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# Drivers for industrial energy efficiency: an innovative framework

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# Abstract

Nearly more than a half of the global delivered energy demand and almost 40% of worldwide $CO_2$ emissions are attributable to industrial activities. Industrial energy efficiency has always improved in recent years, but a large number of energy efficiency measures is still not fully exploited due to existence of a wide range of barriers. Several studies have investigated the barriers to industrial energy efficiency, but few have focused on the most effective means (drivers) of promoting the adoption of energy-efficient technologies and practices. This concerns all the companies and in particular the small and medium-sized enterprises (SMEs) which cover a consistent share of energy consumption, are usually less efficient than large enterprises and have received little attention by researcher as well as policy makers. Starting from the understanding of the barriers and from insights garnered from the extant literature on the drivers for industrial energy efficiency, the aim of this study is to develop an innovative framework of drivers which represents an useful tool that policy makers can use to promote drivers and overcome barriers within enterprises in future energy efficiency policies. So, we have given our own definition of drivers for energy efficiency and we have developed an innovative taxonomy to categorize them. Our framework is characterized by being innovative, rigorous and comprehensive compared to the existent works. In particular, it highlights the difference between policies, affecting the external system in which a company operates, from drivers that act directly inside the organization. We have classified drivers according to four attributes: nature, targeted barriers, actors responsible for their stimulus internally and externally to the firm, and step of the decision-making processes affected by drivers. The final model thus refers to policies that have an impact on companies, and has been shaped according to the suggestions coming from 5 preliminary case studies in manufacturing industries. In an attempt to quantitatively evaluate to which extent energy efficiency is hindered by the barriers and how drivers can foster its increase, we have conducted an empirical investigation of 61 manufacturing SMEs in Lombardy, the richest, most developed and most industrialized Italian region. The investigation has been structured with interviews to holders, managers or other key people regarding investments in energy efficiency. The research highlights the importance of information and economic drivers. Indeed, the sample has pointed out the importance of both content and form of information, i.e. drivers such as information about real costs, trustworthiness of information, clarity of information, knowledge on non-energy benefits and availability of information. In this case it is clear the role played not only by public institutions, but also by industrial associations and groupings, technology-suppliers and other external actors involved in the supply chain of energy-efficient technologies. Public investment subsidies and private financing are of great importance, highlighting the need of availability of internal and external resources to finance the investments. Additionally, awareness has emerged as a relevant driver to promote energy efficiency, since allows to devote proper attention to energy issues, and can be stimulated both by external actors and internal actors, e.g. through sensitization campaigns. Our analysis revealed that the increase of awareness as well as financial analysis and financial support of the investments have emerged as most critical in the decision-making process to adopt an energy-efficient technology. Moreover, the study provides a preliminary analysis of the effect of several factors, such firm's size, firms' energy intensity, and firms' geographical location, in affecting drivers toward the adoption of energy-efficient technologies and practices. This study calls for further research in both barriers and drivers to energy efficiency, as well as pursuing a more thorough classification of indirect benefits of energy-efficient technologies and practices, that seems to result crucial to a widespread increase of industrial energy efficiency.

**KEYWORDS:** Industrial energy efficiency, barriers, drivers for energy efficiency, small- and medium-sized enterprises, manufacturing sector.

# Chapter 1

# Introduction

"*If industrial energy efficiency pays, why is it not happening?"* (Sorrell, Schleich, Scott, & O'Malley, 2000).

## *1.1 Global energy consumption and $CO_2$ emission trends*

According to the International Energy Outlook (EIA, 2011), world energy consumption is expected to increase by 53 percent from 2008 to 2035. Total world energy use rises from 505 quadrillion British thermal units (Btu) in 2008 to 619 quadrillion Btu in 2020 and 770 quadrillion Btu in 2035 (see Figure 1). Organization for Economic Cooperation and Development (OECD) member countries[1] are, for the most part, large energy consumers, but much of the growth in energy consumption occurs in non-OECD nations, where demand is driven by strong long-term economic growth. This is because, in recent decades, OECD countries have been in transition from manufacturing economies to service economies. In fact, energy demand in the OECD economies grows slowly over the projection period, at an average annual rate of 0.6 percent, whereas energy consumption in the non-OECD emerging economies expands by an average of 2.3 percent per year (EIA, 2011).

[1] Current OECD member countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States (http://www.oecd.org/general/listofoecdmembercountries-ratificationoftheconventionontheoecd.htm).

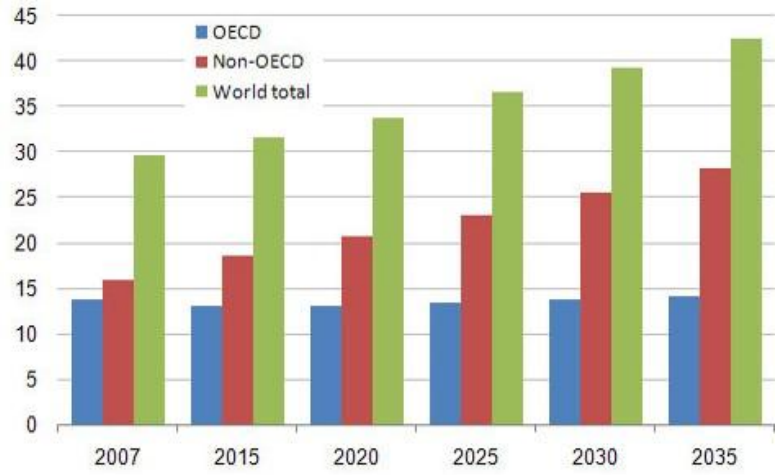



**Figure 1: World energy consumption in quadrillion Btu, 1990-2035. Source (EIA, 2011).**

The world consumption of marketed energy from all fuel sources until 2035 is shown in the Figure 2. Fossil fuels are expected to continue supplying much of the energy used worldwide. Although liquid fuels – mostly petroleum based – remain the largest source of energy, the liquids share of world marketed energy consumption falls from 34 percent in 2008 to 29 percent in 2035, due to the fact that high world oil prices lead many energy users to switch away from liquid fuels when feasible. World natural gas consumption increases by 52 percent, from 111 trillion cubic feet in 2008 to 169 trillion cubic feet in 2035. Coal continues to be an important source of fuel, especially in non-OECD Asia, and world coal consumption is projected to increase from 139 quadrillion Btu in 2008 to 209 quadrillion Btu in 2035, at an average annual rate of 1.5 percent. In many parts of the world, concerns about security of energy supplies and the environmental consequences of greenhouse gas emissions have spurred government policies that support a projected increase in renewable energy sources. As a result, renewable energy is the world's fastest growing form of energy, and the renewable share of total energy use increases from 10 percent in 2008 to 14 percent in 2035 (EIA, 2011).

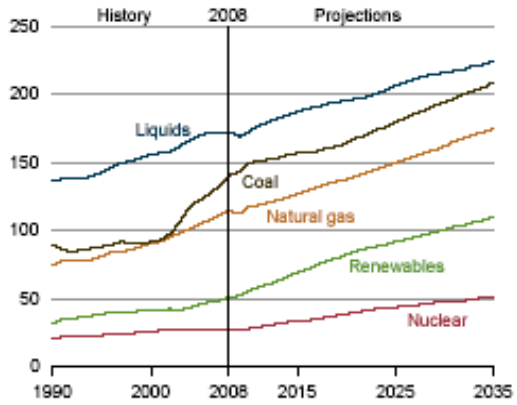



**Figure 2: World energy consumption by fuel in quadrillion Btu, 1990-2035. Source (EIA, 2011).**

World net electricity generation increases by 84 percent, from 19.1 trillion kilowatt-hours in 2008 to 25.5 trillion kilowatt-hours in 2020 and 35.2 trillion kilowatt-hours in 2035. Although the 2008-2009 global economic recession slowed the rate of growth in electricity use in 2008 and resulted in negligible change in electricity use in 2009, demand returned in 2010, led by strong recoveries in non-OECD economies. In general, in OECD countries, where electricity markets are well established and consumption patterns are mature, the growth of electricity demand is slower than in non-OECD countries, where a large amount of potential demand remains unmet. Total net electricity generation in non-OECD countries increases by an average of 3.3 percent per year, led by non-OECD Asia (including China and India), where annual increases average 4.0 percent from 2008 to 2035. In contrast, net generation among OECD nations grows by an average of 1.2 percent per year from 2008 to 2035 (EIA, 2011).

Energy is consumed in the industrial sector by a diverse group of industries – including manufacturing, agriculture, mining, and construction – and for a wide range of activities, such as processing and assembly, space conditioning, and lighting. According to (EIA, 2011), the industrial sector consumed 52% of global delivered energy in 2008 and its energy consumption grows by an average of 1.5% per year through 2035.

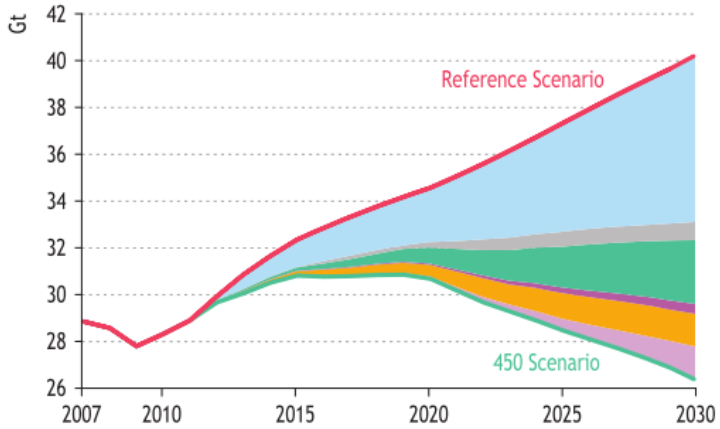
Because of these energy consumptions, it is necessary to mitigate greenhouse gas (GHG) emissions, particularly those relating to energy production and consumption. World energy-related carbon dioxide ($CO_2$) emissions rise from 30.2 billion metric tons in 2008 to 35.2 billion metric tons in 2020 and 43.2 billion metric tons in 2035, an increase of 43 percent over the projection period. About 84% of all $CO_2$ emissions are energy-related, and about 65% of GHG emissions can be attributed to energy supply and energy use (EIA, 2011). From 1990 to 2000, $CO_2$ emissions increased by an average of 1.1% a year, whereas from 2000 to 2007, emissions growth accelerated to 3% a year, despite the increased focus on climate change (EIA, 2011). In the absence of new policies, fossil fuel demand will increase

by 37% from 2007 levels and global energy-related $CO_2$ emissions will grow by 40% according to projections for 2030, as stated by the International Energy Agency (IEA, 2009).

## *1.2 Why Energy Efficiency is important?*

More than half of the global delivered energy demand and almost 40% of worldwide $CO_2$ emissions are attributable to industrial activities (EIA, 2011). If climate change is to be successfully tackled, industry will need to change the way it uses energy and significantly reduce its $CO_2$ emissions. Therefore, energy efficiency is an objective, anyone governments. According to (Piglia, 2012), achieving energy efficiency means using less energy at the same economic activity and quality of services. In other words, energy efficiency aims at reducing the energy used per level of production output (Tanaka, 2011).

Although industrial energy efficiency has improved and $CO_2$ intensity has declined substantially in many sectors in recent decade, making substantial cuts in industrial $CO_2$ emissions will require the widespread adoption of energy efficiency measures and the development and deployment of a range of new technologies. End-use energy efficiency is the largest contributor to $CO_2$ emission abatement in the projections made by the International Energy Agency (IEA, 2009), accounting for more than half of the total savings (see Figure 3). Energy efficiency measures in building, industrial and transport sectors usually have short payback periods and negative net abatement costs, as the fuel cost-savings over the lifetime of the capital stock often outweigh the additional capital cost of the efficiency measure, even when future saving are discounted (EIA, 2011).




| | Abatement ($Mt CO_2$) 2020 | 2030 |
|---|---|---|
| Efficiency | 2 517 | 7 880 |
| End-use | 2 284 | 7 145 |
| Power plants | 233 | 735 |
| Renewables | 680 | 2 741 |
| Biofuels | 57 | 429 |
| Nuclear | 493 | 1 380 |
| CCS | 102 | 1 410 |

**Figure 3: World energy-related CO2 emission by policy measure (projections). Source (IEA, 2009).**

## *1.3 The role of and responses from the European Union*

European Union (EU) interventions on energy issues have a complex genesis. The energy was not included in the agreements of Rome that gave birth to the European Community, as it was for agriculture and special technologies such as coal, steel, and then nuclear. Energy choices and energy taxes have always been different for each EU country, each applying their own national rules on these matters. The EU has started to bring energy within its competence through the doors of the environment, competitiveness, social cohesion, security of supply, scientific research and cross-border trade. The European Union continues to face energy challenges resulting from the rising import dependence, the concerns over supplies of fossil fuels worldwide and a clearly discernible climate change. In spite of this, Europe continues to waste at least 20% of its energy due to inefficiency (European Commission, 2006). The direct cost of our inability to use energy efficiently amounts to more than 100 billion Euros annually by 2020 (European Commission, 2006).

An important breakthrough in the field of environmental and energy policy took place at the European Council meeting of 2007, where ambitious energy and climate change objectives for 2020 were adopted:

- to reduce greenhouse gas emissions by 20%,
- to increase the share of renewable energy to 20%
- to make a 20% improvement in energy efficiency.

Nevertheless, the existing strategy is currently unlikely to achieve all the 2020 targets (European Commission, 2010). In fact, most recent projections show that with current policies Europe will only achieve a 10% cut (see Figure 4).

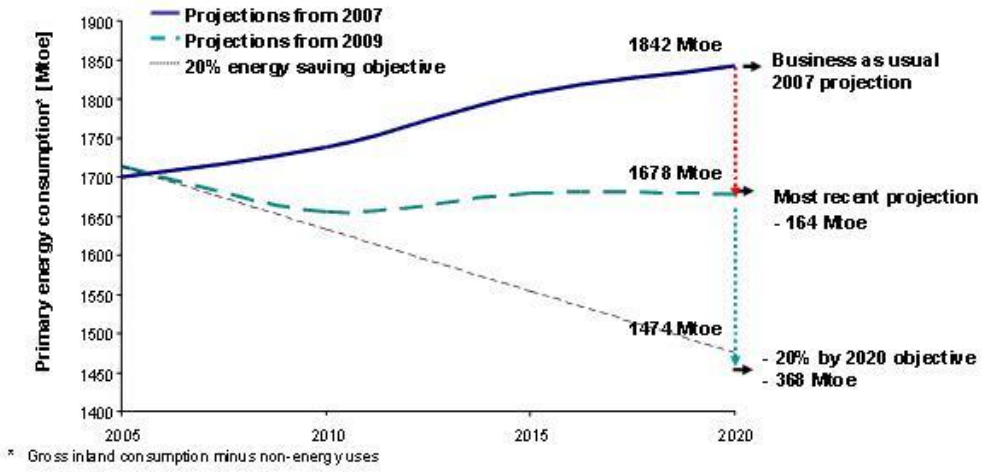



**Figure 4: European Union energy consumption projected to 2020. Source** (European Commission, 2010)**.**

## *1.4 The Italian situation*

The Italian Government has launched several programs in recent decades to address the issue of energy. Measures have been taken for the promotion of renewable energy sources and energy saving, and in some cases it was granted a capital contribution for initiatives promoting renewable sources. The increase in prices of oil and gas led the government to realize that the more convenient way to be undertaken was that of energy efficiency. Moreover, the Inter-ministerial Committee for Economic Planning described some guidelines according to which the emission reductions in the period 2008-2012 had to be contained between 95 and 112 million tones of $CO_2$, to be achieved with the contribution of all sectors (Piglia, 2012).

### *1.4.1 Energy efficiency trends*

The energy efficiency improvement of final consumers was 15% over the period 1990-2010 against 28% for the EU average. The slow progress, especially in the second half of the 90s, was due to industry and transport sectors that had negative performances. After 2000 the increase in energy efficiency has been more rapid: 0.9%/year over 2000-2010 against 0.2%/year over 1995-2000. All sectors showed positive results: in the household sector the improvement in energy efficiency was more rapid in first years of 2000 while industry and transport sectors showed better results in the recent years (ODYSSEE, 2012).

Since 2005 the energy efficiency in the industrial sector is speeding up: there was an improvement of around 7% over the period 2005-2010 after a stabilization before. This acceleration is due to those sectors that in the last years showed an increase in energy efficiency after huge losses in the years 90s and in the first years of 2000: +25% for food and +32% for textile, over the period 2000-2010 with a more rapid improvement in the recent years. In the last years machinery had a loss energy efficiency after improvements over 2005-2007. The best sectors were chemicals and steel with an improvement in energy efficiency of 26% and 18%, respectively since 2000 (ODYSSEE, 2012).

### *1.4.2 Energy efficiency policy measures*

Italy, a member of the EU and a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and to the Kyoto Protocol, is committed to action on climate change. Reducing greenhouse gas emissions and greater energy efficiency are the cornerstones of Italian sustainable energy policy. Moreover, as previously said, European Commission put forward a far-reaching and ambitious package of proposals that aim to deliver on the European Union's commitments to fight climate change and promote renewable energy up to 2020 and beyond. In its efforts to meet the commitments under the UNFCCC, the Kyoto Protocol and the package 20/20/20, Italy has implemented a number of sectoral and cross-sectoral policies and measures that have had, or are expected

to have, a direct or indirect effect on the reduction of greenhouse gas emissions (IEA-Italy, 2009). Policies currently in place or about to be implemented include: (1) the white certificate system, which is aimed at promoting energy efficiency and delivering emissions reductions in all energy end-use sectors; (2) participation in the European Union Emissions Trading Scheme (EU-ETS) and the flexible mechanisms of the Kyoto Protocol; (3) implemented and planned policies and measures to increase the penetration of renewable energy source, through for example the green certificate scheme; (4) incentive scheme to support co-generation; (5) legislation introduced to improve the energy performance of buildings and strengthening their thermal demand requirements (IEA-Italy, 2009).

The first national plan required by Directive of 2006 was prepared and sent to the EU even before the measure was transposed into Italian legislation, which took place in 2008. The plan met the criteria and objectives of European and contained, in 2016, a saving of 9.6% of the average gross final consumption of the five years preceding the entry into force of the Directive (Piglia, 2012).

Regarding the industrial sector, in the recent years the main energy efficiency measures were incentives for replacement with electrical motors and inverters at high efficiency, lighting control systems, high efficiency co-generation and using mechanical vapor compression (ENEA, 2009). Inside the "Industry 2015" Programme to increase the competitiveness of the industry, industrial innovation projects on energy efficiency are settled through announcement and will be finance by the public funds. These programs' aim is energy savings in industrial production and final uses and utilization of renewable energy sources. In fact, the projects concern:

− energy efficiency: high efficiency materials for buildings and bioclimatic architecture, high efficiency machinery and motors, technologies to improve energy efficiency in the industrial process and high efficiency electrical appliances;

− energy production: photovoltaic solar, thermo-dynamic solar, wind and energy by wastes (ENEA, 2009) (ODYSSEE, 2012).

## *1.5 Purpose of the present study*

The global concern for the on-going climate change has drawn more and more attention from public policy makers on improving energy efficiency, as the greatest contribution to energy demand reduction and, in turn, GHG mitigation (EIA 2011). Therefore, the energy efficiency universe represents the context where the present work develops. Specifically, it is of great interest the sub-context of the EU since the European Commission has already backed off with its goal of 20% increase in energy efficiency (European Commission, 2010).

Furthermore, among all the different realities called for improving energy efficiency, the industry is going to be investigated since it consumes more than half on the global delivered energy and emits nearly 40% of $CO_2$ released in the atmosphere (EIA 2011). The focus is on small- and medium- sized enterprises, since each of them consumes energy, is responsible for the increase in $CO_2$ emissions and therefore of climate change, and because each of them can contribute to energy efficiency improvement and to the achievement of the most important goals launched by Europe.

The study starts from the understanding of the barriers, that are obstacles preventing the implementation of energy efficiency measures, even when they are cost-effective, and that may be typically encountered by companies. In this regard, a recent taxonomy, proposed by (A. Trianni & Cagno, 2012), has been adopted for the empirical investigation of the barriers.

Therefore, the purpose of the present work is to develop an innovative framework of drivers for energy efficiency which represents an useful tool that policy makers can use to get insights for future policies regarding energy efficiency. These policies will affect companies that, through the drivers, will be able to overcome the barriers and receive a push towards energy efficiency.

Finally, in an attempt to evaluate to what extent energy efficiency is hindered by the barriers and to what extent it can be increased with the help of drivers, 5 case studies are investigated by means of structured-interviews with holders, managers or other key people of selected small- and medium-sized manufacturing enterprises in order to confirm our theoretical model. Moreover, we have conducted 61 phone interviews adopting a survey methodology for the quantitative evaluation. These 61 companies were chosen in the Lombardy manufacturing sector and the sample will be described in detail in section 6.3.1.

# Chapter 2

# Industrial energy efficiency

Industrial energy efficiency – or conversely, energy intensity which is defined as the amount of energy used to produce one unit of a commodity – is determined by the type of processes used to produce the commodity, the vintage of the equipment used, and the efficiency of production, including operating conditions. Energy intensity varies between products, industrial facilities, and countries depending upon these factors (Mckane, Price, & De la Rue du Can, 2007). Industry contributes directly and indirectly (through consumed electricity) about 37% of the global greenhouse gas emissions, of which over 80% is from energy use (Worrell, Bernstein, Roy, Price, & Harnisch, 2008). Even so, industry has almost continuously improved its energy efficiency over the past decades and (Worrell et al., 2008) asserted that: *"In the near future, energy efficiency is potentially the most important and cost-effective means for mitigating greenhouse gas emissions from industry."* Our approach to industrial energy efficiency is an interdisciplinary approach in which we want to integrate technical, economical and other perspectives. The confluences of various disciplines can facilitate the integration of knowledge from others fields and the collaborations among scientific fields. The role of industrial energy efficiency from a company perspective is of importance as it leads to direct economic benefits, increasing competitiveness and productivity. In fact, increasing energy costs in industry affects negatively results and competitiveness, which may lead to lower production (Patrik Thollander, 2008). Considering the paradox and thus the energy efficiency gap, it is possible to assert, according to (Patrik Thollander & Palm, 2012), that only two general contexts in which an industrial company would let energy efficiency attract attention in the organization: high energy prices or a global environmental crisis forcing companies shifting towards improved energy efficiency. Observing nowadays an increase in climate-related natural disasters, it is consistently approaching the threat that finally leaves industrial companies to become "green". Industrial enterprises are affected by increased energy prices depending on the impact of energy costs on turnover. So, energy intensive industries, such as foundries or pulp and paper industries, are more threatened than non-energy intensive ones. On the other hand, increasing energy efficiency positively and directly affects a company's overall costs. Furthermore, since energy efficiency and environmental issues are addressed by the government through its policies, the theme is likely to be overlooked or underestimated by assigning a low priority by companies. This is

because the energy efficiency prospective of individual companies is based mainly on cost, i.e. it is mainly a monetary perspective, not an environmental or security perspective.

## *2.1 How you can act?*

Energy efficiency is addressed with highest priority to energy intensive companies; nonetheless in many cases, there is not a successful energy management. According to (Patrik Thollander & Palm, 2012) an internal energy management program is perhaps the most important tool with which an industrial company can overcome barriers and improve its energy efficiency. They define energy management as: *"the procedure by which a company works strategically on energy, while an energy management tool is a tool for implementing these procedures; these two concepts are often mixed and used interchangeably".* There are standards for the adoption and practice of energy management such as EN16001 and ISO50001, both designed according to the Deming PDCA cycle, and similar to environmental and quality management systems standards. Concerning energy consumption, that is one of the key issues of energy efficiency, there are two ways with which a company can reduce its energy costs: one is to focus on the supply side, and the other on the demand side. An energy management naturally concerns both sides. To understand energy management, we have to understand not only how to lead an organization but also how to implement sustainable values which becomes embedded in the organization. While the company's incentives are closely related to business-related benefits such as reduced costs, i.e. not solely an incentive to reduce the use of energy but rather the cost of energy, society's incentive in turn is more related to socio-economic benefits such as reduced environmental impact, i.e. not solely related to reducing the cost of energy but rather the use of energy. The establishment of an energy management and the adoption of a long-term energy strategy by the company is essential to making a glue between these different perspectives. Obviously you have trouble in doing this and the adoption of such strategies as well as the establishment of energy management naturally restrict the individual's and organization's freedom. This challenge should not be underestimated and it is more desirable to communicate a new strategy or structure before their adoption enabling people to provide their view of the new approach. So the chance of the accepting of the new structure within the organization are increased. According to (Patrik Thollander & Palm, 2012), two major approaches exist for designing energy management programs, i.e., focusing solely on technology and focusing on purely organizational and behavioral issues. Independent of whether the chosen approach has a predominantly technical or management/organizational emphasis, an energy is needed; a mixture of the two emphases is, of course, optimal.

Speaking more generally about management tool, (Worrell et al., 2008) referring to the study of (Caffal, 1995) state that: *"Staff training in companies' general approach to energy-*

*efficiency reward systems has had good results."* Companies can use benchmarking to compare their operations with those of others, to industry average or to best practice, to improve energy efficiency. They also empathize the role of the government to assist industry in the developing of benchmarking or in making programs of various forms. In fact, several states such as Canada, Denmark, Ireland, Sweden and the USA have instituted voluntary management standards for reducing energy consumption and making energy efficiency.

One of the most practical and immediate means to make energy efficiency by businesses is the replacement of technology by adopting the most efficient on the market. By adopting this new equipment, it is thus possible to produce a change in the production process going towards efficient practices. In some cases, however, the acceptance of new technologies and the change of the production process are not so simple and immediate. For example, in capital-intensive and energy-intensive industries, such as pulp and paper industries where a paper machine costs more than 100 million Euros, a change of production process is not easily accomplished as in the case of changing the lighting in a warehouse. Within industry, systems that support industrial processes can be found to varying degrees in virtually all industrial sectors, regardless of their energy intensity. These industrial systems, which include compressed air, pumping, and fan systems (referred to collectively as motor systems), steam systems, and process heating systems are integral to the operation of industrial facilities, providing essential conversion of energy into energized fluids or heat required for production processes. Motor and steam systems account for 15% and 38%, respectively, of global final manufacturing energy use, or approximately 46 EJ/year (IEA, 2007). Because these systems typically support industrial processes, they are engineered for reliability rather than energy efficiency. If energy efficiency were considered during system design these would not be inherently conflicting goals, since energy efficient industrial systems are frequently more reliable than less energy efficient systems. Industrial systems that are oversized in an effort to create greater reliability, a common practice, can result in energy lost to excessive equipment cycling, less efficient part load operation, and system throttling to manage excessive flow. This is the equivalent of driving a car with one foot on the accelerator and one foot on the brake. Waste heat and premature equipment failure from excessive cycling and vibration are side effects of this approach that contribute to diminished, not enhanced, reliability (Mckane et al., 2007). More sophisticated strategies create reliability through flexibility of response and redundancy in the case of equipment failure, rather than by brute force. The objective of an energy efficient industrial system is analogous to "just in time" manufacturing - to provide the appropriate level of service needed to support the production process, to have a backup plan to address emergencies, and to keep the entire system well-maintained and well-matched to production needs over time. The energy savings can be substantial, with savings of 20% or more common for motor systems and 10 or more for steam and process heating systems (USDOE, 2004), (IEA 2007). The European commission claims that the energy efficiency measures could save up

to 25% of energy used in industry, and argues that most of the improvement measures are found in support processes such as pumping, ventilation and lighting (European Commission, 2006). Implementing sub-metering for the control of consumption in non-energy intensive companies seems to be more easier than for the energy intensive ones. This is in turn closely related to the discrepancy between operational and strategic actions and the initial cost of the investments. Many energy efficiency measures related to service facilities such as ventilation, space heating and lighting, have a lower initial cost than similar measures for heavily capital intensive production process-related investments. In summary, in a business and usual scenario under current paradigm, large improvements of energy efficiency in the industrial sector are unlikely. So the presence of an ambitious energy manager, and the possibility of concrete actions on systems to support the core business may be optimal solutions.

