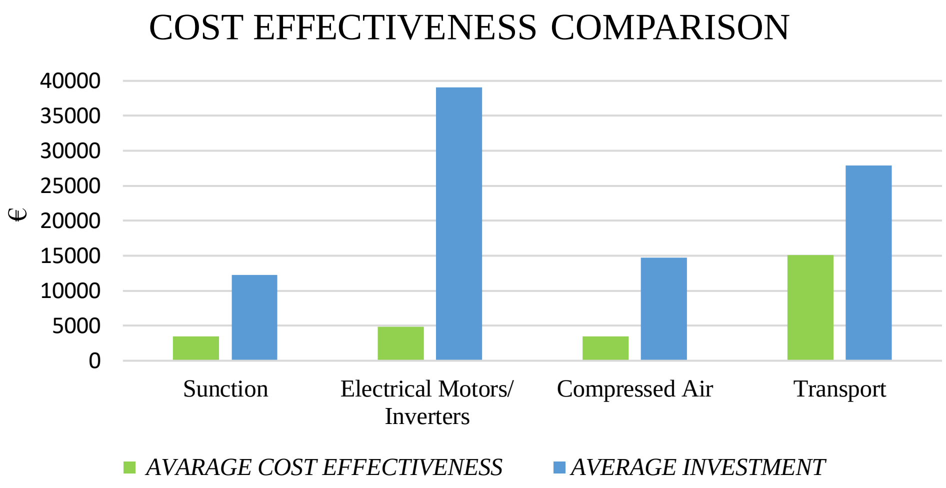

Figure 16: Comparison of investment levels and cost-effectiveness with reference to selected areas of interventions.

Finally given the relevance of this economic indicator to business decisions related to the adoption of efficiency measures (Chapter 1.2) the values of cost-effectiveness levels, associated with potential investments, can be organized by different classes as shown in the figure 17, in this way is possible to observe how the majority of interventions are associated with levels of such indicator around 5,001 and 15,000 euros, signaling positive economic performance for many of the interventions considered in such comparison have been excluded those areas which financial features of investment are not comparable with these displayed in terms of magnitude.

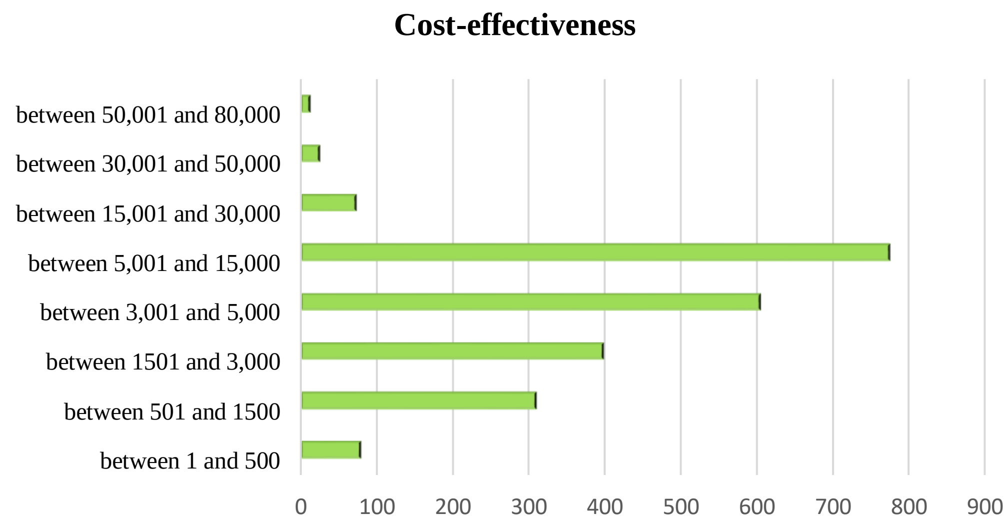

Figure 17: Cost-effectiveness levels of investment referring to all the Areas excluding Production from Renewables and Cogeneration/Trigeneration.

Within the analysis dealing with the relationship between the costs and benefits of energy efficiency measures, for the purpose of stressing the potential of the latter, it is pointed out in the graph 17 how in contemplating the totality of interventions the levels assumed by the cost effectiveness are clustered on intermediate ranges of values (*between 3,001 and 5,000 and between 5,001 and 15,000*), it is also considered necessary to emphasize how such picture is deprived of extremely high values is coupled with EEMs of large magnitude whose investment and savings criticalities (*Cogeneration/Trigeneration, Production from Renewable Sources*).

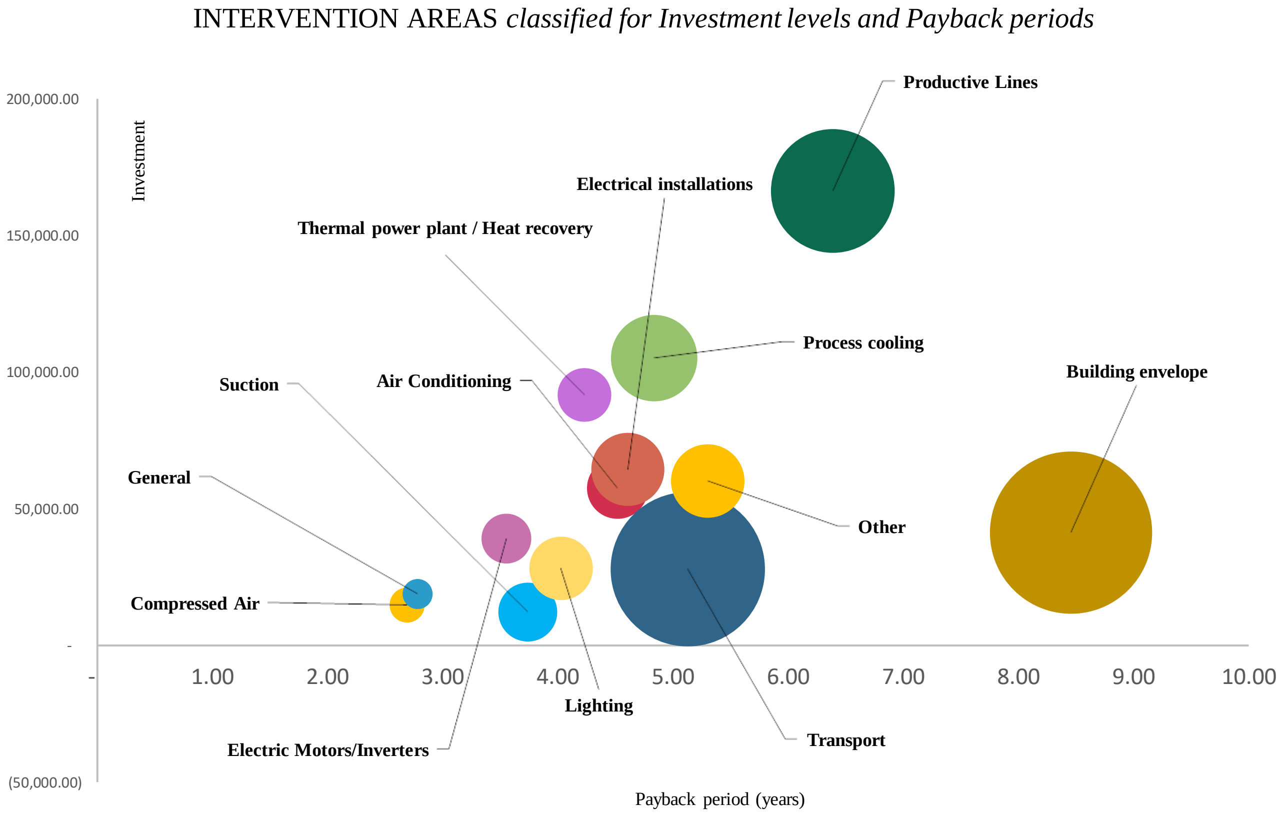

Figure 18: Bubble chart of intervention areas in relation to their investment levels and payback periods.

Turning our gaze on the relationship between energy savings and the payback period of the investments necessary for their concretization, we reiterate the previous reasoning concerning the weight assumed on the total savings by *Cogeneration/Trigeneration* measures and those related to self-production of energy through *Renewable Sources*, which prompted us to exclude them from Graph 18 and 19, through the latter we can observe a clear concentration of the achievable savings pertaining to investments characterized by medium-long Payback Period (up to 5 years) which may constitute a potential constraint for the propensity to adopt the efficiency measure and for the realization of the savings themselves (Chapter 1.2), at the same time about **12%** of the potential conservation can be achieved through less risky investment options from the point of view of business decision makers and thus characterized by shorter payback periods (up to 3 years).

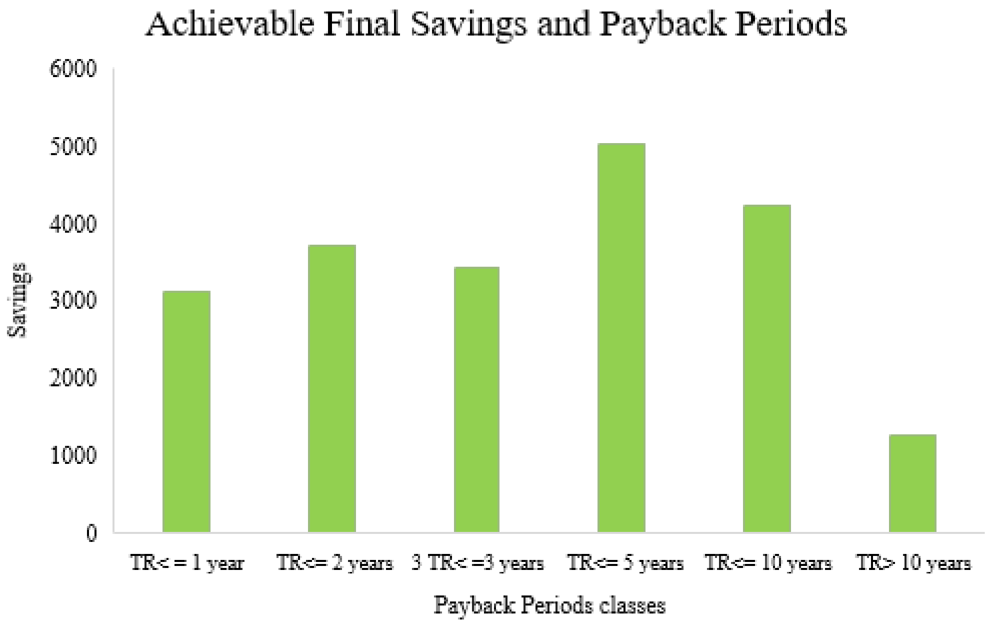

Figure 19 : Achievable Savings organized for the Payback Periods of the related Investments (Production from Renewables and Cogeneration Trigeneration values are excluded).

Looking at the regional distribution of the identified EEMs, as a function of the numerosity of companies in the sector in question situated in the most industrialized regions of the Peninsula, i.e. those located in Northern Italy, the analysis shows a clear concentration in *Lombardy, Piedmont* and *Veneto* of the measures, a symptom also of the commitment made by the regional governments themselves in fostering measures aimed at stimulating the ecological and energy transition and the ensuing reduction of environmental impacts, no intervention and therefore savings are found instead for the regions of Calabria and Val D'Aosta from which no energy audits were received.

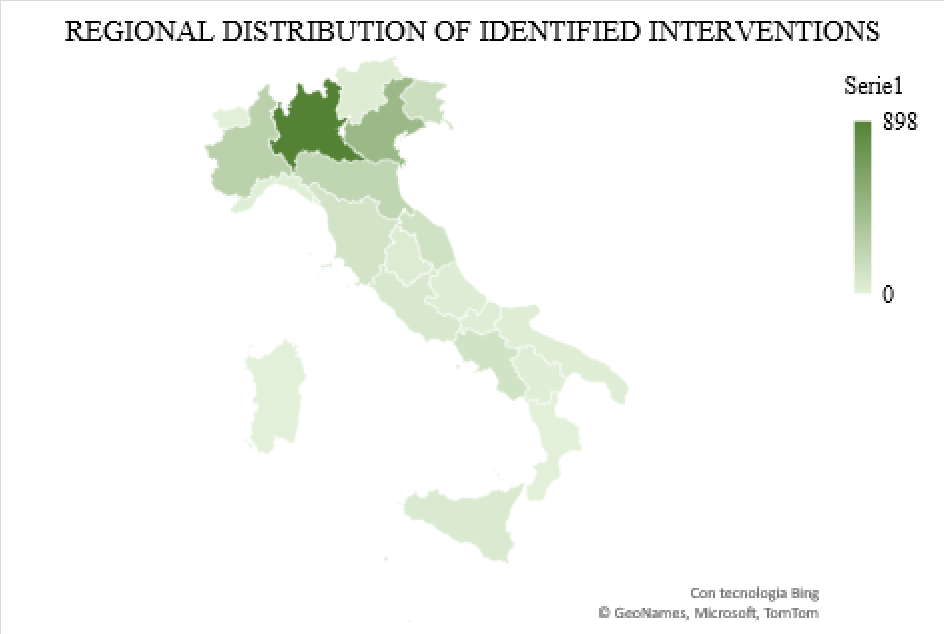

Figure 20: Regional distribution of the identified intervention for the ATECO Sectors 22.21,22.22 and 22.29.

REGION	INTERVENTIONS N°	INVESTMENT €
ABRUZZO	29	6,902,850.00
BASILICATA	17	595,566.00
CALABRIA	0	-
CAMPANIA	110	-
EMILIA ROMAGNA	217	24,239,733.44
FRIULI VENEZIA GIULIA	151	-
LAZIO	62	7,599,805.00
LIGURIA	18	1,472,177.00
LOMBARDY	898	83,987,579.19
MARCHE	114	15,777,453.21
MOLISE	23	-
PIEDMONT	253	40,073,565.27
PUGLIA	25	11,348,250.00
SARDINIA	1	17,250.00
SICILY	51	10,297,741.43
TUSCANY	102	8,048,102.03
TRENTINO ALTO ADIGE	34	1,704,490.00
UMBRIA	39	4,811,378.80
VAL D'AOSTA	0	-
VENETO	452	62,793,437.86

Table 13: Regional distribution of the identified intervention and the investments levels.

The table 13 display the numerosity of energy measure and the relative investment levels which provide an immediate picture of the regional differences, in the table 14 instead are reported the regional distribution of the energy savings realizable by the sector under investigation, please note that those referring to Production from Renewables and Cogeneration/Trigeneration areas of interventions are reported in a separate column.

REGION	**INTERVENTIONS N°**	**SAVINGS** From intervention related to all the Areas excluding Production from Renewables and Cogeneration/Trigeneration **(Toe)**	**SAVINGS** From intervention related to Production from Renewables and Cogeneration/Trigeneration **(Toe)**
ABRUZZO	29	315	271
BASILICATA	17	123	35
CALABRIA	0	-	-
CAMPANIA	110	869	5,779
EMILIA ROMAGNA	217	1,040	1,397
FRIULI VENEZIA GIULIA	151	318	7,849
LAZIO	62	875	1,674
LIGURIA	18	129	71
LOMBARDY	898	4,597	16,434
MARCHE	114	805	2,610
MOLISE	23	135	27
PIEDMONT	253	1,485	15,741
PUGLIA	25	242	3,822
SARDINIA	1	-	-
SICILY	51	251	4,156
TUSCANY	102	579	414
TRENTINO ALTO ADIGE	34	216	84
UMBRIA	39	60	-
VAL D'AOSTA	0	-	-
VENETO	452	1,225	10,552

Table 14: Regional distribution of the achievable energy savings.

3.4) Intra-sectoral Comparison of Identified Interventions and Potential Savings.

In this section are reported the outcomes of the analysis carried out separately for the three sectors under examination, in particular a semi-parallel trend can be seen for the subcategories inherent to the production of plastic articles which exhibit similar values for the variables considered, noticeable differences concern the energy flows consumed, in particular for the sector 22.22.00 are recorded the largest levels pertaining both consumption and the investments to be enacted (**127,225,736.51** €), the following table shows in detail the number of audits received and the respective levels of Investment and Achievable Savings.

	22.21.00	**22.22.00**	**22.29.09**
IDENTIFIED INTERVENTIONS	650	932	1.025
INVESTMENT	88,382,132.2	127,225,736.51 €	108,130,028.24 €
SAVINGS (TOE) Production from Renewables-Cogeneration/Trigeneration	33,653.9	35,912.0	35,861.5
SAVINGS (TOE) All the areas excluding Production from Renewables- Cogeneration/Trigeneration	11,423.2	9,509.16	15,677.56
Average Cost-effectiveness Production from Renewables-Cogeneration/Trigeneration	3,676.1	6,054.5	6,448.6
Average Cost-effectiveness of all the other Areas	6,803.69	7,599.27	7,978.393
PRIMARY ENERGY CONSUMPTION	283,396.18	633,495.35	384,019.83
FINAL ENERGY CONSUMPTION	172,638.17	370,228.76	209,197.86

Table 15: Comparison of Interventions, Investment levels, Energy Consumption and Savings for the three ATECO sectors.

➢ SECTOR 22.21.00

INTERVENTIONS AREA	INTERVENTIONS %	INVESTMENT €	SAVINGS (Toe)	AVERAGE COST-EFFECTIVENESS	SAVINGS %
AIR CONDITIONING	3.49	1,141,677.00	382.13	8,712.18	6.56
BUILDING ENVELOPE	0.18	150,000.00	26.49	5,662.94	0.45
THERMAL POWER PLANT/THERMAL RECOVERY	4.78	2,695,495.00	1,419.90	2,944.87	24.38
COMPRESSED AIR	15.99	747,337.00	389.78	2,665.61	6.99
ELECTRIC MOTORS/INVERTERS	12.87	3,885,609.00	608.04	4,910.42	10.44
ELECTRICAL SISTEMS	11.40	4,147,698.75	752.63	7,099.59	12.92
GENERAL (Monitoring, organization, training, ISO 50001)	15.26	914,910.00	678.72	2,448.26	11.65
INTERVENTIONS ON DISTRIBUTION NETWORKS	0.0	-	-	-	0.00
LIGHTING	20.40	3,227,708.31	569.54	7,475.11	20.40
PROCESS COOLING	3.13	1,890,600.00	370.64	8,326.16	6.36
PRODUCTION LINES	7.90	8,693,341.00	474.85	10,205.72	8.15
PUMPING SYSTEMS	0.0	-	-	-	0.00
REFURBISHMENT	0.0	-	-	-	0.00
SUCTION	1.47	59,426.00	13.45	7,354.45	0.23
TRANSPORTATION	2.57	754,740.00	116.73	12,698.18	2.00
OTHER	0.37	53,000.00	382.13	8,712.18	6.56

INTERVENTIONS AREA	INTERVENTIONS %	INVESTMENT €	SAVINGS (Toe)	AVERAGE COST-EFFECTIVENESS
COGENERATION TRIGENERATION	2.60	34,244,300.00	28,909.10	2,041.73

PRODUCTION FROM RENEWABLE SOURCES	6.19	25,857,290.16	5,548.21	5,310.54

Table 16: Summary of interventions, energy savings and cost effectiveness related to the ATECO code 21.22.00.