## *2.2 Energy efficiency benefits*

Improving industrial energy efficiency imply the desire to reduce overall costs of production in order to maintain competitiveness, reducing vulnerability to rapidly increasing energy prices and price spikes, responding to regulatory requirements for cleaner production (including air quality, solid waste, and greenhouse gas emissions), and meeting consumer demand for greener, more environmentally-friendly products (Mckane et al., 2007). Besides these obvious energy benefits, there are many other benefits related for example to productivity, quality and safety. Many authors have listed benefits or noted individual features to promote a particular type of energy efficiency measures, but few of them have taken a comprehensive view (Mills & Rosenfelds, 1996). Take into account these additional benefits is particularly important to understand what are all the benefits arising from energy efficiency measures, although in some cases estimating the magnitude of these benefits can be difficult (Worrell, Laitner, Ruth, & Finman, 2003).

### *2.2.1 Non-energy benefits*

Below, we show the studies attempting to characterize energy efficiency measures through lists of recognized benefits: the work presented by (Mills & Rosenfelds, 1996); the work of (Pye & McKane, 2000); the new framework of (Worrel et al., 2003); the study of (Lung, Mckane, Leach, & Marsh, 2005); and a series of studies conducted by Lisa Skumatz over a decade, from the year 1997 to 2005.

(Mills & Rosenfeld, 1996) studied the role of 'additional benefits' for building energy efficiency measures, and provided a framework for understanding the many benefits of energy efficiency investments that extend beyond the energy bill savings alone. Although they recognize the national benefits (e.g., improved competitiveness, energy security, net job creation, and environmental protection) as important, the authors provide a detailed

description of user benefits made possible by efficiency technologies. The full set of non-energy benefits reflect: (1) improved indoor environment, (2) noise reduction, (3) labor and time savings, (4) improved process control, (5) increased amenity or convenience, (6) water savings and waste minimization, and (7) direct and indirect economic benefits from downsizing or elimination of equipment. (Mills & Rosenfeld, 1996) note that these non-energy benefits play a key role in consumer decision making. In fact, they argue that: *"While it is common practice to speak of the ways in which energy-efficient technologies help provide equivalent services at lower costs, non-energy benefits can actually add value or otherwise enhance the energy services delivered by efficient technologies."* As a result, efforts to incorporate them in program design and marketing will help accelerate the uptake of energy-efficient technologies.

(Pye & McKane, 2000) recognize that quantifying the total benefits of energy efficiency projects helps companies to understand thoroughly the financial opportunities of investments in energy efficiency measures. They argue that energy savings alone are not primary drivers in industrial decision-making and therefore energy savings should be viewed more correctly as part of the total benefits of an energy efficiency project, rather than the focus of the results. Unfortunately, they do not explain the choice of these potential benefits beyond energy savings and they simply itemize features such as increased productivity, reduced costs of environmental compliance, reduced production costs (including labor, operations and maintenance, raw materials), reduced waste disposal costs, improved product quality (reduced scrap/rework costs, improved customer satisfaction), improved capacity utilization, improved reliability and improved worker safety. By means of this broader set of parameters and some empirical evidence, the authors believe that energy efficiency advocates will certainly gain more credibility within the industrial sector, yet it is critical to quantify both the upside and downside potential. In order to spread energy efficiency, it is also important to understand the decision-making process of business management which, in turn, means: "*understanding the interrelationships of various forms of efficiency and measuring costs and benefits, so that the financial ramifications of our proposals are fully understood and can be communicated to management in terms with which they can identify*" (Pye & McKane, 2000).

(Worrell et al., 2003) develop their framework providing an analysis of 'productivity benefits' borne by adoption of energy efficiency measures. They focus on modeling the impact of productivity increases on the cost-effectiveness and economic evaluation of energy efficiency measures and technologies in the industrial sector.

Five broad categories or common themes are identified, including (not in order of importance):

- Reduced waste, such as reduced waste water, hazardous waste, product waste, materials reduction and use of waste fuels, heat, gas;

- Lower emissions, such as reduced dust, CO, $CO_2$, $NO_x$ and $SO_x$ emissions;
- Improved maintenance and operating costs, such as reduced need for engineering controls, lowered cooling requirements, reduced wear and tear on equipment/machinery, increased facility reliability, reductions in labor requirements;
- Increased production and product quality, such as increased product output/yields, improved equipment performance, shorter process cycle times, improved product quality/purity, increased reliability in production;
- Improved working environment, such as reduced need for personal protective equipment, reduced noise levels, improved temperature control, improved lighting and improved air quality.

The authors have also included an 'other' category to identify those benefits that were outside the other categories, but still worthy of noting. Some examples are: decreased liability, improved public image, delaying or reducing capital expenditures, additional space, and improved worker morale.

According to (Worrell et al., 2003), understanding these benefits and properly incorporating them into cost analyses is important because these improvements can significantly change the cost assessment of the technology and result in a more favorable evaluation. At the project level, the effect of productivity benefits on cost assessments could determine whether or not a project is undertaken. They point out the widespread omission of these benefits in most studies of energy efficiency measures, stressing the importance of developing a methodology that incorporates the productivity benefits of energy efficiency technologies into assessments of energy savings potential in a systematic quantified way. Once the categories are established, the authors put forward a standard framework for analyzing the productivity benefits through the use of energy conservation supply curves (CSC). Figure 5 shows a CSC: the curve graphically displays the cost of each unit of energy conserved as a result of an energy efficiency project against the per-unit cost of energy, allowing for an immediate comparison of the cost of saving energy with the cost of purchasing it.

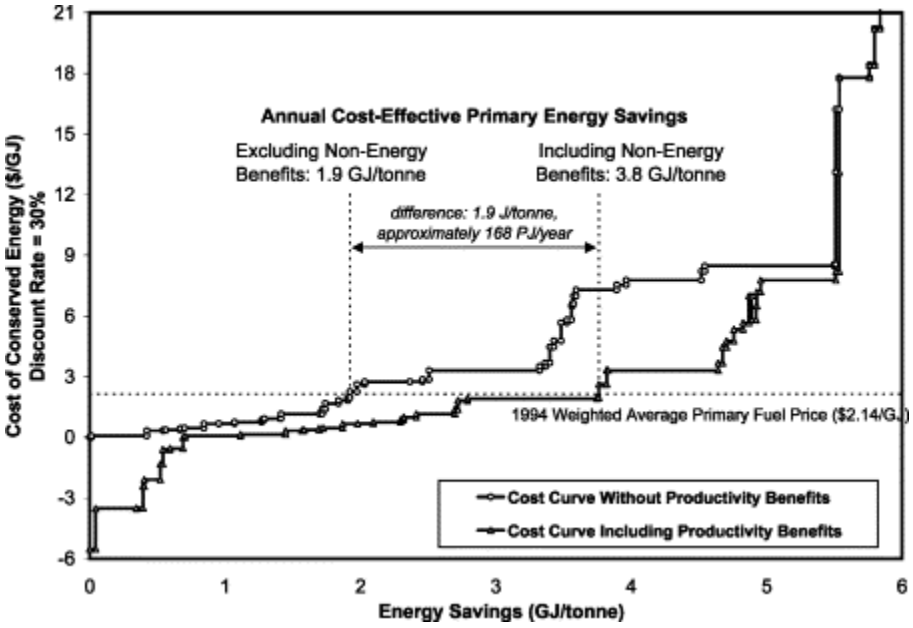



**Figure 5: Conservation supply curves without productivity benefits and including productivity benefits. Source: (Worrel et al., 2003)**

However, (Worrell et al., 2003) recognize that, while including these productivity benefits is important, and conservation supply curves provide an effective means for including them in an analysis, estimating the magnitude of these benefits can be difficult. Consequently, they are confident that, by following a standard framework, the cost evaluation of productivity benefits is formalized and transparent. All in all, the transparency of this evaluation framework is important both to give credibility to calculation and to provide flexibility to an user looking to apply the CSC framework to another scenario.

Similarly, (Lung et al., 2005) examine the importance of 'ancillary savings' resulting from energy efficiency measures adoption in industrial facilities through the use of energy CSC. The term 'ancillary saving', somewhat different from the 'non-energy benefit', refers to: *"ancillary savings refers to all quantifiable cost savings that result from an energy efficiency improvement that are not part of the energy savings from that improvement"* (Lung et al., 2005). However, a part from this different terminology, (Lung et al., 2005) apply the same approach proposed by (Worrell et al., 2003) to a large dataset of energy efficiency projects. The energy efficiency measures' benefits are reduced to five categories, one of which is still the 'other' category. These include: (1) operations and maintenance, such as reduced maintenance costs, reduced purchases of ancillary materials, reduced water consumption, lower cooling requirements, reduced labor costs, lower costs of treatment chemicals; (2) production, such as reduced product waste, increased production, improved product quality, increased production reliability, shorter process/cycle time; (3) work environment, such as increased worker safety, reduced noise levels, improved workstation air quality; (4) environmental, such as reduced hazardous waste, reduced dust emissions, reduced waste

water output, reduced CO, $CO_2$, $NO_x$, $SO_x$ emissions; (5) other, such as achieved rebate/incentive (one-time), reduced/eliminated demand charges, reduced/eliminated rental equipment costs, avoided/delayed costs (one-time).

Another important author, particularly concerned about non-energy benefits, is Lisa Skumatz ((Skumatz & Dickerson, 1998), (Skumatz, Dickerson, & Coates, 2000), (Skumatz & Gardner, 2005)) who has studied some methodologies for a formal evaluation of "hard-to-measures" benefits of energy efficiency measures. Based on the results of several projects completed over the last decades, she has developed and pioneered methods for measuring non-energy impacts – both positive and negative – addressed to residential, commercial and industrial energy efficiency programs. She focuses on quantitative estimates of non-energy benefits, presented from three specific perspectives: (1) utility, ratepayer, and shareholder perspective; (2) societal perspective; (3) customer or participant perspective. However, since the present work focuses on energy efficiency measures related to the industrial sector, we are mainly concerned to the last perspective. Nevertheless, based on the fact that some benefits can cross perspectives (Skumatz & Gardner, 2005), our final synthesis of benefits will present some belonging to the societal level too. In the 'commercial and industrial participants' category, (Skumatz & Gardner, 2005) lists about 20 non-energy benefits: water / wastewater bill savings, operating costs, equipment maintenance, equipment performance, equipment lifetime, productivity, tenant satisfaction / fewer tenant complaints, comfort, aesthetics / appearance, lighting / quality of light, noise, safety, etc. Regardless of the length of the list, she is aware that the list is not comprehensive and suggests that, perhaps, it should be refined case by case depending on which measures are to be considered. As we have stated previously, (Skumatz & Gardner, 2005) has examined a number of different approaches to measure non-energy benefits from the participant perspective. However, for the vast majority of participant impacts, the surveys methodology is needed. Through nearly a decade of research, the author has tested and refined several approaches and, from her findings, it clearly emerges that, even if utilities may run energy conservation programs to reduce energy use, and the commercial/industrial sector may adopt energy efficiency measures, the energy savings alone may not be the highest valued outcome for the adopters.

# Chapter 3

# Barriers to energy efficiency

There is a gap between the opportunities for cost-effective energy efficiency investment identified in energy models and the levels actually seen in practice. Regarding this, (Hirst & Brown, 1990) say that for a variety of reasons, households, businesses, manufacturers, and government agencies all fail to take full advantage of cost-effective and energy conserving opportunities. The result is a significant gap between the current and optimum levels of energy efficiency. According to (Sorrell et al., 2000), the origins of the gap are claimed to lie in a series of barriers such as lack of capital, lack of information or hidden costs, which prevent markets for energy and energy-using technologies from operating efficiently. In their study they give a definition: *"A barrier is a postulated mechanism whose outcome is an organization's neglect of (apparently) cost effective energy efficiency opportunities"*. The core of the debate surrounding the efficiency gap lies in different interpretations of what has been called the paradox of gradual diffusion effective of apparently cost-energy-efficiency technologies. This is the point of view of (Jaffe & Stavins, 1994) saying: *"We use the phrase market barriers to refer to any factors that may account for this apparent anomaly".* (Sanstad, Koomey, 1993) instead state that: *"the term "market barrier" is used to refer to conditions or factors contributing to these gaps between innovation and application, that is, slowing or preventing the attainment of the most cost-effective provision of various energy services."*

According to (Weber, 1997) a barrier model is asked to specify three features: (1) the objective obstacle; (2) the subject hindered; (3) the action hindered. The methodological question of how to determine a barrier model is the following: What is an obstacle to whom reaching what in energy conservation?

Starting from the literature on the topic, we performed a review of the most relevant contributions that categorized the barriers for energy efficiency. Understanding the size and nature of this gap is essential to obtain a complete picture of a complex problem in order to formulate policies to reduce the impact of barriers.

As shown in the literature, barriers are very heterogeneous in nature and were observed for all actors in the market. They are experienced differently among technology adopters and vary between technologies. As a consequence, many different ways to interpret and classify barriers emerged (Fleiter, Worrell, & Eichhammer, 2011).

## 3.1 Background literature on barriers to energy efficiency

The first study which focuses on the problem dates back to 1980 and was conducted by (Blumstein, Krieg, Schipper, & York, 1980) that defined and classified various types of social and institutional barriers to cost-effective energy conservation measures, stating that: *"although economically rational responses to the energy crisis, energy conservation actions may be hindered by social and institutional barriers."* According to their work, six categories of barriers can be identified, although not all barriers can be easily classified to belong to a single category:

1. *Misplaced Incentives*: the economic benefits of energy conservation do not always accrue to the person who is trying to conserve;
2. *Lack of Information:* the efficient working of the market depends on the parties to transactions having adequate information;
3. *Regulation:* if a cost-effective measure conflicts with existing codes or standards, its implementation will be difficult or impossible;
4. *Market Structure:* even though a conservation measure or device is cost effective, it may not be on the market;
5. *Financing:* energy conservation measures often require an initial investment; thus, the availability of capital may be necessary for some measures;
6. *Custom*: if a cost-effective conservation measure requires some alteration in the habits
   of the consumer – affecting the "this is the way we have always done it" – or seems contrary to some accepted value, it may be rejected.

Many works analyzed for this review belong to the 90s, a period in which several authors have focused on the problem of barriers and tried to explain even a single factor which prevents energy efficiency measures to step up to higher potentials. Among these (Hirst & Brown, 1990) play a very important role; they divided the barriers into two types: structural and behavioral. Structural barriers result from the actions of many public- and private-sector organizations and are primarily beyond the control of the individual end-user. Behavioral barriers, on the other hand, are problems that characterize the end-user's decision-making, although they may also reflect structural constraints. (DeCanio, 1993) in his work analyzes the barriers related to investments in energy efficiency. The principal are then represented by: behavior of the companies who do not care to maximize but to satisfy their interests, the problem of attention and focus to the energy problems, asymmetry of information and bias in estimating investment. (Howarth & Andersson, 1993) examine the theory of the market for energy-using equipment, showing that problems of imperfect information and transaction costs may bias rational consumers to purchase devices that use

more energy than those that would be selected by a well-informed social planner guided by the criterion of economic efficiency. In this respect, the authors say: *"Consumers are said to lack full information regarding available energy-efficient technologies, and use a discount rate that is 'too high' in evaluating investments in energy efficiency."* Other barriers considered by them are: split incentives, heterogeneity and lack of capital. (Sanstad, Koomey, 1993) state that there are thus two central themes in the market barriers literature: 1) problems in the development of new markets for products or services incorporating efficiency-related technological innovation and 2) factors that may impede efficiency in such markets once they are established. In their article, they deal with market failures in the sense of neo-classical microeconomics and infer that they can suffer from here generic shortcomings: 1) hidden costs, 2) incorrect parameter specification, and 3) time lags. Finally, they expanded their study on factors such as behavior and society, coming to determine the influence on the barriers of: social factors as cultural norms and family structure that may override financial considerations in efficiency and conservation decisions, behavioral and managerial factors including both economic and apparently non-economic types of influence on decisions, and problems of market structure such as misplaced incentives for energy efficiency, absence of information regarding efficiency possibilities, failures in capital markets, codes and standards impeding cost-effective efficiency investments and limitations on supplies of equipment incorporating innovations in efficiency. (Jaffe & Stavins, 1994) in their work made the first clear distinction between market failure and non-market failure in order to explain the energy paradox. This classification is the basis of the Sorrell et al. taxonomy and will be explained in detail below. (Golove & Eto, 1996) classify barriers in order to offer an explanation of the difference between actual energy-efficiency choices observed in current energy service markets and markets as predicted/described in economic theory. They identified six market barriers: 1) misplaced incentives, 2) lack of access to financing, 3) flaws in market structure, 4) mis-pricing imposed by regulation, 5) decision influenced by custom, and 6) lack of information or misinformation. Then, they added a seventh barrier called "gold plating" suggesting that energy efficiency is frequently coupled with other costly features and is not available separately. (Weber, 1997), after a literature review, identifies the following barriers:

• Institutional barriers: barriers caused by political institutions, i.e. state government and local authorities.

• Obstacles conditioned by the market: market barriers or market failure.

• Organizational barriers: barriers within organizations, especially within firms.

• Behavioral barriers: barriers inside individuals.

(E. L. F. de Almeida, 1998) conducted a study addressing the limits of market forces as the exclusive driving force for energy efficiency. In particular, he analyzed the electric motor

market in France showing that market forces are constrained by the variety of transaction types and by the decision-making practices of agents, in an environment characterized by lack of information and split incentives for adopting energy-efficient technological options. His paper argues that public intervention is a necessary condition for organizing the market and promoting energy efficiency because of the existence of market failures. The market failures that he found in the literature are: inadequate market regulation, leading to pricing distortions, imperfect information on prices, costs and the technology itself, asymmetric information, supply infrastructure limitations, and imperfections in capital markets (when agents do not have uniform access to capital markets at common rates of interest). Like many other authors, (de Almeida, 1998) argues that market failures are a part of the market barriers. In fact, he says: *"empirical markets may have a certain number of barriers to cost minimization, even in a situation where all market failures are corrected."* These barriers are linked to the insufficiently rational behavior of agents, i.e. the concept of bounded rationality due to lack of knowledge.

Another in-depth taxonomy which is worth discussing briefly is presented by IPCC in the TAR (Third Assessment Report) (Dilip, Biswas; Philippe, Crabbe; Luis, Geng; David, Hall; Hidefumi, Imura; Adam Jaffe; Laurie, Michaelis; Gregorz, Peszko; Aviel, Verbuggen; Ernst, Worrell; F., 1999). The interesting point here is that the IPCC describes a classification framework which, although explicitly relevant for barriers to GHG mitigation technology, may be suitable for barriers to energy efficiency too. Chapter 5 of the TAR puts in evidence sector- and technology-specific barriers arranged into seven sources: 1) prices, market for certain energy efficiency measures may be missing or prices distorted; 2) financing, even a simple energy efficiency measure may be subject to high transaction costs which let down its economic viability; 3) trade and environment, tariffs on imported equipment; 4) market structure and functioning, some energy efficiency measures may suffer of weakness of its suppliers making which makes hard the market search; 5) institutional frameworks, misplaced/distorted incentives may not play in favor of an energy efficiency measure; 6) information provision, information on energy efficiency measures should have characteristics of public goods; 7) social, cultural, and behavioral norms and aspirations, inadequate motivation to energy conservation, individual habits may be an obstacle to certain energy efficiency measures.

(Painuly, 2001) focuses on the barriers to renewable energy penetration, categorizing them in: 1) Market failure/imperfection, 2) Market distortions, 3) Economic and financial, 4) Institutional, 5) Technical, 6) Social, cultural and behavioral, and 7) Other barriers (uncertain governmental policies, high risk perception, lack of infrastructure). Another study of 2001 derives from (Brown, 2001) that uses a classification to examine what will be the future role of government. In his paper, a distinction is made between market failure and market barriers on the basis of (Jaffe & Stavins, 1994), that stated:

*1) "…Market failures occur when there is a flaw in the way markets operate. They are conditions of a market that violate one or more of the neoclassical economic assumptions that define an ideal market for products or services such as rational behavior, costless transactions, and perfect information. Market failures can be caused by (1) misplaced incentives; (2) distortionary fiscal and regulatory policies; (3) unpriced costs such as air pollution; (4) unpriced goods such as education, training, and technological advances; and (5) insufficient and incorrect information (Jaffe & Stavins, 1994) …"*

*2) "…Market barriers refer to obstacles that are not based on market failures but which nonetheless con-tribute to the slow diffusion and adoption of energy-efficient innovations. These include: (1) the low priority of energy issues among consumers, (2) capital market imperfections, and (3) incomplete markets for energy-efficient features and products. …"*

Also (Sanstad & Howarth, 1994) take into account the distinction between market barriers and market failure, stating that: *"the equation of normal and efficient markets is a fallacy that can only serve to distort energy policy analysis".* According to the authors, the violation of any of the following conditions constitutes a market failure or market imperfection:

- Agents must hold rational expectations regarding prices and product characteristics, that is, a common set of probabilistic beliefs based on rational assessment of information held by all agents ('perfect information' is a special case);
- markets must be free from externalities and public goods;
- production must be carried out by firms using technologies characterized by constant or decreasing returns to scale;
- a complete set of markets must exist for all present and future goods.

Market failures imply policy intervention and the authors strongly criticize the opponents of government intervention to correct market failures who argue that problems related to transaction costs and imperfect information are 'normal' features of economic life that impose natural frictions in economic affairs. So they turn to a discussion of key market imperfections that may provide explanations for the energy efficiency gap. These market failures include: 1) existing pricing distortions; 2) imperfect information (about market conditions, technology characteristics, etc.); 3) asymmetric information (when parties to a transaction have access to different levels of information); 4) Transaction costs (for gathering, assessing and applying information on the characteristics and performance of energy using equipment); 5) imperfections in capital markets; 6) bounded rationality in energy decisions.

A similar type of distinction has been used by (Patrik Thollander & Ottosson, 2008) in their empirical study focused on the Swedish pulp and paper industry. They use the previous theoretical perspective and then make a breakdown of barriers in market-related and

organizational and behavioral-related barriers. The market related barriers are further divided into non-market failure, i.e. barriers that exist although the market is functioning (heterogeneity, hidden costs, lack of access to capital, and risks) and market failure (split incentives, principal–agent relationship, and imperfect information). Other barriers such as: bounded rationality, form of information, credibility and trust of the source of information, values and culture of the company and lack of power are under the classification of organizational and behavioral-related barriers.

An important contribution can also be found in the study of (A. T. de Almeida, Fonseca, & Bertoldi, 2003) with respect to practical issues that should be addressed by policy-makers in coping with barriers. The study provides an insight on energy-efficient motor technologies, trying to categorize the barriers according to five elements: 1) Awareness of the options, 2) Technical options, 3) Economic barriers; 4) Internal conflicts, and 5) Market structure.

(P Rohdin & Thollander, 2006) aim to investigate the existence and importance of different barriers to the implementation of energy efficiency measures. The barriers in their study are divided in: 1) Economic non-market failure, 2) Economic market failure, 3) Behavioral, and 4) Organizational.

(Nagesha & Balachandra, 2006) identify relevant barriers to energy efficiency and their dimensions in small scale industry. After a literature review, they have divided the barriers in the following categories: 1) Awareness and information, 2) Financial and economic, 3) Structural and institutional, 4) Policy and regulatory, and 5) Behavioral and personal.

(B. S. Reddy & Assenza, 2007) develop their taxonomy of barriers which are divided into three categories:

- *Micro barriers*: occur at the lowest level, for example at the design stage of a program or a project. These can be referred to as the obstacles that are unique to a particular project.
- *Meso barriers*: occur at the intermediate level, i.e., in the implementation stage. These relate to the organizations affiliated with the project. These barriers can be common to a wide variety of projects and can be tackled with efficient organizational design, human resource, as well as time management.
- *Macro barriers*: occur at the highest level: state, market, and civil society. Since these barriers are not project or organization-specific, they cannot be altered by changing project or organizational design.

The rest of the literature analyzed for barriers is summarized in Appendix A

### *3.1.1 The Sorrell et al. taxonomy*

A very important work in the analysis of barriers to energy efficiency has been done by (Sorrell et al., 2000). They taking important elements from (Jaffe & Stavins, 1994) and (Golove & Eto, 1996) proposes a new categorization of barriers, built on the theoretical background of the barrier, i.e. economic, behavioral and organizational. This classification is illustrated in the following table and the important point addressed in the study by Sorrell et al. it is precisely on the inclusion of the two non-economic perspectives, i.e. the behavioral and the organizational.

**Table 1: Barriers to energy efficiency (Sorrell et al. 2000).**

| Perspective | Examples | Actors | Theories |
|---|---|---|---|
| *Economic* | Imperfect information, asymmetric information, hidden costs, risks. | Individuals and organizations considered as rational and aiming at maximizing profits. | Neo- classical economy |
| *Behavioral* | Incapability to process information, form of information, inertia. | Individuals with bounded rationality, with bib-economic behavior and/or under various social influences. | Transaction costs economy, psychology, decisional theories. |
| *Organizational* | Lack of power and/or influence by people in charge of energy management; lack of organizational culture leads to ignore energy issues. | Organizations are considered as social systems influenced by objectives, routines and structures with different power. | Organizational theories. |

*3.1.1.1 The Economic perspective*

The neo-classical economic theory has long been the mainstream for the analysis of the barriers to energy efficiency stating that individuals make decisions in a fully rational manner. The following discussion draws heavily on the Jaffe & Stavins framework in which the market barriers are those factors which prevent the uptake of energy efficiency measures which cost-effective at current prices. On the other hand, market failures refer to those market barriers which (according to economists) justify a public policy intervention to improve the spread of energy efficiency measures. According to this distinction, we note that market barriers which are not market failures may prevent investment in energy efficiency but may nevertheless represent a rational behavior. So, they explain why observed behavior is indeed optimal from the point of view of energy users. Sorrell et al. adopts this perspective and clearly distinguish between non-market failures and market failure barriers.

- The non-market failures

The born of this barriers occurs when the requirements for efficient allocation of resources through well functioning markets are not violated. The basic theorems of welfare economics state that the allocation of resources will be optimal where:

- well defined property rights exist such that buyers and sellers can exchange assets freely;
- market actors behave competitively by maximizing benefits and minimizing costs;
- market prices are known by all consumers and firms;
- transaction costs are zero.

So, in this context, the organization is behaving rationally given the risk-adjusted rate of return on an investment in the existing context of energy, capital and 'hidden' costs. The non-market failure barriers are then: heterogeneity, an energy efficiency measure which is cost-effective on average for a class of users taken in aggregate may not be so for sample of that class; hidden costs, engineering-economic analysis may fail to account for hard-to-measure net benefits; access to capital, some energy users may have access to capital only at costs well above the average borrowing interest and risk, to the extent that high implicit discount rates correspond to truly high risk felt by investors there is nothing particularly wrong.

- The market failures

Neo-classical economists would assert that intervention to encourage economic efficiency is only justified when there exists some form of market failure, or the violations of the conditions for a well-functioning market, as mentioned in the previously. In addition (Jaffe & Stavins, 1994) assert that mere existence of market failure may not be sufficient to justify

intervention; it is also necessary that the benefits arising from an intervention exceed the cost of implementation.
According to (Sorrell et al., 2000) the four general types of neo-classical market failure are:

- incomplete markets;
- imperfect competition;
- imperfect information;
- asymmetric information.

They conduce to four broad types of market failures that are: imperfect information, if the market either produces or transmits insufficient information, participants will be unable to undertake all mutually optimal exchanges; asymmetric information, a particular case of the former when actors to a transaction have access to different levels of information, split incentives, known as the landlord-tenant relationship in which none of the two parties is interested in investing in energy efficiency measures since, on the one hand, the landlord does not directly gain benefit from an investment while, on the other hand, the tenant has only temporary rights on the investment; adverse selection, it exists when one party holds a private information before entering into a contract and thus the premium charged may affect the customer's decision; principal-agent relationship, the principal's problem is to ensure that the agent acts to her benefit, but she cannot evaluate how hard the agent has worked or whether she has been honest.

*3.1.1.2 The behavioral perspective*

By not making a particular energy efficiency investment, an organization may be acting rationally given this broader decision-making context. Hence, these type of barriers do not justify any form of government intervention (Sorrell et al., 2000).
The rationality hypothesis is widely criticized as a poor representation of actual behavior and so an alternative conception of rational behavior, known as bounded rationality. Sorrell et al. give a definition about asserting that: *" individuals do not make decisions in the manner assumed by economic models, but are instead subject to severe constraints on attention, resources and their ability to process information".*
In organizations, this could mean focusing on core activities, such as the primary production process, rather than peripheral issues such as energy use. As a result, the behavior of individuals and organizations is likely to differ significantly from the predictions of economic models.
A systematic alternative to the neo-classical fundamentals has the following principles:

• People trait gains differently from losses and hence undervalue opportunity costs;

• Outcomes received with certainty are weighted more than those with uncertain outcomes;

• Choices depend strongly on how a decision is framed, that is, on the reference point.

This observations lead to three concept from the psychological literature that may yield to barriers to energy efficiency: *credibility and trust*, it is important that information on energy efficiency measures be credible, uncertainty and lack of knowledge all enhance the value of personal recommendations – information from close acquaintances stands out from the mass; *inertia*, potential savings from energy efficiency measures adoption are uncertain, while keeping up the existing even inefficient environment produces certain outcomes; *values*, this represent a concrete improvement in the research since it shows that engineering-economic criteria provide only one element of a decision process.

#### *3.1.1.3 The organizational theory perspective*

An enterprise is doubtlessly a systems with relationships and conflicts among its own individuals and departments. Either individuals or departments each have different cultures which influences decision-making processes. Therefore, it is important to note that the organization of the firm might represent a barrier itself for the adoption of energy efficiency measures. Discipline which uses a range of two ideas to explain different facets of organizational behavior.
The first is power and the extent to which the power relationships inherent in organizational structures affect the ability of individuals or department to influence decisions. The second is organizational culture and the extent to which values, principles and norms of behavior encourage or discourage investment in energy efficiency. The problems are respectively how much power is available to the actors responsible for implementing energy efficiency, and the extent to which environmental values are embedded in organizational culture and procedures and whether this has a significant effect on organizational behavior.

### *3.1.2 Critic to the literature on barriers to energy efficiency*

This section provides some critics to the taxonomies presented. For the sake of clarity, the section is structured in three subsections: the first subsection puts forward some barriers not explicitly addressed or completely missing; the second highlights overlapping elements; the third talks about implicit interactions not previously developed.

#### *3.1.2.1 Missing elements*

Analyzing the taxonomy of Sorrell et al., it can be seen how the problem of technologies and energy resources is neglected. In particular, there is no reference to barriers already mentioned in the literature by Hirst & Brown and Jaffe & Stavins, such as the distortion in energy resources' prices and the low diffusion of energy efficient technologies. The first one

is a quite important aspect for energy efficiency, since the price that consumers pay does not fully reflect the externalities cost for energy, and all the environmental and social costs associated with fuel production, consumption, transmission and use, are not considered. This is one of the main aspect for which the energy problem is not being properly considered at the enterprise level, giving rise to many barriers within the organization. The second one implies that the technologies are not actually fully available, as well as the training and the expertise to manage them. This barrier belongs to a broader categorization: the *technology-related* barriers. They can represent, in some cases, a really important issue for the deployment of energy-efficient technologies. Indeed, as empirically shown by the study of (A. T. de Almeida et al., 2003), the technical characteristics may not be applicable for an energy-efficient technology, thus representing a barrier for which an enterprise will not increase its energy efficiency. Another barrier not considered is access to external expertise. It particularly affects small and medium-sized enterprises that often face problems that are beyond their abilities and therefore neglected or addressed incorrectly causing inefficiencies. Recently, an empirical study proposed by (A. Trianni & Cagno, 2012) claims that small- and medium-sized firms may lack expertise and competence both to identify the inefficiencies and to implement the opportunities in energy efficiency. Moreover, the study highlights that firms show some difficulties even to access external competences. The perception of being already efficient represents an important behavioral barrier towards the adoption of energy-efficient technologies, as shown by (Vine et al., 2003). This barrier, combined with the distortion in fiscal and regulatory policy also neglected in the previous taxonomy, represents a prerequisite for the emergence of a behavioral barrier within the organization, such as lack of interest in energy-efficiency interventions. As underlined by (DeCanio, 1993), the low priority of energy issues might represent another organizational barrier that should be explicitly addressed. As expressed by Hirst & Brown, several factors draw firms to consider energy issues as of minor concern, discouraging investments in energy conservation. Finally, other empirical studies such as (A. Trianni & Cagno, 2012) and (Patrik Thollander, Danestig, & Rohdin, 2007), have identified barriers that are: the lack of expertise and competences to identify the inefficiencies and opportunities and to implement energy efficiency measures.

*3.1.2.2 Overlaps*

The disaggregation of the barriers according to the theoretical models enables to collect and investigate different approaches (e.g. economical, behavioral, and organizational), providing different perspectives to analyze the barriers. Nonetheless, this approach may result in partial overlap of barriers, since the proposed barriers represent, quite often, elements in which implicit interactions exist.

First, the heterogeneity barrier might be the effect of different barriers that cannot be combined. For example, the technological risk perceived varies depending on the type and size of a company as well as the access to capital. The same holds true for the hidden costs

barrier, that might be quite specific for a firm and thus limiting the economic performance of an intervention. For these reasons, heterogeneity of the technology is recognized as a barrier to energy efficiency, but it does include many different issues that should be investigated separately. Another problem arises from the barrier imperfect information that Sorrell et al. define as a single barrier, but it could be more appropriate to see this market failure as a set of barriers, comprehensive of all the problems related to the information flow. On the one side, we can see overlaps with hidden costs, by means of the transaction costs for gathering, analyzing and applying interventions, as mentioned by (Brown, 2001) stating that: *"the time and cost of collecting information is part of the transaction costs faced by consumers".* On the other side, imperfect information encompasses the market failure asymmetric information, that leads to adverse selection, moral hazard and split incentives. Finally, adverse selection barrier may be the result of bounded rationality, in a context in which the decision-maker does not know the benefits of the opportunities, and may imply that the choice will be made on the most evident characteristics. Nonetheless, bounded rationality leading to adopting imperfect evaluation criteria might be used also in principal-agent relationship dynamics, where the criteria of judging the investments are affected by approximations (maybe due to lack of time or competences). In this case it is clear that the bounded rationality barrier, which Sorrell et al. consider as behavioral, overlaps with barriers belonging to power, which is an organizational barrier.

*3.1.2.3 Barriers interactions*

Sorrell et al., in their model, admit to possible interactions between the barriers. These are the possible relationships (e.g. causal, combined effect, etc.) between barriers that, if neglected, could result in having problems when identifying and developing policies and measures to address those barriers. We would prefer to call them 'implicit interactions', as said by (Andrea Trianni, Cagno, Worrell, & Pugliese, 2013): *"…because the definition of barriers themselves implies those interactions. It can be seen that this concept differs from that of overlap, in which two barriers partially look at the same problem, since in this case the barriers are distinct, but there is a link between them."*

Looking at the taxonomy by Sorrell et al., some implicit interactions can be highlighted. At first lack of time, attention and competences to understand the information represent barriers strictly related to the adoption of approximate criteria to evaluate energy efficiency investments, that Sorrell et al. combine in the bounded rationality barrier. Principal-agent relationships represent a dynamic in which two separate barriers act simultaneously: i.e. the lack of instruments to control operators and opportunistic agent-behavior. The combined action of the two barriers might result in the use of higher rates of return. Moreover, principal-agent relationship, which Sorrel et al. consider as market failure and therefore as an economic barrier, can be translated in: the lack of internal control that is an organizational barrier. Finally, access to capital represents the barrier that looks at the

economic and financial availability, in terms of both borrowed capital and internal funds, of the enterprise with respect to the capital devoted for investments in energy efficiency opportunities. This is modified by the concurrent effect of two separate barriers: on the one side, the priorities, that are strictly related to the behavior of decision-makers (their sensibility to energy efficiency, etc.); on the other side, the effective total available capital, that is an economic barrier.

## 3.2 A taxonomy for empirical investigation

After the analysis and the criticism of the literature, we are now well aware of the context of barriers to energy efficiency. From the missing elements, it is known as the issues have been addressed as a whole but a classification that encompasses them together is lacking. In this respect, in order to clearly identify the barriers, all the barriers within the taxonomy should be clearly distinguished, thus avoiding any possible overlap or implicit interaction. Moreover, in order to be a really useful tool for enterprises and policy-makers in understanding the barriers to industrial energy efficiency, the taxonomy needs to be developed and shaped to be easily used in an empirical investigation. Within the empirical investigation, a key point for the effectiveness of policies to improve adoption of energy efficiency measures is represented by the ability to clearly distinguish the spectrum of influence of the barriers. In fact, the spectrum of influence of the barriers is able to highlight how general or specific the effect of the barrier is on the firm‘s decisions. It is also important to understand what are the external actors involved in the generation of these barriers to good design countermeasures. All these aspects leads us to adopt the taxonomy proposed by (Andrea Trianni et al., 2013).

### *3.2.1 Description of barriers of the adopted taxonomy*

The taxonomy has been developed to include the relevant barriers observed in the literature and will separate the barriers assigning them to the actors involved. To identify these actors, the authors have followed the approach proposed by Hirst & Brown (which will be described in the next chapter). Barriers inhibit the shift from the status quo to the status of energy efficiency improved arise within this market, and not only within the single enterprise. Nonetheless, the enterprise and the actors within the market are subject to regulation. Regulation and policy may affect the diffusion of technologies and/or energy suppliers imposing standards or particular policies to regulate the market, may modify the price and/or the availability of services/products, and also can influence a single firm through various policies. The barriers have been reduced to lowest independent denominator, reaching a high level of detail, presenting elements that might occur autonomously. This prevents from overlapping or implicit interactions, as found in the literature. Therefore, slightly modifying definition given by Sorrell et al., *“a barrier is a*

*postulated mechanism that inhibits investment in technologies that are both energy efficient and (apparently) economically efficient",* without the necessity that one or more other barriers occur. It is interesting to note that the external barriers reflect on the economic, the information and technology-related barriers, thus representing the impact of the external context on the firm.

**Table 2: Barriers to energy efficiency (Trianni et. all 2013)**

| Origin | Actor/Area | Barriers |
|---|---|---|
| *External* | Market | Energy prices distortion |
| | | Low diffusion of technologies |
| | | Low diffusion of information |
| | | Market risks |
| | | Difficulty in gathering external skills |
| | Government/Politics | Lack of proper regulation |
| | | Distortion in fiscal policies |
| | Technology /Services Suppliers | Lack of interest in energy efficiency |
| | | Technology suppliers not updated |
| | | Scarce communication skills |
| | Designers and manufacturers | Technical characteristics not adequate |
| | | High initial costs |
| | Energy suppliers | Scarce communication skills |
| | | Distortion in energy policies |
| | | Lack of interest in energy efficiency |
| | Capital suppliers | Cost for investing capital availability |
| | | Difficulty in identifying the quality of the investments |
| *Internal* | Economic | Low capital availability |
| | | Hidden costs |
| | | Intervention-related risks |
| | Behavioral | Lack of interest in energy-efficiency interventions |
| | | Other priorities |
| | | Inertia |
| | | Imperfect evaluation criteria |
| | | Lack of sharing the objective |
| | Organizational | Low status of energy efficiency |
| | | Divergent interests |
| | | Complex decision chain |
| | | Lack of time |
| | | Lack of internal control |
| | Barriers related to competences | Identifying the inefficiencies |
| | | Implementing the interventions |
| | Awareness | Lack of awareness ignorance |

To adapt the taxonomy for the empirical investigation are taken into account principally the internal barriers, considering interactions with external barriers and adding two categories generally called technology-related barriers and Information barriers.

*Technology-related barriers*

This barrier is mainly due to two external barriers that are low diffusion of technologies and lack of interest in energy efficiency. The first is attributable to market conditions while the second to behavior of suppliers of technology. Both still have the same effect on the company that can perceive technology as not available since the low diffusion on the market, or because of the lack of interest by technology suppliers.

*Information barriers*

This barrier is composed of a set of others barriers and includes external problems regarding the company due to the flows of information. In particular, for a practical investigation on a firm, it is possible to find lack of information on costs and benefits in which the effects of several external barriers could be appreciated. First low information diffusion that refers to the time needed to refine and disseminate information on energy-efficient technologies, as defined by (Jaffe & Stavins, 1994). Second the lack of proper regulation which refers to problems about shortcomings of the system of regulations regarding the problem of energy efficiency and therefore a negative context in which it operates the organization. Last the technology suppliers not updated on the new energy-efficient solutions for which, if companies that manufacture, distribute and service energy-efficient products provide only limited training to keep their employees abreast of the latest technologies, their customers will not be sufficiently and adequately informed, thus possibly selecting inefficient or even obsolete technologies (Hirst & Brown, 1990).

Another barrier belonging to this category is unclear information by technology suppliers that might depend on the lack of communication skills by technology suppliers. Moreover, the lack of proper regulation, in terms of classes of performance for energy efficiency (described above) might inhibit a clear comprehension of the information.

Trustworthiness of the information source is an important barrier that affect the flow of information. It might occur when technology suppliers have scarce communication skills to promote energy efficient technologies or due to a lack of interest in providing clear and detailed information to their clients. It is also an obstacle that occurs when the company does not trust the supplier of information and therefore is considered an unreliable source. If you encounter this issue all information received will be placed in the background and not considered as useful. In fact as stated by (Sorrell, Schleich, Scott, & O'Malley, 2000): *"One possible explanation for why people pass up information that is both useful and free is that they do not trust the source*". This is the problem of credibility and trust.

The last aspect about information flow is the information issues on energy contracts. This barrier as reported by Sorrell et al., refers to the fact that different options in energy contracts might be presented in a form that might be unclear and not-vivid, thus resulting unattractive for the customers. In addition the reduction of energy costs by firms implies lower returns for energy suppliers, thus energy suppliers might be not interested have their clients informed about energy-efficient solutions.

*Economic barriers*

In this section we present the barriers related to the economic evaluation of an energy-efficiency investment.
Low capital availability: as demonstrated by several empirical studies, even with a great awareness on the benefits of energy-efficient technologies, and considerable commitment of management and personnel to energy, the firm does not have sufficient own capital to invest in energy-efficient technologies.
Hidden costs: those costs might differ significantly from the estimate in investment analyses. Within this category all the transaction costs to obtain information on energy efficiency investment and related personnel training, fall. As proposed by (Ostertag, 1999): *"Even if these costs are not really transaction costs, they may still be subject to frequent omission in cost evaluations without justification"*. A further classification within this category can be provided, i.e., hidden costs can be distinguished according to the project stage in which they occur. Pre-intervention hidden costs includes the research of energy inefficiencies and opportunities to increase energy efficiency. In addition to the expenditures for energy audits, as underlined by (Jaffe & Stavins, 1994), the costs to perform a preliminary evaluation of the investment and the costs to understand the debt carrying capability should be included. Considering the post-intervention hidden costs, as empirically studied by (P Rohdin & Thollander, 2006), it is possible that the costs to train personnel on the proper use of the new technology, developing new procedures for maintenance, adapting to the modified production system may represent a barrier to invest in energy-efficient technologies.
Intervention-related risks: as suggested by Jaffe and Stavins, some uncertainties and risks occur when implementing the energy efficiency interventions. As shown by (Sanstad, Blumstein, & Stoft, 1995), in criticizing the (Hassett & Metcalf, 1993) model, the discount rates for future costs and benefits exceed consistently the conventional rule of thumb rates chosen for investments, i.e. either the rate of return available on investments with comparable risk or the rate at which the purchase is financed.

From these internal barriers was made an integration to extend the taxonomy to the study of the practical case. To do so have been taken into consideration some of the external barriers. As regards the economic aspect should be considered all the barriers relating to providers of capital that directly affect the low capital availability. Cost for investing capital

availability and difficulty in identifying the quality of the investment then act directly on the company further increasing the difficulty in finding capital. This can improve problems such as interventions not sufficiently profitable for which some enterprises often rationally discard investments with a rate of return lower than their internal rate of return. This can be particularly critical and thus represent a barrier for those energy-efficient technologies that require a significant change for the enterprise.

High initial costs to adopt new energy-efficient technologies represent an important barrier that needs to be integrated in the economic ones. This barrier might reflect the high design and manufacturing costs for delivering an up-to-date energy efficiency measure, and then the investment will not be taken into consideration especially when company face of informational problems with regard to non-energy benefits. In addition have to be accounted the external risks, for which, as suggested by (Hirst & Brown, 1990), uncertainties regarding future energy prices might represent a barrier to investments.

*Behavioral barriers*

These are barriers related to the behavior of operators and decision-makers within the firm so are purely internal and attributable exclusively to internal factor of the company.
Having other priorities is a barrier particularly critical for small and medium-sized enterprises, since quite often the decision-makers might be focused exclusively on few core business activities. Therefore, they tend to exclusively evaluate the interventions with considerable impact on the main production system activities, thus disregarding energy efficiency, as emerged in empirical research of (A. Trianni & Cagno, 2012), (P Rohdin & Thollander, 2006) and (Patrik Rohdin, Thollander, & Solding, 2007).

Regarding inertia, as Sorrell at al. pointed out, this barrier represents the resistance to change and risk, and the more radical the higher it will be. Agents resist change because they are committed to what they are doing and justify inertia by downgrading contrary information. Individuals also treat gains differently from losses, thereby undervaluing opportunity costs. All these factors create a bias against energy efficiency since this involves investing in hardware with uncertain outcomes and represents a departure from the status quo.

Imperfect Evaluation Criteria: the decision-makers might not have the proper knowledge or criteria to evaluate investments. In particular the decision-maker might adopt approximate criteria or routines, as suggested by (DeCanio, 1993): *"By providing good information about the economic performance of energy saving investments, owners and management can make decisions based on realistic assessments of what those investments are likely to yield".*
In other cases the decision-maker might adopt criteria for the evaluation (as pay-back

period, or rate of return of the investment) without any relationship with the uncertainty associated to the different alternatives to be evaluated. In that study is also reported the problem of lack of sharing the objectives for which some misalignments between the behavior of personnel and energy management objectives might occur.

Lack of Interest in Energy Efficiency: this barrier includes several elements, each of those contributing to the perception that energy issues are not sufficiently interesting: energy costs do not have sufficient weight with respect to the firm‘s production costs and the firm perceives itself as already efficient. These problems are purely internal but, unlike behavioral barriers hitherto mentioned, they have correlations with some external barriers. For this empirical taxonomy (Andrea Trianni et al., 2013) say that it is necessary to highlight these links. This exception became true since it reflects how attentive the firm is towards energy efficiency. The energy prices distortion, the lack proper regulation, in terms of minimum standards for energy efficiency, the distortion of fiscal policies and a distortion in energy policies will deeply affect the interest of the firm with respect to energy efficiency issues.

*Organizational barriers*

The organizational barriers arise from the interaction of different functions within an enterprise in improving energy efficiency.

The condition of *low status of energy efficiency*, as shown by (Sorrell at al., 2000), it refers to the functions devoted to energy management that do not have sufficient power to act effectively to improve energy efficiency. The power and the influence of an energy management depends upon its formal authority, the control it has of scarce resources and its access to information. It is commonly the case that energy management has a relatively low status and is viewed as a peripheral issue by top management.

As suggested by (Jaffe & Stavins, 1994)and reported by several others the decision-maker might not gain the benefits from improving energy efficiency: this is the problem of *split incentives*.

A *complex decision chain*, as proposed by (Sorrell et al., 2000) occurs when the decision process involves several functions, and the information flow might not be straight and smooth.

With the barrier of *lack of time* the decision-maker does not have enough time to consider energy efficiency opportunities. This frequently happens when other priorities are and especially the energy efficiency problems are not seen as support to the core business.

Without adequate control systems established by the management, the personnel within firms might not implement energy efficiency practices and born a problem called *lack of internal control*. This phenomenon has been investigated in the study by (Sorrell et al., 2000), thus leading to the principal-agent relationships and the consequent adoption of higher return rates for energy-efficient technologies.

*Barriers related to the competences*

In order to implement energy efficiency interventions, specific competences have to be available within the organization. Although the investment in energy efficiency were undertaken, the lack of competence could lead to incorrect use and therefore do not achieve the desired objectives. Indeed, those barriers can be particularly critical for small and medium-sized enterprises, in which personnel might be trained to operate equipment, to analyze inefficiencies, opportunities, and to implement the needed actions.
*Identifying the inefficiencies* is a barrier that might occur when, even with a great awareness of the energy issues, and consciousness of the benefits of energy-efficient technologies, specific competences on methods and tools to identify energy waste are lacking.

*Identifying the opportunities* is similar to the previous one, and represents the difficulty to identify the opportunities to improve energy efficiency.

*Implementing the interventions* is a barrier that shows the difficulty to implement practices and interventions for energy efficiency, without the support of external consultants or personnel.

Also this set of barriers need an integration from the external ones and in particular for the *difficulty in gathering external skills*. In implementing the energy efficiency interventions is usual to need an help form the external, the prices and/or availability of consultants might represent a barrier in the supply of existing energy-efficient technologies, as suggested by (A. Trianni & Cagno, 2012).

*Awareness*

This barrier aims at pointing out the ignorance of decision makers on energy efficiency and the complete lack of interest in energy issues.
*Lack of awareness (or ignorance)* represents a status of the decision-makers in which, as reported by (A. T. de Almeida et al., 2003), they simply ignore the possible benefits coming from the implementation of energy efficiency opportunities. The increased awareness within the chain of decision port also great benefit in terms of overcoming other barriers.

### *3.2.2 Spectrum of influence of the barriers*

As the barriers have been categorized according to their origin, there is another important characteristic for the empirical investigation to analyze the possible interactions among the barriers. The spectrum of influence of the barriers is able to underline how general or specific the effect of the barrier is on the firm‘s decisions. Becoming more specific with respect to energy-efficient technologies, we can distinguish between three different levels:

• Barriers to investments: those barriers are not specifically related to energy efficiency, but generally consume the necessary resources for any investment and intervention. In this regard the *low capital availability*, *inertia*, *imperfect evaluation criteria* and *lack of time* do not necessary refer exclusively to energy efficiency, but rather can be considered as general barriers to investments.

• Barriers to energy efficiency: those barriers represent a hurdle for any investment in energy-efficient technologies. Thus, they can be investigated regardless of the specific intervention to be considered. So, the barrier *difficulty in identifying the inefficiencies* represents a general barrier for energy efficiency investments, thus not depending on a specific intervention.

• Intervention-related barriers to energy efficiency: those barriers, whose values strictly depend on the specific energy-efficient technology to be considered, can be investigated exclusively considering a specific investment. After that consideration *hidden costs* can be investigated in their real values exclusively considering a specific investment in an energy-efficient technology

**Table 3: Taxonomy of barriers for empirical investigation (Trianni et al. 2013)**

| | |
|---|---|
| Technology-related barriers | Technologies not adequate |
| | Technologies not available |
| Information barriers | Lack of information on costs and benefits |
| | Information not clear by technology suppliers |
| | Trustworthiness of the information source |
| | Information issues on energy contracts |
| Economic | Low capital availability |
| | Investment costs |
| | Hidden costs |
| | Intervention-related risks |
| | External risks |
| | Intervention not sufficiently profitable |
| Behavioral | Lack of interest in energy-efficiency interventions |
| | Other priorities |
| | Inertia |
| | Imperfect evaluation criteria |
| | Lack of sharing the objective |
| Organizational | Low status of energy efficiency |
| | Divergent interests |
| | Complex decision chain |
| | Lack of time |
| | Lack of internal control |
| Barriers related to competences | Identifying the inefficiencies |
| | Implementing the interventions |
| | Implementing the interventions |
| | Difficulty in gathering external competences |
| Awareness | Lack of awareness ignorance |

# Chapter 4

# Drivers for energy efficiency

## *4.1 Literature review of energy efficiency policies*

Energy efficiency is considered as the most effective way to reduce greenhouse gas (GHG) emissions from fossil fuel as well as to mitigate climate change. Economic and political interventions are inevitable to face these concerns. These actions include legislation, incentives to investment, energy generation targets, taxation, research and development (R&D) incentive programs, voluntary programs, etc. Many countries have chosen to respond to energy and environmental challenges. Among these responses there is the development of energy policies that are actions implemented by governments that normally lead to energy efficiency improvement.

If we consider the entire system, we find the government on the top and, below, several actors such as local authorities, utilities, financial institutions, energy supply, energy service companies (ESCOs), industrial association groups (IAGs), manufacturers, etc., thanks to which the decisions taken at the highest level can penetrate within single companies.

By looking at some definitions of energy efficiency policies derived from literature review, we can find:

1. (European Commission, 2006): *"Energy efficiency improvement measures': all actions that normally lead to verifiable and measurable or estimable energy efficiency improvement."*

*2.* (Nilsson, 2007): ***"****Energy efficiency policies, per se, are a remedy against an increasing global energy demand."*

*3.* (Streimikiene, Volochovic, & Simanaviciene, 2012): ***"****Energy efficiency policies are just one type of energy policy, namely that serving environmental goals of less pollution and less resource depletion by enabling the same economic benefit with less input."*

These policies are generated by an external system to the company, but they aim at influencing the behavior of industries. There is therefore a link between the two systems generated by these policies. This aspect is covered by (Tanaka, 2011) stating that*:* ***"****Industry's possibilities for using energy more efficiently involve many technical actions*

*implemented under diverse political, economic, business and managerial circumstances. In theory, energy efficiency policies could target each of these elements."* From his study, it results that the number of policies is growing and shifting in focus following two trends. One trend has been the shift from energy conservation (aimed at absolute energy savings) to energy efficiency (aimed at reducing the energy used per level of production output). Another trend has been the increasing emphasis on climate change and sustainable development objectives in recent years. In his work, Tanaka states that governments use two general policy approaches and various streams of influence to encourage industries to improve their energy efficiency. These approaches differ in their sphere of influence: one is targeted to industry and its specific sector, and the other relates more broadly to the social and industrial context in which the company operates. He also groups energy policies in three main categories: prescriptive, economic and supportive. Prescriptive policies are regulations, mandates and agreements that directly compel specific actions by industry companies and associations. Economic policies are taxes and tax reductions, directed financial support, cap and trade schemes, and differentiated energy prices that seek to influence the cost-effectiveness of technical actions. Finally, supportive policies are energy efficiency opportunity identification tools, cooperative measures, capacity building and technical information and assistance information which help to establish a favorable environment in which industry might more easily implement energy efficiency actions. Tanaka also provides criteria for the evaluation of policies and analyzes in detail the specific area that they affect, followed by examples of policies grouped according to the geographical area, through surveying more than 300 policies implemented by governments in International Energy Agency (IEA) member countries, as well as in Brazil, China, India, Mexico, Russia and South Africa. Another interesting contribution comes from (Kemp & Volpi, 2008) who have studied the diffusion of clean technologies, finding that is affected not exclusively by environmental regulations, but also by other policies: subsidies for R&D and investment, pollution taxes and energy taxes, regulations other than environmental, competition policy and sector policies. Also policy goals, covenants and the implementation of the policies may affect clean technology diffusion.