The table 16 shows the relevant information pertaining interventions in the sector *22.21.00* Manufacture of Plastic Packaging, bear in mind that in this table and in the following ones, the areas for which primary consumption is considered are reported separately, the subsector under investigation is distinguished by the smallest degree of audits received, this depict a scenario for which the bulk of the interventions identified concern *Lighting Systems, Thermal Power Plant/Thermal Recovery* and *Electrical Systems* which represent the **20.40%**, **24.38%** and **12.92%** respectively of the associated potential savings, turning our gaze on the other two areas of intervention, particularly significant is the role played in terms of energy conservation by Cogeneration and Trigeneration plants, this is equal to **28,909.10** toe associated to an investment of **34,244,300** € , overall against a total initial expenditure of **88,382,132.2**€ the sector would be able to accomplish total savings equivalent to **38,916 toe** from interventions pertaining all the areas excluded Production from Renewables and Cogeneration/Trigeneration and **11,423.2 toe** from this two latter areas.

DESCRIPTIVE STATISTICS	
Average Investment €	146,228.31
Average Savings (Toe)	67.81
Average Cost Effectiveness €	5,625.43
Standard Deviation Savings (Toe)	325.34
Standard Deviation Investment €	409,091.33
Standard Deviation Cost-Effectiveness€	8,223.38
Median Savings (Toe)	4.91
Median Investment€	20,000.00
Average Revenue Per Capita €	354,171.95
Average Sales Revenues€	37,057.74
Average Number of Employees	113.56
Average Rotation of invested capital	1.17

Table 17: Summary of the descriptive statistics for the ATECO code 21.22.00.

The table 17 shows some of the relevant descriptive statistics in relation to the industry under investigation, the large variability shown and the relative deviations from the mean reflect the different magnitudes of the interventions themselves, it is pivotal to mention that these data come from a subsample of the original obtained through a merge with data available in the AIDA database, therefore, some of the initial observations are not included in the statistics, in addition, the statistics obtained from the data extracted from Aida are calculated for firms involved while those on investment, savings and cost-effectiveness are obtained by considering the total number of interventions therefore a single firm is associated with multiple observations (methodology also applied for the subsequent descriptive statistics Tables 19 and 21).

These statistics clearly show the intense activity of the sector characterized by an average number of employees per company involved of **113.56** whose per capita revenues, as a consequence of the greater numerosity of firms considered, is the higher of the ATECO code under investigation and amount to **354,171,95** euros, the sector for an average investment of **146,228.31€** characterized by a cost effectiveness on average of **5,625.43** €, could achieve an average savings per intervention equivalent to **67.81 toe,** particularly distant from the median of this latter variable's distribution.

➢ <u>SECTOR 22.22.00</u>

INTERVENTION AREA	INTERVENTIONS %	INVESTMENT €	SAVINGS (Toe)	AVERAGE COST-EFFECTIVENESS	SAVINGS %
AIR CONDITIONING	3.54	1,811,593.00	327.19	5,329.62	3.56
BUILDING ENVELOPE	0.52	73,249.50	9.60	7,786.81	0.10
THERMAL POWER PLANT/THERMAL RECOVERY	3.54	3,271,021	1,695.09	8,793.05	18.47
COMPRESSED AIR	19.16	2,386,611	1,032.55	3,458.87	11.25
ELECTRIC MOTORS/INVERTERS	6.56	1,260,818.24	224.10	5,823.37	2.44
ELECTRICAL SYSTEMS	8.79	10,059,113.96	933.80	5,564.36	10.17
GENERAL (Monitoring, organization, training, ISO 50001)	16.69	1,627,221.00	969.59	2,334.74	10.56
INTERVENTIONS ON DISTRIBUTION NETWORKS	0.00	-	-	-	0..00
LIGHTING	25.33	5,391,997.93	1,692.54	5.5423.69	18.44
PROCESS COOLING	3.81	3,503,003.00	685.02	9,789.37	7.46
PRODUCTION LINES	8.27	12,960,887.54	1,555.11	14,621.63	16.49
PUMPING SYSTEMS	0.00	-	-	-	0.00
REFURBISHMENT	0.13	778.80	-	-	0.00
SUCTION	1.84	198,631.50	31.52	5,421.71	0.34
TRANSPORTATION	1.44	136,900.00	8.66	15,329.95	0.09
OTHER	0.39	107,976.00	14.72	5.821,56	0.16

INTERVENTION AREA	INTERVENTIONS %	INVESTMENT €	SAVINGS (Toe)	AVERAGE COST-EFFECTIVENESS
COGENERATION TRIGENERATION	2.54	53,057,989	29,238.67	7,168.43
PRODUCTION FROM RENEWABLE SOURCES	7.39	37,540,678.80	7,632.48	4,940.54

Table 18: Summary of interventions, energy savings and cost effectiveness related to the ATECO code 22.22.00.

Even for the sector *22.22 Manufacture of plastic packaging nca* it is evident the powerful role played by the measures concerning *Lighting equipment*, *Production Lines* and *Thermal Power Plant/Thermal Recovery*, as shown in the Table the above such areas encounter the greatest levels of deliverable savings equal to **18%**, **16.5%** and **18.5%** of the total respectively, all the way it is imperative to highlight the impact achieved in this case by the interventions with a *General* nature which attain almost **11%** of the total achievable savings.

The sector stands out, relative to the others under consideration, for the highest level of investment, indeed trough an overall investment of **127,225,736.51** € the enterprises considered would be able to realize **35,912** toe of energy saving by investing in interventions pertaining all the areas exclude Production from Renewables and Cogeneration/Trigeneration and **9,509.16** toe investing in these two latter areas.

The statistics in the Table 19 show a sector composed of about 90 employees per company whose per capita revenues are in average around **391,510,24** euros, the data also show efficiency in the use of resources, evidenced by the value assumed by the rotation of capital, **1.4** times per year indicative of a good rationalization of materials, as far as audits are concerned the sector could achieve about **57** toe of savings for each individual intervention against an average total investment of **143,135, 3211** euros, all the way the average is strongly affected by large-scale interventions such as Trigeneration plants, as evidenced by the median of the particularly low savings distribution.

DESCRIPTIVE STATISTICS

Average Investment €	140,270.93
Average Savings (Toe)	51.45
Average Cost Effectiveness €	5,968.22
Standard Deviation Savings (Toe)	248.26
Standard Deviation Investment €	402,143.63
Standard Deviation Cost-Effectiveness €	9,740.61
Median Savings (Toe)	5.53
Median Investment €	20,000.00
Average Revenue Per Capita €	391,510.24
Average Sales Revenues€	31,862.93
Average Number of Employees	89.76
Average Rotation of invested capital	1.10

Table 19: Summary of descriptive statistics pertaining the sector 22.22.00.

➢ SECTOR 22.29.09

Sector 22.29.09 Manufacture of plastic articles shows high percentages of the total interventions for the Areas inherent to *Electrical Systems, Production Line*s, *Compressed Air and General* which represent respectively the **46% 12% 7%** and **12%** of the total achievable energy conservation, considering instead the average cost-effectiveness it's interesting to observe the Electrical System and Production Lines values, which once taken into account the numerosity of intervention shows the highest values.

Finally, the sector against an overall expenditure of **108,130,028.24** € would be able to realize respectively **35,861.5 toe** (for all the areas for which we consider final energy consumption) and **15,677.56 toe** (from Production from renewables and Cogeneration/Trigeneration areas) of energy savings

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INTERVENTION AREA	INTERVENTIONS %	INVESTMENT €	SAVINGS (Toe)	AVERAGE COST-EFFECTIVENESS	SAVINGS %
AIR CONDITIONING	1.97	498,530.40	177.15	4,160.34	2.05
BUILDING ENVELOPE	0.70	230,771.50	31.28	23,022.47	0.36
THERMAL POWER PLANT/THERMAL RECOVERY	2.32	174,286.00	145.30	2,967.25	1.68
COMPRESSED AIR	17.47	2,073,383.71	644.61	3,876.70	7.44
ELECTRIC MOTORS/INVERTERS	9.51	2,124,887.76	423.34	4,145.79	4.66
ELECTRICAL SYSTEMS	12.41	7,818,010.51	4,211.15	7,333.68	46.36
GENERAL (Monitoring, organization, training, ISO 50001)	18.10	2,994,801.00	1,006.29	3,886.96	11.08
INTERVENTIONS ON DISTRIBUTION NETWORKS	0.00	-	0	-	0.00
LIGHTING	18.35	4,640,026.62	870.97	6,177.63	9.59
PROCESS COOLING	2.32	1,334,667.00	311.35	6,569.84	3.43
PRODUCTION LINES	11.72	11,102,862.67	1,128.89	11,277.02	12.43
PUMPING SYSTEMS	0.00	-	0	-	0.00
REFURBISHMENT	0.00	-	0	-	0.00
SUCTION	1.51	99,064.00	16.05	4,963.27	0.18
TRANSPORTATION	1.51	167,900.00	36.84	17,575.84	0.41
OTHER	0.12	200,000.00	81.00	2,469.14	0.89

INTERVENTION AREA	INTERVENTIONS %	INVESTMENT €	SAVINGS (Toe)	AVERAGE COST-EFFECTIVENESS
COGENERATION TRIGENERATION	2.09	43,758,874.00	29,308.75	7,152.64
PRODUCTION FROM RENEWABLE SOURCES	5.47	32,792,877.83	6,552.75	5,365.92

Table 20 : Summary of interventions, savings and cost effectiveness related to the ATECO code 22.29.

DESCRIPTIVE STATISTICS

Average Investment €	119,091.44
Average Savings (Toe)	46.92
Average Cost Effectiveness €	6,269.78
Standard Deviation Savings (Toe)	212.27
Standard Deviation Investment €	303,302.88
Standard Deviation Cost-Effectiveness€	8,396.46
Median Savings (Toe)	4.83
Median Investment€	16,000.00
Average Revenue Per Capita €	328,707.20
Average Sales Revenues€	32,207.64
Average Number of Employees	99.58
Average Rotation of invested capital	1.11

Table 21: Summary of descriptive statistics pertaining the sector 22.29.00

The sector in question shows considerable average revenues per individual company considered equivalent to **32,207.64** euros, at the same time it is characterized by the lowest level of capital turnover (1.11 times per year) accompanied by the lowest value of achievable savings per intervention, relative to the other two sectors considered, particularly distant from its median, an average investment of **119,091.44** euros would thus allow possible savings of **46.92 toe**.

The following graphs show for each sector investigated the cumulative distribution of realizable savings relative to the paybacl period classes to which the associated investments refer, in particular the graphical analysis pertains to the intervention areas for which we evaluate final consumption, it excludes interventions concerned with energy production from renewable sources and trigereative and cogenerative plants.

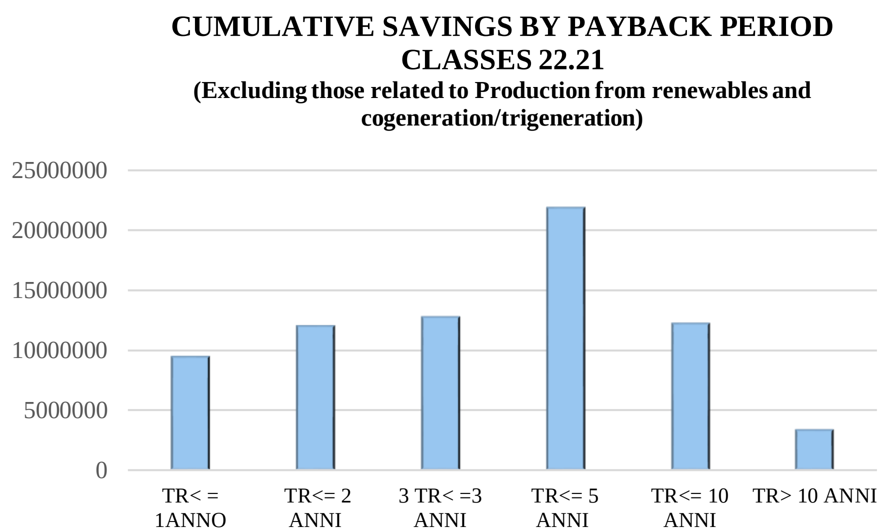

Figure 21 : Cumulate Achievable Savings referring to all the other areas organized by payback period classes 22.21.00.

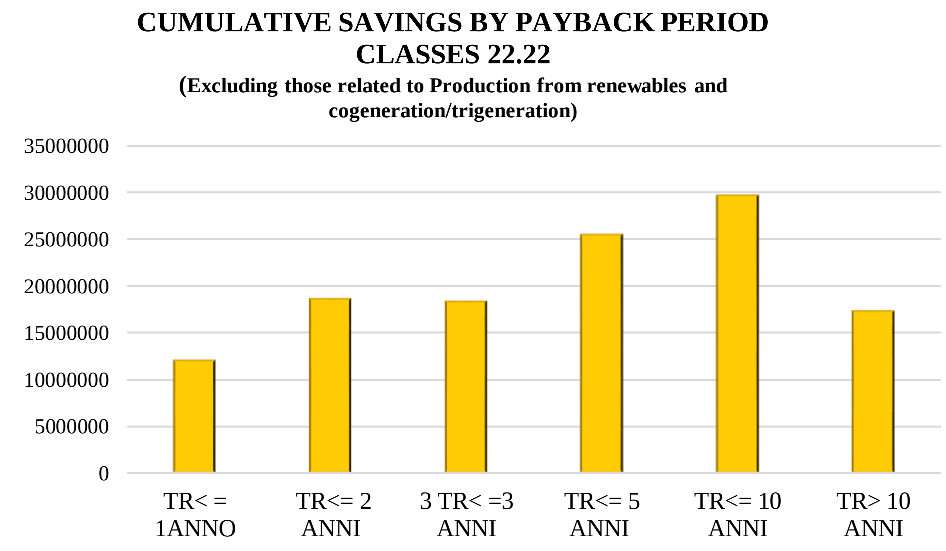

Figure 22 : Cumulate Achievable Savings referring to all the other areas organized by payback period classes 22.22.00.

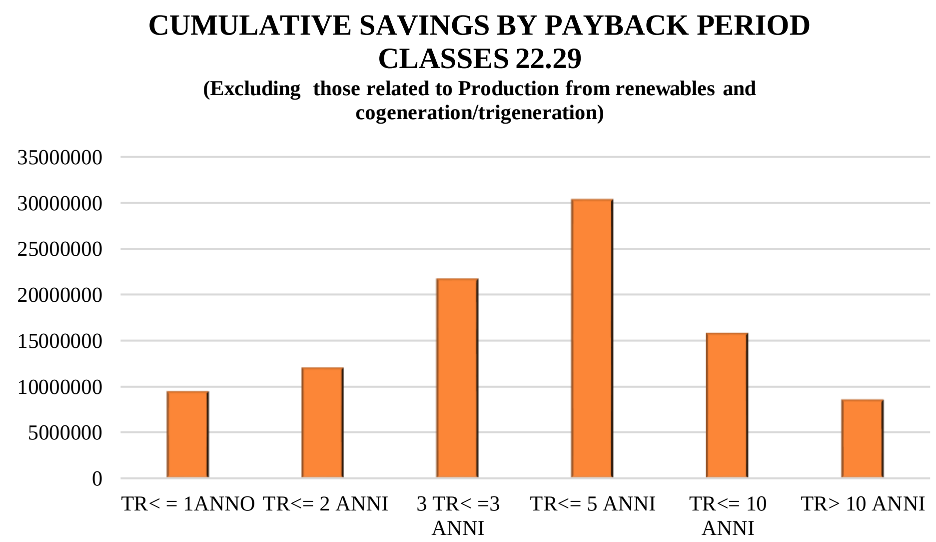

Figure 23: Cumulate Achievable Savings referring to all the other areas organized by payback period classes 22.29.00.

The analysis of the payback time of the investments to be enacted shows two similar scenarios for codes *22.22.00* and *22.29.00* pertaining the predominance of the fifth class (<=10) accompanied by lower values for the lower payback period classes, particularly, the productions of nca plastic articles (22.29) see notably low cumulative savings for the first time classes being considered while the first of the three codes examined, *22.21.00*, shows a pattern in which the fourth class outperforms the next by lessening the weight of long-term investments on the total savings and the first class related to notably short investments sees the bulk of the associated consumption reduction, these differences are closely attributable to the different sources of conservation and thus types of measures considered, while for the *production of plastic packaging* (22.21) the preponderance of energy conservation originates from replacements of lighting equipment in the case of the *manufacture of plastic articles nca* (22.29) interventions on production lines and renewable sources assume equally central roles.

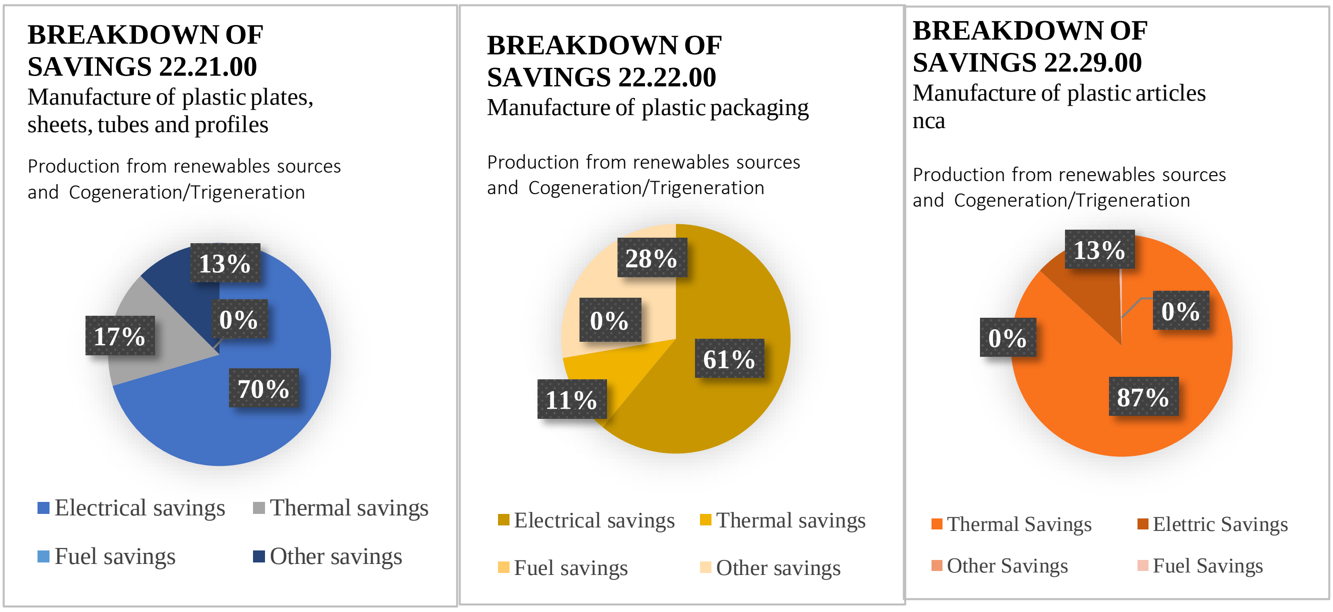

Figure 24 : Breakdown of savings pertaining Production from renewable sources and Cogeneration/Trigeneration ATECO 22.22, 22.21 and 22.29.