### *4.1.1 Worldwide policies*

After providing these basic concepts, in the first part of the review we will focus on policies through the analysis of studies on OECD (Organization for Economic Co-operation and Development) countries and other states of the world (Brazil, China, South Africa, Malaysia, India, Taiwan, Korea, Bangladesh, Thailand, etc.). The second part instead will focus only on the energy efficiency policies over European geographic area.

According to (Anderson & Newell, 2004), one of the largest energy programs focused on industry is the American Information Assessment Center's (IAC) program, that offers energy audits to SMEs. A preliminary study focused on the United States derives from (Blumstein

et al., 1980) who focused their attention on the strategies to overcome social and institutional barriers. As stated by the authors, these strategies should be taken by the government and are divided into six categories: informing, leading, market-making, rule-making, pricing, and rationing. Informing refers to government actions aimed at providing information in several ways (by sponsoring research, by supporting libraries and by providing education and training). Leading consists in encouraging energy conserving behavior by leadership or in altering social norms of behavior. Market-making means to create markets for energy-conserving products or services through purchasing policies; in this case, the government could create markets in the role of entrepreneur, undertaking development and demonstration projects, or in the role of financier, underwriting loans. Rule-making includes rules for commercial transactions, affecting what is sold and who is permitted to buy or sell. With pricing, government policies can influence the incentives to consume or conserve by changing the net price of energy or energy consuming and conserving commodities. Prices can be set by regulation, by taxes or by subsidies. Finally, rationing means that the government can use rationing to conserve scarce resources by limiting consumption. At the end of the paper, some criteria for comparing and evaluating strategies are introduced.

(Hirst & Brown, 1990) have conducted a theoretical study arguing that the large untapped existing potential for improving US energy efficiency, able to save money and improve environmental quality, is due to structural and market barriers that inhibit adoption of cost-effective energy-efficient practices and measures. They identified numerous policy options for addressing these barriers. For example, the authors believe that *"increasing taxes on fuels or strengthening the pollution-control requirements associated with the extraction, transportation, and conversion of fuels would better align fuel prices with the full social costs of fuels production. Eliminating special incentives in the federal tax code for fuels production and modifying the regulation of electricity and gas prices could also reduce the disparity between fuel prices and costs".* The authors have then pointed out other possible policy solutions of different nature such as: publish fuel-price forecasts, offer financial incentives, provide tax credit, increase government funds for energy efficiency research and programs, modify state regulation of utilities, adopt energy efficiency codes and standards, conduct public information programs, provide visible leadership from top government and corporate officials, conduct demonstration programs, expand labeling and rating programs, conduct energy audits to assess the cost effectiveness of energy-efficient practices and measures. Hirst and Brown give also indications about the actors who affect energy efficiency purchasing and operations. Key players are recognized in: governments, energy suppliers, financial institutions, manufacturers, ESCOs, contractors and energy users.

(Worrell et al., 2001) presented a review of trends, barriers and opportunities for technology transfer, that is a process involving the trade and investment in technology, the selection, adoption, adaptation, and dissemination of industrial technology. They studied

the processes of technology transfer between and within countries, based on international experiences and focusing on OECD and developing countries. Regarding the policies, they found that information programmes are useful tools to increase consumers' awareness, acceptance, and use of particular technologies or utility energy conservation programmes. These information programmes include educational brochures, videos, audits, and labeling programmes. Energy audit programmes are considered as a more targeted type of information transaction than advertising. International partnership of firms can be also a successful tool to transfer technologies. According to the authors, direct subsidies, soft-loans, tax credits or other favorable tax treatments represent a traditional approach for promoting activities that are thought to be socially desirable. Finally, technology transfer projects need continued support from the technology supplier that is beneficial to both the technology user and supplier: in fact, the user can benefit from experience from other licensees, and the licensor gets an opportunity to gain further market entrance.

(Worrell & Price, 2001) investigate three policy scenarios, entailing different degrees of commitment to improve energy efficiency to address the energy, economic and environmental challenges faced by the US industry. The first scenario (business-as-usual, BAU) represents what would occur if certain policies were not implemented; the second scenario (Moderate) is based on the establishment of voluntary agreements with industry that set modest annual energy efficiency improvement commitments; finally, the third scenario (Advanced), sets higher voluntary energy efficiency improvement commitments. In BAU scenario energy intensity shows a slight grow of 0.7%/year, while for moderate scenario is 8% lower. Advanced scenario instead is expected to result in a considerable energy savings giving a strong push to reduce GHG emissions and showing better results for energy use (about 16.5% less than BAU). Industrial sector policies and programs are designed to address a number of barriers to investments in energy efficiency, including willingness to invest, information and transaction costs, profitability barriers, lack of skilled personnel, and other market barriers. Voluntary sector agreements between government and industry are used as the key policy mechanism to improve energy efficiency and to reduce greenhouse gas emissions because, as stated by the authors, an integrated policy accounting for the characteristics of technologies, plant-specific conditions, and industrial sector business practices is needed. Beside the presentation of various policies and programs that fall under the scope of voluntary industrial sector agreements, the authors have interestingly provided their categorization according to five groups: voluntary programs; information dissemination; investment enabling; regulations; and research, development and demonstration. Voluntary programs contain expanded challenge programs, expanded Energy Star buildings and green lights, expanded Energy Star and climate wise program and expanded pollution prevention programs. Information programs include expanded assessment programs and product labeling and procurement. Investment enabling programs include expanded state programs (Clean air programs), expanded ESCO/utility programs and financial incentives. Regulations regards motor standards and

certification, state implementation plans/clean air partnership fund. Finally, research and development programs include expanded demonstration programs and expanded R&D programs.

Also (Brown, 2001) analyzes policy programs in the United States, finding that: *"information programs and technical assistance can help make up for incomplete information by reducing the consumer's cost of acquiring and using needed information"*. In addition, the author gives importance to technical demonstration, public and private R&D, regulatory policy and programs of funding. A more recent study about American policies has been developed by (Gillingham, Newell, & Palmer, 2006), focused on the adoption of energy-efficient equipment and building practices rather than on energy research and development. They analyzed the state of the art of American energy efficiency policies classifying them into four categories: appliance standards, financial incentive programs (for energy-efficient investments), information and voluntary programs, and management of government energy use.

By taking a look outside specifically developed policies for the United States, we can find several interesting contributions in the literature. (Geller, Harrington, Rosenfeld, Tanishima, & Unander, 2006) have indeed reviewed and compared programs in US, as well Japan and Western Europe. The authors give importance to government funded R&D to minimum standard efficiency saying that: *"policy makers should ensure that efficiency standards are technically and economically feasible".* They find also that voluntary agreements between governments and the private sector can be effective especially when complemented with financial incentives, technical assistance where needed, and the threat of taxes or regulation if companies fail to meet their commitments. Finally, importance is given to financial subsidies, information dissemination and training, stating that: *"In general, energy efficiency policies and programs work best if they are integrated into market transformation strategies, addressing the range of barriers."*

(Nan Zhou, Levine, & Price, 2010), studying Chinese energy efficiency policies, highlight their relevance in reducing the growth in energy demand, but also their capability to reduce the need for investment in energy supply, thus releasing capital for other investments to support important social goals. It was placed an exceptional emphasis on energy- efficiency for two decades providing many benefits to China and, in terms of energy-related carbon dioxide ($CO_2$) emissions and reduced stress on global energy resources, to the world. The main examples of policies presented in this work are grown after the announcement of 20% reduction in energy intensity target stated in *11$^{th}$ Five-Year Plan*. One is the *Medium and Long-Term Plan for Energy Conservation* of 2004 that sets out specific targets for the industrial, transportation, and buildings sectors. This is a broad program that includes many projects and a list of top ten priorities. Among those, we can find: monitoring, taxes and incentives, laws and education programs. Later, in 2006, the Decision on Strengthening Energy Conservation deal with changes in China's industrial structure for reducing energy

intensity. The Decision stresses the importance of energy efficiency, prioritizes clean energy in the power generation and also promotes tax and fiscal policies to support energy conservation, as well as reform of energy pricing. The *Energy Conservation Law* is a policy that governs the administration of energy policies, the proper use of energy resources, and the promotion of energy-saving technologies and energy-related environmental protection. This measure has been revised in 2008, clarifying the legal basis for the measures included in the *11th Five-Year Plan* identifying the organizations of government responsible for implementing the plan, prohibiting many high energy-consuming products, authorizing provinces to penalize companies deemed to be using energy wastefully, and providing the basis for the creation of special fund and incentive policies for energy efficiency. Finally, they deal with the description of other policies that apply to particular sectors as: industry, buildings, transportation, appliance of standard and labeling and government procurement; without neglecting the existence of cross-sectorial policies that cut across end-use sectors. (Andrews-Speed, 2009) also deals with the situation in China examining measures to enhance energy efficiency. He examines characteristics of an energy efficiency policy asserting that it requires a unique combination of measures including regulatory instruments, financial incentives, information provision, and the mix of measures needs to be adapted to the situations of each particular country. It is then deepened the role of government, as: *"Energy efficiency should not be restricted to just energy policy, but should become an integral part of most government policies"*. Hence, an effective energy efficiency policy encompasses regulations, pricing education and information, as well as the encouragement of active participation of all parts of society also analyzing Chinese government programs. The Development Research Centre of the State Council has published the most authoritative report, having as main priorities: integrating environmental priorities into energy policy, increasing the use of hydro-electricity, renewables, nuclear energy and natural gas and the development of alternative transport fuels. It is then picked up the *Energy Conservation Law,* already cited from (Nan Zhou et al., 2010), concluding that: *"Security of energy supply remains the key concern, but substantially more emphasis is being placed on energy conservation and energy efficiency than before, and on environmental priorities"*. The study has also analyzed the case of industry, that remains the key focus of Chinese energy conservation efforts. Enterprises have indeed been charged with setting up management groups, establishing procedures for energy audits, drawing up energy saving plans, investing in energy saving technologies, and introducing internal incentives to save energy. Others crucial policies are: financial and fiscal policies, such as providing income tax deductions; policy support for upgrading existing facilities to save energy; penalties for enterprises which do not report the required information, which falsify information or which fail to establish the required internal management systems; special training programs; voluntary agreements; closing small and outdated plants; and a number of specific measure in the power sector. In addition, Chinese government is taking steps to raise the level of awareness of the energy challenges facing the country helped by the media in monitoring energy use and saving, and in raising

public awareness. Hence, the authors conclude that: *"…government's current campaign is having some effect in the short-term, as inefficient plants are closed and new technologies introduced. The question is whether this trend of improvement can be sustained…"*. In a more recent study, (Liu, Niu, Bao, Suk, & Shishime, 2012) have dealt with case studies taken in the Chinese province of Taicang. Starting from the extant literature, they identify the importance of externally coercive, normative and mimetic pressures recognized by the institutional sociology. In particular, the latter encompasses pressure from the organizations with mandatory power, normative pressure from the industrial associations, and mimetic pressure from the business competitors. The paper then explores others policies as well as the role of others actors, such as agencies that promulgate and enforce existing regulations on industrial energy efficiency, or government able to enhance the company's energy saving by announcing future mandatory energy efficiency standards.

(Vine et al., 2003) present the result of a work completed within the International Energy Agency's Demand-Side Management Program and supported by 13 participating countries plus the European Commission. Indeed, the aim of the paper is twofold: on the one hand, to focus on the potential effectiveness of the reform of the electricity industry for promoting energy efficiency and load management; on the other hand, to evaluate the potential effectiveness of new policies for promoting energy efficiency and load management in California. The author's interest has arisen looking at the efforts made by many countries to initiate reforms of their power sectors to stimulate private investment, increase operation and management efficiencies, and lower the cost of power. Moreover, (Vine et al., 2003) believe that restructuring electric industry may force regulators and policy makers to re-examine existing policies for promoting load management and energy efficiency. In some cases, restructuring electric industry replaces the traditional relationship between a single monopoly provider and customers with a new set of relationship among retail electricity suppliers and customers. However, it is uncertain whether this type of restructuring will overcome important market barriers to energy efficiency that inhibit the effective functioning of markets for energy-efficient products and services. As the authors note, energy efficiency policies are an appropriate government strategy to overcome these barriers. In their work, they call policies under the name of *mechanisms*. Reviewing existing mechanisms implemented in other countries, the authors classify them into four categories: control mechanisms that direct energy businesses to change behavior; funding mechanisms that provide funding for other mechanisms; support mechanisms that provide support for behavioral changes by end users and energy businesses; and market mechanisms that use market forces to encourage behavioral changes by end users and electricity businesses. Control mechanisms include: mandatory sourcing of energy efficiency, energy-efficiency license conditions for electricity businesses, integrated resource planning, energy efficiency and load management as alternatives to network expansion and revenue regulation. Funding mechanisms include exclusively: public benefits charge for energy efficiency and financing of energy efficiency by electricity businesses.

Support mechanisms include: sustainable energy training schemes for practitioners; energy centers; creation of entrepreneurial energy organizations; development of the ESCO industry; promotion of energy efficiency by industry associations; aggregation of electricity purchasers to achieve energy efficiency; and voluntary agreements for energy efficiency. Finally, market mechanisms include: taxes on energy; tax exemptions and incentives for energy efficiency; provision of consumption information on customers' electricity bills; communication of pricing and other information for energy efficiency; energy performance labeling; development of an energy-efficiency brand; cooperative procurement of energy-efficient appliances and equipment; energy performance contracting; competitive sourcing of energy services; competitive sourcing of demand-side resources; and demand-side bidding in competitive markets. (Vine et al., 2003) have also developed evaluation criteria to assess the likely effectiveness of each mechanism in promoting energy efficiency and load management. It was not possible to use a simple quantitative indicator since its levels vary depending on the context within each mechanism is applied. In addition, it was difficult to obtain quantitative data for mechanisms already implemented. Therefore the authors have used evaluation criteria such as: demonstrated effectiveness, flexibility within the social environment, cost-effectiveness, etc.

(Saidel & Alves, 2003) use a geographical classification of the policies focusing on OECD countries asserting that: *"Due to several reasons ranging from environmental concerns to security of energetic supply, almost every country in the OECD has implemented a host of energy-efficiency policies."* So they analyze government programs saying that they fit into five basic categories: (1) restrictive regulations, (2) information to the public, (3) creation of market asymmetries, (4) funding/loans programs and (5) state capital/private capital partnerships. The authors have also detailed which actions might be stimulated by those initiatives. In particular, class (1) programs rely on restrictive legislation in order to ensure that manufactured/marketed products are in accordance with energy-efficiency performance standards. Class (2) initiatives aim at raising public awareness of energy efficiency issues in order to achieve better market penetration of energy-efficient technologies. Class (3) measures work by tipping the scale in favor of energy-efficient technologies and appliances. Class (4) policies refer to purchasers and energy consumers that otherwise would not be able to make use of energy- efficient technologies because of their high initial costs. Finally, class (5) includes research partnerships in which governmental departments set research goals and choose private research projects for financial funding through competitive solicitation processes. The authors recognize the cross-correlation between policies noting that: *"initiatives in the third group are frequently a combination of measures from the first and second groups. Additionally, policies in class 5 are sometimes a mix of class 4 (funding) and 2 (information) measures."*

(Geller, Schaeffer, Szklo, & Tolmasquim, 2004) analyze the particular case of the Brazilian policies for energy-efficiency and renewable energy. They note that such policies over the

past 25 years mainly attempted to reduce the country's dependence on foreign energy supplies and stimulate the development of domestic energy sources. Policies for increasing modern renewable energy sources were very successful, while policies for increasing energy efficiency and expanding natural gas use were moderately successful. In their research, a set of proposed policies aimed at increasing energy efficiency or renewable energy use is analyzed. Focusing on energy efficiency initiatives in the industrial sector, the main actions are related to the adoption of standards and to the push towards the acceptance of efficient technologies as well as alternative energy sources (Combined heat and power (CHP) systems, CHP systems fueled by natural gas, thermal power plant, renewable energy use). As a matter of example, the study illustrates the *national electricity conservation program (PROCEL)* that, together with the National Testing and Standards Agency, has established both energy efficiency test procedures and an efficiency labeling program, and has also provided recognition and promotion of top-rated energy-efficient products. (Geller et al., 2004) also note a policy derived from the regulatory agency for the electric sector (ANEEL), that has begun requiring distribution utilities in Brazil to invest at least 1 % of their revenues in energy efficiency programs. Moreover, other important policies from Brazilian government include: establish energy intensity reduction targets for major industries through voluntary agreements between the government and industry, and variation in taxes and government programs for new technologies and energy sources. Finally, (Geller, Schaeffer, Szklo, & Tolmasquim, 2004) highlight the importance of a long-term commitment from the government, the presence of a comprehensive set of policies to overcome technical, institutional and market barriers and an active engagement of the private sector.

(Blok, 2005) conducted an international study to show that high rates of reduction of specific energy consumption in several sectors, including the industrial one, can still be achieved. The author has argued on the one hand that developing technologies are very important for increasing rates of energy efficiency improvement, on the other hand that the most important instrument Governments have used so far to stimulate technological development is research and development funding. (Blok, 2005) has also recognized that R&D subsidies do not represent the only instrument Governments has to accelerate innovation toward higher energy efficiency. In fact, he has highlighted the following policy approaches: technology forcing standards or incremental standard-setting; cooperative technology agreements between industry and government; technology procurement (with which a sufficiently large buyers group is organized to require the delivery of products with a certain energy efficiency level); and government funding. Nonetheless, the author concluded that, in order to add completely new technologies to the portfolio, other policies will necessarily play an important role. For example: energy R&D infrastructure should be maintained and built up; successful innovators should be rewarded creating a system similar to that for scientists; contests directed at a specific need for new technology should be held.

(Ottinger, 2006) outlined available efficiency measures, their economic advantages and means by which they may be and have been implemented in an international context. The author has analyzed how several countries have passed comprehensive legislation promoting industrial efficiency. Thailand, for example, has implemented a number of measures to increase energy efficiency in the industrial sector, including: demand management, financial incentives, minimum efficiency standards for machinery, and the provision of support structures. The author identified additional measures to increase energy efficiency: removal of subsidies for fossil fuel, nuclear and electricity systems (following the example of: Brazil, China, the Czech Republic, India, the Netherlands, Poland, the United Kingdom and Russia); incentives; education and training; use of externality costs and life-cycle costing; taxes on pollution and inefficient products; standards; environmental impact assessment and audits; research, development and technology transfer. Also government procurement is regarded as an useful measure, as government agencies at all levels are major purchasers of buildings, appliances, vehicles and other energy-consuming items. So, purchasing standards for government agencies, as well as imposing them to purchase only the most efficient item, can create markets for energy-saving products, reduce their prices, and help to educate the public about their advantages. Lastly, the author highlights the relevance of utility programs. Since electricity and gas utilities are knowledgeable about energy and have relationships with their customers, they are acknowledged to be in a good position to support educating customers about savings achievable through energy efficiency and encourage the purchase of efficient products.

(Sovacool, 2009), relying on extensive research interviews and supplemented with a review of the academic literature, assesses the most effective paths to promote renewable energy and energy efficiency. The study is based on 181 semi-structured ethnographic interviews at 93 institutions in Belgium, Canada, Denmark, France, Germany, Japan, Korea, the Philippines, Singapore, Spain, Switzerland, United Kingdom, and above all the United States over the course of 3 years. The author focuses on the policy mechanisms to promote renewable electricity and energy efficiency. Given that the impediments (barriers) facing energy efficiency and renewable energy sources are simultaneously technical, economic, political, and social, it is reasonable that the selected optimal policies target each of these dimensions. Sovacool identifies four policy mechanisms resulting with the strongest support, namely: eliminating subsidies for conventional and mature energy systems; altering electricity prices; forcing utilities to adopt renewables; and increasing funding for renewable power through a national systems benefit charge. According to the author, eliminate conventional subsidies would bring three important changes. Firstly, it would send market signals to consumers and encourage more rational use and valuation of power resources. Secondly, it would improve competition in the electricity industry, eliminating the unfair advantage given to nuclear and fossil-fuel technologies; and, thirdly, abolishing energy subsidies would free up billions of dollars of government revenue that could be funneled back into R&D on newer technologies or fund other programs. Altering electricity

prices consists in some actions such as: abolishing price caps that would enable electricity rates to reflect current market prices and volatility; eliminating declining block-rate pricing that would create an incentive for industries to promote energy efficiency and consume less electricity; and internalizing external costs that would drastically raise electricity prices, but would also ensure that electricity is accurately priced. The third most important policy consists in making renewable power mandatory by implementing national feed-in tariffs (FITs). FITs obligate electric utilities to purchase the electricity from renewable energy resources in their service area for a specified period of time, and ensure a stable investment stream for project developers, as the profitability of projects is guaranteed. This type of pricing system makes it easier for developers to obtain bank financing for investments in renewable energy. As noted by the author, national FIT represents the best option to encourage quick expansion of renewable power. Moreover, despite the extra initial costs, national FIT policies quickly depress electricity prices. Considering the fourth most relevant policy, the author highlights the role of a national systems benefit charge (SBC) aiming at distributing public information and promoting energy efficiency. The policy is focused on information and education campaigns, public demonstrations, energy audits, certification programs, demand side management programs, etc. The article also discusses why these policy mechanisms must be implemented comprehensively, not individually, if the barriers to renewables and energy efficiency are to be overcome.

In the work of (Alam Hossain Mondal, Kamp, & Pachova, 2010), a critical review of policies and institutional settings has been performed, in order to support decision-makers in formulating renewable energy policies and future plans for Bangladesh. A draft renewable energy policy of 2002 and revised in 2008 provided modalities and procedures, tariff regulations, fiscal and other incentives for implementation of renewable energy technologies, and guidelines for establishment of an independent renewable energy authority. For the success of these policies it is stressed the importance to have a local institutional context that should fit with the technology — including cultural aspects, policy programs, financial incentives, levels of education, etc. Therefore, in a well-functioning institutional context, government support and supporting policy framework should play a large role giving financial support, technical education, information dissemination, and availability of material and hardware.

(Hasanbeigi, Menke, & Pont, 2010), performed a review of present energy policies in Thailand. They begin with the 1992 Energy Conservation and Promotion Act (ENCON Act), a law aimed at improving energy efficiency and increasing the share of renewable energy in the national mix. ENCON Act also sets a levy on petrol in order to fund the Energy Conservation Program (ENCON Fund) and gives financial assistance for energy efficiency improvement and the promotion of renewable energy in Thailand. For what concerns financial aspects, the ECON fund gives the approval to set-up an Energy Efficiency Revolving Fund managed by financial institutes providing low-interest loans to designated companies

to invest in energy efficiency. Furthermore, the authors have analyzed other fiscal policies to promote energy efficiency in industry including: cost-based tax incentives; performance-based tax incentives; Incentive through Board of Investment; accelerated depreciation; and the 30% subsidy program. Finally, the Electricity Generation Authority of Thailand runs a demand side management (DSM) program offering energy audit services and load management to industrial plants. The DSM office also started an high efficiency motor program in Thailand and conducted a pilot 'Energy Service Company' project in four industries with limited success through a funding support from the ENCON Fund.

In the study of (Millar & Russell, 2011), it is analyzed the Caribbean situation for the adoption of sustainable manufacturing practices. The results of the survey suggest several opportunities for the governments. Indeed, they are recognized as a major funder financially supporting manufacturers who are willing to adopt sustainability practices; as an auditor providing assessments of current practices and accrediting manufacturers as 'sustainable manufacturers'; as a facilitator providing free training and seminars on sustainable manufacturing; and as a regulator/enforcer pursuing and punishing major polluting companies. Consequently, the main policies suggested by the same manufacturers are: monetary and fiscal incentives such as tax breaks and concessions; assistance to manufacturers to identify alternative; encouragement of recycling programs, provision of funding/grants or low interest loans; implementation of a tariff structure to discourage polluters; creation of a campaign to increase awareness and provide and/or facilitate training and education for interested manufacturers.

(Abdelaziz, Saidur, & Mekhilef, 2011) present a comprehensive literature review about industrial energy saving by management, technologies and policies. Concerning the policies, they claim that energy policy is the medium by which a given entity (often governmental) has decided to address energy development issues, including energy production, distribution and consumption. Several attributes of energy policy have been identified. Indeed, they may include: legislation, international treaties, incentives to investment, agreements, guidelines for energy conservation, taxation, energy efficiency standards, energy guide labels. It is interesting to note that the authors take into account some actors related to policies, stating that: *"Industrial energy policy can be viewed as a tool for developing a long-term strategic plan, covering a period of 5-10 years, for increasing industrial energy efficiency and reducing greenhouse gas emissions. This policy engages not only the engineers and management at industrial facilities, but also includes government, industry associations, financial institutions, and others"* (Abdelaziz et al., 2011). Furthermore some policies are listed, such as: regulations / standards that are applied to particular pieces of equipment such as motors, boilers, etc., and can require that industrial facilities conduct energy audits or adopt an energy management system; fiscal policies that include imposition of taxes, tax rebates, investment tax credits, and establishing investment bank lending criteria for promotion of energy efficiency; and agreements / targets between

government and industry based on specified energy efficiency improvement targets or based on specific energy use or carbon emissions reduction commitments. Moreover, they highlight several national policies with various purposes, depending on the country: some aim to reduce $CO_2$ emissions, others to spread information among companies, establish benchmarking, introduce energy management and motivate staff to ensure investments in new equipment.

### *4.1.2 European countries policies*

We show now the situation in Europe, passing from Northern-Western (e.g. Sweden, Finland, United Kingdom, France, the Netherlands) to Southern-Eastern Europe (Slovenia, Lithuania, Greece). In the last decade, European environmental policy has proliferated into a vast array of directives, decisions and regulations that cover all aspects of the environmental impact of commerce: air quality, industrial pollution, waste and water management, resource use, biodiversity, and noise pollution (Uhlaner, Berent-Braun, Jeurissen, & Wit, 2012). An important contribution to energy efficiency in Europe was given by (European Commission, 2006) that addresses a number of activities and services, such as the availability of energy auditing for small and medium-sized industrial customers. The study also highlights the availability of energy efficiency funds to all market actors and promotes energy audits and financial incentives for the adoption of energy efficiency measures and energy services. According to (Thollander, Danestig, & Rohdin, 2007), the directive stresses the need to discuss possible end-use energy policy initiatives directed at small and medium-sized enterprises (SMEs) in a national context. So they have analyzed this case in Swedish industries analyzing government programs that have occurred over the years. The Swedish Ministry of Enterprise, Energy and Communications argues that energy policies should be general and not targeted towards one single technology, and categorizes energy policy instruments into: economic policy instruments like taxes, subsidies, financial incentives, etc.; administrative policy instruments like rules and regulations; and informative policy instruments like information campaigns/programs. Some of the energy programs like the EKO-Energy program concerning voluntary agreements and PFE that offer a tax discount on electricity, the implementation of an energy management and the introduction of standardized routines for energy efficiency, were directed to energy intensive industries. Moreover, (Thollander, Danestig, & Rohdin, 2007) look at the efforts done towards SMEs, reporting a 2006 nationwide action from the Swedish Energy Agency (SEA) constituted by a series of informative seminars. The SEA has also financially supported the local authority energy consultancy (that provide consumers with independent advice on energy matters) in each municipality. Always looking at Sweden, another project, named ELOST, has involved energy audits and focused on the reduction of electricity use as an adjustment to an assumed electricity price increase. Moreover, (Thollander et al., 2007) presented the Project Highland, a local energy program, and the evaluation of its performance. Project Highland is the most extensive action targeting the

adoption of energy efficiency measures in SMEs, including 340 energy audits in six municipalities, of which 139 audits were made at manufacturing industries. A major result of the project is the effectiveness of *"using intermediaries like local authority energy consultants and regional energy agencies, the concept of local energy programs",* in terms of public money spent in relation to energy saved. A more recent study by (P. Thollander & Dotzauer, 2010) deals with SMEs. They have identified industrial energy programs such as energy audit programs and long-term agreements (LTAs) as one of the most common means of promoting energy efficiency in industry. In addition they analyze an European policy called *"The European Energy End-Use Efficiency and Energy Services Directive"* (ESD), providing the necessary indicative targets as well as mechanisms, incentives and institutional, financial and legal frameworks to remove existing market barriers and imperfections. This policy also creates the conditions for the development and promotion of a market for energy services and for the delivery of other energy efficiency improvement measures to final consumers.

A recent study of (Y. Wang, 2006) reviews renewable electricity development, focusing on policies that have been enacted to promote renewable electricity. The study provides explanations behind policy successes and failures taking into account that Swedish renewable energy policy has developed in a context of uncertainty around nuclear issues. In fact, such uncertainty had an effect in formulating renewable energy policies. The author has grouped policies according to three main categories: (1) price-setting and quantify-forcing policies, which mandate prices or quantities; (2) investment cost reduction policies, which provide incentives in the form of lower investment costs; and (3) public investments and market facilitation activities, which offer a wide range of public policies that reduce market barriers and facilitate or accelerate renewable energy markets. As stated by (Wang, 2006), policies taken to promote renewable energy in Sweden are so far: investment subsidies, subsidies for research and technology demonstration, tax policies including emission taxes and tax relief for renewable energy, and quantity-forcing policies (quota systems). Analyzing policies with more detail, investment subsidies provide the security for investors as they decrease both financial barriers and costs, and allow government to maintain a firm control. Tax policies have become very important because they account for externalities and thereby reflect some of the social costs of energy use. Research, development and demonstration (RD&D) programs are instead pursued to reduce the costs, and introduce new energy technologies, both for renewable energy and energy efficiency. Thanks to the subsidies for R&D, Swedish universities are providing more applied research and industrial collaboration, establishing a number of "hubs" or "Centers of Competence". Finally, under the quota systems, governments set political targets and let the market determine prices through certificate markets. The quota system has been introduced in Sweden through a electricity certificates trading system, under which the producer can sells the electricity produced in the electricity market and receives revenue for the sale. As the certificate received from the State can be sold, the producer can receive

an extra revenue. Therefore, producers of electricity based on renewable sources of energy receive revenues both from the sale of electricity and from the sale of certificates. The advantage of such a system would be the elimination of the subsidies from the state budget and the introduction of competition between different producers of electricity from renewable sources, which in turn is expected to reduce the total costs. Also (Johansson, 2006) look at Sweden and analyzes climate policy instruments for industry, and the possibility of different policy instruments to contribute to reductions in industrial $CO_2$ emissions, while preserving the competitiveness of industry, is evaluated theoretically. The consequences of increasing the cost of $CO_2$ emission in various industrial sectors are also discussed and he focused on policies such as carbon and energy taxes, emission trading, and regulations. In particular, Johansson illustrates the difficulty in designing these policies that are often adapted in such a way that some of their potential advantages are eliminated. In fact, carbon taxes can impose unacceptable costs on industries, emission trading may have a little effect on production level and regulations could result inefficient as the emission will be reduced to low levels.

The study of (Sivill, Manninen, Hippinen, & Ahtila, 2012) explores the development priority of energy performance measurement in Finland. Although the external pressures have increased, the study highlights that a persistent gap exists between technologically and economically viable energy efficiency measures and those carried out in reality. According to the authors, energy performance measurement can influence the success of energy management: in fact, a performance measurement system is able to provide an organization with a means of control, performance evaluation and decision support. They also show some policies supporting the implementation of energy management in industry in Finland. These include: increasing energy costs, environmental regulations, fiscal measures, rising environmental and social concern and public support in the form of research and development, and the establishment of voluntary agreements and investment subsidies.

(Vidil & Marvillet, 2005) describe the various mechanisms behind innovation process in the energy field in both French and European context using three different examples: compact heat exchangers, refrigeration equipment, hydrogen and fuel cells. Each of them has been analyzed in detail and some policies for their penetration have been identified. The authors have highlighted the viewpoint of manufacturers claiming that they play a vital role for the innovation, as they carry out research and development, make prototypes and finally put new technologies on the market. Hence, it is explained which may be the role of these intermediaries. In addition, government can intervene giving regulatory restriction in the technology's sector, such as stringent emission standard for environmental pollutants. The authors have then identified a set of policies to disseminate new technologies. For example, manufacturers could be obliged to develop new products and systems, improve their design, or integrate innovative component to promote new machine architectures. Or

yet, laboratories and private companies could develop research for promoting demonstration activities and technology transfer to the industry.

Remaining in the Northern Europe, (Green, 1996) analyzes policies in the UK for the promotion of CHP technology. The research explores some governmental programs and agencies that are responsible for regulations of electricity environment and gas, focusing also on local authorities. According to this study, governments are in charge of many initiatives: make legislations and regulations, encourage urban corporations to invest in energy efficiency, give a clear strategy to formulate and implement energy efficiency plan, and support the European Commission's initiatives. In particular, the author has words for the UK government regarding European policies like the EC's SAVE program and $CO_2$. Indeed, the author states that: *"EC policy is therefore limited in its effectiveness by the resistance of some member states, including the UK."* Hence, for those programs the UK government should provide its own support, both political and economic, ensuring them to be properly framed. (Foxon et al., 2005) have analyzed policies for the penetration of renewable energy technologies in the UK. Following their framework, policies have two main purposes: to contribute at reducing UK carbon emissions, as well as to assist the development of a UK renewable industry. In some cases, there may be a tension between the relative importance of these two objectives. They analyzed some policy instruments as: public support for innovation given by UK government's Energy White Paper, and the UK's first market support scheme for renewables which offered renewable energy developers the opportunity to bid for contracts to sell electricity at a fixed premium price for a fixed term. Policies are then identified for a strong market penetration of new technologies. These policies include: support for R&D; market development policies, such as niche market support, long-range targets and obligations; and financial incentives, such as capital subsidies, tax credits and hypothecation of revenues. The authors conclude stating that: *"policy should also have an understanding of innovation as a system, and recognize that the technologies considered are diverse and face different challenges."* Similar work has been performed by (Dieperink, Brand, & Vermeulen, 2004), who are responsible for analyzing the diffusion of energy-saving technologies in Dutch industries. The authors identify transfer of information, learning process and cooperation within innovation networks for stimulating and accelerating the diffusion of environmental innovations as major forces. In particular, the government is recognized to be a crucial player and the effectiveness of governmental policy on environmental technology or on specific incentives offered by that policy are studied. Therefore, a government can use some instruments such as: requirements stipulated in permits; stimulating companies to set-up environmental management system; multi-year agreement with the energy sector; restrictive policy on the amount of energy used; and R&D instruments requiring co-operation within the business community. The authors interestingly find that the introduction of a subsidy system (in terms of subsidies to conduct feasibility studies and loans to make investments),does not lead to a higher diffusion rate. Finally, the research has briefly considered the aspect of the dynamics of

government intervention to better understand the way in which public policies can act. In doing that, the authors believe it is necessary to take into account the whole mix of instruments in the hand of a government, such as direct regulation, economic instruments, communicative instruments, and forms of self-regulation such as target-group policy, agreements with the private sector, environmental management, certification and their effects in the course of time. This topic is detailed in the study of (E. Luiten, Van Lente, & Blok, 2006) for which the effect of government intervention will depend on the dynamics of the manufacturing industry. In their research, they focus on how governmental R&D support can be effective in selected industrial process technologies: two for pulp and paper industry (impulse technology and shoe press technology) and two for iron and steel industry (strip casting technology and smelting reduction technology). Analyzing case studies, they conclude that decisions about R&D support of industrial energy-efficient technologies require an assessment of the existing (international) technology network. This requires an understanding of the actors, of the technology network and of the technology itself. Similar results have been found in a previous study by (E. E. M. Luiten & Blok, 2003) focused exclusively on the development of strip casting technology. The authors have identified all the aforementioned elements, but, for the specific case, highlight that *"various governments played a role in stimulating the development of strip casting technology. In general, the effect of government intervention was limited".* This effect is valid for this specific case but cannot be generalized. So, technology network with its mechanisms and providing information on energy-efficiency improvements and investments costs, is required to improve the effect of government intervention in the field of industrial energy-efficiency R&D and innovation.

Considering policies in Northern Europe SMEs, (Uhlaner et al., 2012) focus on the prediction of the engagement of Dutch SMEs in environmental management practices. Instead of listing a series of policies, the authors find that several endogenous factors, including tangibility of sector, firm size, innovation orientation, family influence and perceived financial benefits from energy conservation, predict a SMEs' level of engagement in selected environmental management practices. Indeed, as stated by (Gadenne, Kennedy, & McKeiver, 2009), environmental management practices are defined as actions undertaken by a business to reduce the environmental impact of their operations, and include active or deliberate strategies aimed at monitoring of company waste, producing or selling environmentally friendly products, and searching for more environmentally friendly products and services. The growing recognition that SMEs have a significant aggregate influence on the environment has fueled research into environmental management practices among smaller firms. Access to resources, decision-making process, values, norms, and sensitivity to brand reputation and image are just some of the aspects that researchers suggest may differentiate SMEs from large corporations and thus help to explain differences in their environmental practices, as also supported by (Williamson, Lynch-Wood, & Ramsay, 2006). Even if most of literature arguments and the available

empirical research contrast SMEs with larger firms, (Uhlaner et al., 2012) propose that size effects exert an influence on the likelihood of engagement in environmental management practices even within the SME size range. The authors have notably considered also the *tangibility* of sector, which includes tangible products sector (agriculture, manufacturing and construction), tangible services sector (transportation and communication), and intangible services sector (financial and business services). The authors argued that firms in more tangible sectors are likely to be closely monitored and be more aware of environmental issues, so that they are more likely to be in a position to benefit from the adoption of higher environmental standards and/or be required to adopt such standards (e.g. complete environmental certification programs, such as ISO 14001) to satisfy suppliers and customers. Moreover, according to (Uhlaner et al., 2011), the fact that a company is family-run may put significant, positive social pressures on firms, because family businesses are more socially responsible than non-family businesses, as the former often combine economic objectives with the traditional roles of the family social unit, and are typically strongly embedded in their local communities. Finally, the authors explore as a potential predictor the perceived financial benefits of energy and natural resource conservation, arguing that financial benefits are especially important to SMEs.

Moving towards Eastern Europe, (Streimikiene et al., 2012) analyze the energy efficiency policies in Lithuania, starting from a very wide analysis of European Union policies.. The main Lithuanian policy document to promote energy efficiency is the National Energy Efficiency Programme for 2006–2010, setting targets such as usage of renewable, renovation of buildings and updating energy facility increasing energy efficiency of energy production and use in all sectors. There are also two Energy Efficiency Action Plans adopted in Lithuania (2001 and 2008) that present an overview of the current energy consumption situation and describe newly adopted and envisaged energy efficiency measures aimed at the improvement of energy efficiency. Finally, (Streimikiene et al., 2012) show that the most common measures used in industry Lithuanian sector are voluntary agreements, financial measures and law on the environment, but state that: *"the impact of these measures on energy savings in industry is not easy to assess".* (Streimikiene, Ciegis, & Grundey, 2008) in a previous work on Lithuania listed a series of policies to analyze their impact in various fields. In particular, the Energy Law adopted in 2002 defines the principal objectives of state energy regulation and priorities of energy policy in Lithuania. This law also imposes particular restrictions on the technologies that will be imported. Other policies for energy efficiency are the National Energy Strategy (until 2020) on the restructuring and development of the energy sector, and the subsequent aforementioned National Energy Efficiency Programme. Finally, a Special Programme is described for Implementation of Energy Saving Measures. This program is established for financing programs of energy conservation and their effective utilization, and for the implementation, operation and development of utilization means of local and renewable energy resources. The program

resources are used for granting loans to finance programs and projects and carry out the function of Energy Efficiency Fund, which was operating in Lithuania from 1996 up to 2000.

It is interestingly appreciable the contribution provided by (Al-Mansour, 2011) who considers energy efficiency improvements as *"the main tools of energy policy to improve the competitiveness of the economy, security of supply, and environmental protection"*. Therefore, governments of IEA member countries are increasingly turning to energy efficiency measures to meet GHG (greenhouse gas) mitigation, energy security and economic development goals. This work reviews energy efficiency policies in Slovenia, starting from strategies and laws adopted from the Slovenian National Assembly (Parliament) for energy policy. One of the most important document was the ReNEP (Resolution on the National Energy Programme), as it defines the long-term development goals, orientation of energy supply, energy systems and mechanisms for the stimulation of the use of RES (renewable energy sources). Moreover, the Government can support, through the Department of Efficient Energy Use and Use of Renewable Energy Sources (within the Ministry of the Environment and Spatial Planning), the development and the use of renewable energy sources through its public competition program with which it promotes EE and renewable energy investments, and programs to increase their use.

In the work of (Kounetas, Skuras, & Tsekouras, 2011), focused on manufacturing industries in Greece, information barriers and the relative policies to overcome them, such as technical support, assumption of specialized personnel or demonstration projects, have been explored. In addition to that, the authors highlight that energy efficiency policies should be coordinated with regional policies providing infrastructure and/or direct financial support to businesses.

There are then works that do not refer to actual policies applied in any specific country, rather are based on a theoretical approach to provide useful advice to policy makers. (Elliott & Pye, 1998) analyze a set of four possible policies that would address market failures in industry and encourage more sustainable business practices that could lead to a more profitable industrial sector. First, providing incentives for investment in new production equipment and granting tax credits for investment in new production equipment to encourage replacement of older ones is recognized as a relevant policy. Additionally, the study points out the importance of expanding research, development and demonstration investment, and in accelerating the adoption of efficient technologies. This policy is related to the funding of research and support programs, that facilitate the process efficiency improvement and the creation of a pool of trained scientists, engineers, and technicians. It is then taken into account the increased use of recycled feedstock eliminating favorable tax treatment of virgin materials and the change in recycling practices to increase the volume of clean feedstocks. Finally, the study considers barriers related to CHP Production, expediting environmental permitting of CHP systems, incorporating provisions into utility restructuring to allow sale of excess power, and providing programs

to educate end users on how to implement CHP. It is noted from the authors that, since each policy addresses a different issue, effects of these policies are additive. Moreover, it is not addressed the barrier of low energy prices, so economy-wide carbon and energy tax strategies would impact industrial energy consumption by making more efficiency opportunities cost-effective.

The works up to now described identify and review policies from a theoretical or an empirical study, analyzing their possible impact on various sectors. (Oikonomou, Becchis, Steg, & Russolillo, 2009) instead identify the effects of parameters that determine energy saving behavior and their role stating that: *"they are crucial and can determine the outcome of energy efficiency policies; therefore policymakers should properly address them when designing policies."* In analyzing energy efficiency policies, they put emphasis on the behavioral factor, highlighting how their instruments are mostly designed on the basis of a normative perspective of market behavior of economic actors, which are assumed to receive the market signals and act on the grounds of their own rationality. Hence, the authors want to "*identify the relationships between various economic variables that determine the behavior towards energy efficiency*" (Oikonomou et al., 2009). Some key policy lessons can be drawn: (a) policies can be 'smart' targeting at both use and investments, (b) taxing individuals is not enough for long-run energy saving, as information campaigns and market instruments are necessary to induce collective behavior, (c) policies stressing the moral obligation to conserve energy can increase their acceptability, (d) financial compensation for savings must take place in the short-run in order to enable end-users to monitor their daily energy use, (e) behavioral change can be triggered in the medium-run by self-monitoring policies, and (f) enabling financing options through policy schemes can overcome substantial market barriers of consumers towards energy efficiency investments. This is a very interesting study from the policy-maker perspective, as it provides interesting insights about how energy efficiency policies should be designed and built up to be effective and successful. A similar theoretical work has been developed previously by (Golove & Eto, 1996), in which they analyze three rationales for public policies intervention to promote energy efficiency in the energy service markets: 1) government can intervene to reduce market failures, assisting individuals and firms in achieving their rational economic objectives and improving net social welfare; 2) institutional arrangements, including government regulation of (through efficiency standards, for example) and participation in the market (through DSM programs, for example) can reduce transaction costs, facilitate the development of markets that are currently hindered by high costs, and increase net social welfare; and 3) government can do for firms and individuals what they are unwilling to do for themselves. In fact it is highlighted the interventionist conception of the role of government. Nonetheless, the authors point out that *"it is unlikely that, even when public policies are appropriate, there will ever be a single best policy solution (e.g., government minimum efficiency standards); instead, multiple approaches to*

*overcoming market failures or reducing high transaction costs tailored to particular circumstances are more likely to be appropriate."*

## *4.2 Literature review of drivers for energy efficiency*

The literature highlights that only few articles have provided a solid theoretical background of drivers for energy efficiency. An interesting contribution has been provided by (B. S. Reddy & Assenza, 2007) who list the drivers by examples and try to categorize them in: 1) Awareness, 2) Decrease in technology price levels, 3) Increase in energy prices, 4) Technology appeal, 5) Non-energy benefits and 6) Environmental regulations. Indeed, this is the only study, together with the very recent one by (Aflaki, Kleindorfer, & Miera Polvorinos, 2012), that provides a theoretical basis on drivers specifically to industrial energy efficiency. Nonetheless, it is worth pointing out that drivers are not the main topic, rather they are coupled with barriers. (Aflaki et al., 2012) deal with drivers for energy efficiency projects in industry identifying three major value drivers: savings intensity, "green" image, and project complexity. Their study is interestingly supplied by a preliminary and unstructured analysis of the impact of drivers on decision-making process and on the perceived risk giving some interesting hints. In particular, four factors are evaluated to be essential to the effective management of industrial energy efficiency projects: reliable measurement, management systems, tested and reliable technologies and financial and technical expertise. Other theoretical works have been encountered relating to cross-cutting themes such as eco-innovation (Bleischwitz & Schmidt-bleek, 2009), efficient use of material (Steger & Bleischwitz, 2011) or green practices (Diabat & Govindan, 2011) and (Azevedo et al., 2011). Exploring these areas seems to be of interest since we want to have the more clear picture as possible on the field encompassing the closely related areas. (Bleischwitz & Schmidt-bleek, 2009) deal with drivers for specific barriers related to the acceptance of eco-innovation and list them as: 1) "feel good factor", 2) applicability of social norm, 3) individual benefits, 4) ease of implementation and 5) being part of something. Although not explicitly related to industrial energy efficiency, the analyses of those drivers is considered still of interest, as it might reflect possible links between energy efficiency and eco-innovation. (Steger & Bleischwitz, 2011) analyze another important issue, such as the efficient use of materials, identifying and giving attributes to drivers, rather than developing a structured theoretical framework. Based on the analysis of the interaction between theory and practice, they have identified four fundamental pillars for the identification of drivers: 1) technological progress, 2) structural change, 3) infrastructure investments and 4) new lifestyle for green markets. Finally, considering the impact of drivers, they conceptualized their idea giving a definition. Another branch of particular interest for industrial energy efficiency is represented by green practices, whose drivers have been studied by (Diabat & Govindan, 2011) and by (Azevedo et al., 2011). (Diabat & Govindan, 2011) extracted a list of drivers for the green supply chain from a

thorough literature review, as well as from interviews with industrial experts. In particular, they put in evidence a set of drivers, as follows: certification of suppliers' environmental management system, environmental collaboration with suppliers, collaboration between product designer and suppliers to reduce and eliminate product environmental impact, government regulation and legislation, green design, certifications, integrating environmental management onto planning and operations, reducing energy consumption, reusing and recycling materials and packaging, environmental collaboration with customers, and reverse logistic. A very recent work from (Zailani, Jeyaraman, Vengadasan, & Premkumar, 2012), provided similar considerations, stating that: *"a sustainable supply chain demands that practices like environmental friendly packaging, return of end-of-life and used products to the producer as well as the eco friendly handling of returns, recycling, remanufacturing and adequate waste disposal are enabled and are deemed to be important elements".* (Azevedo et al., 2011) investigate the relationship between green practices of supply chain management and supply chain performance. A theoretical framework was derived from a literature review, resulting in the following set of drivers: environmental collaboration with suppliers, environmentally friendly purchasing practices, working with designers and suppliers to reduce and eliminate product environmental impact, certifications, reverse logistics, environmental collaboration with customers, environmentally friendly packaging, working with customers to change product specifications, and decreased consumption of hazardous and toxic materials. The field of the green practices is of great importance because, as stated by (Azevedo et al., 2011), the increased pressure from community and environmentally conscious consumers has led to rigorous environmental regulations. Indeed, regulations force manufacturers to integrate environmental concerns into their management practices. Nonetheless, the adoption of ecologically responsible practices is not a merely issue to meet legislative requirements, as those practices can produce sustainable competitive advantage and improve enterprises' long-term profitability. This topic has been discussed by (Millar & Russell, 2011) in which drivers for the adoption of sustainable manufacturing practices are analyzed. The authors point out that *"the ability to differentiate themselves (manufacturers) from their competitors as drivers is encouraging, as this implies that manufacturers may willingly adopt sustainable practices, motivated by the potential long-term competitiveness of their firms rather than being forced to do so by legislation or mandatory compliance*." In addition to this theme, the study has also highlighted the importance of indirect benefits from these investments ,such as increasing quality or reducing waste.

Additionally, the work by (Gan & Smith, 2011) and (Marques & Fuinhas, 2011) are interesting. In their studies, they synthesize the potential factors that have been argued to have contributed to the development of renewable energy in general, even if some of the drivers considered by them are far from those we believe to be related to industry. Some of these factors include: energy price, natural resources endowments, gross domestic product (GDP), government R&D expenditures on renewable energy, $CO_2$ emissions, policies related

to research, innovation and market deployment, and social pressure. It is apparent that these drivers are biased towards the government and to the higher organs facing environmental issues as the increase of greenhouse gas emissions. In addition, (Björheden, 2006) aims to identify and analyze some important drivers and to establish their effects on forest energy development in Sweden. The author identifies the following drivers: subsidies, economic pressures, awareness of public opinion, and research; but he also highlights that policies and political decisions are strong drivers, especially when manifested through legislation, taxation and duties. Hence, we can note how the term policy is here confused with the term driver.

In the literature, instead of providing a theoretical framework for drivers to energy efficiency, several authors have defined drivers for a very defined field of application. (Thollander & Ottosson, 2008) have defined some driving forces for energy efficiency, categorized as market-related driving forces, potential energy policies, as well as organizational and behavioral factors. Market-related driving forces include: the cost reductions resulting from lower energy use; the threat of rising energy prices and international competition; the support from energy service companies (ESCOs); and third party financing. Moreover, potential energy policies include: investment subsidies for energy efficiency technologies; offering detailed support from energy experts; publicly financed energy audits by energy consultant/sector organizations; beneficial loans for energy efficiency investments; networks within the sector; and information and support through sector organization. Finally, behavioral and organizational-related driving forces include: green image of corporation; long-term energy strategy; people with real ambition; environmental management systems; and improved working conditions. So, the authors have tried to analyze the driving forces, stressing the implementation of cost-effective energy efficiency measures.

(Rohdin et al., 2007) have conducted an empirical study focused on a Swedish foundry industry. The authors have analyzed a selection of the aforementioned drivers, namely: people with real ambitions; long-term strategies; third party financing; environmental management systems; international competition; and environmental company profile. It is notably the contribution in the literature provided by (de Groot et al., 2001), who have performed an empirical study upon Dutch firms, trying to identify the factors that determine the investment behavior of firms. The authors divide the driving forces into two classifications: market related and policy related driving forces. The former include: direct installation of equipment by public utilities; green image of corporation; cost reductions resulting from lower energy use. On the other hand, policy-related driving forces include: fiscal arrangements; investment subsidies; special financing possibilities for investments; and long-range plans within sector. In addition to that, (de Groot et al., 2001) have then tried to understand the attitude of the companies towards environmental policies, namely:

voluntary agreements; investment subsidies; energy standards in terms of technology standard; energy standards in terms of maximum energy use; and energy taxes.

(Worrell et al., 2001) have found some policies for technology transfer (described in section 4.1) by adding also that the implementation of technologies and practices depends on the motivation of management and personnel, external driving forces (e.g. voluntary agreements, legislation and standard setting), economics (i.e. profitability), availability of financial and human resources. The authors have also pointed out that *"environmental legislation can be a driving force in the adoption of new technologies and higher energy prices can increase the implementation rate of efficient practices".* (Hasanbeigi et al., 2010), in their empirical study on Thai industries, analyze, government policies and their consequences on the lower levels of society. The article has then focused its attention towards industry and analyzes the key drivers in Thailand, taking the useful suggestions coming from industries and experts. In detail, they found that the main drivers are: reducing final product cost by reducing energy cost; rise of energy prices; improving staff health and quality and products' quality; improving compliance with companies environmental targets and long-term strategy; improving reputation and recognition; and management vision and understanding about energy efficiency. (Kemp & Volpi, 2008) try to make a distinction between drivers and policies, calling *endogenous factors* the awareness of the existence of an innovation, learning economies and increased competition, and *exogenous factors* the changes in energy prices, regulations and market structures. It is moreover interesting the world by (Streimikiene et al., 2008) that, focusing on Lithuanian companies, separates the concept of legal policy and framework to achieve the efficiency from that of measures regarded as actions that directly affect enterprises. After making an overview of energy efficiency policies, the authors analyze measures in some sectors and find that the major driving forces for industry are: increasing in energy prices, availability of information, fiscal measures such taxes; and soft loans and subsidies.

### *4.2.1 Criticism to the existent literature*

As aforementioned, the literature review highlights that no clear distinction can be appreciated between drivers and policies. Indeed, the works by (de Groot et al., 2001), (Thollander & Ottosson, 2008), (Gan & Smith, 2011), (Björheden, 2006) and (Azevedo et al., 2011) tend to confuse them. Instead, we intend policies as actions implemented by the government that, through several actors such as local authorities, utilities, financial institutions, energy supply, ESCOs, IAGs, manufacturers, etc., generate directly or indirectly drivers. It is important to have in mind the distinction between policies and drivers to understand what companies have to do to overcome the inefficiencies. Some authors separated policies and drivers although that was not the purpose of their study, such as the work of (Worrell et al., 2001). Also (Hasanbeigi et al., 2010) separated, perhaps unwittingly, the concept of policy from the one of driver. Indeed, they do not provide definitions, but

simply use two different treatments. (Kemp & Volpi, 2008) have tried to make a distinction between drivers and policies, but the differences between these two aspects is not well-argued. (Streimikiene et al., 2008) have tried to make a distinction, but even in this case it is not clearly conceptualized the difference. Moreover, few works, such as those of (Hirst & Brown, 1990) and (Abdelaziz et al., 2011), have highlighted the possible actors of the energy supply chain, while others such as (Cooremans, 2009; Hasanbeigi et al., 2010) have tried to highlight the main steps of the decision-making process. In our opinion, however, a connection between drivers and possible actors that could stimulate them is missing, as well as a relationship between drivers and each step of the decision-making process. It is clear that we need to give a theoretical classification in order to cover all aspects involving industry. Moreover, we have classified drivers according to four attributes: nature, targeted barriers, actors responsible for their stimulus internally and externally to the firm, and step of the decision-making processes affected by drivers.