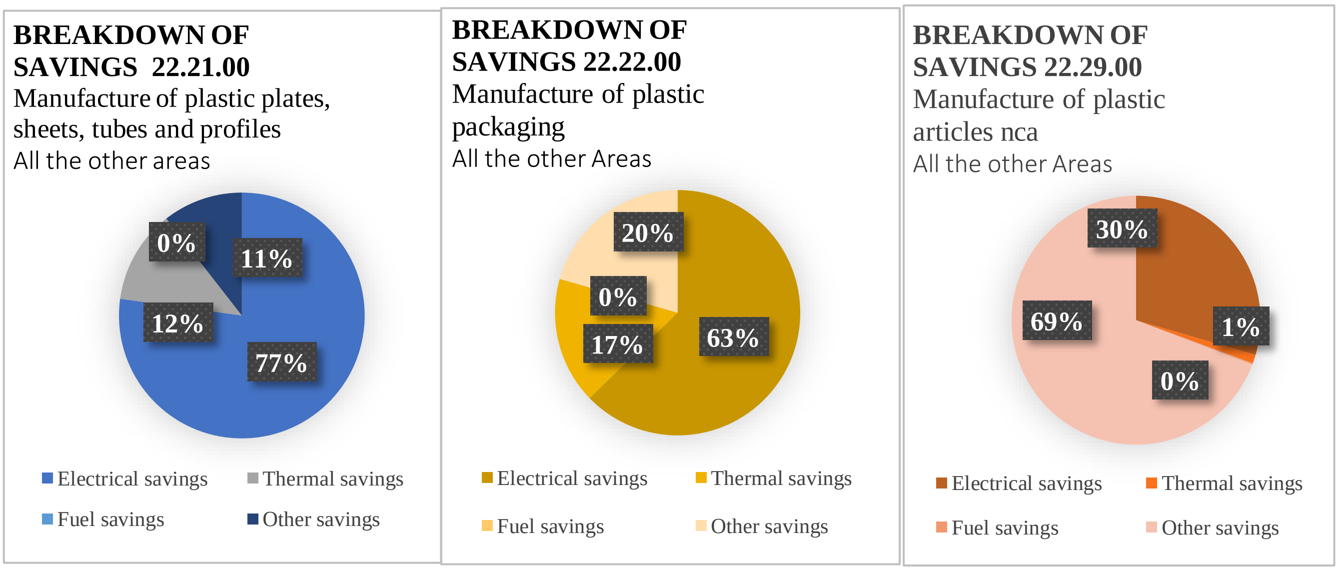

Figure 25 : Breakdown of saving pertaining All the Areas excluding Production from renewable sources and Cogeneration/Trigeneration ATECO 22.22, 22.21 and 22.29.

With regard to the breakdown of energy savings in each of the subcategories analyzed we find, as far as it pertains to interventions associated with primary energy consumption (Figure 24), a high incidence of the *electric vector* which presents for two of the three ATECO codes particularly high percentages (**70%** in *22.21.00*, **60%** in *22.22.00*) while the *thermal* flux assumes comparatively very high value in the sector *22.29.00*, this decomposition accurately reflects the predominance of interventions concerning energy production from non-fossil sources in the first two and measures relevant installations of Trigenerators and Cogenerators in the last in all categories the fuel-related savings are zero, .

Turning our gaze to all efficiency measures pertinent to the other areas (all excluding Production from Renewables sources and Cogeneration/Trigeneration), as highlighted in Figure 25, the dynamics appear different, in detail the weights assumed by *other savings* and *thermal* conservations vary greatly between codes, for example the former stand at **69%** in the sector *22.22.00* and only **11%** in *21.22.00*, similarly thermal savings vary from **1%** in sector *22.29.00* to **17%** in 22.22.00, again this strictly mirror the specificity of the predominant interventions areas

The territorial distributions of interventions, breaking down the analysis into the three subcategories, the outcomes regarding the entirety of the data are even more evident, indeed, the northern regions of the Peninsula experience a particularly high concentration of energy efficiency measures when compared to the rest of the country, in detail Lombardy and Veneto see the greatest values, while Campania is an exceptional case for two of the three sectors under consideration, furthermore, sector 22.22 *Manufacture of plastic packaging shows*, relatively to the other ATECO codes, significant levels of intervention even for the central and southern regions of the Nation, the maps 26, 27 and 28 provide an immediate idea of how interventions are localized in different Italian territories.

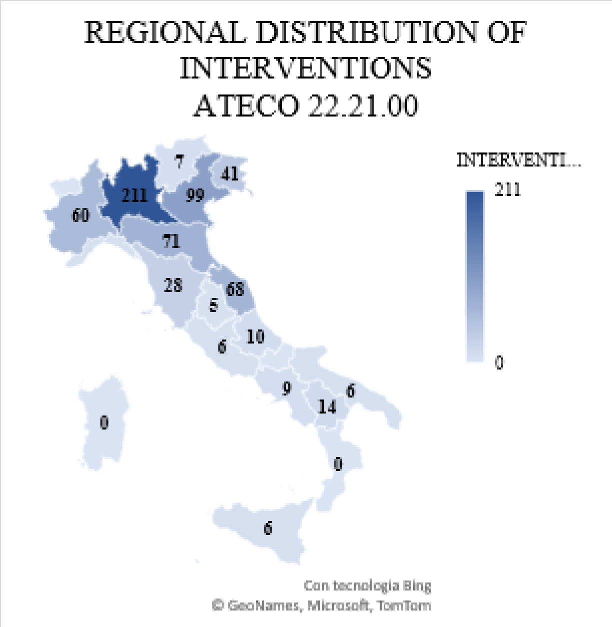

Figure 26: Regional distribution of intervention for ATECO 22.21.

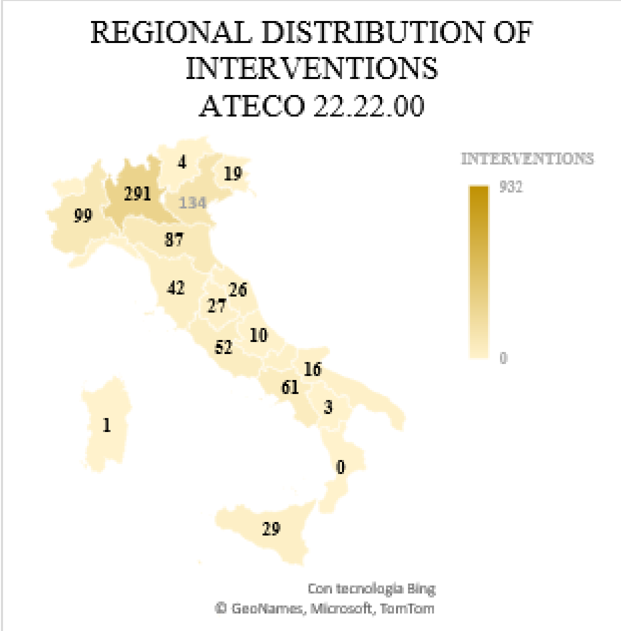

Figure 27: Regional distribution of intervention for ATECO 22.22.

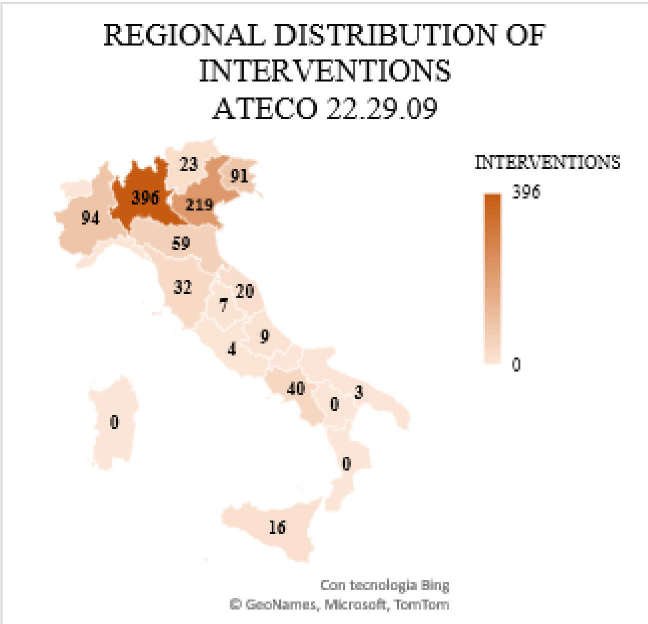

Figure 28: Regional distribution of intervention for ATECO 22.29.

4) Econometric approaches for the analysis of Energy Saving performances.

4.1) Energy Efficiency Sectorial Studies: literature review.

The efforts carried out by ENEA, for continuous improvement of the portal through which companies can upload documentation related to energy audit obligations, has led to the establishment of a unique database of its kind; the information on the realized and the realizable energy efficiency measures, in parallel with those related to the energy vectors consumed by enterprises, offer the opportunity to assess patterns of savings performances in the different Italian production sectors.

This chapter focuses on the use of econometric methodologies, for the analysis of the aforementioned data.

The use of such methodology would allow the identification of foundational traits of the company, the interaction between companies and the socio-economic context capable of influencing the ability and possibility for production sites to implement EEMs (energy efficiency measures).

In particular, the content of the audits (Chapter 1.5) allows us to assess how economic indicators related to the interventions themselves and characteristics of the obligated parties may represent a barrier to the achievement of national energy efficiency commitments.

Before proceeding with the exposition of the approach used, it is essential to recall the evolutions of the literature on the subject on which this work has its roots, all the way, sectoral studies in the field of energy efficiency mostly pertain to the analysis of specific measures, focusing on the different benefits related to the adoption of specific facilities, technologies, systems and behavioral measures, few are instead the contributions adopting a generalized approach aimed at assessing how different factors, inherent multiple facets of the company and the context, allow companies to move towards improved savings performances.

A relevant strand of literature is composed of the studies conducted by Cagno and Trianni, the two authors in collaboration with several researchers have carried out multiple empirical works concerning the drivers and barriers that can affect the adoption of energy efficiency measures (Cagno and Trianni et al., 2014[14]

[14] *Barriers and Drivers for Energy Efficiency: Different Perspectives from an Exploratory Study in the Netherlands* Enrico Cagno, Andrea Trianni, Ernst Worrell and Federica Miggiano (2014)
[14] *An Empirical Investigation of Barriers, Drivers and Practices for Energy Efficiency in Primary Metals Manufacturing SMEs* Andrea Trianni, Enrico Cagno and Stefano Farnè (2014)
[14] *Evaluating the barriers to specific industrial energy efficiency measures: an exploratory study in small and medium-sized enterprises;* Andrea Trianni and Enrico Cagno (2014)

Cagno and Trianni 2015[15], Cagno and Trianni et al., 2019[16], Cagno and Trianni et al., 2021[17]), although these contributions mostly adopt statistical approaches (correlation analysis) or methodologically different from econometric models there are important exceptions, e.g. the work done by Enrico Cagno in collaboration with Nevenka Hrovatin, Janez Dolšak and Jelena Zorić, this investigates how relevant are perceived by companies barriers and drivers for the adoption of EEMs compared to other contextual factors.

The analysis focuses on small and medium-sized enterprises in the manufacturing sector, in Slovenia, precisely, the authors constructed *a linear probability* and *logit model* in which the response variable analyzed consists of a dichotomous variable representative of the likelihood of adoption of the measures, two versions of this two models were inquired in depth, the first examines the factors influencing past investment decisions (the dependent variable in this case is a binary variable equal to one if the firm has invested in EEMs in the past three years relative to the period taken as a reference), inherent efficiency measures, while the second identifies factors that may shape future investment decisions (dependent variable with a value of one if the firm plans to implement EEMs in the next two years and zero otherwise), such models include a wide range of explanatory variables categorized into three groups, *firm and business-related characteristics* (including for instance the firm size, its profitability, the ownership, its innovativeness and its sales in foreign markets), *energy and energy efficiency-related characteristics* (including predictors as energy intensive, the presence of personnel expert in dealing with energy issues, energy audit etc.) and *perceived barriers and drivers* (consisting in high investment costs, their eventual low returns, the competence needed and finally informational, behavioral, technological and organizational barriers).

Summarizing the relevant finding, the study revealed that the culture internal to the firms and their innovative capabilities increase importance given to energy conservation in manufacturing SMEs, considering the past decision of investment, among the *firms variables*, only *debt* affects negatively the probability of introducing the measures, stressing the how relevance of having access to capital for the realization of them is a crucial obstacle for small and medium enterprises, focusing instead on *energy-efficiency* predictors, they show how firms that have implemented *awareness programs* as well firms that have carried out an *energy audit* are more likely to implement EEMs; turning our attention on the outcomes pertaining future investment decision, the firm's ability to innovate becomes relevant in the logit model , this latter outcome underline how research and development activities for the realization of a firm culture aware of energy management are crucial for the adoption, for the group of *energy-efficiency determinants,*

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[15] *Diffusion of Motor Systems Energy Efficiency Measures: An Empirical Study Within Italian Manufacturing SMEs* Andrea Trianni and Enrico Cagno (2015)

[15] *Linking energy efficiency and innovation practices: Empirical evidence from the foundry sector;* Andres Ramirez-Portilla Andrea Trianni and Enrico Cagno (2015)

[16] *A Framework to Characterize Factors Affecting the Adoption of Energy Efficiency Measures Within Electric Motors Systems* Enrico Cagno, Davide Accordini and Andrea Trianni (2019)

[17] *How important are perceived barriers and drivers versus other contextual factors for the adoption of energy efficiency measures: An empirical investigation in manufacturing SMEs;* Nevenka Hrovatin, Enrico Cagno, Janez Dolšak and Jelena Zorić (2021)

in contrast with the finding pertaining past interventions, several elements turn out to be significant, *energy-intensive* firms for instance, because of the pressing imperative to reduce the costs coupled with energy flows are more likely to take up EEMs, and this is true also for the case in which an high *potential for energy savings* can be found, finally future energy efficiency intervention show a different pattern than past investments, particularly concerning the role of *perceived barriers and drivers*, while for past decisions they are not significant, in this second case several parameters become central in stimulating positively the adoption of EEM, precisely, *competence-related* and *organizational barriers*, contrary *behavioral* and *technological barriers* significantly reduce the probability of future diffusion, showing once again how the construction of this internal consciousness, even though the exploitation of external linkages for the acquisition of the knowledge base needed, could affect the energy conservation pattern of a productive sector.

Hrovatin, Dolšak and Zorić (2016) have realized another interesting study (*Factors impacting investments in energy efficiency and clean technologies: empirical evidence from Slovenian manufacturing firms)* in which they implement an econometric approach for investigating on factors impacting *environmental investmen*t looking at Slovenian manufacturing firms.

In detail, they examined environmental investments initially as a homogeneous group and then they separated them into *energy efficiency* and *clean technologies* investments, for this purposes a panel data pertaining actual investment decision was exploited and two probit models were used, the approach respectively evaluate, the probability for firms to carry out an environmental investment and, separately, the probability associated to carry out investment in *clean technologies* and in *energy efficiency* measures.

Economic factors related to characteristics of the enterprises as *profitability* (ROA), *indebtedness* (debt ratio), *innovative capabilities* (a firm's R&D activity) and *energy costs* were used in these approaches as a predictor, but in line with the categorization of drivers and barriers previously discussed (chapter 1), they also incorporated in the models *market-driven elements* (which includes the exposure to international competition, managers' expectations of the future demand evolution and macroeconomic conditions especially considering the impact of 2008 financial crisis) and *regulation* (which includes the environmental regulation and the industry specificities) .

The authors finding reinforce those of Cagno e Trianni et al., related to a correlation analysis applied to the SMEs in the Italian manufacturing sector (*Empirical investigation of energy efficiency barriers in Italian manufacturing SMEs;* 2012), indeed economic *firm-related* factors are found extremely relevant in impacting *environmental investments' decisions*, *energy costs* as well the *firm's market share* and its *innovative ability* positively impact on the likelihood of investing in environmental technologies, the same results have been obtained looking at *market-related factors*, including export orientation and optimistic managerial expectations, while for *organizational factors* a limited role was found, instead when the two types of investment were analyzed separately, *research and development* activities no longer was significant, while *energy costs* have statistically significant impact not only on energy efficiency but also on clean technologies investments increasing the likelihood of enterprises' expenditures in this two areas, moreover the researchers have underlined how *favorable expectations* about the future demand positively impact energy efficiency investment, turning our gaze on the role of the *macroeconomic conditions*, the financial crisis, according to this work, shape positively the likelihood of clean technologies investments while did not had a statistically significant impact on energy efficiency investments, following the reasoning of Hrovatin, Dolšak and Zorić could be explained because energy efficiency measure are perceived as cost-saving and, therefore, less impacted by the global crisis.

In the context of this brief summary of the relevant literature on the subject, it is necessary to bring to the reader's attention the empirical contribution of Anderson and Newell pertaining the relevance of *information programs* for technology adoption, which utilize the data deriving from energy audits, in detail, the two economist considered a set of potential energy-saving projects related to the US manufacturing sector, recommended by the auditors of the US Department of Energy's Industrial Assessment Centers (IAC) programme, and exploited a logit model with plant-level fixed effects (Chamberlain, 1980; Hamerle and Ronning, 1995) in an attempt to control also for unobserved differences between plants in the propensity to adopt, more precisely this model was replicated three times.

The first model focuses on testing the assumption that a firm will adopt a particular project if the perceived net expected benefits are positive given the project characteristics and the relative rate of investment hurdle (*payback model*), the second model starts from the results of previous contributions in the literature that stress how implementation costs were found to have a stronger effect on energy conservation investments than energy savings, in order to test whether this is also the case for IAC participants, they developed a *cost-saving* model, finally, for the third model the authors focused on the fact that business decision-makers are more sensitive to physical energy savings than to price differences, therefore, they explored the possibility that energy prices and quantities have different effects on the likelihood of adoption through a *price-quantity* model, the predictors used in the models relate to the *specific projects implemented* (engine systems, thermal systems, combustion systems, electrical energy and industrial design projects) and the *ancillary costs* faced by companies, Anderson and Newell found that adoption rates are higher for projects with *shorter payback periods*, *lower costs, higher resulting annual savings, higher energy prices,* and *greater energy conservation*; the two authors also emphasized how installations are **40%** more sensitive to upfront costs than to annual savings, identifying important policy implications, as subsidies appear to be more effective in promoting energy-efficient technologies than increases in energy prices.

The following table summarizes some of the most relevant studies on the field centered on the use of econometric methodologies for investigating the drivers and barriers inherent in the adoption of efficiency measures.