# Chapter 5

# Analysis Model

## *5.1 A novel approach of drivers for energy efficiency*

Policies directly or indirectly generate drivers that, from the company perspective, are considered to be any action which is performed to eliminate or reduce one or more barriers. In the review of the literature, taking into account also papers focused on environmental issues and on the adoption of renewable energy sources, we have garnered some definition of drivers. Having in mind the needed distinction between policy and drivers, we provide below a list of definitions trying to discuss the key features that allowed to provide a new definition of drivers for energy efficiency.

### *5.1.1 Definition of drivers for energy efficiency*

(B. S. Reddy & Assenza, 2007) define drivers "*as the factors that promote private investment in energy efficiency".* This statement seems indeed to be too restrictive, as is focused exclusively on investments, while energy efficiency addresses many other barriers. Also (Worrell et al., 2003) in their article on productivity benefits face this problem. They define driver as: "*a factor that will help accelerate the uptake of energy efficient technologies and practices".* However, the authors do not focus on the effects that the drivers have on the decision-making process.

(Patrik Thollander & Ottosson, 2008) have tried instead to broaden the concept of driving force, claiming that: "*A driving force might be seen as the opposite of a barrier, in other words, different types of factors that stress investments in technologies that are both energy-efficient and cost-effective".* Here it is interesting to note that, as barriers are of various nature, i.e. not merely economic, also drivers might affect the firm's organization as well as the behavior of decision-makers and agents. Nonetheless, in this case, it does not seem fully correct to describe drivers as the negative of barriers. In fact, a driver can be the medium through which overcome various types of barriers. For example, having a management team with real ambition and commitment can be very helpful in eliminating the inertia barrier. Additionally, it is worth pointing out that this kind of driver has a much greater potential, as might be able to generate a greater awareness of the top management and therefore can stimulate actions such as information retrieval. It is evident from this example that a driver does not stimulate an action in just one direction. Moreover, the

human influence, such as rational behavior, directly affects a driving force and its results. (Steger & Bleischwitz, 2011) cope with this issue and provided a definition of drivers: "*Drivers shall be understood as specific and evident factors leading to increased or reduced resource consumption in an economy. Their character might be direct or indirect, external to actors (such as policies) or internal (such as behavioral factors).*" Hence, it is clear that, as in reality the activities are influenced by a number of inconsistent forces, people respond to a variety of pressures, and drivers are related to many other aspects which have an impact on them. (Vine et al., 2003) have provided the clearest and most comprehensive distinction between a driver, called "program", and a policy (mechanism), stating that: "*Mechanisms are initiatives that aim to overcome policy and program barriers that prevent the pursuit of cost-effective energy efficiency and load management activities and the achievement of national energy policy goals. Mechanisms assist the implementation of programs but are targeted at the organizations that develop and implement these programs. In contrast, energy efficiency and load management programs are specific actions taken by utilities and others, with the aim of influencing energy-using behavior. Programs are targeted at energy end users, as distinct from mechanisms that are targeted at the developers and implementers of programs*".

To complete the review, we have decided to extend the boundaries of our literature, thus going beyond definitions of drivers specifically for energy efficiency. Indeed, we have covered other areas concerning e.g., green practices, green engineering or green innovation, in order to have a more detailed picture of the possible actions that can somehow positively affect energy efficiency. By doing this, it is worth noting that many of the drivers correspond to those for energy efficiency, although their definition has been provided for other fields of investigation. As a matter of example, (Bleischwitz & Schmidt-bleek, 2009) when dealing with eco-innovation, define drivers "*as specific and evident agents or factors leading to increased or reduced pressure on the environment.*" This definition clearly points out that only environmental related problems are addressed, not fully considering the economic, organizational and behavioral aspects. Similarly, observing the contribution given by (Gan & Smith, 2011) and (Marques & Fuinhas, 2011) on renewable energy sources, drivers are defined respectively as *"factors that are likely to stimulate renewable energy development"* and *"factors promoting the use of renewable energy sources."* (Björheden, 2006), confusing the concepts of policy and driver, stated that: "*Policies and political decisions are strong drivers, especially when manifested through legislation, taxation and duties. Other examples of drivers are the economic pressure from systems other than bio-energy ('market forces'), public opinion and research."*

At the end of this review, a formal definition of drivers can be formulated as follows: "Drivers are factors that force towards the adoption of energy-efficient and cost-effective technologies or practices, influencing a portion of the company or a part of the decision

making in order to provide a thrust towards energy efficiency". Hence, it is apparent that drivers do not merely allow to reach an energy efficiency improvement, but are also able to reduce any kind of negative environmental impact. Often, increasing energy efficiency cannot be achieved through the support of only one driver, but it is necessary a cooperation of multiple drivers simultaneously. Moreover, we can say that drivers have a direct effect or an indirect effect on energy efficiency: for example, drivers aimed at tackling specifically environmental concerns have an indirect impact on energy efficiency. In fact, implementing projects for the reduction or abatement of, e.g. green-house gases emissions may also result in an increased energy efficiency. On the other hand, several drivers for energy efficiency can bring numerous advantages to businesses, such as, e.g., reduced emissions of greenhouse gases; increased product and process quality; lower operating costs; acquisition of an advantage competitive on competitors.

### *5.1.2 A novel classification of drivers for energy efficiency*

In order to assess and judge the desirability, the effectiveness and the acceptability of proposed policy changes, it is of crucial importance to obtain clear empirical insights on how to foster the adoption of energy efficient technologies and practices within the industrial sector. To do that, it is of fundamental importance to come up with a comprehensive taxonomy able to distinguish the drivers. In fact, without a clear understanding of the enterprises' needs, future energy efficiency policies would be abruptly ineffective and inefficient. In addition to that, how these decisions can be influenced by governance strategies, how firms are likely to respond to various possible policies, and how they judge the feasibility and acceptability of these measures, are crucial research issues to be explored. Therefore, we describe below a comprehensive list of drivers for overcoming the inefficiencies within the companies.

*Voluntary agreements*: this driver directly results from the government's public policies, or collaboration between different companies. Volunteers enter into a contract that brings benefits in terms of energy efficiency. It is also stimulated the adoption of new technologies in contrast to standards ones. According to (De Groot, Verhoef, & Nijkamp, 2001), this driver can be very successful, because firms look favorably to have the freedom in deciding how to cope with the government desire to increase the quality of the environment. Indeed, according to (Worrell et al., 2001), voluntary agreements are new approaches to industrial energy efficiency improvement in industrialized countries, as contracts between the government (or another regulating agency) and a private company, association of companies or other institution. It is interesting that the content of the agreement may vary and requires the effort by both parties. In fact, private partners are committed to attain certain e.g., energy efficiency improvement, emission reduction target, etc. On the other side, government partner *"may promise to financially support this endeavor, or promise to refrain from other regulating activities".* Nonetheless, as indicated by (Aflaki et al., 2012),

voluntary agreements might bring several advantages to companies in terms of energy efficiency project profitability and visibility of energy efficiency initiatives, beyond the compliance with existing regulations, e.g. thanks to the specific instruments (like certificates), that can be traded in appropriate markets.

*Efficiency due to legal restrictions (regulations and standards)*: strict environmental regulations and their compliance associated costs could force industry to adopt innovative measures. Since it is a kind of obligation to apply energy efficiency investments, it seems difficult that would bring a real and consistent raise of awareness by the company and its management. Nonetheless, this driver is recognized as particularly important to overcome the barriers such inertia. Indeed, Governments can intervene with rules and regulations, such as environmental and safety standards, to stimulate this driver. Although referring to environmental issues, (B. S. Reddy & Assenza, 2007) note that environmental regulations can force producers and consumers to internalize the environmental costs into the price of their energy goods and services in the form of increased environmental compliance costs. Therefore, environmental costs can send a price signal to the market, aiming to increase investments in energy efficiency.

*Green image*: as mentioned by (Hasanbeigi et al., 2010) for Thai textile industry, this is an important driver for energy efficiency. Having a good image is in fact very important for many companies. This category also includes all the pressures that derive from non-governmental organizations (NGOs), quite relevant especially in the field of environment and green practices. As stated by (Zhu & Sarkis, 2006), community groups, environmental organizations and other potential lobbies can mobilize public opinion in favor of or against a firm's environmental policy, and the media have the ability to influence society's perception over a firm. In fact, in agreement with (Patrik Rohdin et al., 2007) and (Zailani et al., 2012), organizations are facing increasing global community inquiries through media and non-governmental organizations pertaining to the sustainability aspect of their development. In addition, many suppliers are often under considerable pressures from their customers and some of the external pressures could become sources of opportunity for companies in order to improve their environmental control (Zhu & Sarkis, 2006). Most importantly, those pressures can be absorbed by the clients who transfer them directly to the company. In fact, customers can give enterprises a "premium" or "discount" for pursuing energy efficiency sustainability objectives and accomplishments. Therefore, companies are starting to consider green technologies and practices as a way to derive business opportunities from reputation management (Aflaki et al., 2012). Furthermore, as stated by (Patrik Rohdin et al., 2007), considering that public interests are strongly tied with business strategies in any industry, positive or negative public opinion on a firm's environmental performance represents an important factor affecting the way firms do businesses. Also in the field of environment, (Marques & Fuinhas, 2011) found that social pressure and social acceptance are relevant factors to the challenges of renewable energy

use. Especially in this area, where public opinion becomes increasingly environmentally aware (Björheden, 2006), this driver assumes great importance.

*Long-term energy strategy:* several empirical pieces of evidence revealed that this is one of the most powerful driver for energy efficiency (e.g., (Patrik Rohdin et al., 2007) in Swedish foundry industry, (Hasanbeigi et al., 2010) in textile and cement Thai industry). Moreover, although not strictly referable to energy efficiency, (Diabat & Govindan, 2011) and (Azevedo, Carvalho, & Cruz Machado, 2011) have found that, to pose considerable challenges for the management of the firms, involving long-term energy strategy is very important also for green management and green supply chain. Indeed, this driver can eliminate or reduce any kind of negative environmental impact through green supply chain management (GSCM), as it also includes environmental management systems. Thanks to the adoption of a long-term energy strategy, energy and environmental management systems are more likely to be successful, and energy efficiency investments are encouraged. It is worth noting that having in place a long-term energy strategy, as well as environmental management, as pointed out by (Zhu & Sarkis, 2006), can "*be viewed as a stimulus for innovation and more efficient allocation of business resources, not just as a requirement for regulatory compliance."*

*Willingness to compete*: companies often make most of their investments in accordance with their core business and prefer those that improve their market position (Cooremans, 2011). As a consequence, willingness to compete in relation to energy efficiency problems might foster investments in this area. According to (De Groot et al., 2001), promoting competition functions as an incentive generating a mechanism that forces firms to obtain strategic information. In fact, when energy efficiency practices are seen by the company as competitive tools, these issues are no longer treated as marginal, rather they become of primary importance to achieve business goals. The willingness to compete can also affect the growth of other drivers such as financial ones, as (Matus, Xiao, & Zimmerman, 2012) noted about green chemistry and green engineering: "*Government is like a matchmaker between academia and industry. Firms can submit particular problems that they are willing to fund….If any research groups are interested in that particular project, they can submit a proposal. The top proposals are usually invited to present to government officials, who then decide who will receive the industrial grant".*

*Management with real ambition and commitment*: looking at enterprises as political systems, in which conflicts take place, it is possible that energy efficiency is downgraded as a peripheral issue in case of lack of power by the responsible of energy issues (Sorrell et al., 2000). Therefore, it is really important to have a management with real ambition and commitment towards energy efficiency. In fact, as reported by (Hasanbeigi et al., 2010), management with a clear vision on energy efficiency improvement represents a relevant driver to increase energy efficiency and overcome the existing barriers. Other evidence of the relevance of this factor can be found in other areas such as green innovation. (Qi, Shen,

Zeng, & Jorge, 2010). In this respect, corporations have implemented proactive environmental strategies and practices by using management initiatives for mitigating the impacts of company activities on the environment, affecting also energy efficiency.

*Staff with real ambition*: this driver creates a culture in which employees are genuinely empowered and focused on the customer, invests in people through good communications and training, and flattens and inverts the organizational pyramid. According to (Worrell et al., 2001), the implementation of technologies and practices depends also on the motivation of personnel. As stated by (Duggan, 1996), when combined with behavioral aspects, having staff with real ambition represents a powerful tool in demonstrating what can be achieved if the key messages of 'winning' and 'manufacturing winners' were adopted. Moreover, it is likely that a staff with real ambition will increase the overall efficiency of the enterprises, with a more appropriate use of the available resources, including energy.

*Increasing energy tariffs*: it is interesting that, when facing energy efficiency issues, companies try firstly to lower the energy costs and not necessarily save energy, as pointed out by (Hasanbeigi et al., 2010). Moreover, when companies face high energy prices, their first look is often at the share of energy cost on the total product cost. In case the share of energy cost is not a significant portion of the final product cost, it is likely that companies will limit their efforts for energy efficiency. Therefore, according to (Streimikiene et al., 2008), increasing energy tariffs is an economic instrument to promote energy efficiency, and also includes the threat of rising energy prices, as stated by (Patrik Thollander & Ottosson, 2008). (Marques & Fuinhas, 2011) have confirmed the existence of this driver in the environmental field, in particular regard to renewable energy resources. Higher input tariffs tend to cause substitution for other inputs, so if adequate, prices of traditional fossil energy sources could encourage the use of renewable energy. This would happen only if prices of fossil energy sources were significant in explaining the use of renewable sources.

*Cost reduction from lower energy use*: with this driver, the company is warmly invited to consume less energy, thanks to an immediate perception of cost reduction. According to (Patrik Thollander & Ottosson, 2008), this is a market-related driver or a driver that is attributable to market conditions outside the company; so these initiatives can arise from the government that can reduce taxes due to a lowered energy use, or from clients pushing companies to cut energy costs rather than losing market share. However, it must be noted that this driver is purely internal and therefore implemented by the company.

*Public investments subsidies*: this is probably the most widely known driver for energy efficiency. The (European Commission, 2006) states that subsidies and loans are ‘financial instruments for energy savings’. The creation of funds to facilitate the implementation of energy efficiency programs (Worrell & Price, 2001) and to promote the development of a market for energy services, can constitute an appropriate tool for the provision of non-

discriminatory start-up funding in such a market. Subsidies may be made available to companies through government policy and may therefore be supportive in steering investments towards higher energy efficiency. In fact, (Streimikiene et al., 2008) assert that the main goal of this driver is to support public and private sectors for achieving environmental projects and to reduce the negative impact of economic activities on the environment. This is found as a driver for energy efficiency also from: (Patrik Thollander & Ottosson, 2008), (De Groot et al., 2001), (Hasanbeigi et al., 2010), (Aflaki et al., 2012).

*Private financing*: this driver refers to loans that the company can obtain from financial institutions. As stated by (Hasanbeigi et al., 2010), financial institutions can provide low-interest loans to designated companies to invest in energy efficiency projects, under specific criteria and conditions set. Therefore barriers like access to capital, stringent pay back criteria and other economic hurdles can be overcome. This driver also includes the so called third party financing, a contractual arrangement involving a third party (for example an ESCO), in addition to the energy supplier and the beneficiary of the energy efficiency improvement measure, that provides the capital for that measure and charges the beneficiary a fee equivalent to a part of the energy savings achieved as a result of the energy efficiency improvement measure (European Commission, 2006). This financing is made available to the market place in order to cover partly or totally the initial project costs for implementing energy efficiency improvement measures, and so the firm limits the investment costs by using part of the financial value of energy savings to repay the third party with interests.

*Management support:* often a company does not undertake investments in energy efficiency because it is not able to manage the project, its development and its subsequent implementation (Aflaki et al., 2012). This type of support can be derived for example from ESCOs that provide technical, commercial and financial services, needed for energy efficiency projects (Painuly, Park, Lee, & Noh, 2003). ESCOs take project performance risk (technical risks associated with the project), arrange financing for the project and, depending on their agreements with the clients, may also take customer credit risk (financial risks), as stated by (Möllersten & Sandberg, 2004). This driver is also important when companies have to face many bureaucratic procedures that stretch much the time to implement a new technology / procedure. In the study of (Aflaki et al., 2012) the importance of the complexity and ambiguity of energy efficiency projects is stressed. In particular, people tend to avoid situations where uncertainty is present. In terms of EE projects, such avoidance results in missing the adoption of projects that external experts evaluate as cost-effective, but are internally viewed as being either too complicated or too ambiguous.

*Technical support*: The insertion of a new machine as well as the introduction of new management practices always lead to downtime and production disruptions. This risk becomes particularly critical when the interruption lasts for a prolonged time. In the case of

energy-efficient practices and technologies that you do not know the full potential consequences of the installation, this problem becomes particularly critical. (Liu et al., 2012) assert that: "*Providing technical support shall be emphasized to enhance the capacity of the companies, particularly the SMEs, to operate more energy efficiently"*. Therefore, this driver is particularly useful to overcome barriers that involve technical risks such as production disruption. The technical support could come from technologies suppliers, installers, ESCOs, etc., to ensure ease of implementation of new technologies by firms, as stated by (Bleischwitz & Schmidt-bleek, 2009) and (Aflaki et al., 2012). (Vidil & Marvillet, 2005) regarding suppliers stated that: *"They oversee the correct installation of plants including initial acceptance in accordance with a suitable procedure; they ensure that the plant is maintained according to good practice; and at the end of the plant's life cycle they ensure that disposal is carried out, again in accordance with good practice."*

*External energy audits/sub metering*: energy audit is an inspection, survey and analysis of energy flows for energy conservation to reduce the amount of energy input into the system without negatively affecting the output. According to (Abdelaziz et al., 2011), it helps any organization to analyze its energy use and discover areas where energy use can be reduced and waste can occur, plan and practice feasible energy conservation methods that will enhance their energy efficiency, serve to identify all the energy streams in a facility, quantify energy usage, in an attempt to balance the total energy input with its use. In fact, the lack of sub metering is a strong barrier within organizations that prevents to identify inefficiencies and then figure out where to intervene. (European Commission, 2006) states that: *"energy audit schemes are designed to identify potential energy efficiency improvement measures and which are carried out in an independent manner, to all final consumers, including smaller domestic, commercial and small and medium-sized industrial customers".* In this case , e.g., ESCOs and suppliers as mentioned by (Patrik Rohdin et al., 2007), can help companies to solve organizational problems, such as lack of sub metering..

*Programs of education and training*: increased staff awareness would be less interesting without a program of education and training. Indeed, in case a company implements energy-efficient technologies or practices without the needed knowledge by the effective agent on its proper use, a relevant portion of efficiency would not result to be fully exploited. In this regard, programs of education or training may be provided by the technology supplier, manufacturers, etc., or even within a company (e.g., in larger enterprises). According to (Hasanbeigi et al., 2010), educational programs can be arranged for companies at different levels according to the level and position of personnel. In fact, as stated by (Liu et al., 2012): *"the employee's ability could be enhanced by school education and job training. The education level of employees and the frequency of internal training on energy saving are adopted as proxies of learning capacity"*. Nonetheless, it can be interestingly noted that this enlarges the range of people to be involved in programs of education and training, including not only operational staff, but also the firm's

management, as they aim at increasing the awareness of people involved in a production system (Abdelaziz et al., 2011). This is an aspect explored also by (Matus et al., 2012) in the field of green engineering and innovation. In fact, engineers or scientists without the necessary background and training, would unlikely develop green or more cost-effective practices**.**

*External cooperation*: the collaboration with the industrial sector in which a company operates in fact generates the exchange of free information and the ongoing confrontation, as noted by (Patrik Thollander & Ottosson, 2008) in a study on Swedish pulp and paper industry. Through these collaborative practices, companies remain active in their field and well-informed. Additional examples can be found in the study of (Aflaki et al., 2012), in which partnerships and their characteristics are divided and classified depending on the characteristics of the investment for which they are necessary. According to (Azevedo et al., 2011) and (Duggan, 1996) this driver is manifested by collaborating with suppliers, working with designers to reduce and eliminate product environmental impact and working with customers to change product specifications. Additionally, (Möllersten & Sandberg, 2004) showed that cooperation between companies and ESCOs can provide opportunities for improving competitiveness. In fact, the authors believe that this type of cooperation can help companies to develop new core competence that is the knowledge about the main products, how they are produced efficiently and how to make good business based upon them. Moreover, external cooperation is considered as a driver by (Diabat & Govindan, 2011), as alternative materials and equipment that minimize environmental impacts can be more easily found thanks to the collaboration with suppliers.

*Awareness*: it derives mainly from advertising campaign. Increased awareness on the importance of making energy efficiency is recognized as an important element to put energy efficiency in a strategic position and not downgraded it to a peripheral issue of normal operations, as well as investments (i.e. operational priorities and investment priorities will be shifted towards energy efficiency). Awareness is the key point of consciousness to begin to undertake an energy efficiency strategy. In addition as pointed out by (A. Trianni & Cagno, 2012) growth of awareness can help in implementing management interventions that are often overlooked due to lack of awareness or ignorance.

*Technological appeal:* in some cases, the suppliers of the technologies also undertake to maintain the appeal of technological equipment and it is a particular driver for the acceptance by the company. As stated by (B. S. Reddy & Assenza, 2007), if the energy-efficient equipment gives an impression that it looks ‘modern’, ‘appealing’, and ‘fashionable’, it is more likely that consumers would purchase that technology. These non-economic motivations, in general, dominate the decisions primarily of high-income groups, for whom technological appeal is the major driving factor (B. S. Reddy & Assenza, 2007).

*Knowledge of non-energy benefits*: (B. S. Reddy & Assenza, 2007) assert that this is an important driver because non energy benefits often motivate decisions to adopt energy-efficient measures. They include: (1) improved indoor environment, comfort, health, quality, safety, and productivity; (2) reduced noise; (3) labor and time savings; (4) improved process control; (5) increased reliability, amenity or convenience; and (6) direct and indirect economic benefits from downsizing or elimination of equipment. (De Beer, Worrell, & Blok, 1998) say that new technologies have other benefits as well, for example, increased productivity or improved product quality. (Worrell, Laitner, Ruth, & Finman, 2003) note that non energy benefits play a key role in the company decision-making. As a result, efforts to incorporate them in program design and marketing will help accelerate the uptake of energy-efficient technologies. (Bunse, Sachs, & Vodicka, 2010) say that: *"These non-energy benefits could be for example lower maintenance costs, increased production yield, safer working conditions and many others. Some authors argue that additional productivity benefits should be included, for example in modeling parameters in an economic assessment of the potential of energy efficiency improvements"*. (Aflaki et al., 2012) in their work state that the magnitude of potential savings is an important driver of profitability, as it directly affects operational expenditures and shareholder value. Also (Aguirre, Villalobos, Phelan, & Pacheco, 2011), assessing the relative industrial energy efficiency across manufacturing enterprises, note that one of the main drivers for the projects across all industry segments is the desire to increase process productivity. These improvements can be obtained e.g., including lowering costs, increasing yields and reducing energy-use costs. Therefore, incorporating non energy benefits into cost analysis procedures is very important, because indirect benefits can significantly affect the cost assessment of a given technology and result in a more favorable evaluation. (Millar & Russell, 2011) point out that: *"improved quality, efficiency and reduced waste are key performance criteria that will drive these companies to adopt more sustainable practices"*. This driver is stimulated by various external actors but, in case of medium and large enterprises, can also receive an internal boost, since energy might be related to health and safety issues (Qi et al., 2010).

*Availability of information*: in order to enable final consumers to make better-informed decisions concerning their individual energy consumption, they should be provided with a reasonable amount of information and with other relevant information, such as information on available energy efficiency improvement measures, comparative final consumer profiles or objective technical specifications for energy-using equipment. The government shall establish appropriate conditions and incentives for market operators to provide more information and advices to final customers on energy end-use efficiency (European Commission, 2006). In addition, as stated by (De Groot et al., 2001), the public-goods nature of information provides good arguments for such a governmental role in providing and disseminating information, or that this should happen if the analyzed situation provides confidence in the institutions. To obtain information knowledge varies over sectors and over firms with particular characteristics.

*Clarity of information:* all types of information relating to energy efficiency should be widely disseminated in an appropriate form. This information must be sufficient to properly design and implement energy efficiency improvement programs, and to promote and monitor energy services and other energy efficiency improvement measures (European Commission, 2006).

*Information about real costs*: as aforementioned, the efforts on improving energy efficiency are directly related to the relevance of energy costs on total production costs. Indeed, as pointed out by (Hasanbeigi et al., 2010), if the energy price would represent its real price, thus including externalities that would dramatically affect fossil fuels prices, energy users would necessary work towards energy efficiency improvement, with consequent reduction of needed governmental intervention. (De Groot et al., 2001) note that the relatively small amount of money spent on energy is acting as a barrier preventing to invest in new technologies. Indeed, this can be an indicator that the costs of acquiring information and incorporating the new technologies within the firm, often exceed the expected energy savings. In other words, energy extensive firms apparently have no incentives to consider the possibilities for energy saving. This aspect is also present in other fields such as green innovation. As reported in the study by (Bleischwitz & Schmidt-bleek, 2009), internalizing externalities is not just a legitimate principle for environmental policy, rather a major driver of eco-innovation, especially when it leads to stable expectations in favor of long-term goals, such as $CO_2$ reduction.

*Trustworthiness of information*: often happens that information are available to companies, but they are not taken into account, because the source is not considered as reliable. This is the problem of credibility and trust, as highlighted by (Sorrell et al., 2000). Perceptions of credibility will depend on a variety of factors including: the nature of the source (e.g. private, governmental, charity or pressure group); past experience with the source; the nature of interactions with the source; recommendations from colleagues; and recommendations / impressions from a wide range of contacts within professional and social networks. Concerning the industry, actors such as IAGs or consultants may play an important role, as are often considered as trustworthy (Ramirez, Patel, & Blok, 2005). In fact, as (Painuly et al., 2003) note, credibility was one of the determining factors for the success of ESCOs in Canada. Also (Aflaki et al., 2012) remarks that, among others, the use of guarantees can foster investments in energy efficiency technologies.

The following table reports some research areas to which literature dealt with drivers.

**Table 4: Driver's research areas**

| Drivers | Energy efficiency | Environment | Green Practice | Innovation |
|---|---|---|---|---|
| Voluntary agreements | x | x | | |
| Efficiency due to legal restrictions (reg. and stds) | x | x | x | x |
| Green image | x | x | x | x |
| Long-term energy strategy | x | | x | |
| Willingness to compete | x | | x | x |
| Management with real ambitions and commitment | x | | x | x |
| Staff with real ambitions | x | | | x |
| Increasing energy tariffs | x | x | | x |
| Cost reduction from lower energy use | x | x | | |
| Public investment subsidies | x | x | x | |
| Private financing | x | | | |
| Management support | x | | | |
| Technical support | x | | | x |
| External energy audit/sub metering | x | | x | |
| Program of education and training | x | | x | x |
| External cooperation | x | | x | x |
| Awareness | x | x | x | |
| Technological appeal | x | | | x |
| Knowledge of non-energy benefits | x | x | x | x |
| Availability of information | x | x | x | |
| Clarity of information | x | x | x | |
| Information about real costs | x | | | x |
| Trustworthiness of information | x | | | |

In the following tables, we have grouped all the theoretical and empirical literature that has been considered as useful to describe our drivers.

**Table 5: Theoretical literature of drivers for energy efficiency**

| Driver | Theoretical Literature |
|---|---|
| Voluntary agreements | (European Commission, 2006), (Marques & Fuinhas, 2011), (Worrell et al., 2001) |
| Efficiency due to legal restrictions (regulations and standards) | (European Commission, 2006),(Marques & Fuinhas, 2011), (B. S. Reddy & Assenza, 2007), (Qi et al., 2010), (Diabat & Govindan, 2011), (Tseng, Chiu, Tan, & Siriban-Manalang, 2012), (Worrell et al., 2001) |
| Green image | (Qi et al., 2010), (Marques & Fuinhas, 2011), (Bleischwitz & Schmidt-bleek, 2009) |
| Long-term energy strategy | (Diabat & Govindan, 2011), (Azevedo et al., 2011), (Abdelaziz et al., 2011) |
| Willingness to compete | (Bleischwitz & Schmidt-bleek, 2009) |
| Management with real ambition and commitment | (Diabat & Govindan, 2011), (Qi et al., 2010), (Worrell et al., 2001) |
| Staff with real ambition | (Worrell et al., 2001) |
| Increasing energy tariffs | (B. S. Reddy & Assenza, 2007), (Marques & Fuinhas, 2011), (Bleischwitz & Schmidt-bleek, 2009), (Worrell et al., 2001) |
| Cost reduction from lower energy use | (Marques & Fuinhas, 2011) |
| Public investments subsidies | (European Commission, 2006), (Marques & Fuinhas, 2011), (Worrell et al., 2001) |
| Private financing | (European Commission, 2006), (Worrell et al., 2001) |
| Management support | ------ |
| Technical support | (B. S. Reddy & Assenza, 2007), (Bleischwitz & Schmidt-bleek, 2009) |
| External energy audits/sub metering | (European Commission, 2006), (Diabat & Govindan, 2011), (Abdelaziz et al., 2011) |
| Programs of education and training | (European Commission, 2006), (Bleischwitz & Schmidt-bleek, 2009), (Diabat & Govindan, 2011), (Azevedo et al., 2011), (Tseng, Chiu, Tan, & Siriban-Manalang, 2012), (Abdelaziz et al., 2011) |
| External cooperation | (Diabat & Govindan, 2011), (Azevedo et al., 2011) |
| Awareness | (B. S. Reddy & Assenza, 2007), (Tseng et al., 2012), (Azevedo et al., 2011) |
| Technological appeal | (B. S. Reddy & Assenza, 2007) |
| Knowledge of non energy benefits | (Bleischwitz & Schmidt-bleek, 2009), (Qi et al., 2010), (Marques & Fuinhas, 2011), (Bunse et al., 2010) |
| Availability of information | (European Commission, 2006), (Diabat & Govindan, 2011) |
| Clarity of information | (European Commission, 2006), (Diabat & Govindan, 2011) |
| Information about real costs | (Bleischwitz & Schmidt-bleek, 2009) |
| Trustworthiness of information | (Sorrell et al., 2000) |

**Table 6: Empirical literature of drivers for energy efficiency**

| Driver | Empirical Literature |
|---|---|
| Voluntary agreements | (Patrik Thollander & Ottosson, 2008), (De Groot et al., 2001), (Patrik Rohdin et al., 2007), (Streimikiene et al., 2008), (Aflaki et al., 2012) |
| Efficiency due to legal restrictions (regulations and standards) | (Patrik Thollander & Ottosson, 2008),(De Groot et al., 2001), (Patrik Rohdin et al., 2007), (Qi et al., 2010), (Matus et al., 2012), (Björheden, 2006) |
| Green image | (Patrik Thollander & Ottosson, 2008), (Hasanbeigi et al., 2010), (Qi et al., 2010), (Duggan, 1996), (Matus et al., 2012), (Björheden, 2006), (Zhu & Sarkis, 2006), (Aflaki et al., 2012), (Parmigiani, Klassen, & Russo, 2011), (Zailani et al., 2012) |
| Long-term energy strategy | (Patrik Rohdin et al., 2007), (Hasanbeigi et al., 2010), (Aflaki et al., 2012) |
| Willingness to compete | (Patrik Thollander & Ottosson, 2008), (De Groot et al., 2001), (Matus et al., 2012), (Patrik Rohdin et al., 2007), (Millar & Russell, 2011) |
| Management with real ambition and commitment | (Patrik Rohdin et al., 2007), (Hasanbeigi et al., 2010), (Qi et al., 2010) |
| Staff with real ambition | (Patrik Rohdin et al., 2007), (Duggan, 1996) |
| Increasing energy tariffs | (De Groot et al., 2001), (Patrik Rohdin et al., 2007), (Hasanbeigi et al., 2010), (Gan & Smith, 2011), (Patrik Thollander & Ottosson, 2008), (Björheden, 2006), (Streimikiene et al., 2008) |
| Cost reduction from lower energy use | (Patrik Thollander & Ottosson, 2008), (De Groot et al., 2001), (Aflaki et al., 2012) |
| Public investments subsidies | (Patrik Thollander & Ottosson, 2008), (De Groot et al., 2001), (Matus et al., 2012), (Björheden, 2006), (Hasanbeigi et al., 2010), (Streimikiene et al., 2008), (Aflaki et al., 2012) |
| Private financing | (Patrik Thollander & Ottosson, 2008) |
| Management support | (Painuly et al., 2003), (Aflaki et al., 2012), (Möllersten & Sandberg, 2004) |
| Technical support | (Patrik Rohdin et al., 2007), (Vidil & Marvillet, 2005), (Aflaki et al., 2012), (Liu et al., 2012) |
| External energy audits/sub metering | (Patrik Thollander & Ottosson, 2008), (Patrik Rohdin et al., 2007) |
| Programs of education and training | (Hasanbeigi et al., 2010), (Duggan, 1996), (Azevedo et al., 2011), (Matus et al., 2012), (Streimikiene et al., 2008), (Vidil & Marvillet, 2005), (Liu et al., 2012) |
| External cooperation | (Patrik Thollander & Ottosson, 2008), (Duggan, 1996), (Zhu & Sarkis, 2006), (Azevedo et al., 2011), (Aflaki et al., 2012), (Möllersten & Sandberg, 2004) |
| Awareness | (Zhu & Sarkis, 2006), (Azevedo et al., 2011), (Vidil & Marvillet, 2005) |
| Technological appeal | ------ |
| Knowledge of non energy benefits | (Worrell et al., 2003), (Patrik Thollander & Ottosson, 2008), (Hasanbeigi et al., 2010), (Qi et al., 2010), (Matus et al., 2012), (Patrik Thollander, Karlsson, Söderström, & Creutz, 2005), (Aflaki et al., 2012), (Millar & Russell, 2011), (De Beer et al., 1998), (Aguirre, Villalobos, Phelan, & Pacheco, 2011) |
| Availability of information | (De Groot et al., 2001), (Gan & Smith, 2011), (Streimikiene et al., 2008) |
| Clarity of information | (De Groot et al., 2001), (Gan & Smith, 2011) |
| Information about real costs | (Hasanbeigi et al., 2010) , (Aflaki et al., 2012) |
| Trustworthiness of information | (Painuly et al., 2003), (Ramirez, Patel, & Blok, 2005), (Aflaki et al., 2012) |

### *5.1.3 Internal VS external drivers*

It is now relevant to make a distinction between internal and external drivers, as it allows to understand which actions might be promoted internally, or for which external support should be required.

Internal drivers mean something that the company is able to implement and continue independently to achieve efficiency. In fact according to (Zeng et al., 2011): *" Internal driving forces are resulted from company's internal motivation (enterprise itself)."* Obviously, a growth of awareness and therefore a commitment is required by the organizations. The stimulus to the drivers must derive from policies at a higher level, as noted in the previous sections. The company is therefore able to provide for itself the implementation of drivers as: willingness to compete, cost reduction from lower energy use, long-term energy strategy, people with real ambition and management with real ambition and commitment. For example, if a company was empowered on the problem of efficiency by special policies to increase the awareness, the research of internal staff could be targeted to ambitious people. Or, similarly, if the efforts on adopting energy efficient practices by rivals have been properly publicized and are resulting in an increase of market share, a company may look favorably to adopt a long-term energy strategy.

On the other hand, it is interesting to note the difference with external drivers, as they are the result of policies drafted and decided by other actors. In this case, very few enterprises have the strength to change or influence such policies. Therefore, they can only decide whether or not to exploit them, with the exception of efficiency due to legal restriction, that forces enterprises to comply with standards or requirements. External drivers are: technical support, technology appeal, private financing, increasing energy tariffs, management support, external energy audits, green image, public investment subsidies and those related to provision of information. According to (Zeng et al., 2011) external drivers can be divided into three categories, namely: government (i.e. efficiency due to legal restriction, public investments subsidies), market (i.e., green image or willingness to compete) and social driving force (i.e. , availability of information or external cooperation).

Finally, some drivers can either be external or internal. Indeed, programs of education and training can be an internal action arising out of a corporate initiative, but at the same time being also external. In fact, an external body can perform, e.g., training courses regarding how to use raw materials more efficiently. In this way, education and training appears to be a driver has not required an extra effort by the company, and therefore should be accounted as external. It is now clear that, if internal training and education courses for personnel, has been organized with the effort of the company itself, the driver should be considered as internal. Other examples of both internal and external drivers are: voluntary agreements, knowledge of non-energy benefits, external cooperation and increased awareness. As reported in the table below, we want to highlight with this distinction who

generates the driver, but also, and more importantly, what the firm can do solely by its own efforts.

**Table 7: Internal and external drivers**

| Drivers | Internal driver | External driver |
|---|---|---|
| Voluntary agreements | • | • |
| Efficiency due to legal restrictions (reg. and stds) | | |
| Green image | | • |
| Long-term energy strategy | • | |
| Willingness to compete | • | |
| Management with real ambitions and commit | • | |
| Staff with real ambitions | • | |
| Increasing energy tariffs | | • |
| Cost reduction from lower energy use | • | |
| Public investment subsidies | | • |
| Private financing | | • |
| Management support | | • |
| Technical support | | • |
| External energy audits/sub metering | | • |
| Programs of education and training | • | • |
| External cooperation | • | • |
| Awareness | | • |
| Technological appeal | | • |
| Knowledge of non-energy benefits | • | • |
| Availability of information | | • |
| Clarity of information | | • |
| Information about real costs | | • |
| Trustworthiness of information | | • |

With this distinction it is possible to focus on the external drivers to understand the actors, within the supply chain of energy efficiency technologies, responsible for their stimulation and which kind of action they can implement. The model used to develop this further drivers classification refers to the Porter's model concerning competitive advantage and the value chain. We provide below a scheme that illustrates which actors are considered in the next analysis.

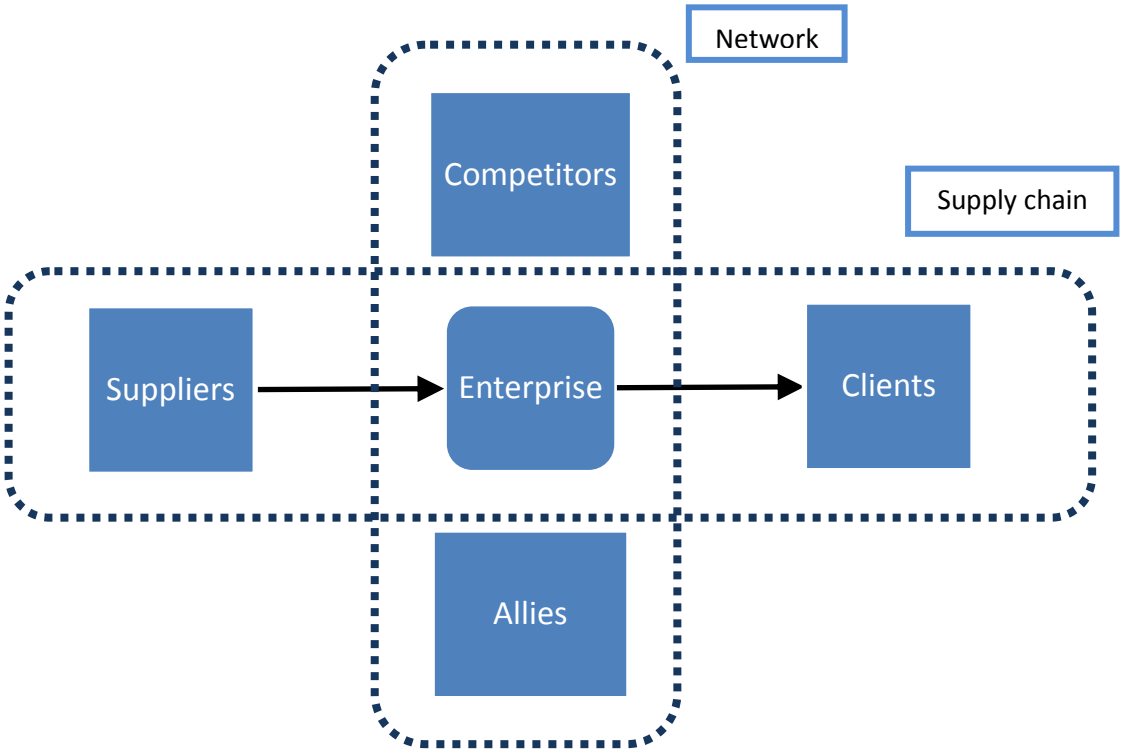



**Figure 6: Actors around the enterprise**

Competitors as well as allies are part of the network in which the company operates; in this branch, industrial or category associations are also included. The actors in the supply chain include clients that, as aforementioned, might act directly to create some drivers, as well as suppliers. In the following, we present an integration of the preliminary scheme developed by (Hirst & Brown, 1990) through which we illustrate the different actors affecting the decision-making process about energy efficiency investments.

Indeed, our study wants to analyze the decision-making process of a single enterprises as well as the contest in which the company is inserted, thus classifying the actors responsible for the implementation of drivers. Energy Efficiency "supply chain" refers to all the external actors who might affect, directly or indirectly, the adoption of an energy-efficient technology and practice. In this regard, federal, state, local governments represent the highest level of the external system, from which most of the policies that stimulate the drivers come from. Drivers stimulated directly from those actors are: increasing energy tariffs, voluntary agreements, regulations and standards, awareness, public investments subsidies and those related to information.

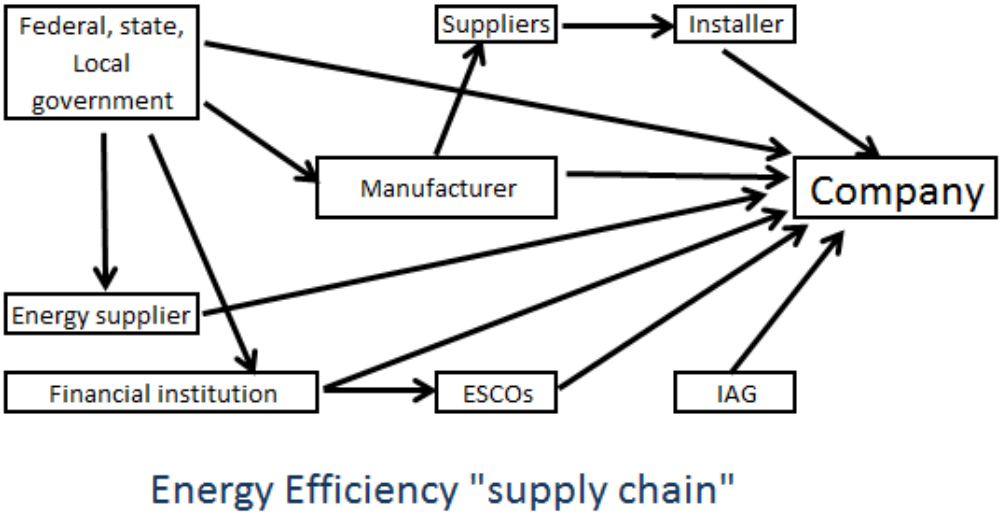



**Figure 7: Energy efficiency supply chain**

There is a punctual, still relevant difference from the framework of (Hirst & Brown, 1990) regarding the financial institutions, because here it is assumed that they can be influenced directly by the government. This aspect concerns any sensitization or government programs involving banks over energy efficiency issues. Financial institution, such as banks, act for generating private financing in which they can support enterprises, e.g., with soft loans. Similar support can be provided by ESCOs, that can also offer management and technical support, external energy audits, programs of education and training, knowledge of non-energy benefits. Notably, ESCOs can also be a reliable source from which enterprises could obtain complete and accurate information. IAGs can help enterprises to find information, thus increasing their knowledge of interventions, as well as their indirect benefits. IAGs have also a function to stimulate companies' awareness on energy issues, contributing to the implementation of drivers such as awareness and programs of education and training. Energy suppliers might be the responsible, together with the Government, of the driver "increasing of energy tariffs". Energy suppliers can also stimulate some informative drivers such as availability and trustworthiness of information, providing clear information on how to use energy more efficiently.

With respect to the framework by (Hirst & Brown, 1990), we have added two relevant intermediaries between enterprises and manufacturers. In fact, in many cases technology manufacturers are not always in direct contact with the enterprises. Rather, the latter refers to its suppliers. In addition to that, we wanted to specifically highlight the existence of technologies installers. Hence, it is apparent that the process of retrieval and start-up of a new equipment in an enterprise can require three steps, from manufacturers, to

suppliers, to installers, with consequent information issues, often perceived as unavailable and unreliable, rather confusing.. Moreover, the information flow might be inhibited by split incentives among those actors, as the different parties cannot appropriate right benefits for that investment, resulting in energy efficiency opportunities to be likely foregone. Of course, in some cases technology suppliers and even manufacturers provide directly installation service. In a nutshell, all those actors are responsible to stimulate drivers such as: technical support, technological appeal (attributable only at manufacturers), management support, external energy audits, external cooperation, program of education and training and provision of information.

**Table 8: Actors responsible for the stimulus of drivers**

| Drivers | Government | En. Suppliers | Manufacturers | Tec. Suppliers | Installer | Fin. Institut. | ESCOs | IAGs | Clients | Concurrent | Allies | Company |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Voluntary agreements | • | | | | | | | | | | • | • |
| Efficiency due to legal restrictions (reg. and standards) | • | | | | | | | | | | | |
| Green image | | | | | | | | | • | | | |
| Long-term energy strategy | | | | | | | | | | | | • |
| Willingness to compete | | | | | | | | | | | | • |
| Management with real ambitions and commitment | | | | | | | | | | | | • |
| Staff with real ambitions | | | | | | | | | | | | • |
| Increasing energy tariffs | • | • | | | | | | | | | | |
| Cost reduction from lower energy use | | | | | | | | | | | | • |
| Public investment subsidies | • | | | | | | | | | | | |
| Private financing | | | | | | • | • | | | | | |
| Management support | | | | • | | | • | | | | | |
| Technical support | | | • | • | • | | • | | | | | |
| External energy audits/sub metering | | • | | • | | | • | | | | | |
| Programs of education and training | • | | • | • | | | • | • | | | | • |
| External cooperation | | | | • | | | • | • | • | • | • | • |
| Awareness | • | • | • | • | | | | • | | | • | |
| Technological appeal | | | • | | | | | | | | | |
| Knowledge of non-energy benefits | | | • | • | | | • | • | | | | • |
| Availability of information | • | • | • | • | • | | • | • | • | • | • | |
| Clarity of information | • | • | • | • | | | • | • | • | | • | |
| Information about real costs | • | • | | | | | • | • | | | • | |
| Trustworthiness of information | • | • | • | • | | | • | • | | • | • | |

### *5.1.3 Energy efficiency policies VS driving forces*

Drivers are to be borne by a contribution that can be of various nature and come from various actors at different levels of the system. The main actors are: the government (either central or local), financial institutions, industrial associations, technology providers, manufacturers, installers, ESCOs, energy suppliers, concurrent, allies, clients and the company. So we want now to focus our attention on the possible actions policy makers can implement, and that can give rise to the drivers. It is interesting to note that some of the drivers can take origin by the same actions. For example, every information driver can be stimulated by actions involving information campaigns. Drivers such as e.g., taxes, loans, will instead be closely related to economic actions. Other drivers, more related to tackle behavioral issues, will be the result of applying regulations and defining standards. However, it is important to note that there is not a punctual correlation between drivers and possible actions; indeed, the born of a driver does not include aspects of a single type but encloses actions of various kinds. For example voluntary agreements can taken up from informative actions and at the same time, if properly designed, have an economic impact on the company. This aspect suggests that a driver cannot be seen as the negative of a barrier that is specific and targeted to particular aspects. Therefore, we can group the possible actions to stimulate the drivers in three categories: 1) regulatory, 2) economical, 3) informative. In the following table we will denote both the actions by policy-makers that will surely make a strong lever on the spur of the driver (two dots), and those that stimulate them to a lesser extent (one dot) or either actions that are potential levers as they may activate drivers (empty dot). It is clear that in some cases, policy-makers cannot be able to make appropriate policy to stimulate those drivers, as it happens to some internal drivers (such as e.g., staff with real ambition, management with real ambition and commitment, cost reduction from lower energy use and external cooperation), or e.g., drivers that imply the cooperation of intermediaries.

**Table 9: Nature of actions for the stimulus of drivers**

| Drivers | Regulatory | Economical | Informative |
|---|---|---|---|
| Voluntary agreements | | o | ● |
| Efficiency due to legal restrictions (reg & stds) | ●● | | |
| Green image | | | ● |
| Long-term energy strategy | ●● | | |
| Willingness to compete | ● | | |
| Management with real ambitions and commit. | | | |
| Staff with real ambitions | | | |
| Increasing energy tariffs | ●● | | |
| Cost reduction from lower energy use | | | |
| Public investment subsidies | | ●● | |
| Private financing | | ● | |
| Management support | o | ● | o |
| Technical support | ● | o | |
| External energy audits/sub metering | ● | ●● | |
| Programs of education and training | ● | ●● | |
| External cooperation | | | |
| Awareness | | | ●● |
| Technological appeal | o | | |
| Knowledge of non-energy benefits | o | o | o |
| Availability of information | | | ●● |
| Clarity of information | ● | | |
| Information about real costs | o | o | o |
| Trustworthiness of information | ●● | o | |

Informative actions involve all aspects related to both the information content and its flow to the company. These actions indeed strongly stimulate drivers such as availability of information and awareness; moreover, voluntary agreements and green image are stimulated by informative actions, although with minor influence. It is worth noting the role of states and government in providing information, as stated by (European Commission, 2006): *"Member States shall ensure that information on energy efficiency…is transparent and widely disseminated to the relevant market actors"*. Policy-makers, through providing information of energy efficiency practices and their results could also raise the awareness. It is important to note that a regulatory action cannot raise awareness immediately, rather its action has to be evaluated over a long period, as the continuous application of a norm could little by little make the applicant aware of the problem. Regarding green image, the policy maker can provide information to the public, raising its awareness and making customers aware of the energy problem. Therefore, external pressures on energy issues

can step up and push the company towards having a green image. With regard to voluntary agreements, governments could provide information so that every company can evaluate in the best way any possibility related to energy efficiency and take full advantages from these types of agreements. Informative are potential actions in drivers such as management support, knowledge of non-energy benefits and information about real costs. In the first case, governments can give some information about entering in contract with consultant or with ESCOs so it is a secondary action. For example, if a company wants to enter into a contract with ESCOs but it does not have the necessary information to do it, this possibility will be discarded before it starts because of a lack of information. Regarding knowledge of non-energy benefits and information about real costs instead it can provide information through data received from manufacturers or installers and then make them public and available to the company.

Economic actions look at the monetary aspect, and are also widely recognized as one of the strongest actions. Those actions stimulate drivers such as private financing, management support, external energy audits, public investment subsidies and program of education and training. Regarding external energy audit and public investment subsidies, it refers to a context in which the government allocates funds to promote audit within companies or are offered subsidies for investments in energy efficiency. Another strong influence actions is made on programs of education and training, for which often government funded courses which will then be held by relevant organizations. Private financing and management support are stimulated to a lesser extent. For example, the policy makers may provide either incentives or rewards for those organizations who are concerned to finance investments in efficiency or to provide managerial support. Actions of an economic nature may represent potential levers for driver such as: voluntary agreement, knowledge of non-energy benefits, trustworthiness of information, technical support and information about real costs. Regarding knowledge of non-energy benefits or information about real costs, the policy maker could provide reward to the organizations that make public this information. For the trustworthiness of information government could allocate financial aid to make sure that suppliers information take a document that certificate their expertise. Finally, regarding voluntary agreement or technical support, actors involved in those drivers could be enhanced with remuneration or financial aid.

Regulatory involves all norms and standards aimed to push companies towards energy efficiency. These type of actions are strong levers to boost drivers as: long-term energy strategy, increased energy tariffs, efficiency due to legal restriction and trustworthiness of information. They also stimulate: willingness to compete, programs of education and training, clarity of information and technical support. For long term energy strategy, governments could begin to impose standards relating to the businesses that push to adopt this type of strategy. For example, they may require enterprises to accomplish certain energy standards within a given period, with periodic checks. The regulative stimulus may

also impact on increasing energy prices, because making policies affecting the energy suppliers will directly affect a firm's energy consumption; in fact taxes could increase having a direct effect on the cost of energy. Energy efficiency due to legal restriction is a driver on taxation laws and standards, therefore falls naturally under this category. Increasing trustworthiness of information policy makers could develop programs to ensure that a source of information is certified if it wants to operate in the market. A minor impact of this nature of driver can be developed on the clarity of information for which, however, a government can provide standard datasheets of information to ensure them to be clear and understandable. A similar type of influence can be made on programs of education and training, technical support, or external energy audit. As an example, the European Community could establish that energy services providers have to give an account of their results on energy consumption doing audits at predetermined time intervals within companies they provide. The government could disseminate the concept of willingness to compete, so that companies can perceive energy efficiency as an useful tool to acquire a competitive advantage over competitors. Intervening on the market the policy maker could set standards so that each company will perceives as the only competitive lever energy efficiency. The actions of this nature have also the potential ability to influence drivers such as: technological appeal, management support, knowledge of non-energy benefits and information about real costs. In particular for the last two policies could be set up for making public all the effects of an intervention in energy efficiency by taking into account direct and indirect benefits. For the technological appeal the government could influence manufacturers providing construction standards so that the technology will appear better for the investors. Finally, regarding management support, rules could be made establishing that the provider of energy efficiency practices or technologies also provides a managerial support.