Study	Country/sample	Econometric model/dependent variable	Main findings [1)]	
			Barriers	Drivers
Schleich and Gruber (2008) [3]	Germany 2848 SMEs, small industrial and services	Logit for each sub-sector Dependent variable: binary - active adopters	In metal sector: unknown split of energy consumption between thermal and electricity, rented space (split incentives). In wood working and processing: rented space.	No explicit analysis. Energy intensity and size are not significant barriers/drivers in manufacturing.
Schleich (2009) [3]	Germany 2848 SMEs	Logit and probit (for sector and sub-sectors 2 dependent variables: 1) active adopters in the past; 2) active adopters in the past and planning in the future.	In metal sector (for active adopters in the past and future): rented space.	No explicit analysis.
Trianni, Hrovatin, Dolšak and Zorić (2016)	Slovenian manufacturing SMEs	Linear probability Logit model for past and future investment decisions. Dependent variable likelihood of adoption of the measures	Access to capital, organizational, behavioral and competence related barriers.	Awareness, Energy intensity, research and development expenditures
Hrovatin, Dolšak and Zorić (2016)	Slovenian manufacturing SMEs	Probit models Dependent variable Enviromental investments	Access to capital and perceived behavioral and technological barriers	Innovative ability, energy cost and firms market share.
Anderson and Newell (2004)	USA SMEs, manufacturing, 39,920 IAC* project recommendations in 9034 plants (*US Department of Energy's Industrial Assessment Center)	Fixed effect logit Dependent variable: project adoption (binary)	Payback period, project (investment) cost. Energy savings (driver) are much less important than investment costs (barrier). Project costs (barrier) have more than double effect than energy prices (driver) 2).	Annual savings, quantity of energy saved, price of energy. Motor systems projects have the highest adoption probability.
Abadie et al. (2012)	USA SMEs, manufacturing, 101,286 project recommendations in 13,462 IAC assessments	Probit Dependent variable: implemented project recommendation (binary)	Payback time, number of recommendations, location (states with higher GDP in manufacturing), natural gas as a primary resource stream of EE.	Cost reductions, expected savings (benefits), electricity as a primary resource stream in EE investments, location (states with greater greenhouse gas (GHG) emissions).
Fleiter et al. (2012)	Germany 542 SMEs, industrial and non-industrial in energy audit program Sonderfonds	Fracti for past and future investment decisions.onal logit, factor analysis Dependent variable: adoption rate (share of adopted EEMs in all recommended)	High investment costs (subjective and objective), lack of capital (for larger investments) [4)].	Audit quality (in one model); energy intensity (in one of 3 models).

Study	Country/sample	Econometric model/dependent variable	Main findings [1]	
			Barriers	Drivers
Kostka et al. (2013)	China 480 SMEs, multisector	Ordinary least squares (OLS) Dependent variable: total EE activities (binary) – normalised sum of 5 dummies for EE activities	None [5].	Size, energy cost (intensity), energy manager, informed business manager, firm's growth ambition, energy loan, labour-intensive sector.
Blass et al. (2014)	USA SMEs, manufacturing, 5836 recommendations in 752 IAC assessments	Logit Dependent variable: 1) adopted recommendations (binary); 2) adopted process and equipment change recommendations (binary)	Investment cost.	Involvement of operations manager (for process and equipment change recommendations).
Boyd and Curtis (2014)	USA 321 MEs, manufacturing	Multivariate regressions Dependent variable: energy intensity (as a proxy for energy (in)efficiency)	Strong production targets in high energy firms. Low impact of management practices and targets in low energy industries.	Lean manufacturing operations. Higher impact of good management practises in high energy industries.
Cantore (2017)	Viet Nam, the Philippines, Moldova 214 ME and LE, manufacturing and other industrial sectors	Logit, Principal component analysis (PCA) (on 8 groups of variables) Dependent variable: planned investments in the EE projects over next 5 years (binary)	Energy certification (EMS), microeconomic constraints (principal component); top management commitment.	Energy audit, past investments in EE (in the last 2 years), planning/considering energy management innovation.

Table 22: Summary of the prevalent econometric methodologies utilized for analyzing energy efficiency barriers and drivers;

Source: Author's elaboration on Hrovatin, Dolšak and Zorić and Trianni (2021).

4.2) The Data.

The database held by ENEA is unique in its kind, generating the opportunity for an in-depth analysis of company traits and their impact on the past and future evolution of energy efficiency measures in the various Italian production sectors.

This study exploits this data bank in relation to the ATECO sectors inherent to the production of plastic and rubber articles (the equivalent of NACE C22.1.1, C22.2.2 and C22.2.9), in particular, the initial database (prior preparation of the sample for the statistical analysis) presents **2608** observations representing the energy efficiency measures identified, for the time period 2018, in various production sites by the energy auditors.

The above-mentioned database includes parameters pertinent to the *identified energy efficiency interventions* and others relating to the *company* itself.

As regards the former, these refer not only to the description and type of the identified energy efficiency measures, but include in addition information pertinent to the investment necessary for their implementation and the relative *net present value, payback periods and cost- effectiveness*, consequently information is also reported on the different types of energy savings that can be achieved by means of the aforementioned measures.

As regards the variables linked to the enterprise itself ENEA is able to collect, through the audits, details concerning: the *company name*, their *ID code* for the identification of production sites associated to the same VAT (multi-site companies); the *region* of belonging of the production sites as well as the *province*; the presence of mechanisms for *monitoring* the energy flows of the production site considered; the achievement of *ISO5000 certification* which guarantees the presence of a system for the management of energy vectors; finally, it is possible to make a distinction between the obliged parties, i.e., to assess whether the company considered is a large company or an energy-intensive company.

Taking into account that this information, for sector 22.00, has never been processed before, the database required considerable effort to carry out data validation and necessary corrections, in detail the following changes were made to the source database:

- Energy efficiency interventions with associated total *energy savings equal to zero* were removed as they were not relevant for the purposes of the analysis.
- Interventions resulting from audits not relevant to the obligation period were removed from the database.

- *Energy savings* and *Investments values*, associated with interventions, that were particularly distant from their average (with reference to both tails of the distribution) were checked by verifying the contents of the audits
- Corrections were made, where necessary, to the values of *energy savings* by applying due conversions
- Where *Investment* and *Cost-effectiveness* levels were missing, these were inspected and, if necessary, included, on the bases of the content of the audits
- Payback periods were included where missing if related information were present in the audits

Furthermore, for the purposes of the analysis, energy consumption levels of the production sites considered were attached to the above-mentioned data, as a result, the database exhibits electrical, thermal, and gas consumption levels, distinguishable into primary energy consumption, which are associated with intervention areas involving activities of self-production of energy flows, and final energy consumption relevant to all other intervention areas.

Finally, in order to expand the focus on the features of the company that are capable influencing the energy savings performance and thus stimulate or discourage the adoption of EEM, a merge with the AIDA DATABASE was realized, more precisely, in line with the literature on the subject, through the ID code of the companies, information related to the *pro-capita revenues levels, the number of employees, the revenues from sales levels*, *the debt ratio* (indicating the percentage of a company's assets that are provided via debt) and the *capital turn over* (representing the number of times the capital invested in current operations returns to it in liquid form), were identified in this database and selected, the realization of the aforementioned merge in addition to the previous validation brought the observations to **1364** units.

4.3) The Methodological Approach.

4.3.1 The selected models and the response variables

In section 4. 1 we highlight the predilection, of the literature on the issue, in the use of nonlinear regression models exploiting a dichotomous response variable, which assumes a value equal to 1 in case of adoption of the measure for improving energy efficiency, in line with this approach this study involves the utilization of a logistic regression model, all the way the response variable exploited in this case is obtained as *the ratio between realizable energy savings pertinent to the single interventions and the overall consumption of energy carriers of the considered production site*, therefore its dichotomous version assumes a value equal to 1 if the observed energy performance exceeds the average of its own distribution, the ultimate goal thus is to evaluate which factors (inherent both the interventions and the firms themselves) stimulate an above-average energy savings performance, furthermore, the above described method of analysis, in the course of the chapter is compared to a linear regression model with ordinary least squares to which a logarithmic transformation is applied to the dependent variable and in which fixed effects are introduced for the site ID code, this latter modeling choice arises from the awareness of the presence of multisite firms and thus of common uncontrolled characteristics among such sites capable of influencing energy savings performances.

Furthermore, as underlined in the previous chapters, the interventions concerning *Production from Renewable sources* and *Cogeneration/Trigeneration*, as they concern self-production of energy flows, are evaluated through the *primary energy consumption* and consequently the energy savings in tonnes of oil equivalent are considered by applying the relative factor conversion, for this reason the EEMs pertinent to these two areas are analyzed separately from EEMs related to all the other areas, moreover in light of the composition of the database itself the use of a logistic regression tool and/or the introduction of fixed effects into the pooled ols model becomes meaningless and therefore a simple linear regression model is implemented for the analysis of such areas (see Chapter 5.1.2).

In detail, the *logistic regression* model is formulated as follows:

$$P(y_i=1|X_i)=\frac{e^{\beta_0+B_1X_1+B_2X_2\ldots B_kX_k}}{\left(1+e^{\beta_0+B_1X_1+B_2X_2\ldots B_kX_k}\right)}$$

Where $P(y_i=1\,|\,X_i)$=*is the odds that, given a set of explanatory variables ($X_1 \ldots X_k$), the intervention allows to achieve an energy saving performance higher than the average one*, or alternatively, the probability that the ratio between energy savings and energy consumption associated to an intervention, is higher than the average value of this ratio, given the predictors, that can be written as:

$$Performance_{i2018} = \begin{cases} 1 \; if \; \frac{Total\ savings\ (toe)}{Total\ consumption\ (toe)} > \; mean\left(\frac{Total\ savings\ (toe)}{Total\ consumption\ (toe)}\right) \\ 0 \;\; otherwise \end{cases}$$

In which *i*= *i-th* intervention.

While the Pooled OLS regression model is formulated as follows:

$$Log(Y)=\beta_0+\beta_1X+\ldots\ \beta_kX_k+\epsilon$$

With the fixed effects becomes:

$$Log(Y)=\beta_1X+\ldots\ \beta_kXk+\gamma D_1+\ \gamma D_2\ldots+\ \gamma D_{K+}\epsilon$$

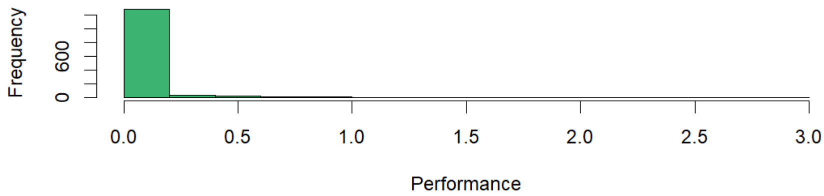
Note: the introduction of the fixed effects dummies requires the removal of the intercept.

Where the X represent the chosen predictors, β the associated coefficients and ϵ is the residual error term, all way in this case the response variable, given by the ratio of energy savings to energy consumption, is not exhibited as dichotomous but as a continuous variable, furthermore, by examining its distribution graphically, both considering the dependent variable that was built for interventions related to *Production from Renewables* and *Cogeneration/Trigeneration* (Figure 30) and the one built with reference to interventions pertaining to *all other areas* of intervention (Figure 29), it is evident a concentration of observations for values lower than 0.25, as a consequence the modeling choice of applying, to above-mentioned ratio, the logarithm has been made in order to approximate its distribution to a Gaussian one.

The reference period T for each variable was not detailed in the formulation of the model since the data only refer to the year 2018.

Histogram of response variables: The use of the logarithm in the pooled OLS

Histogram of Performance (Final energy consumption)



Histogram of Logarithm of Performance(Final energy consumption)

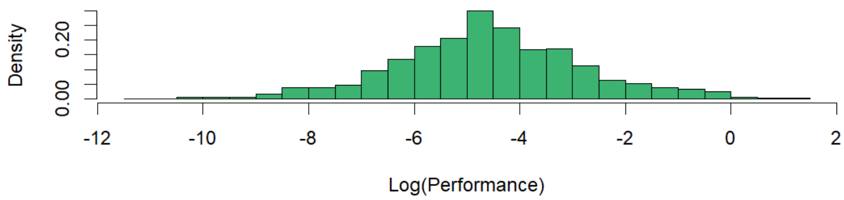
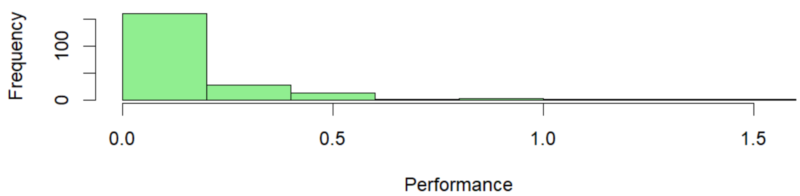


Figure 29: Comparison of the histogram of energy saving performance with the histogram of its logarithm (all the other areas).

Histogram of Performance (Primary energy consumption)



Histogram of Logarithm of Performance(Primary energy consumption)

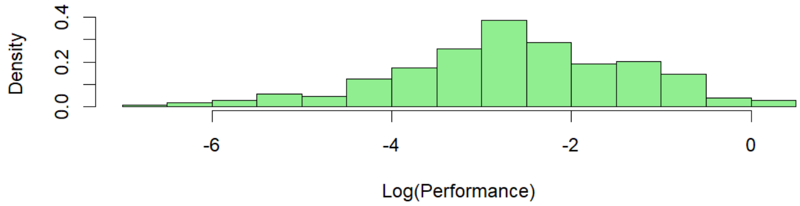


Figure 30 :Comparison of the histogram of energy saving performance with the histogram of its logarithm (Production from Renewables and Cogeneration/Trigeneration).

4.3.2 The predictors

The presence of variables referring to the enterprise and not to the intervention, such as for example energy consumption or alternatively the AIDA variables, means that if a company carries out multiple interventions, the values of the aforementioned variables are repeated for each intervention carried out by the same company, this peculiarity of the database was evaluated jointly with the ascertainment that multiple production sites (therefore multiple interventions) are linked to the same firm, thus generating the possibility that specific uncontrolled elements of the enterprise, common to different production sites, affect the energy saving performance, the evaluation therefore led to the choice of logit and ols models with fixed effects in order to control for common characteristics of the sites through the introduction a dichotomous variable for each production site having the same ID code and therefore associated with the same company, however based on the results obtained, regarding the goodness of the models themselves, the fixed effects were removed from the logistic regression and kept instead in the OLS case.

Both the models are estimated using maximum likelihood (ML) estimation method.

Based on the previous description of the database, the predictors used in the models are summarized in the following table.

Predictors Name ***($X_1, X_2 \ldots X_k$)***	**Variable description**	**Logistic Regression**	**Pooled OLS**	**Pooled OLS** with fixed effects
INVESTMENT	Investment level associated with the EEM.	☑	☑	☑
VAN	Net present value of the investment.	☑	☑	☑
PBP	Payback period associated to the investment.	☑	☑	☑
GI	Dichotomous variable =1 if the EEM considered comes from an audit of a large company.	☑	☑	
ENERGY_INTENSIVE	Dichotomous variable =1 if the EEM considered comes from an audit of an energy intensive company.	☑	☑	
MONITORING	Dichotomous variable =1 if the EEM considered comes from a production site subjected to monitoring.	☑	☑	
ISO 5000	Dichotomous variable =1 if the EEM considered comes from a production site owning a system for managing energy vectors.	☑	☑	
FIXED EFFECTS	N-1 dummy for each production site having the same ID code so pertaining to the same firm.			☑
	n-1 dummy variables for the regional macro-areas			
NORTH-EAST	Dichotomous variable =1 if the intervention considered comes from a production site located in the North-east area of the peninsula.	☑	☑	☑

NORTH-WEST	Dichotomous variable =1 if the intervention considered comes from a production site located in the North-west area of the peninsula.	☑	☑	☑
SOUTH	Dichotomous variable =1 if the intervention considered comes from a production site located in the south area of the peninsula.	☑	☑	☑
	AIDA variables (2018).			
REVENUES	Company revenues from sales.		☑	
REVENUES_PROCAP	Company revenues per employee.	☑	☑	☑
EMPLOYEE	Company number of employees.		☑	
DEBT_RATIO	Debt ratio indicating the company's total debt, as a percentage of its total assets.	☑	☑	☑
CAPITAL_TURNOVER	Capital Turnover that measures the efficiency of the concerned company to use its assets in income.	☑	☑	☑

Table 23: Description of the variables included in the models, where the ticks represent their inclusion or not in the models.

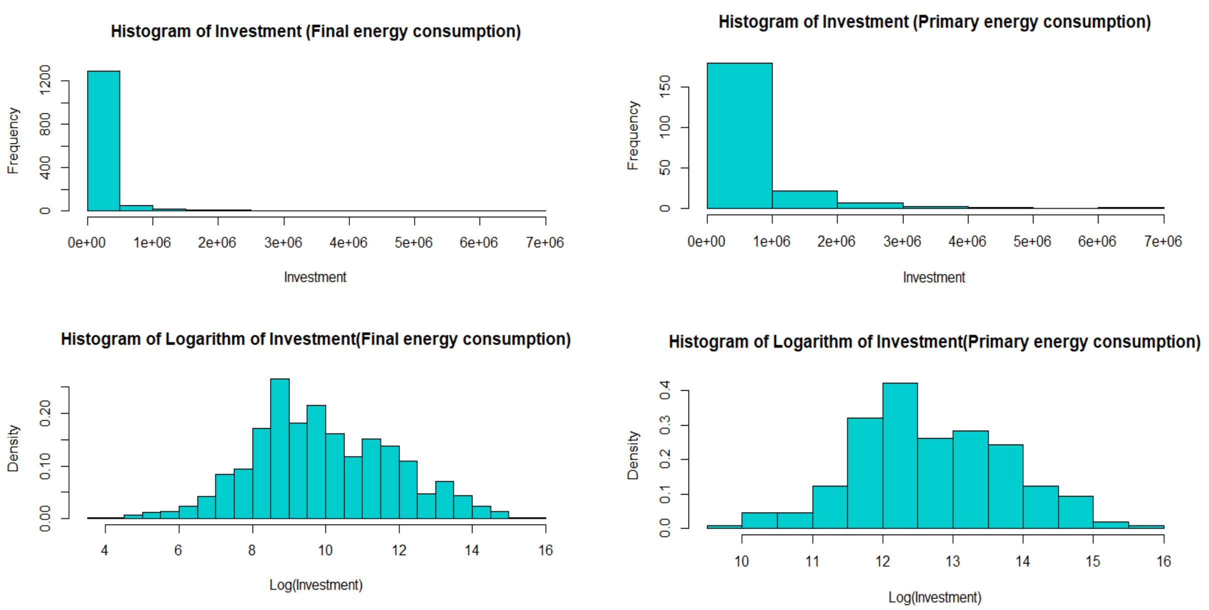


Figure 31: Comparison of the histogram of Investment levels with the histogram of its logarithm.

Regarding the *investment* variable, its whole distribution is marked by observations that are notably distant from the mean; in order to minimize the incidence of very high levels of investment and approximate its distribution to a Gaussian distribution (figure 31), in all the model considered this parameter enters under logarithm.

The distinction between EMMs referring to "all the other areas" of intervention and the EEMs relating to the *Cogeneration/Trigeneration* and *Production from Renewables* also entails a modeling distinction, in fact for EEMs relating to final consumption, dichotomous variables can be introduced indicating the area to which they belong in an attempt to verify whether the investment in certain areas affects energy saving performance in a contradistinctive way, a modeling choice that makes no sense considering primary consumption as it refers to only two areas of intervention.

N-1 DUMMY FOR INTERVENTION AREAS (FINAL CONSUMPTION)[18]

AIR CONDITIONING	Dichotomous variable =1 if the intervention belonging to the **AIR CONDITIONING AREA**
THERMAL POWER PLANT/THERMAL RECOVERY	Dichotomous variable =1 if the intervention belonging to the **THERMAL POWER PLANT/THERMAL RECOVERY AREA**
COMPRESSED AIR	Dichotomous variable =1 if the intervention belonging to the **COMPRESSED AIR AREA**
ELECTRIC MOTORS/INVERTERS	Dichotomous variable =1 if the intervention belonging to the **ELECTRIC MOTORS/INVERTERS AREA**
ELECTRICAL SYSTEMS	Dichotomous variable =1 if the intervention belonging to the **ELECTRICAL SYSTEMS AREA**
GENERAL (Monitoring, organization, training, iso 50001**)**	Dichotomous variable =1 if the intervention belonging to the **GENERAL** (Monitoring, Organization, Training, ISO 50001) **AREA**
LIGHTING	Dichotomous variable =1 if the intervention belonging to the **LIGHTING AREA**
PROCESS COOLING	Dichotomous variable =1 if the intervention belonging to the **PROCESS COOLING AREA**
PRODUCTION LINES	Dichotomous variable =1 if the intervention belonging to the **PRODUCTION LINES AREA**
SUCTION	Dichotomous variable =1 if the intervention belonging to the **SUCTION AREA**
TRANSPORTATION	Dichotomous variable =1 if the intervention belonging to the **TRANSPORTATION AREA**

Table24: Summary of the constructed N-1 dummy for intervention areas (Final consumption).

[1] Are excluded the intervention areas for which, once that the database has been validated and the merge realized, no interventions are found

The formulation of the referred models, and accordingly also the eventual transformation of the inserted variables, has been attained after having tested numerous possible alternative methods, as described in the appendix 2, until arriving at particularly robust results, for these motivations the compared models are particularly differentiated even though they both offer a good reading key for the energy performance of the plastics sector.

Always for the purposes of the robustness of the analysis in the OLS model, since the fixed effects per se control for common factors of the production sites belonging to the same company, the dummy variables related to Monitoring, Iso5000, Large Enterprise (GI) and Energy intensive are removed, for the same reasons, the sensitivity of the logit models to the choice of threshold for the construction of the dichotomous response variable was tested by contrasting the output from the same model but with the binary variable having a value of one if energy performance is greater than the median of its own distribution (see Appendix 2), and although the obtained significances are in line, the latter have a much lower goodness of fit.

4.3.3 Criterion for the selection of the models

As far as pooled OLS models without fixed effects are concerned, their goodness can be gauged by considering the *R-squared*, which is a statistical measure in a regression model that determines the proportion of variance in the dependent variable that can be explained by the independent one, in the course of this analysis, however, greater attention is paid to adjusted R-squared, which is a modified version of the first that adjusts for the number of predictors in a model, thus reflecting the number of variables introduced in the indicator of the model goodness, this is formulated as:

Adjusted R^2 =

$$1 - \frac{(1 - R^2)\,(n - 1)}{n - k - 1}$$

Where R_2 is the R-squared of the model, *n* the number of observations and *k* the numerosity of predictor variables.

On the criterion chosen for assessing the goodness of the logit models, we could resort to the use of the Akaike Information Criterion (AIC) which provides "*an estimate of the information lost when a specific model is used to represent the process that generated the data*", anyway in the context of this analysis particular attention is devoted to the Bayesian information criterion (BIC) which is a well-known general approach to facilitate the selection of a regression model that prefers parsimonious models over more complex ones, this means that it adds a penalty related to the numerosity of parameters estimated in the model, in a way to account the impact that this numerosity has on the goodness of the fit (Schwarz 1978, Raftery 1995), it is used to assess two contending models, indeed following Jeffrey-Raftery (1995), if the difference in BIC between the two models is 0-2, this constitutes "weak" evidence in favor of the model with the smaller BIC while if the difference in BICs greater than 10 constitutes ‘very strong’ evidence in favor of the model with smaller BIC.

The BIC is calculated as follows:

$$-2\log(L) + k \cdot \ln(n)$$

Where *L* stands for the Likelihood of the model, *k* for the number of parameters and *n* is the sample size.

4.3.4 Correlation among predictors

For the purposes of understanding the analysis it is important to underline the only correlation found between the predictors, precisely that between two of the AIDA variables, indeed both considering the database with reference to the *Production from Renewable sources* and *Cogeneration/Trigeneration* areas and that relating to *all the others areas*, a Pearson linear correlation coefficient between REVENUES and the number of EMPLOYEES respectively equal to **0.869** and **0.889** is deduced, therefore the variable REVENUES PER CAPITA is directly introduced into the models in the light of the fact that this predictor fully contains the aforementioned correlated variables .

4.3.5 The white certificate variable

Finally, In order to verify the extent to which the presence of policies to encourage certain interventions can boost energy saving performances a special dichotomous variable, named *white certificates*, was constructed, as highlighted in the first chapter white certificates are one of the main policy instruments used to foster EEMs in Italian industry, thanks to the white certificate guidelines issued by the GESTORE SERVIZI ENERGETICI it was possible to detect which EEM are eligible for this policy tool.

For the areas *Production from renewable sources* and *Cogeneration / Trigeneration* there are some clarifications to be made, the first of these two areas is subject to incentive tools other than white certificates therefore the variable was not built for this area, while as regards the latter there is instead a special type of certificates to be considered, *the white certificates for CAR*, regulated by the Ministerial Decree 05/09/2011 which states that the measure access is granted to cogeneration projects having date of entry into operation (as a result of new construction or renovation) after March 6-2007, for a period of 10 calendar years or alternatively if combined with a district heating network, for a period of 15 calendar years, starting from January 1 of the year following the entry into operation, from this we deduce that for the construction of the variables the quantum of information required is particularly extensive and in light of the fact that some of these data are not retrievable the white certificates dummy was not constructed for the area.

White certificate has been constructed exclusively with reference to all other intervention areas, according to the following:

INTERVENTION AREAS	**Construction of the WHITE CERTIFICATE variable**
AIR CONDITIONING	**1** if the intervention concerns a heat recovery and/or refrigeration system **0** otherwise
BUILDING ENVELOPE	NA[19]
THERMAL POWER PLANT/THERMAL RECOVERY	**1** for any registered heat recovery and for EEM referring to process chiller **0** otherwise
COMPRESSED AIR	**1** for intervention on compressed air/compressor replacement **0** otherwise
ELECTRIC MOTORS/INVERTERS	**1** for motor/inverter replacement if savings > 5 toe **0** otherwise
ELECTRICAL SYSTEMS	**1** only for power quality interventions **0** otherwise
GENERAL	**1** per each introduced management and monitoring system **0** otherwise
LIGHTING	**1** for LED introduction if energy savings > 5 toe **0** otherwise
PROCESS COOLING	**1** per replacement/introduction of refrigerant system **0** otherwise
PRODUCTION LINES	**1** only in case of press replacement excluding hydraulic presses **0** otherwise
SUCTION	**0** for all the intervention
TRANSPORTATION	**0** for all the intervention
OTHER	NA

Table 25: Description of the construction of the variable WHITE CERTIFICATE for “all the other areas”.

Following these guidelines, it was possible to set up the variable for **1093** energy efficiency interventions, further reducing the database observations, in order not to lose any further relevant data, the introduction of the variable “white certificates” and its effects are evaluated separately, which implies for “ final consumption intervention areas” the development of four different models: the logit with and without incentives and the OLS with and without incentives.

[1] NA has been attributed if no intervention in this area can be associated with a white certificate.

5)Estimation Results.

5.1) Econometric models without the *white certificate* variable.

As mentioned in the previous section, the construction of the incentive-related variable led to a further shrinking of the database considered, moreover, in the course of analysis it was found that this factor is capable of taking on an extremely prominent role in shaping the firms' energy performances , so it is deemed necessary to evaluate its introduction into the models in a separate section, indeed, the next subsections report the findings gotten in the absence of such a variable .

5.1.1) The Logit Models and Ols Models *for all the intervention areas.*

(Excluded Production from Renewables and Cogeneration/trigeneration)

In the previous chapter has been described how the *logistic regression model* and the *pooled ols model* with and without fixed effects were formulated as well as the variables incorporated, let us now turn our attention to the findings achieved with this frameworks for what pertain all the intervention areas excluding those involving auto-production of energy flows, in particular, the subsequent table shows in comparison the output obtained using the cited approaches estimated using maximum likelihood (ML) estimation method.

Before proceeding with the exposition of the results it turns out to be necessary to bring to the reader's awareness that logistic regression is a probability model referencing an odds ratio, which is a different way of portraying a probability (i.e. Y=1), in point of fact it is the ratio of the number of ways in which the event may occur to the number of ways in which it does not occur, (i.e., favorable outcomes to unfavorable outcomes) so that in such a regression model the estimated coefficient represents the log of an odds ratio, allowing us to compare the odds for the event Y = 1 (in this case energetic performance greater than the mean of its distribution) before and after the variation in one or more predictors, this implies a distinct methodology for the interpretation of the coefficients themselves, by computing the **exponentiation of β_i** it is in fact possible to comprehend the **multiplicative effect** that a unit change in X_i has on the probability of seeing the event Y=1 realized, alternatively by computing **$[\exp(\beta_i)-1]*100$** it is possible instead to estimate the **expected percentage change** in odds for the event Y = 1 corresponding to an increase of one unit in X_i, for these reasons the results obtained are evaluated by applying both these transformations.

Regarding the interpretation of the coefficients in the pooled OLS model, having applied the logarithm to the dependent variable, the coefficients associated with the predictors (i.e.,β_i) can be interpreted as the expected percentage change in Y corresponding to a unit change in $X_{i.}$

[

	POOLED OLS without fixed effects	Std.error	POOLED OLS with fixed effects	Std.error	Logistic model	Std.error
Log(Investment)	0.831***	(0.020)	1.008***	(0.016)	1.501***	(0.118)
VAN	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
PBP	-0.115***	(0.010)	-0.164***	(0.008)	-0.099***	(0.036)
GI	-0.611***	(0.082)			-0.995***	(0.323)
ENERGY_INTENSIVE	-0.421**	(0.210)			-1.131	(0.713)
MONITORING	-0.369***	(0.074)			-1.028***	(0.270)
ISO 5000	0.130	(0.173)			-0.333	(0.736)
NORTH-EAST	0.086	(0.096)	-5.745**	(2.765)	-0.032	(0.350)
NORTH-WEST	0.176**	(0.079)	-10.568***	(1.656)	0.090	(0.288)
SOUTH	-0.181	(0.132)	-8.316**	(3.263)	-0.132	(0.430)
REVENUES_PROCAP	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
DEBT_RATIO	0.009***	(0.002)	-0.081*	(0.042)	0.006	(0.013)
CAPITAL_TURNOVER	-0.080	(0.082)	-4.845***	(1.857)	-0.292	(0.311)
Air Conditioning	-0.102	(0.185)	-0.093	(0.135)	-0.766	(0.676)
Compressed Air	0.238**	(0.100)	0.375***	(0.072)	-2.388**	(1.049)
Electric Motors/Inverters	-0.477***	(0.117)	-0.289***	(0.084)	-1.935***	(0.621)
Electrical Systems	-0.272**	(0.115)	-0.438***	(0.083)	-1.844***	(0.452)
General	0.444***	(0.110)	0.419***	(0.079)	-0.236	(0.542)
Process Cooling	-0.435**	(0.184)	-0.338**	(0.135)	-1.792***	(0.637)
Production Lines	-0.321***	(0.118)	-0.203**	(0.088)	-1.617***	(0.404)
Suction	-0.472*	(0.286)	-0.381*	(0.214)	-12.912	(509.349)
Transportation	-0.827***	(0.215)	-0.672***	(0.144)	-1.261	(1.544)
Thermal Power Plant/Thermal Recovery	0.673***	(0.213)	1.196***	(0.156)	0.262	(0.650)
Other	-0.787*	(0.456)	-0.135	(0.327)	-0.810	(1.616)
Constant	-11.452***	(0.310)			-14.662***	(1.465)
Observation	1364				1364	
R2	0.643					
Adjusted R2	0.636					
Akaike Inf. Crit.					577.353	
Bayesian Inf. Crit					**707.8076**	
Residual Std. Error			0.626 (df = 947)			
F Statistic			201.813*** (df = 417; 947)			

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Note:*p<0.1; **p<0.05; *** p<0.0**1**

Table 26: Estimation results of the pooled OLS and the logistic regression for the all the other areas of interventions.

The parameters related to the economic dimension of the energy efficiency measures show very encouraging results, all the approaches used lead us to observe a significant and positive role of the *investment* level in influencing the future level of energy performances in the sector of plastic and rubber production, obviously, the greater the initial investment made for the implementation of the measures, the higher is likelihood for businesses to experience a superior performance, in the pooled OLS model without fixed effects the impact of the investments level alteration on the dependent variable can be interpreted in terms of elasticity as the logarithm is applied to this predictor (in order to reduce the impact of observations particularly distant from the mean), therefore a variation percentage of the same is associated with an increase in savings performance equal to **0.83%,** for the OLS model including fixed effects the elasticity among the two variables concerned reach **1.0%**.

In the logit approach we observe the same significant and positive relationship, if the *investment* carried out by the production sites increase (at the unitary level) its multiplicative effect on the odds (energy savings performances above its average) is about **4.49** (**exponential of β_i**).

As regard the payback periods, we can confirm that if the period necessary to recover the initial expenditure augment financial concern arise for the company decision makers, disincentivizing the implementation of EEMs, in the OLS without fixed effects we observe a **0.11%** reduction of the dependent variable related to a unit increase of the predictor, while once that we control for traits pertinent to the firms, exploiting the fixed effects, such percentage reduction is equal to **0.16%**, considering instead the logistic regression the same alteration of *PBP* led to an higher percentual variation of the odds ratio consisting in **10.41%.**

Turning our attention on the variables inherent firms traits, in the OLS framework without fixed effects, we discern the role played by the parameters GI (large company), MONITORING and ENERGY INTENSIVE, the first assume significance with a negative coefficient and this coveys that the bigger is the size of the production site concerned the lower is the possibility to experience a superior performance, precisely, if GI assume value equal to one this will guide response variable to decrease in percentage of **0.61%**, in this case, therefore, the dimension of the company or site considered impacts negatively the energy efficiency paths that could be concretized, similarly in the logistic regression we find a percentual variation of the odds ratio of about **10.46%**.

This relation between the firm size and the energy savings performance could be explained, considering the OLS model deprived of fixed effects in which ENERGY INTENSIVE has proved to be significant and negative, with a lower value than GI.

In particular energy intensive enterprise sees a percentage reduction in the energy performance of about **0.42%**, indeed the magnitude of energy consumption of this companies generate pressure for energy cost reduction than for large enterprises, and is likely to be associated with a better awareness of their consumption profile (and then with a better ability to plan effective energy savings measures).

Where energy intensive is not anymore significant (the logistic regression) these explanations lose their meaning and we may find another cause by accounting for the fact that larger firms have a different perception of drivers and barriers to EEM adoption (Cagno and Trianni, 2013)[20].

The empirical research done on energy efficiency barriers and drivers predominantly assesses the energy intensity of firms in terms of costs faced by them for energy carriers, the uniqueness of the data possessed by ENEA allows us to directly evaluate the magnitude of these flows, in a portion of empirical contributions the assumption for which the intensity of energy carriers, therefore their costs, incentivizes the adoption of efficiency measures has been confirmed (Kostka et al, 2013; Henriques and Catarino, 2016[21]; Fresner et al., 2017[22]), in other cases the results have led to the opposite scenario (Schleich and Gruber, 2008[23]; Fleiter et al, 2012[24]), all the way in this study the negative role played by the above-mentioned parameter cannot be explained through a comparison of costs, in this case having dependent factors as a ratio in which the denominator are consumption flows of firms such a relationship could be due to the greater weight assumed by them compared to the realizable savings pertinent the individual interventions, especially considering that a considerable portion of the EEMs within the database, taken individually, provide for not so high values of realizable savings in tonnes of oil equivalent.

As far as the MONITORING parameter is concerned, it also leads, in the OLS without fixed effects formulation, to a of the energy saving performance **(- 37%)**, however this does not directly drive to the fact that monitoring production activities worsens the evolution of energy efficiency paths in fact, this relation demonstrates how the parties subjected to monitoring have, in order to carry it out correctly, introduced mechanisms for an accurate individuation and quantification of the energy carriers consumed as well the possible savings that could be materialized, the estimates regarding this latter aspect are therefore more precise than those of other firms subjected to the energy audit obligation, therefore the performance is "negatively" affected, finally the same result is obtained in the logistic modeling choice and the multiplicative effect on the odds ratio (Y=1) is equivalent to **2.795** (exponential of β_i).

[20] *Empirical investigation of energy efficiency barriers in Italian manufacturing SMEs.*
Cagno and Trianni. (2013).

[21] Motivating towards energy efficiency in small and medium enterprises.
Henriques and Catarino (2016).

[22] *Energy efficiency in small and medium enterprises: Lessons learned from 280 energy audits across Europe.*
Fresner, Fabio Morea, Christina Krenn, Juan Aranda Uson and Fabio Tomasi.

[23] *Beyond case studies: Barriers to energy efficiency in commerce and the services sector.*
Schleich and Gruber (2008).

[24] *Adoption of energy-efficiency measures in SMEs – An empirical analysis based on energy audit data.*
Fleiter, Schleichb and Ravivanpongc (2012).

The dummies representing the geographical location of the firms from which the audits, and so the relative interventions, have been received , assume different roles in the models considered, in the linear regression formulation, with fixed effects, we clearly see the significance of all the three geographical macro areas, for instance in the NORTH-EAST area relative to all the other locations including those referring to the central part of Italy used as baseline area (in the light of the fact that has not been included in the models), we see a percentage reduction of the energy performance equivalent to **5.7%**, a decrement even higher if we instead consider the southern regions of the peninsula, the parameter SOUTH led to **8.31%** decrement of the energy savings performance level with respect to the other scenarios, finally for the NORTH-WEST parameter has been found the highest relative decrease of the dependent variable of about **10.57%,** looking at this results we can affirm that firms located in the north-east regions of the nation exhibits the best energy saving performances**.**

Considering alternatively the model without fixed effects, only one macro area assumes significance, i.e., the NORTH-WEST area, it is interesting to note how its coefficient changes if we do not control for the characteristics of the firms, becoming positive and therefore the measures identified in firms located in such regions lead to a percentage increase in the performance equal to **0.18%**.

No significance was found for macro geographical areas in the logistic modelling choice.

The AIDA parameters assume relevance exclusively for the linear regression models; for what concern the outcomes achieved including the dummy representing the fixed effects, we observe a significance for the parameters *debt ratio* and *capital turnover*, in particular this latter result would indicate that greater the number of times in which the company is able to recover the capital invested in management through sales and revenues the lower the energy saving performance achievable.

Despite the general expectation that firms with higher profitability, and in this case a higher aptitude for dynamic cash flows, face fewer financial constraints and thus be more inclined to adopt EEM, the empirical evidence in several contributions, especially for what concerns manufacturing SMEs did not confirm this hypothesis, in this case instead we see a clear negative role of capital turnover indicating how an efficient management is not necessarily linked to increases in energy efficiency, percentage *reduction* of the performance equal to **4.84%** has been found for the *capital turnover* unitarian variation.

Shifting our attention to the impact of the financial liabilities of firms (*debt ratio*), in the literature such impact is generally used to evaluate how the availability of finances impinges on energy efficiency paths, alternatively measured by considering the company's profitability; several empirical works suggest that access to capital, may be a particularly prominent real economic barrier specially for SMEs, enterprises encounter numerous challenges related to debt servicing due to a relatively higher share of liabilities which discourages the adoption of the measures, anyway the such contributions on the issue once again offer opposing propositions, for instance Kounetas and Tsekouras [25](2008) found that profitability has a deleterious influence on energy efficiency investments, while DeCanio and Watkins[26] (1998) did not find that the debt-to-equity ratio behaving as a real barrier.

Concerning the finding obtained here for indebtedness, the parameter (*debt ratio*) assumes relevance in both OLS approaches, but again conflicting results are found, in the modelling choice not including dummies controlling for the presence of firm characteristics (fixed effects) a unit increase in liability leads to a slight percentage increment in the dependent variable (**0. 009%**), in the opposite modelling choice, therefore controlling for factors common to the production sites examined, the coefficient of this variable becomes negative although it remains particularly low (**- 0.08%**), these outcomes would suggest the influence of an increase in the quantity of assets financed through debt differentially effects energy saving performance in connection with the traits of the enterprise in question.

As for the results inherent to fixed effects themselves (OLS model), since these dummies are constructed exploiting the site ID code, they cannot be explicitly listed in this analysis as particularly sensitive information would be displayed, so here we simply confirm that they are significant for the majority of the sites considered, validating the existence of specific features, not controlled by the other predictors, common to sites belonging to the same VAT, these findings open the way for further investigation of these traits capable of generating better energy performances.

To conclude, the intervention areas show different patterns of behavior although the majority of them are significant in all the models exhibited, beginning with the OLS model not including fixed effects we observe how, relative to all the other intervention areas and to the baseline one (presented by lighting as it is not incorporated in the modelling), *Compressed air, General* and *Thermal power plant/Thermal recovery* assume a positive impact on the response parameter, in particular, the investment on efficiency measures pertaining to *Compressed Air* would lead to an improvement in savings performance of **0.24%,** while for the behavioral/organizational EEMs (*General* area) an augmentation of the dependent variable, relatively to the other areas, of **0.44%** is expected, and for the last of the three areas mentioned is found the highest increment, of about **0.67%.**

For the OLS model with fixed effects, the same results seen above regarding the areas of intervention can be confirmed, with the exception of the *Compressed Air* parameter, which assumes a negative coefficient in this approach, hence when we control for the traits inherent to the company, the implementation measures in this area, relatively to all the other areas, leads to a decrement in savings performances of **-0.093%**.

[25] *The energy efficiency paradox revisited through a partial observability approach*.
Kounetas and Tsekouras (2008).
[26] *Investment In Energy Efficiency: Do the Characteristics of Firms Matter?*
DeCanio and Watkins (1998).

Examining the logistic model output, we cannot confirm the positive repercussions on the dependent variable previously seen for intervention areas, in this approach the numerosity of parameters having significance is reduced (only *Compressed air, Electric motors/inverters, Electric Systems, Process Cooling and Production Lines* are significant) and all exhibit a negative coefficient, for instance, the introduction of an energy efficiency measure for the improvement of the *Process Cooling* has a multiplicative effect on the odds ratio, relative to implementing measures pertaining to other areas, of about **-6.01** (exponential of β_i).

5.1.2 The Ols Model *for Production from Renewables and Cogeneration/trigeneration.*

Given the magnitude, of both economic and technical dimension, of the interventions relating to the installation of plants for the *Production of energy* carriers *from Renewable sources* and for *Cogeneration/Trigeneration* processes, it is extremely rare to observe more than one intervention of this type implemented by the same company, an ascertainment further corroborated by the numerosity of the database, i.e., **208 observations**.

For these reasons the modelling choice of introducing fixed effects loses its meaning, and for the same reasons the logistic regression model is not an adequate approach, we therefore proceed to expose the findings obtained using a linear regression model devoid of fixed effects.

Results are in general consistent with those described for all other intervention areas in previous section.

Dependent variable:	**Log(Performance)**	
	POOLED OLS (Without fixed effects)	
		Std.error
Log(Investment)	0.747***	(0.078)
VAN	-0.000	(0.000)
PBP	-0.069***	(0.024)
GI	-0.436**	(0.199)
ENERGY_INTENSIVE	-0.443	(0.425)
MONITORING	-0.525***	(0.170)
ISO 5000	-0.201	(0.434)
NORTH-EAST	0.472**	(0.229)
NORTH-WEST	0.295	(0.187)
SOUTH	0.086	(0.247)
REVENUES_PROCAP	-0.000	(0.000)
DEBT_RATIO	0.016*	(0.009)
CAPITAL_TURNOVER	-0.256	(0.198)

Constant		-10.583***
		(1.048)
Observations	208	
R2	0.453	
Adjusted R2	**0.420**	
Residual Std. Error	1.000 (df= 195)	
F Statistic	13.472*** (df= 12; 195)	
==============================		
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 27: Estimation results of the pooled OLS for the areas production from renewables and Cogeneration/Trigeneration.

The role played by the investment level is confirmed also for these two intervention areas, in this case leads in the pooled OLS model to a relevant percentage change in the dependent variable due to a 1% change in the *investment* itself, equal to **0.75%**, while for its net present value we still not find any significance.

Turning our gaze on another relevant dimension of the expenditures on EEMs, the *payback period*, we observe, as for the previous results but with a lower magnitude, how longer periods required to recover the investment negatively affect the response variable, a unitary variation of it would lead to a decrease in the savings performance for companies equal to **0.07%** .

Regarding the dummies representing the features of the business considered, in this case, as for all the other intervention areas (Chapter 5.1.1) we observe the significance of the GI parameter, precisely, we are able to spot a negative role played by this specific trait leading to a reduction of the response variable of about **0.44%**, nonetheless in this case, we cannot explain it as a matter of energy carriers consumed, otherwise energy intensity would prove to be significant.

Taking into consideration the body of works in the field, different empirical studies do not clarify the weight assumed by some company and business-related traits, such for instance the firm *size*, anyway we should bear in mind that this latter aspect can impact on the magnitude of other barriers such the difficulties found in accessing the capital needed and directly or indirectly negatively shaping the energy performances.

Even for these areas of intervention the presence of mechanisms for MONITORING energy flows is significant, its negative role is once again attributable to the improved estimates that such mechanisms entail.

Turning our gaze on the macro regional areas, the coefficients of the linear regression model suggests the significance only of the *northeast* predictor; measure identified in production sites located in this regions, compared to the baseline scenario (the central area) and the other parameters (south and northwest), led to an expected percentage variation of Y equal to **60.32%**, which can be explained by underlining the large number of interventions observed in production sites located in this regional area.

As far as the AIDA variables are concerned, we can only spot the significance of the *debt ratio*, even for this model we can confirm that if we do not control for the traits of the firms a slight increase of the response variable, consisting in **0.016%**, is associated to a unitarian increase of the firm's indebtedness.

It is all the more necessary to bring to the reader's attention that these results are influenced by the low number of observations relevant to these areas of intervention.

5.2) Econometric models with the *white certificate* variable

Section 4.3 details the procedure for the construction of the white certificates parameter, which enables us to gauge how the existence of incentive policies can affect the energy saving performance of companies, all the way, based on the information provided by **GSE**, it was possible to develop it only for certain intervention areas, consequently approaches refer to a restricted database of **1079** observation, in the next subsection we will examine the findings achieved by utilizing the maximum likelihood (ML) estimation method both the logit and ols models for the family of intervention areas that do not employ self-production of energy ("all the other intervention areas").

5.2.1) The Logit Models and Ols Models *for all the intervention areas.*

(Excluded Production from Renewables and Cogeneration/trigeneration)

In the subsequent table are reported, in comparison, the results obtained using the linear regression models (including and not including the fixed effects) and the logistic regression approach.

Dependent variable:	**Log(Performance)**				**Performance_dummy(2)**	
	Coefficients' POOLED OLS (Without fixed effects)	**Std.error**	**Coefficients' POOLED OLS with fixed effects**	**Std.error**	**Coefficients' Logistic model**	**Std.error**
Log(Investment)	0.658***	(0.027)	0.872***	(0.021)	0.994***	(0.103)
VAN	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
PBP	-0.150***	(0.011)	-0.207***	(0.009)	-0.193***	(0.036)
WHITE CERTIFICATE	0.187**	(0.081)	0.104*	(0.057)	0.289	(0.202)
GI	-0.572***	(0.087)			-1.167***	(0.246)
ENERGY_INTENSIVE	-0.564**	(0.225)			-1.195**	(0.558)
MONITORING	-0.307***	(0.077)			-0.770***	(0.206)
ISO 5000	0.166	(0.182)			0.553	(0.458)
NORTH-EAST	-0.014	(0.100)	-10.667**	(4.427)	-0.233	(0.268)
NORTH-WEST	0.137*	(0.082)	-13.464***	(2.609)	0.113	(0.222)
SOUTH	-0.231	(0.146)	-14.974*	(5.231)	0.047	(0.368)
REVENUES_PROCAP	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
DEBT_RATIO	0.007***	(0.002)	-0.014	(0.056)	0.004	(0.006)
CAPITAL_TURNOVER	-0.032	(0.085)	-0.732	(2.937)	-0.264	(0.231)
Air Conditioning	0.458***	(0.177)	0.289*	(0.121)	0.550	(0.421)
Compressed Air	0.539***	(0.096)	0.548***	(0.065)	0.336	(0.283)
Electric Motors/Inverters	-0.102	(0.114)	-0.380	(0.081)	-0.066	(0.337)
Electrical Systems	0.343**	(0.165)	0.025	(0.114)	0.789**	(0.384)
General	0.689***	(0.112)	0.575***	(0.078)	1.088***	(0.286)
Process Cooling	0.260	(0.180)	0.177	(0.126)	1.200***	(0.434)
Production Lines	0.402***	(0.121)	0.286***	(0.084)	0.882***	(0.313)
Suction	-0.128	(0.267)	-0.060	(0.194)	-14.010	(532.752)
Transportation	-0.389*	(0.202)	-0.380**	(0.129)	-0.091	(0.758)
Thermal Power Plant/Thermal Recovery	1.235***	(0.201)	1.541***	(0.142)	1.817***	(0.504)
Constant	-10.138***	(0.344)			-8.268***	(1.112)
Observation	1079		1079		1079	
R2	0.537					
Adjusted R2	0.527					
Akaike Inf. Crit.					939.7693	
Bayesian Inf. Crit					**1064.364**	
Residual Std. Error			0.626 (df = 947)			
F Statistic			201.813*** (df = 417; 947)			
================						
Note:* p<0.1; **p<0.05;	*** p<0.01					

Table 28: Estimation results of the pooled OLS and the logistic regression introducing white certificate (all the other intervention areas).

The results listed above, with regards to all areas of intervention not involving self-generation of energy carriers, show how once the parameter representing the incetivation tool is being introduced, the role being played by the level of *investment* continues to be significant and beneficial, in fact in the OLS without fixed effects we observe how the elasticity between the aforementioned predictor and the response variable is the equivalent of **0.658**, while once we introduce the fixed effects dummies it augment to **0.872.**

In the logistic regression to a unitarian increment of the initial expenditure faced by the business is coupled with particularly high percentual variation in the odds for the event "higher-than-average energy saving performance", which is equal to **170.2%.**

The weight assumed by longer *payback period* in reducing the energy savings performance is also here confirmed, in the OLS model not including fixed effects the augment of such temporal dimension would lead to a **0.150%** reduction of the response variable, while if we control for the traits of the production site the impact of such parameter on the performance is even greater (**-0.207%**), turning the gaze on the logistic regression the expected percentual variation of the odds ratio is equivalent to **-21.28%**, overall the outcomes relating PBP are in line with the empirical findings of Anderson and Newell[27] (2004), suggesting that the risk inherent in energy efficiency interventions, therefore inherent in their different technical nature and in some cases in their economic dimension, requires shorter Payback periods, we can state that the parameter effectively behave as a barrier to EEMs adoption.

The introduction of *White Certificates* did not produce any variations regarding the role of MONITORING, GI and ENERGY INTENSIVE, in the OLS model without fixed effects and in the logistic version all the three indicators are significant showing negative coefficients.

In detail, the OLS model (without fixed effects) convey a variation in the response variable associated with the presence of monitoring mechanisms of **-0.31%**, while if the company is a large company, its energy saving performance is reduced by **-0.52%**, and instead if the company in question is characterized by significant energy consumption, its performance decreases by **-0.57%**.

In the logit model, on the other hand, the actuation of the monitoring for the sites concerned causes a change in the odds ratio of **-53.6%**, while a large enterprise confronts heavily reduced performances of **-230.35%**, and finally in the case of an *energy-intensive* company, the response factor is decremented of **-221.23%.**

[27] *Information programs for technology adoption: the case of energy-efficiency audits.*
Anderson and Newell (2004).

The fixed effects introduced for the site code again are significant for the majority of sites considered, indicating, even in this model, the presence of factors common to them capable of bearing on our response variable.

With regard to the regional macro areas, we obtain results parallel to those achieved in the models without the *white certificate*, in the linear regression formulation, with fixed effects, we clearly see the significance of all the three geographical macro areas, anyway for interventions deriving from production activities located in the southern Italy is found the highest percentage reduction, relatively to all the other Italians macro areas, of the response variable, equal to **-14.97%**, the relative variations that results for NORTHWEST and NORTHEAST, on the other hand, are respectively, equal to **-13.45%** and **-10.67%.**

Indebtedness (*debt ratio*) demonstrates a similar pattern of behavior to the cases with no white certificates, bearing a notably small, positive and significant coefficient in the linear model excluding fixed effects and once the existence of incentive instruments for EEMs adoption is taken into effect, no other significance for variables tied to firm productivity, i.e., AIDA parameters, is found, in all three approaches.

Intervention areas seem to adopt different weights and roles in these models; in the case of OLS without fixed effects, the most of these parameters assume significance, and in contrast to the results seen in section 5.1.1, once the availability of incentive mechanisms is accounted for, all the (significant) intervention areas display a positive coefficient with the exception of *Transport*, in point of fact an investment in a measure to improve energy consumption for transport brings about a slight reduction, relative to all other areas, of performance equal to **-0.4%,** while for the General parameter we obtain the highest percentage change, always relatively speaking, of energy saving performance, i.e. **0.7%.**

Moving our interest to the probability model, we detect a different outcome from the modelling excluding the incentives: the areas *Electrical Systems, General, Process Cooling, Production Lines* and *Thermal power plant/ Thermal recovery* are found to be significant, all with a positive coefficient, while the latter mentioned displays the highest multiplicative effect on the odds ratio (6.15), the former (*Electrical systems*) is connected with the lowest multiplicative effect, i.e., **2.2,** this result could be due to a different impact of incentive scheme modelled.

Finally, for what concern the protagonist variable in this framework, we are able to detect its significance only in the OLS formulations, both the model shows for the WHITE CERTIFICATE a positive coefficient, anyway when we control for firms characteristics the role assumed by this incetivation tool decrease, in fact in former OLS (without fixed effects) the parameter is coupled with a performance variation of **0.19%** and such alteration reach the value of **0.10%** if we consider the linear regression model with the fixed effects.

Despite the small magnitude of these coefficients, it is necessary to emphasize that the information content of the variable itself is particularly poor, further information on the economic size of these incentives would enrich the analysis, perhaps allowing a different magnitude to be found for the associated coefficients, moreover, the literature on the subject still seems to be far from including instruments reflecting national and/or regional policy, other than the audits, in the modeling choices, anyway the obtained outcomes confirm the need to expand perspectives on adoption of EEMs.

In order to place more emphasis on these policy stimuli, an attempt was made to assess whether this variable assumes a different role once those factors that are prominent in the database because of its form, i.e., the intervention areas, were removed, a logistic regression model was therefore developed with the same structure as the previous one but with the removal of the above-mentioned predictors, as shown in Table 29, not only the role of white certificates but also the role of the variables related to the company itself is revealed**.**

Dependent variable:	**Performance_dummy(I)**	
	Coefficients' Logistic model	**Std.dev**
Log(Investment)	0.975***	(0.090)
VAN	-0.000	(0.000)
PBP	-0.194***	(0.037)
GI	-1.268***	(0.241)
ENERGY_INTENSIVE	-1.228**	(0.545)
MONITORING	-0.756***	(0.197)
ISO 5000	0.493	(0.445)
WHITE CERTIFICATE	0.438**	(0.175)
NORTH-EAST	-0.215	(0.262)
NORTH-OVEST	0.100	(0.212)
SOUTH	-0.018	(0.348)
REVENUES_PROCAP	-0.000	(0.000)
DEBT_RATIO	0.006	(0.006)
CAPITAL_TURNOVER	-0.296	(0.224)
Constant	-7.572***	(0.953)
Observations	1093	
Akaike Inf. Crit.	961.099	
Bayesian Inf. Crit	**1035.856**	

==============================
Note: *p<0.1; **p<0.05; ***p<0.01

Table 29: Estimation results of the logistic regression introducing white certificates and removing all the interventions areas.

For the latter model the results inherent in the significant variables are in line with what was discovered earlier, for example a negative role is evidenced for ENERGY_INTENSIVE, MONITORING and GI variables, longer *payback* period still be associated to a reduction of the response parameter while the increase of the investment to an its augment, with regard, instead, to geographic areas and AIDA indicators no significance is detected.

A positive and significant coefficient associated with white certificates is identified, capable in this case of increasing the odds ratio, for the event “energy savings performance above the average one”, of about **55%**, all the way the results of this model should be evaluated very cautiously since the removal of the parameters related to the areas of intervention leads to a worsening of the BIC compared to the case in which these are incorporated in the models, even if such it is a slight deterioration also due to the reduced number of parameters considered.

5.3)Future research directions.

The review of the literature and empirical studies, for the understanding of the drivers and barriers experienced by companies regarding energy efficiency measures, shows the tendency to bring at the center of the analysis factors purely related to productivity, management and culture of the company, the different perception of the barriers themselves has been investigated in connection with these features, as for the external context instead this seems to be perceived mostly in terms of competition in the market, i.e., in the majority of the inquired studies extremely prominence is given to indicators which reflect the pressure exerted by the external context looking mostly at market forces and although some authors explicitly included elements of the legislative context such as energy audits, the attention paid to the role of regional and national policies seems to be notably scarce especially considering the empirical contributions adopting econometric models.

A specific geographic location, such as a region, assumes certain "genetic" traits, the local policies adopted, the industrial clusters that are present, and the population culture itself in terms of perceptions of the actions needed to tackle climate change, are all factors that indirectly or directly create stimuli or impediments to future energy efficiency pathways, following this reasoning, the use of econometric models with spatial connotations would essentially allow for the evaluation of the effect assumed by these elements in the different spatial references selected and to compare them.

In addition, the present study exploits for the first time a really extensive database by adopting an approach that is aware of the role of incentive policies but nevertheless limited to the introduction of a single instrument, white certificates, with national validity, there is thus the possibility of enriching this approach, not only by expanding the sphere of incentive mechanisms introduced in the model but also by recognizing the existence of policies at the regional level common to different production sites perhaps capable of determining different energy-saving performance, furthermore, the information contained by the variable white certificates is extendable by factoring in the economic level assumed by that policy support rather than exclusively considering its presence and/or absence.

Another limitation of the approaches used in this area is related to the choice of the models themselves, in most empirical evaluations we see researchers focused on whether or not to verify the adoption of the measures through logistic regression models, this study differs in that the response variable itself is obtained as the ratio of achievable savings to experienced consumption streams and then transformed to logistic if that ratio exceeds the average value of its own distribution, all the way the basis on which that variable is built would allow us to further sophisticate the entire exercise by considering an ordered logit model, that is, constructing an ordinal response variable whose different values are associated with specific quantiles of the distribution of that ratio, this would allow us to analyze factors capable of influencing specific ranges of performance.

In conclusion, the use of econometric models for the evaluation of walkable pathways in terms of energy efficiency seems to be a vein of literature with enormous potential pertaining to the possibility of using models capable of recognizing the presence of spatial correlation, broadening the factors generally considered and introduced in the models by also turning our gaze to the role assumed by normative tools, and the rising possibility of exploiting very robust data from agencies in charge of maintaining and improving databases inherent in energy audits.

Conclusions.

The concept of energy efficiency is now the protagonist in a scenario in which saving in energy consumption is proving to be fundamental for the fight against the rise in global average temperatures, a role that is even more stressed if we consider how this scenario concurrently sees increased needs for energy independence of the member countries of the European Union.

The growing recognition of the relevance assumed by pathways for improving energy efficiency has conducted over time to profound changes in the European, and consequently Italian, regulatory framework regarding the end uses of energy flows, requiring continued efforts from households and businesses.

In particular, the latter encounter a number of technical, behavioral, economic and market barriers that discourage business decision makers from pursuing energy efficiency paths, and therefore impacting on the national capability to achieve the arranged national and sectoral objectives with regard to enhanced energy efficiency, moreover, these barriers and their impact seem assume different magnitudes depending on the characteristics of the measures and of the companies themselves.

This study exploits, for the first time, a data bank consisting of information collected through one of the currently central tools for managing energy flows in production, energy audits; in Italy ENEA is, according to Legislative decree 102/2014 on Energy Efficiency, the entity in charge of setting up and maintaining this database, as well as of verifying that the content of the audits is in line with the defined guidelines.

This study focuses, in detail, on the information related to energy consumption and the efficiency measures that could be implemented pertaining the audits received by the plastics production sector in 2018.

Since the interventions themselves, identified through the audits, are of a different nature, these may be associated with specific areas, i.e., *Air Conditioning, Compressed Air*, *Electric Motors/Inverters*, *Electrical Systems, General, Process Cooling, Production Lines, Suction, Transportation, Thermal Power Plant/Thermal Recovery, Other*, *Production from renewables and Cogeneration/Trigeneration*, in particular these latter two areas are distinguished in that they pertain to the installation of plants capable of self-generating energy carriers along with the energy savings obtainable with their introduction, therefore they are analyzed separately.

The analysis focuses on the use of econometric methodologies to identify factors characterizing companies, the socio-economic context and energy efficiency interventions capable of generating above-average energy saving performance, in particular, the study also recognizes the importance, for invigorating the adoption of the measures, of the most relevant incentive tool in the industry, in the field of energy efficiency, namely white certificates.

Precisely, we investigate the existence of barriers and drivers to the adoption, of interventions designed to reduce energy consumption for a given end use, exploiting, in line with the literature on the matter, on one hand logistic regression models in which the response variable acquires dichotomous character and equal to one if the energy performance of the considered site exceeds the average one, in the other hand the approach has been complemented by linear regression model, in particular, this latter has been characterized by the modelling choice of introducing fixed effects for the site code in an effort to investigate deeply the eventual existence of common traits to production sites belonging to the same company able to affect the dependent variable, which have proved to be significant.

Although different approaches were tested we can summarize the results obtained by recognizing the existence of firm characteristics as well as characteristics of the interventions themselves, identified through the areas of categorization, that are actually able to affect the energy efficiency paths of production sites.

Large companies, even disregarding the energy flows consumed and the impact of the obligation to realize energy audits, seem to have a different perception of the barriers themselves and therefore they exhibit lower performances, relative to other companies, on the other hand energy-intensive companies, facing a greater need to cut energy costs, display in this study a relatively improved energy savings performance (with respect to large enterprises), moreover, the presence of monitoring mechanisms for energy carriers also shows a negative effect on the response variable, anyway, these results must be evaluated taking into account that our dependent variable is a ratio at the denominator of which are the consumption flows of the enterprises, which obviously assume greater weight than the achievable savings inherent in the individual interventions placed at the numerator, especially considering that a substantial part of the EEMs within the database, taken individually, predict not very high values of achievable savings in tons of oil equivalent.

The models cited above also include parameters related to the productivity of the firms from which the diagnoses are obtained, these variables were elicited by exploiting an adjunct database, AIDA, in detail the role of per-capita revenues, indebtedness, and capital turnover were explored.

The first of the three parameters does not seem to assume any significance in any of the approaches developed, while considering the indebtedness of the firms, it can act as a slight barrier to adoption or alternatively, if we control for the inherent characteristics of the firms themselves, it can turn into a tool capable of bringing about positive variation in energy performances, as regard the capital turnover instead, an indicator of management efficiency, it shows a negative impact on our response variable contrary to the general expectation that more dynamic firms, having access to more dynamic cash flow, would be able to invest relatively more in efficiency measures.

The models have also confirmed the relevance of the economic/financial dimension linked to the interventions themselves in determining the aforementioned performances, higher levels of investment conduce to superior energy savings performances, all in all, if the time required to recover the expenditures initially incurred by the companies is extended, the risk assumed by these interventions dissuades their adoption, the risk associated with longer payback period thus appears to act as a real barrier, the weight of which could fluctuate considering the different technical nature of the measures themselves.

Spatial elements were introduced by assessing the origin of the measures identified, i.e., the regional macro area was controlled using dichotomous variables, and it can be seen that in relation to the other areas, the firms located in the southern part of Italy seems to perform less well, for the north-east and north-west macro areas in the different approaches, contrasting results have been obtained, however the very significance of these parameters suggests the existence of a path for a greater sophistication of the approach itself, in order to better reflect the weight assumed by these spatial components, or rather, by the elements characterizing the genetics of a given geographical location in determining the energy performance of companies.

The introduction of the white certificates variable in the aforementioned models conduct us to discover its, albeit small, significant and positive coefficient; the presence of tools capable of reducing the weight taken on by energy efficiency barriers of an economic nature seems to achieve its purpose by stimulating alteration in the path of efficiency of the sites considered, this leads us to the inevitable conclusion that a greater recognition of the role played by the legislative context is necessary for a future expansion of research in the field.

In conclusion, the investigation of role assumed by certain firms characteristics still offer an ample research margin for a better understanding of the directions that these traits assume.

Althougt, the literature on the subject provides a vast panorama of different findings regarding the aforementioned factors, however, there are few approaches that extend themselves to spatial and political dimensions, introducing context elements other than market conditions and competition into the analyses.

This study offers a springboard for such approaches, empirically justifying their need.

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Appendix 1: Tested models.

In this section, for simplicity, we will refer to variables such as GI, MONITORING, ISO5000 AND ENERGY INTESIVE as “firm dummies”.

The following table shows in comparison the results obtained regarding the goodness of the tested models.

MODELS FOR ALL THE INTERVENTION AREAS (excluding production from renewables and Cogeneration/Trigeneration)	**BIC**	**AIC**	**Adjusted R^2**
OLS MODEL (Fixed effects + firm dummies)	5370.184	3183.768	
OLS MODEL+ Fixed effects Without firm dummies	5363.438	3182.24	
OLS MODEL + Firm dummies Without fixed effects	4310.912	3182.24	0.6365
OLS MODEL with WHITE CERTIFICATE (Fixed effects + firm dummies)	4134.984	2201.273	
OLS MODEL with WHITE CERTIFICATE + Fixed effects Without firm dummies	4128.124	3583.405	
OLS MODEL with WHITE CERTIFICATE + Firm dummies Without fixed effects	3272.585	3143.006	0.5266
LOGIT MODEL [28] (Fixed effects + firm dummies)	5540.254	3359.1	
LOGIT MODEL +firm dummies Without fixed effects	**707.808**	**577.35**	
LOGIT MODEL+ fixed effects Without firm dummies	6614.345	4438.4	
LOGIT MODEL with WHITE CERTIFICATE (Fixed effects + firm dummies)	5586.219	3657	
LOGIT MODEL with WHITE CERTIFICATE + Firm dummies Without fixed effects	**1064.364**	**939.77**	
LOGIT MODEL with WHITE CERTIFICATE + Fixed effects Without firm dummies	5507.148	3583.4	

[28] All the logit models here assume as a response variable a binary one which assume value equal to one if the energy saving performance is higher than the average of its own distribution.

LOGIT MODEL with WHITE CERTIFICATE + Firm dummies Without fixed effects and n-1 dummy for Intervention areas	1035.856	961.0991	
MODEL FOR *Production from Renewables and Cogeneration/Trigeneration.* **OLS MODEL +** Firm dummies Without fixed effects	651.6546	604.929	0.4196

TESTING THE ROBUSTNESS OF THE RESULTS

LOGIT MODEL INVESTIGATING A BINARY RESPONSE VARIABILE CONSTRUCTED USING THE MEDIAN AS A TREESHOLD

(Equal to 1 if the energy savings performance exceeds the median one)

MODELS FOR ALL THE INTERVENTION AREAS (excluding production from renewables and Cogeneration/Trigeneration)	**BIC**	**AIC**	**Adjusted R^2**
LOGIT MODEL (Fixed effects + firm dummies)	11739.76	9558.564	
LOGIT MODEL +firm dummies Without fixed effects	1427.028	296.574	
LOGIT MODEL+ fixed effects Without firm dummies	**11732.54**	9556.564	
LOGIT MODEL with WHITE CERTIFICATE (Fixed effects + firm dummies)	8685.973	6757.246	
LOGIT MODEL with WHITE CERTIFICATE + Firm dummies Without fixed effects	**1244.352**	1119.757	
LOGIT MODEL with WHITE CERTIFICATE + Fixed effects Without firm dummies	8246.466	6322.723	

LOGIT AND OLS MODEL IN WHICH THE BASELINE INTERVENTION AREA IS COMPRESSED AIR. (Models in which is inserted the parameter Lighting and removed Compressed air)

MODELS FOR ALL THE INTERVENTION AREAS (excluding production from renewables and Cogeneration/Trigeneration)	**BIC**	**AIC**	**Adjusted R^2**
OLS MODEL+ Fixed effects Without firm dummies	5161.293	2980.095	
OLS MODEL + Firm dummies Without fixed effects	4194.528	4058.856	0.6659
LOGIT MODEL+ Firm dummies Without fixed effects	683.2973	552.8429	
OLS MODEL with WHITE CERTIFICATE+ Fixed effects Without firm dummies	4128.124	2199.397	
OLS MODEL with WHITE CERTIFICATE+ Firm dummies Without fixed effects	3272.585	3143.006	
LOGIT MODEL with WHITE CERTIFICATE+ + Firm dummies Without fixed effects	1064.364	939.7693	

APPENDIX 2: The R scripts.

R codes for regression models referring to the intervention areas Production from Renewable sources and Cogeneration/Trigeneration.

Database:

```
>primari<-primari_03_02[,-14]

>PRIMARI<-na.omit(primari)

names(PRIMARI)<-
c("TIp","REGIONp","MULTISITEp","MULTISIDE_CODEp","PROVINCEp","MUNICIPALITYp","CFp","PIVAp","MACRO_ACTSITEp
","ATECOp","ACTIVITYp","MONITORING2DATAp","INTERVENTIONp","INTERVENTION_TIPEp","INVESTMENTp","PBPp","Class
es_PBPp","SAV_ELECTRICALtepp","SAV_THERMALtepp","VANp","DISCOUNT_RATEp","INTERVAREAp","SAV_THERMALKWHTp","
SAV_OTHERtepp","IDp","SAV_TOTtepp","SAV_FUELtepp","SAV_ELETTRICALKWHTp","COSTEFFECTIVENESSp","RAGSOCp","MO
NITORINGp","GIp","ENERGY_INTENSIVEp","ISO5000p","CONSUM_ELECTRICALPRIMARYtepp","CONSUM_TOTPRIMARYtepp","CO
NSUM_TOTFINALtepp","CONSUM_THERMALtepp","CONSUM_GAStepp","CONSUM_ELECTRICALFINALtepp","REVENUESp","EMPLOYE
ESp","DEBT_RATIOp","CAPITAL_TURNOVERp","REVENUES_PROCAPp")
```

correlation analysis

```
>cor(PRIMARI[,c(15:17,20,26,29,37,41,42,43,44,45)])

>summary(PRIMARI)
```

Histogram of Investment

```
>hist(INVESTMENTp, col="cyan3",main="Histogram of Investment (Primary energy
consumption)",xlab="Investment")

>hist(log(INVESTMENTp), breaks=20, prob=TRUE,xlab="Log(Investment)", main="Histogram of
Logarithm of Investment(Primary energy consumption)", col="cyan3" )
```

Response variable and the removal of observation with consumption values equal to 0

```
>Performance2=SAV_TOTtepp/CONSUM_TOTPRIMARYtepp

>PRIMARI$Performance<- Performance2

>PRIMARI2<-PRIMARI[-c(6,30:31,86,159),]
```

Histogram of response variable

```
>hist(PRIMARI2$Performance,xlab="Performance", col="lightgreen",main="Histogram of Performance
(Primary energy consumption)")

>hist(log(PRIMARI2$Performance), breaks=20, prob=TRUE,xlab="Log(Performance)", main="Histogram
of Logarithm of Performance(Primary energy consumption)", col="lightgreen" )
```

Regional Macreoareas dummies

```
>pNORDEST<-ifelse(PRIMARI2$REGIONp %in% c("Veneto","Emilia romagna","Trentino Alto
Adige","Friuli Venezia Giulia"),1,0)

>pNORDOVEST<-ifelse(PRIMARI2$REGIONp %in% c("Piemonte","Liguria","Lombardia"),1,0)
```

```
>pSUD<-ifelse(PRIMARI2$REGIONp %in% c
("Molise","Campania","Sicilia","Sardegna","Puglia",'Basiliicata'),1,0)
```

Pooled OLS models

Ols with fixed effects and all the predictors included

```
>MODp4=lm(log(Performance)~log(INVESTMENTp)+MONITORINGp+ISO5000p+GIp+ENERGY_INTENSIVEp+VANp+PBPp+REVENUES_PROCAPp+CAPITAL_URNOVERp+DEBT_RATIOp+pSUD+pNORDEST+pNORDOVEST+factor(IDp)1,data=PRIMARI2)
```

```
>modp4.1=stepAIC(MODp4)
```

```
>BIC(MODp4)
```

Pooled OLS without fixed effects

```
>MODp4.2=lm(log(Performance)~log(INVESTMENTp)+MONITORINGp+ISO5000p+GIp+ENERGY_INTENSIVEp+VANp+PBPp+REVENUES_PROCAPp+CAPITAL_TURNOVERp+DEBT_RATIOp+pSUD+pNORDEST+pNORDOVEST,data=PRIMARI2)
```

R codes for regression models referring to all intervention areas excluding Production from Renewable sources and Cogeneration/Trigeneration.

Removing from the database white certificate and NA values

```
>FINALInocf<-FINALI[,-14]
```

```
>FINALIna<-na.omit(FINALInocf)
```

```
>names(FINALIna)<c("TIf","REGIONf","MULTISITEf","MULTISIDE_CODEf","PROVINCEf","MUNICIPALITYf","CFf","PIVAf","MACRO_ACTSITEf","ATECOf","ACTIVITYf","MONITORING2DATAf","INTERVENTIONf",
"INTERVENTION_TIPEf","INVESTMENTf","PBPf","Classes_PBPf","SAV_ELECTRICALtepf","SAV_THERMALtepf","VANf","DISCOUNT_RATEf","INTERVAREAf","SAV_THERMALKWHTf","SAV_OTHERtepf","IDf","SAV_TOTtepf","SAV_FUELtepf","SAV_ELETTRICALKWHTf","COSTEFFECTIVENESSf","RAGSOCf","MONITORINGf","GIf","ENERGY_INTENSIVEf","ISO5000f","CONSUM_ELECTRICALPRIMARYtepf","CONSUM_TOTPRIMARYtepf","CONSUM_TOTFINALtepf","CONSUM_THERMALtepf","CONSUM_GAStepf","CONSUM_ELECTRICALFINALtepf","REVENUESf","EMPLOYEESf","DEBT_RATIOf","CAPITAL_TURNOVERf","REVENUES_PROCAPf")
```

Correlation Analysis

```
>cor(FINALIna[,c(15:17,20,26,29,37,41,42,43,44,45)])
```

```
>attach(FINALIna)
```

Regional Macroarea

```
NORDEST<-ifelse(FINALIna2$REGIONf %in% c("Veneto","Emilia romagna","Trentino Alto
Adige","Friuli Venezia Giulia"),1,0)
```

```
NORDOVEST<-ifelse(FINALIna2$REGIONf %in% c("Piemonte","Liguria","Lombardia"),1,0)
```

```
SUD<-ifelse(FINALIna2$REGIONf %in% c
```

Response variable

```
>Performance=SAV_TOTtepf/CONSUM_TOTFINALtepf
```

```
>par(mfrow=c(2,1))
```

Histogram of the response variable

```
>hist(Performance, col="mediumseagreen",main="Histogram of Performance (Final energy
consumption)")
```

```
>hist(log(FINALIna$Performance), breaks=20, prob=TRUE,xlab="Log(Performance)", main="Histogram
of Logarithm of Performance(Final energy consumption)", col="mediumseagreen" )
```

Removing from the database the observation for with the response values are equal to infinite (consumption = 0)

```
>FINALIna$Performance<-Performance
```

```
>FINALIna2=FINALIna[-c(51:53,198:201,407,406,536:538,732,1027:1029, 1317:1319),]
```

Dummies interventions areas

```
>CompressedAir1<-ifelse(FINALIna2$INTERVAREAf=="Aria compressa",1,0)

>Sunction1<-ifelse(FINALIna2$INTERVAREAf=="Aspirazione",1,0)

>ThermalPlant_Recovery1<-ifelse(FINALIna2$INTERVAREAf=="Centrale termica/Recuperi termici",1,0)

>Airconditioning1<-ifelse(FINALIna2$INTERVAREAf=="Climatizzazione",1,0)

>Cooling1<-ifelse(FINALIna2$INTERVAREAf=="Freddo di processo",1,0)

>General1<-ifelse(FINALIna2$INTERVAREAf=="Generale (monitoraggio, organizzazione, formazione,
ISO 50001)",1,0)

>Other1<-ifelse(FINALIna2$INTERVAREAf=="Altro",1,0)

>ElectricalInstallations1<-ifelse(FINALIna2$INTERVAREAf=="Impianti elettrici",1,0)

>Bulding1<-ifelse(FINALIna2$INTERVAREAf=="Involucro Edilizio",1,0)

>ProductionLines1<-ifelse(FINALIna2$INTERVAREAf=="Linee produttive",1,0)

>ElectricMotors1<-ifelse(FINALIna2$INTERVAREAf=="Motori elettrici/Inverter",1,0)

>Transport1<-ifelse(FINALIna2$INTERVAREAf=="Trasporti",1,0)

>Refurbishment1<-ifelse(FINALIna2$INTERVAREAf=="Rifasamento",1,0)
```

Pooled OLS models

Model with all the variables including an interaction between investment and intervention areas

```
>MOD3=lm(log(Performance)~log(INVESTMENTf)+MONITORINGf+ISO5000f+GIf+ENERGY_INTENSIVEf+Compresse
dAir1*INVESTMENTf+Sunction1*INVESTMENTf+Airconditioning1*INVESTMENTf+ProductionLines1*INVESTMEN
Tf+Cooling1*INVESTMENTf+General1*INVESTMENTf+Other1*INVESTMENTf+ElectricalInstallations1*INVEST
MENTf+ElectricMotors1*INVESTMENTf+Transport1*INVESTMENTf+ThermalPlant_Recovery1*INVESTMENTf+Sun
ction1+Airconditioning1+ProductionLines1+Cooling1+General1+Other1+ElectricalInstallations1+Elec
```

```
tricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENUES_PROCAPf+
CAPITAL_TURNOVERf+DEBT_RATIOf+factor(IDf)-1,data=FINALIna2)
```

Removing interactions

```
>MOD3.3=lm(log(Performance)~log(INVESTMENTf)+MONITORINGf+ISO5000f+GIf+ENERGY_INTENSIVEf+Compres
sedAir1+Sunction1+Airconditioning1+ProductionLines1+Cooling1+General1+Other1+ElectricalInstalla
tions1+ElectricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENU
ES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf+factor(IDf)-1,data=FINALIna2)

>summary (MOD333)

>plot(MOD3)
```

Models without GI, ENERGY_INTENSIVE, MONITORING AND ISO5000

```
>MOD3.4=lm(log(Performance)~log(INVESTMENTf)+CompressedAir1+Sunction1+Airconditioning1+Producti
onLines1+Cooling1+General1+Other1+ElectricalInstallations1+ElectricMotors1+Transport1+ThermalPl
ant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENUES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf+fa
ctor(IDf)-1,data=FINALIna2)

>stargazer(MODDD3,type="text",omit = "(IDf)")

>summary(MODDD3)
```

Model without fixed effects

```
>MOD3.5=lm(log(Performance)~log(INVESTMENTf)+MONITORINGf+ISO5000f+GIf+ENERGY_INTENSIVEf+Compres
sedAir1+Sunction1+Airconditioning1+ProductionLines1+Cooling1+General1+Other1+ElectricalInstalla
tions1+ElectricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENU
ES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf,data=FINALIna2)

>summary (MOD333.1)

>BIC( MODDD3)
```

Comparison of the models

```
>stargazer(MOD3,MOD3.3,MOD3.4,MODL3.5, type="text", omit="IDf")
```

Logistic Regression models

Response variable

```
>Performancedummy=ifelse(FINALIna2$Performance>mean(FINALIna2$Performance),1,0)
```

Logistic Regression model with all the variables

```
>MODL5=glm(Performancedummy~log(INVESTMENTf)+MONITORINGf+ISO5000f+GIf+ENERGY_INTENSIVEf+Compres
sedAir1+Sunction1+Airconditioning1+ProductionLines1+Cooling1+General1+Other1+ElectricalInstalla
tions1+ElectricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENU
ES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf+factor(IDf)-1,data=FINALIna2,binomial(link=logit))

>summary(MODL5)
```

Logistic Regression model without GI, ENERGY_INTENSIVE, MONITORING AND ISO5000

```
>MODL7=glm(Performancedummy~log(INVESTMENTf)+CompressedAir1+Sunction1+Airconditioning1+ProductionLines1+Cooling1+General1+Other1+ElectricalInstallations1+ElectricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENUES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf+factor(IDf)-1,data=FINALIna2,binomial(link=logit))
```

```
summary(MODL7)
```

Logistic Regression model without fixed effects

```
>MODL7.2=glm(Performancedummy~log(INVESTMENTf)+MONITORINGf+ISO5000f+GIf+ENERGY_INTENSIVEf+CompressedAir1+Sunction1+Airconditioning1+ProductionLines1+Cooling1+General1+Other1+ElectricalInstallations1+ElectricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENUES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf,data=FINALIna2,binomial(link=logit))
```

```
>BIC(MODL5)
```

Logistic Regression model with white certificate

Response variable and database without consumption =0

```
>Performance1=SAV_TOTtepf1/CONSUM_TOTFINALtepf1

>FINALIcw$Performance1 <- Performance1

>FINALIcw1<-FINALIcw[-c(44:45, 159:160, 318:319,423:424,573,807:808,1040:1042),]
```

Dummies Regional Macroareas

```
>NORDEST1<-ifelse(FINALIcw1$REGIONf1 %in% c("Veneto","Emilia romagna","Trentino Alto Adige","Friuli Venezia Giulia"),1,0)

>NORDOVEST1<-ifelse(FINALIcw1$REGIONf1 %in% c("Piemonte","Liguria","Lombardia"),1,0)

>SUD1<-ifelse(FINALIcw1$REGIONf1 %in% c
("Molise","Campania","Sicilia","Sardegna","Puglia",'Basiliicata'),1,0)
```

Dummies Intervention areas

```
>CompressedAir2<-ifelse(FINALIcw1$INTERVAREAf1=="Aria compressa",1,0)

>Sunction2<-ifelse(FINALIcw1$INTERVAREAf1=="Aspirazione",1,0)

>ThermalPlant_Recovery2<-ifelse(FINALIcw1$INTERVAREAf1=="Centrale termica/Recuperi termici",1,0)

>Airconditioning2<-ifelse(FINALIcw1$INTERVAREAf1=="Climatizzazione",1,0)

>Cooling2<-ifelse(FINALIcw1$INTERVAREAf1=="Freddo di processo",1,0)

>General2<-ifelse(FINALIcw1$INTERVAREAf1=="Generale (monitoraggio, organizzazione, formazione, ISO 50001)",1,0)

>ElectricalInstallations2<-ifelse(FINALIcw1$INTERVAREAf1=="Impianti elettrici",1,0)

>Bulding2<-ifelse(FINALIcw1$INTERVAREAf1=="Involucro Edilizio", 1,0)

>ProductionLines2<-ifelse(FINALIcw1$INTERVAREAf1=="Linee produttive",1,0)

>ElectricMotors2<-ifelse(FINALIcw1$INTERVAREAf1=="Motori elettrici/Inverter",1,0)
```

```
>Transport2<-ifelse(FINALIcw1$INTERVAREAf1=="Trasporti",1,0)

>Refurbishment2<-ifelse(FINALIcw1$INTERVAREAf1=="Rifasamento",1,0)
```

Dummy Response variable

```
>Performancedummy1=ifelse(FINALIcw1$Performance1>mean(FINALIcw1$Performance1),1,0)
```

Logistic Regression model with all the variables

```
>MODl12=glm(Performancedummy1~log(INVESTMENTf1)+MONITORINGf1+ISO5000f1+WHITECERTIFICATEf1+GIf1+
ENERGY_INTENSIVEf1+CompressedAir2+Sunction2+Airconditioning2+ProductionLines2+Cooling2+General2
+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2+SUD1+NORDEST1+NORDO
VEST1+VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1+factor(IDf1)-
1,data=FINALIcw1,binomial(link=logit))

>summary(MODl12)
```

Logistic Regression model without GI, ENERGY_INTENSIVE, MONITORING AND ISO5000

```
>MODl12.1=glm(Performancedummy1~
log(INVESTMENTf1)+WHITECERTIFICATEf1+CompressedAir2+Sunction2+Airconditioning2+ProductionLines2
+Cooling2+General2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2+S
UD1+NORDEST1+NORDOVEST1+VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1+factor(ID
f1)-1,data=FINALIcw1,binomial(link=logit))

>summary(MODl12.1)
```

Logistic Regression model without fixed effects

```
>MODl12.2=glm(Performancedummy1~log(INVESTMENTf1)+MONITORINGf1+ISO5000f1+WHITECERTIFICATEf1+GIf
1+ENERGY_INTENSIVEf1+CompressedAir2+Sunction2+Airconditioning2+ProductionLines2+Cooling2+Genera
l2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2+SUD1+NORDEST1+NOR
DOVEST1+VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1,data=FINALIcw1,binomial(l
ink=logit))
```

Logistic Regression model without GI, ENERGY_INTENSIVE, MONITORING AND ISO5000 and Fixed effects

```
>MODl12.4=glm(Performancedummy1~log(INVESTMENTf1)+MONITORINGf1+ISO5000f1+WHITECERTIFICATEf1+GIf
1+ENERGY_INTENSIVEf1+SUD1+NORDEST1+NORDOVEST1+VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+
DEBT_RATIOf1,data=FINALIcw1,binomial(link=logit))

stargazer(MODl12.4,type="text")
```

Pooled OLS Models with white certificate

Pooled OLS model (with interaction)

```
>MOD12=lm(log(Performance1)~log(INVESTMENTf1)+MONITORINGf1+NORDOVEST1+NORDEST1+SUD1+ISO5000f1+W
HITECERTIFICATEf1+GIf1+ENERGY_INTENSIVEf1+CompressedAir2*INVESTMENTf1+Sunction2*INVESTMENTf1+Ai
rconditioning2*INVESTMENTf1+ProductionLines2*INVESTMENTf1+Cooling2*INVESTMENTf1+General2*INVEST
MENTf1+ElectricalInstallations2*INVESTMENTf1+ElectricMotors2*INVESTMENTf1+Transport2*INVESTMENT
f1+ThermalPlant_Recovery2*INVESTMENTf1+CompressedAir2+Sunction2+Airconditioning2+ProductionLine
```

```
s2+Cooling2+General2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2++VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1+factor(IDf1)-1,data=FINALIcw1)
```

Pooled OLS model without interaction and GI, ENERGY_INTENSIVE, MONITORING AND ISO5000

```
>MOD12.11=lm(log(Performance1)~log(INVESTMENTf1)+NORDOVEST1+NORDEST1+SUD1+WHITECERTIFICATEf1+CompressedAir2+Sunction2+Airconditioning2+ProductionLines2+Cooling2+General2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2++VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1+factor(IDf1)-1,data=FINALIcw1)

>mod13=stepAIC(MOD132)

>summary(mod13)

>BIC(mod13)
```

Pooled OLS model without fixed effects

```
>MOD14=lm(log(Performance1)~log(INVESTMENTf1)+MONITORINGf1+NORDOVEST1+NORDEST1+SUD1+ISO5000f1+WHITECERTIFICATEf1+GIf1+ENERGY_INTENSIVEf1+CompressedAir2+Sunction2+Airconditioning2+ProductionLines2+Cooling2+General2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2++VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1,data=FINALIcw1)

>summary(MOD14)
```

Logistic Regression model with the response variable constructed using the median (without white certificate)

Response variable

```
>PerformanceME1=ifelse(FINALIna2$Performance >median(FINALIna2$Performance),1,0)

>MODL20=glm(PerformanceME1~log(INVESTMENTf)+MONITORINGf+ISO5000f+GIf+ENERGY_INTENSIVEf+CompressedAir1+Sunction1+Airconditioning1+ProductionLines1+Cooling1+General1+Other1+ElectricalInstallations1+ElectricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENUES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf+factor(IDf)-1,data=FINALIna2,binomial(link=logit))
```

Logistic Regression model without GI, ENERGY_INTENSIVE, MONITORING AND ISO5000

```
>MODL21=glm(PerformanceME1~log(INVESTMENTf)+CompressedAir1+Sunction1+Airconditioning1+ProductionLines1+Cooling1+General1+Other1+ElectricalInstallations1+ElectricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENUES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf+factor(IDf)-1,data=FINALIna2,binomial(link=logit))

>summary(MODL22)
```

Logistic Regression model without fixed effects

```
>MODL22=glm(PerformanceME1~log(INVESTMENTf)+MONITORINGf+ISO5000f+GIf+ENERGY_INTENSIVEf+CompressedAir1+Sunction1+Airconditioning1+ProductionLines1+
Cooling1+General1+Other1+ElectricalInstallations1+ElectricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENUES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf,data=FINALIna2,binomial(link=logit))

>BIC(MODL22)
```

Logistic Regression model with the response variable constructed using the median (with white certificate)

```
>MODl20=glm(SCD1me~log(INVESTMENTf1)+MONITORINGf1+ISO5000f1+WHITECERTIFICATEf1+GIf1+ENERGY_INTENSIVEf1+CompressedAir2+Sunction2+Airconditioning2+ProductionLines2+Cooling2+General2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2+ABRUZZO2+BASILICATA2+CAMPANIA2+EMILIA_ROMAGNA2+FRIULI_VENEZIA_GIULIA2+LAZIO2+LOMBARDIA2+MARCHE2+PIEMONTE2+PUGLIA2+SICILIA2+VENETO2+TRENTINO_ALTOADIGE2+VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1+factor(IDf1)-1,data=FINALIcw1,binomial(link=logit))
```

Response variable

```
>PerformanceME<-ifelse(FINALIcw1$Performance1 >median(FINALIcw1$Performance1),1,0)
```

Logistic Regression model with all the variables

```
>MODl19=glm(PerformanceME~log(FINALIcw1$INVESTMENTf1)+MONITORINGf1+ISO5000f1+WHITECERTIFICATEf1+GIf1+ENERGY_INTENSIVEf1+CompressedAir2+Sunction2+Airconditioning2+ProductionLines2+Cooling2+General2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2+SUD1+NORDEST1+NORDOVEST1+VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1+factor(IDf1)-1,
data=FINALIcw1,binomial(link=logit))

>summary(MODl19)

>BIC(MODl19)
```

Logistic Regression model without fixed effects

```
>MODl19.1=glm(PerformanceME~log(FINALIcw1$INVESTMENTf1)+MONITORINGf1+ISO5000f1+WHITECERTIFICATEf1+GIf1+ENERGY_INTENSIVEf1+CompressedAir2+Sunction2+Airconditioning2+ProductionLines2+Cooling2+General2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2+SUD1+NORDEST1+NORDOVEST1+VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1,
data=FINALIcw1,binomial(link=logit))

>summary(MODl19.1)

BIC(MODl19.1)
```

Logistic Regression model without GI, ENERGY_INTENSIVE, MONITORING AND ISO5000

```
>MODl29=glm(PerformanceME~log(FINALIcw1$INVESTMENTf1)+WHITECERTIFICATEf1+CompressedAir2+Sunction2+Airconditioning2+ProductionLines2+Cooling2+General2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2+SUD1+NORDEST1+NORDOVEST1+VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1+factor(IDf1)-1, data=FINALIcw1,binomial(link=logit))

>BIC(MODl29)
```

Models Including the Parameter Lighting and deprived of Compressed Air WITHOUT WHITE CERTIFICATE

Pooled OLS without fixed effects

```
MOD3.3=lm(log(Performance)~log(INVESTMENTf)+MONITORINGf+ISO5000f+GIf+ENERGY_INTENSIVEf+lighting1+Sunction1+Airconditioning1+ProductionLines1+Cooling1+General1+Other1+ElectricalInstallations1+ElectricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENUES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf,data=FINALIna2)
```

Pooled OLS with fixed effects and with GI, ENERGY INTENSIVE, MONITORING and ISO5000

```
MOD3.5=lm(log(Performance)~log(INVESTMENTf)+lighting1+Sunction1+Airconditioning1+ProductionLines1+Cooling1+General1+Other1+ElectricalInstallations1+ElectricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENUES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf+factor(IDf)-1,data=FINALIna2)
```

Logit model without fixed effects

```
MODL7.22=glm(Performancedummy~log(INVESTMENTf)+MONITORINGf+ISO5000f+GIf+ENERGY_INTENSIVEf+lighting1+Sunction1+Airconditioning1+ProductionLines1+Cooling1+General1+Other1+ElectricalInstallations1+ElectricMotors1+Transport1+ThermalPlant_Recovery1+NORDEST+NORDOVEST+SUD+VANf+PBPf+REVENUES_PROCAPf+CAPITAL_TURNOVERf+DEBT_RATIOf,data=FINALIna2,binomial(link=logit))
```

Models Including the Parameter Lighting and deprived of Compressed Air WITH THE WHITE CERTIFICATE

Pooled OLS without fixed effects

```
MOD14.11=lm(log(Performance1)~log(INVESTMENTf1)+MONITORINGf1+NORDOVEST1+NORDEST1+SUD1+ISO5000f1+WHITECERTIFICATEf1+GIf1+ENERGY_INTENSIVEf1+lighting2+Sunction2+Airconditioning2+ProductionLines2+Cooling2+General2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2++VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1,data=FINALIcw1)
```

Pooled OLS with fixed effects and without GI, ENERGY INTENSIVE, MONITORING and ISO5000

```
MOD12.143=lm(log(Performance1)~log(INVESTMENTf1)+NORDOVEST1+NORDEST1+SUD1+WHITECERTIFICATEf1+lighting2+Sunction2+Airconditioning2+ProductionLines2+Cooling2+General2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2++VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1+factor(IDf1)-1,data=FINALIcw1)
```

Logit model without fixed effects

```
MODl12.24=glm(Performancedummy1~log(INVESTMENTf1)+MONITORINGf1+ISO5000f1+WHITECERTIFICATEf1+GIf1+ENERGY_INTENSIVEf1+lighting2+Sunction2+Airconditioning2+ProductionLines2+Cooling2+General2+ElectricalInstallations2+ElectricMotors2+Transport2+ThermalPlant_Recovery2+SUD1+NORDEST1+NORDOVEST1+VANf1+PBPf1+REVENUES_PROCAPf1+CAPITAL_TURNOVERf1+DEBT_RATIOf1,data=FINALIcw1,binomial(link=logit))
```

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