### *5.1.4 Internal nature of driving forces*

After identifying the nature of the actions to promote drivers that can be done by policy-makers we now turn to the same analysis referred to internal action to stimulate the driver. The external action does not necessarily translate directly within the firm, and in the transition from external to internal environment may have a change. By nature of the driver we mean how the driver is perceived in the enterprise, or what kind of changes it brings to the enterprise. It is really important to be clear about the difference between nature and effect. in fact effect refers to the result of a driver, or the benefits that its implementation can bring. A regulatory action may be made by drivers such as: long term energy strategy, voluntary agreements, efficiency due to legal restriction and green image. Having a long term energy strategy in an enterprise means to operate according to well-defined practices. If there is the takeover of this driver, the organization will be undergoing changes in terms of procedures, practices and standards to be applied in such a way that the strategy would bring the desired results. Likewise participating in voluntary agreements will bring changes

of regulatory nature, as it may provide restrictions or the introduction of new processes for which the company will have to adapt. This driver also presents an informative aspect although to a lesser extent than regulatory one. This is due to the fact that the conclusion of voluntary agreements will undoubtedly lead to an input of information that will necessarily be contained in a contract. External pressures from organizations such as NGOs or the media that lead to the change of public opinion and therefore the birth of the driver green image are translated into rules for the company. In particular, the pressing demands of the customers often lead to the introduction of new practices or modification of existing procedures to adapt to the demands, looking at the emergence of new standards or internal rules. The driver efficiency due to legal restrictions, finally, is uniquely related to external norms and standards, thus reflecting directly the nature of external action. Economic drivers include: staff with real ambition, management with real ambition and commitment, increased energy tariffs, cost reduction from lower energy use, willingness to compete, private financing and public investment subsidies. For some of the drivers mentioned above is obvious the economic nature such as private finance, public investments subsidies, cost reduction from lower energy use and increased energy tariffs for which the economic aspect is the main and also derives from the nature of the external action. Having staff with real ambition, as well as having management with real ambition and commitment, can lead to changes in the economic aspect. For example, the stimulation of these two drivers can act on wages, so that the ambitions and the commitment of the parties might be related to the energy performance of the company. These two drivers also lead to the consequences of an informative nature, as the reward allocated to increase the ambition can be derived on the basis of performance measurement. In this way some useful information on how the staff and management have to operate can then be obtained. Although this aspect related to information, the nature of these drivers remain mainly economical. The driver willingness to compete is classified under this category, as the main action of the competition in the market is related to capital. Hence, e.g., issues related to energy efficiency are becoming increasingly important and therefore more and more resources (also economic) are allocated to address them. Drivers with an informative nature are: technical support, management support, external energy audit, knowledge of non-energy benefits, external cooperation, programs of education and training, awareness and all the drivers related information. For the latter, it is clear the reason of the informative nature since it refers to the flow of information that must be provided and which enters inside the company. Knowledge of non-energy benefits also refers to those aspects coming a little more specifically about the type of information as well as information about real cost. Cooperation with the outside and an increase of awareness also lead to have information. For example form the collaboration with an allied company that has already implemented energy-efficient practices useful information can be can obtained, thus increasing the knowledge for a future implementation of the action. When a company receives support, which can be managerial or technological, is essentially related to the information which is received by this aid. With regard to technology suppliers, they

can therefore provide information on how to operate with an equipment or on how often to do maintenance. Similarly consultants can provide the data necessary for managers to better manage energy efficiency projects. With the driver external energy audit organizations come within the company to make measurements and provide the results to stakeholders. Therefore, this driver assume surely an informative aspect for the company that will dispose therefore of useful data for a better internal control, management, as well as production planning. Finally, the driver technological appeal could be classified as informative according to nature, since the adoption of technologies driven by this force will surely bring with itself a flow of information that otherwise the company would not have known. In the following table the internal classification of driven by nature is illustrated. Two dots are reported for a strong dependence, one dot for a minor dependence.

**Tabella 10: Nature of drivers**

| Drivers | Regulatory | Economical | Informative |
|---|---|---|---|
| Voluntary agreements | ●● | | ● |
| Efficiency due to legal restrictions (reg & stds) | ●● | | |
| Green image | ●● | | |
| Long-term energy strategy | ●● | | |
| Willingness to compete | | ●● | |
| Management with real ambitions and commit. | | ●● | ● |
| Staff with real ambitions | | ●● | ● |
| Increasing energy tariffs | | ●● | |
| Cost reduction from lower energy use | | ●● | |
| Public investment subsidies | | ●● | |
| Private financing | | ●● | |
| Management support | | | ●● |
| Technical support | | | ●● |
| External energy audits/sub metering | | | ●● |
| Programs of education and training | | | ●● |
| External cooperation | | | ●● |
| Awareness | | | ●● |
| Technological appeal | | | ● |
| Knowledge of non-energy benefits | | | ●● |
| Availability of information | | | ●● |
| Clarity of information | | | ●● |
| Information about real costs | | | ●● |
| Trustworthiness of information | | | ●● |

### *5.1.5 Driving forces VS energy efficiency barriers*

As mentioned earlier, drivers are means to eliminate or reduce one or more barriers. Based on the classification of drivers that we listed above and on the taxonomy of barriers for empirical investigation by. (Cagno, Worrell, Trianni, & Pugliese, 2013) discussed in Chapter 3, we will discuss which barriers can be overcome by the implementation of a driver. We should acknowledge that the dynamic between barriers, as well as the dynamic between drivers, has not been taken into account in the evaluation of the relationship between drivers and barriers. This means that it was not considered the fact that a driver can overcome some barriers over time. For example, long-term energy strategy, addressing behavioral and organizational barriers, could bring economic benefits after a certain period of time, overcoming thereby economic barriers.

**Table 11: Drivers VS Barriers**

| | Barriers for empirical investigation* | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Drivers** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Voluntary agreements | | | | | | ● | | | | | | | ● | | | | | | | | | | | | | | |
| Efficiency due to legal restrictions (reg. and stds) | | | ● | ● | | | | | | | | | | ● | ● | | | | | | ● | | | | | | |
| Green image | | | | | | | | | | | | | | ● | | | | ● | ● | | ● | | | | | | |
| Long-term energy strategy | | | | | | | | | | | | | ● | ● | | | ● | ● | ● | | ● | | | | | | |
| Willingness to compete | | | | | | | | | | ● | ● | | ● | ● | ● | | ● | ● | ● | ● | ● | | | | | | |
| Management with real ambitions and comm. | | | | | | | | | | ● | ● | | ● | ● | ● | | ● | ● | | ● | ● | ● | | | | | | ● |
| Staff with real ambitions | | | | | | | | | | | | | ● | ● | ● | | ● | | | | ● | ● | | | | | | ● |
| Increasing energy tariffs | | | | | | | | | | | | ● | ● | ● | | | | | | | | | | | | | |
| Cost reduction from lower energy use | | | | | | | | | | | | ● | | ● | | | | ● | | | | | | | | | |
| Public investment subsidies | | | | | | | ● | ● | | ● | | ● | | ● | | | | | | | | | | | | | |
| Private financing | | | | | | | ● | ● | | ● | | | | | | | | | | | | | | | | | |
| Management support | | | | | | | | | | ● | | | | | | ● | | | | | | | | | ● | ● | |
| Technical support | | | | | | | | | ● | | | | | | | | | | | | | | ● | ● | ● | ● | |
| External energy audits/submetering | | | | | | | | | | | | | ● | | | ● | | | | | | | ● | ● | | ● | |
| Programs of education and training | | | | | | | | | | | | | | | | | | | | | | | ● | ● | ● | ● | ● |
| External cooperation | | ● | ● | ● | ● | | | | | | | | | | | | | | | | | | | ● | | ● | ● |
| Awareness | | | | | | | | | | | | | ● | ● | | | | | | | | | | | | | ● |
| Technological appeal | ● | | | | | | | | | | | | ● | | | | | | | | | | | | | | |
| Knowledge of non-energy benefits | ● | | ● | | | | | | ● | ● | | ● | | | | ● | | | | | | | | | | | |
| Availability of information | | ● | ● | | | | | | ● | ● | | | | | | ● | | | | | | | | | | | |
| Clarity of information | | ● | | ● | | ● | | | ● | ● | ● | | | | | ● | | | | | | | | | | | |
| Information about real costs | | | ● | | | ● | | | ● | ● | ● | ● | | | | ● | | | | | | | | | | | |
| Trustworthiness of information | | | | | ● | | | | ● | ● | ● | | | | | ● | | | | | | | | | | | |

**Table 12: Legend of barriers**

| *Barriers for empirical investigation | | |
|---|---|---|
| 1 | Technologies not adequate | TECHNOLOGY-RELATED BARRIERS |
| 2 | Technologies not available | |
| 3 | Lack of information on costs and benefits | INFORMATION BARRIERS |
| 4 | Information not clear by technology suppliers | |
| 5 | Trustworthiness of the information source | |
| 6 | Information issues on energy contracts | |
| 7 | Low capital availability | ECONOMIC |
| 8 | Investment costs | |
| 9 | Hidden costs | |
| 10 | Intervention-related risks | |
| 11 | External risks | |
| 12 | Intervention not sufficiently profitable | |
| 13 | Lack of interest in energy efficiency intervention | BEHAVIORAL |
| 14 | Other priorities | |
| 15 | Inertia | |
| 16 | Imperfect evaluation criteria | |
| 17 | Lack of sharing the objectives | |
| 18 | Low status of energy efficiency | ORGANIZATIONAL |
| 19 | Divergent interests | |
| 20 | Complex decision chain | |
| 21 | Lack of time | |
| 22 | Lack of internal control | |
| 23 | Identifying the inefficiencies | BARRIERS RELATED TO COMPETENCES |
| 24 | Identifying the opportunities | |
| 25 | Implementing the interventions | |
| 26 | Difficulty in gathering external competences | |
| 27 | Lack of awareness or ignorance | AWARENESS |

From the literature analysis, we note that (B. S. Reddy & Assenza, 2007) have only mentioned which can be the effect of drivers on barriers, stating that: "…*removing a barrier (or risk) means getting rid of a barrier altogether…"* and *"…reducing a barrier (or risk) means that the barrier remains in place, but that its deterrent effect is diminished…"*. Inspired by these insights, we believe that a driver can affect more than one barrier, and its effect can completely eliminate barriers or just partially reducing them.

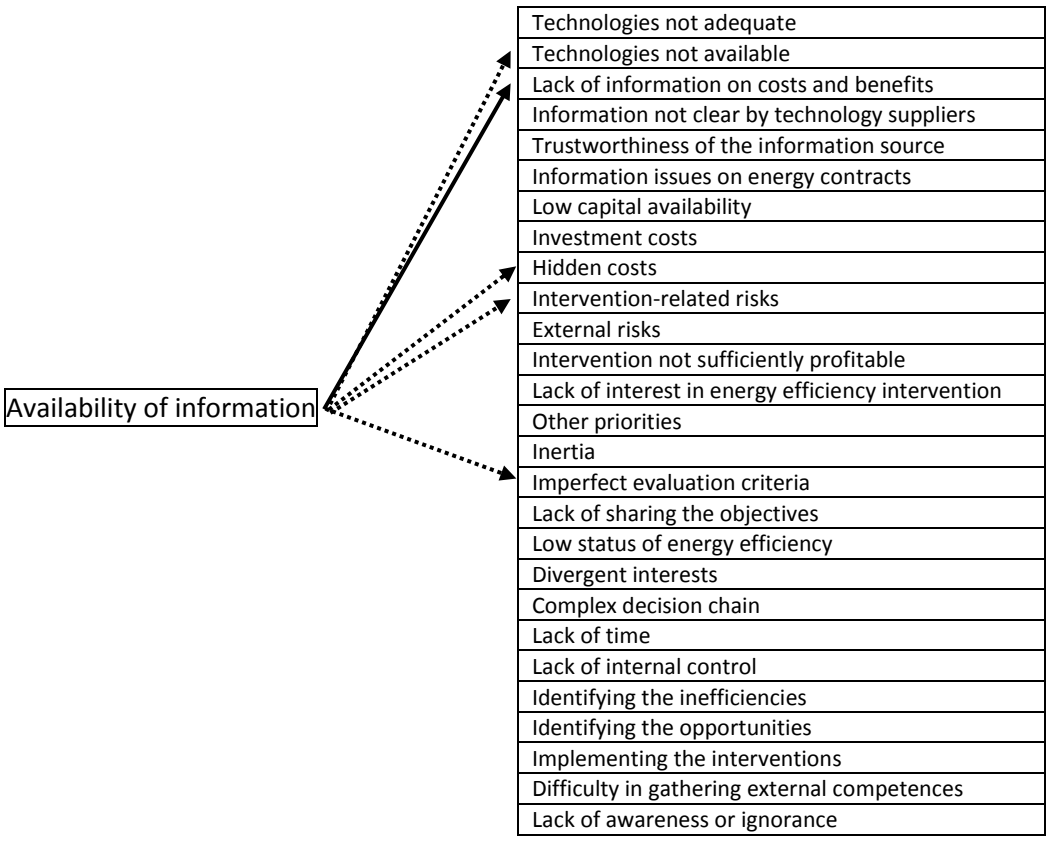



**Figure 8: Barriers affected by availability of information**

For example, availability of information involves all types of information that may be useful to an enterprise, namely: information related to the presence on the market of new technologies, information related to the possibility to take advantage of special incentives, information related to the possibility to enter into contracts with ESCOs to obtain certain services, etc. As it can be inferred, this driver completely overcomes the barrier *lack of information on costs and benefits* (solid line), and creates the conditions to reduce other barriers such as *hidden costs*, *intervention-related risk*, *technologies not available* and *imperfect evaluation criteria* (dashed line) which, however, may need other drivers to be completely overcome. Indeed, making information available to a decision maker, with respect to a specific investment, can reduce the capital needed for gathering, analyzing and applying them. Therefore, availability of information allows to reduce the barrier *hidden costs* which however requires the technical support driver in order to reduce the disruption of the plant in case of substitution of one or more pieces of equipment, or even to train staff for the application of new practices. Instead, *intervention-related risk* may need drivers such as private financing, public investment subsidies, management support, knowledge of non-energy benefits or information about real costs. In fact, these drivers

could reduce the decision-makers' uncertainty on investments. *Technologies not available* may require an advertising campaign specifically to spread a new technology, as stated by (Saidel & Alves, 2003), noting that 'information to the public' is a government program aimed at raising public awareness of energy efficiency issues, in order to achieve better market penetration of energy-efficient technologies. Finally, the barrier *imperfect evaluation criteria* may not be completely overcome through the availability of information, as the decision-maker may not have the knowledge or the proper criteria to evaluate investments, thus requiring management support or energy audits to find the inefficiencies and opportunities.

Many legal constraints reflect the will of governments in facing important issues, such as those relating to climate change. The driver efficiency due to legal restrictions (regulations and standards) pushes companies to follow very specific rules. In fact, in order to comply with the regulations, companies are forced to follow carefully what is imposed by the higher bodies. In this way, barriers such as *other priorities*, *inertia* and *lack of time* could be completely eliminated. Moreover, a standard can be a vehicle of information and may force technology suppliers to provide information according to a predetermined procedure, affecting in this way the barriers *lack of information on costs and benefits* and *information not clear by technology suppliers*.

Private financing and public investment subsidies are drivers of economic nature that stimulate the interest of all companies. Both these drivers may completely overcome the barriers *low capital availability* and *investment costs*, which are the most frequent issues encountered within companies, and reduce the barrier *intervention-related risk*, since companies may perceive a reduced risk associated to the investments. The driver public investment subsidies allows also to reduce the barriers *intervention not sufficiently profitable* and *other priorities* because the investor can be attracted by subsidies for investments not considered before. Therefore, next to the core business, an interest towards energy efficiency could arise.

From table 11, we can see that drivers of a certain nature do not affect any barriers grouped into macro-areas. Interestingly, drivers of regulatory nature do not seem to impact on technological barriers, economic barriers, barriers related to the competences and awareness. The introduction of regulations in the company leads to overcome obstacles mainly related to the information, behavior and organization. Drivers of economic nature mainly face economic barriers, with the addition of barriers related to behavior, organization and awareness. Indeed, we cannot appreciate an effect on information, competences-related or even technology-related barriers. It is worth pointing out that the latter in particular are addressed only by drivers of informative nature. Moreover, informative drivers seem to have the largest effect on the majority of the barriers, addressing organizational barriers, competences-related, economic barriers as well as behavioral ones.

## 5.2 Energy efficiency decision making

In this section we will analyze the main steps of decision making that will lead to investments in energy efficiency. To achieve an increase in energy efficiency, it is necessary to go through several steps that can encompass various areas or actors within the company usually involved in an investment assessment. If one or more of these steps encounters barriers, progress of the investment will be delayed, or even interrupted. After the definition of this steps, it is possible to figure out where is targeted every driver in decision-making, and obtaining useful information also on the actors involved.

### *5.2.1 Decision making steps for energy efficiency investments*

Analyzing the literature (Tonn & Martin, 2000) talk about decision making process and regarding investments in energy saving, point out that: *"decision making refers to the behavior of firms with regard to choosing whether or not to implement energy savings measures".* Also (Cooremans, 2012) gives a definition about decision making: *"A decision is a step in a decision-making process, defined as a dynamic chain of actions and events".* The dynamic consider that decision making is not as a point in time but the result of a process along which occurs events to reach a final decision. Cooremans models the decision-making according to three phases: identification (diagnosis), development (build-up of solutions), and selection (evaluation of the different solutions and choices)". She takes into account the factors that may affect or interfere with the decision-making chain. This process is influenced indeed by (1) organizational and external contexts along any number of points that surround it, (2) actors involved, and (3) characteristics of the investment and of the investment decision to be made. In the study of (Cooremans, 2012) is emphasized that the decision making depends on the type of investment, highlighting the particular interest in strategic investments. It is then developed a model that would fit all types of investment.

After a re-categorization of the studies founded in the literature, with respect to some decision problems, in the following will be described decision making steps that will be the base for our model. Most industrial and utility technical-assistance programs have focused on only one or two of these steps. It is important that resources be available for all steps to achieve high implementation rates of energy efficiency investments. Final project phases, particularly startup and employee training, can be the most critical to maximizing long-term savings potential (Elliott & Pye, 1998).

*Awareness:* (Hasanbeigi et al., 2010) states that: "*raising the awareness of staff and top management is the basic step in the process of energy efficiency improvement in industry*". If the people in industry are more aware of the importance of energy efficiency and the

benefits they get by improving energy efficiency in their plants, new technologies and practice for energy efficiency will be taken more into account.

*Needs*: this step includes the analysis of problems and understanding them in order to find an optimal solution for efficiency. Even if the firm is aware of energy efficiency, the management should make an extra effort for identifying the inefficiencies and overcoming them.

*Opportunity identification*: staff could imagine potential solutions for energy efficiency, and sought opportunities untapped by the company to solve its problems of inefficiency. When a need is identified company should then be able to recognize the opportunities that have to meet that need. Without this step no potential energy efficiency decisions have yet to be imagined in the minds of any of the firm's employees in spite of the fact that there are a large number of opportunities available (Tonn & Martin, 2000). Management as well as staff must therefore be able to look inside the enterprise and identify these insights

*Technology identification*: once opportunities have been identified, it is necessary to seek the suitable technologies available on the market. Searching for new energy savings technologies (as well as opportunities) may result in changes to other routines, such as adopt a particular process, followed by the firm.

*Planning*: the technologies must then be placed in the context of the company, taking into account e.g., the physical layout. It also needs to be checked for compatibility with new deployments of existing technologies, to simplify as much as possible their integration. The project must be clear, specific and vivid to be entirely understood by those who will deal with the subsequent implementation phases.

*Financial analysis*: in this phase are analyzed all the costs that the company faces for the implementation of the technology or practice object of the investment. These costs and their rate of return must meet the corporate investment criteria to ensure that the investment will be undertaken and implemented. It is therefore necessary a detailed analysis of costs to be addressed and their acceptance from the top management.

*Financing*: when all costs are clear, it is necessary to find funds to bear the investments. The search can be done in various ways and according to different procedures depending on the company and the context in which it operates. Even this step is crucial because it is the last economic hurdle for launching the implementation of energy efficiency program.

*Installation*: when the financial analysis and the financing part are overcome is time to put into effect the investment. The technology will be purchased and the practice will be implemented in according to the plan designed in the planning phase.

*Start up*: after installation, the machinery has to be set-up, appropriate routines have to created, and the proper implementation has to be ensured.

*Training*: the technology or the procedure applied now has to work. Everybody who will use it or will interface must be properly prepared, because incorrect use may lead to lack of exploiting the project's benefits. Appropriate manuals or training courses will be provided to personnel to ensure proper operation, and the achievement of desired results.

Based on the classification of the drivers and by referring to the ten steps analyzed, we have developed a decision making reduced to six steps, each of which turns out to be independent from the others. In the following we will provide the rationale of our choice, supported by some examples. Moreover, and new with respect to previous literature, we have modeled the drivers that can eliminate (or at least reduce) barriers affecting each step. We have decided to merge needs and opportunity identification because both relate to the fact that once awareness is rooted within the company, a way to find out all the inefficiencies and then adopt the best solutions has to be pointed out. In fact they are two closely related concepts, as well as financial analysis and financing. When the financial analysis is performed, it is usually correlated to the research of the financial source from which get the money. If the top management believes that the expenditure meet the enterprise's criteria, it must then also approve the way for getting the money. Finally, installation, start-up and training are combined in a single step since the installation phase is ended with the start-up, and the training becomes necessary for the proper use of the object of the investment, ensuring that it does not lose its cost-effectiveness once put into practice.

Decision making steps:

1. Awareness
2. Needs and opportunity identification
3. Technology identification
4. Planning
5. Financial analysis and financing
6. Installation, start-up and training

These spheres of influence are also the subject of our study in which we want to analyze what drivers affect specific steps of the decision-making and therefore which actors are involved in interfering with this process. In fact, the actors involved influence the course of the decision-making process and its result, which can be a negative, positive, or no-decision.

### *5.2.2 The effect of barriers on decision making process*

We will discuss now about barriers that affect the different steps of decision making. Barriers will be grouped in macro areas, as the model would then become too complex if it is adopted the taxonomy in detail with 27 barriers and the detail of macro areas could be lost.

**Table 13: Effects of barriers on decision making steps**

| | DECISION MAKING STEPS | | | | | |
|---|---|---|---|---|---|---|
| **Barriers** | **1** | **2** | **3** | **4** | **5** | **6** |
| Technological | | | • | | | |
| Informative | • | | • | • | • | |
| Economic | | | | | • | |
| Behavioral | • | • | • | | • | |
| Organization | • | | | • | | • |
| Competences | | • | | • | | • |
| Awareness | • | • | | | | |

As regards the growth of awareness, information barriers are addressed such as the lack of information on the real benefits. Also behavioral and organizational barriers such as divergent interest are included, because of they lead the corporate awareness away from the issue of energy efficiency. Finally, it is obviously of primary importance the barrier related to awareness, the so called lack of awareness or ignorance.

The second decision step is certainly affected by the influence of barriers relating to the competences as identifying the inefficiencies and identifying the opportunities. These are the most important barriers for this step, because they block the crucial point of this step. To these, behavioral barriers such as inertia and those related to awareness may be added. The inertia in particular limits the freedom to identify new opportunities as it is a resistance to change.

Concerning the identification of technologies, the main barriers are certainly those related to technology. If the technologies are inadequate or unavailable, the identification becomes very difficult or even impossible by the company. In this point, information barriers such as the presence of information not clear from suppliers of technology, are also inserted. This can ensure that the individual responsible for identifying may distort the information and therefore to not consider efficient technologies for their future implementation. Finally behavioral barriers can act at this point: particularly the inertia barrier, which often moves the interests just to keep the status quo.

Information barriers and those related to competences essentially deals with the planning phase. The lack of reliability of the information source leads a designer to not considering them at this stage. In addition, the barrier implementing the interventions presupposes a lack of skills in the implementation that is present therefore also in this phase. Organizational barriers may become just as important as the roles are not well defined or the lack of power as well as the lack of time can lead to inadequate planning.

Financial analysis sees the main influence of economic barriers such as lack of capital, investment is not sufficiently profitable or high investment costs. All these economic barriers are quite often correlated, creating a monolithic entity inhibiting the investments. Additionally, behavioral and informative barriers are also involved. In particular imperfect evaluation criteria leads to a distortion in evaluating the investments, so that a cost-effective investment may be not properly considered and then discarded by the decision maker.

Finally, the installation, start-up and training phase relates mainly to barriers of competence as implementing the interventions and difficulties in gathering external expertise. As previously explained, if an investment in energy efficiency is not properly executed in all its phases, it could easily turn into yet another practice that it is not efficient. In addition to that, this step also involves organizational barriers such as lack of internal control: if it occurs on the actual application of the new procedure or on the proper use of the new machine, the efficiency will not increase.

### *5.2.3The effect of drivers on decision-making process*

Awareness is the first step of decision making, without which energy efficiency is not seen as an opportunity. It appears to be an important step toward energy efficiency thanks to which it gives rise to numerous advantages. Therefore, people with real ambition could really create a culture within the firm that aims to affront efficiency problems in relations to production ones. We should not forget, however, management with real ambitions, because it is necessary that top management shows interest in these problems by developing values, norms and routines that emphasizes firm’s interest in energy efficiency. There are other drivers that may have the effect of raising awareness within the company and then push it to consider the problems of energy efficiency very important. The most important is awareness that tackle the principal problems of this step. Raising the awareness within the company is the objective of this decision making step and this driver is definitely a turning point for the success of this step helping to overcome barriers of behavior and ignorance that are basic problems for this step.

For needs and opportunity identification. In this regard, external energy audits is a valuable tool to fill certain gaps which are very common in industries, such as lack of knowledge on the equipment energy consumption. Knowing the consumption of departments or of the company in general help to provide a clearer picture of the situation. So, for the decision maker is easier to look for possible opportunities to delete inefficiencies and rise energy efficiency status of the company. Another useful driver is external cooperation generating the exchange of free information so that companies are well-informed with no additional costs. It can be an useful driver because any collaborations between firms and any external organization such as ESCOs, IAGs or other companies would give the opportunity to have much information on the evaluations of inefficiencies. Firms could also compare themselves with other companies in the same industrial sector or otherwise determine whether the internal performance differ a lot from the reference values, i.e. making benchmarks.

Technology identification is the third step of the decision-making, separated from the previous one because we want to refer to the information necessary to find the technologies available on the market appropriate for companies. For this purpose, availability of information becomes indispensable, coupled to the support from manufacturers in order to spread advanced technologies already available on the market. The choice of a company when it is decided to buy a new technology is usually based on the information that it receive; so that the availability and the content of this information will lead definitely the choice of the purchase. Another factor that may be crucial in the choice of a new technology is certainly the knowledge of non-energy benefits. From new purchase may arise benefits related to safety, cleanliness or comfort of environments that might be interesting coupled to the issue of energy efficiency. In fact, if the awareness of energy efficiency is not still deeply rooted in the company the knowledge of these co-benefits could be a strong help for the takeover of cost-effective technologists. In the fourth step named planning, the decision maker must understand how these can be inserted within the company taking into account all the boundaries, including those relating to the layout and to interactions with the rest of the existing machines, in order to avoid any interference. Technical support may result in a very useful driver for this step. If designers are not well confident which such a type of investment some experienced people can provide this type of support giving that help necessary to avoid any mistakes or neglect important aspects. During this phase it is essential to have clear and reliable information on which base an accurate planning. The clarity of information is surely a critical point due to the fact that sometimes. Some of these projects are not take into account because they are too difficult to deal with. These obstacles could certainly be addressed by the presence of more clear and easy information about characteristics of investments. The design phase then could proceed more quickly and the possibility that errors will be committed would surely fall. In regard to efficient technologies the information are often confusing and not certified and so not considered. So, providing standardized and reliable information the designer sees

himself protected and avoided to commit errors by relying on those information that are not deemed reliable.

Financial analysis and financing is the fifth step that turns out to be quite delicate because it involves economic aspects. Each firm adopts a particular criterion for investment that depends on many factors, such as the size of the company and the availability of resources both linked to the financial exposure. Therefore, it becomes important to consider not only the investment costs but also operating costs to be incurred during the entire useful life. Financial analysis tend to overestimate efficiency potential because of the so called hidden costs, that include overhead costs for management, disruption, staff training and the costs associated with gathering, analyzing and applying information. Taking into account information about real costs could help to overcome these barriers. Given so, the financial evaluation will be more accurate and made with full knowledge of the true situation. Once all costs are clear, it is necessary to find funds to address them and to overcome the corresponding barriers, i.e. access to capital and financial risks. There are several alternatives to be followed for this purpose, for example public investment subsidies or private financing that could be made available to companies through government or financial institutions. Both this instruments provide money to the company but, especially private funding, require a refund of the money with interest which could vary the economic valuation of the investment. Knowing the source of financing is therefore useful for proper a financial evaluation

Finally, if the financial constraints are exceeded positively, the new technology can purchase it is ready to be installed in the plant, setting-up and prepared for working. It is important that the staff is well trained because an incorrect use of the technology or a wrong procedure may lead to a cancellation of the benefits. So, programs of education and training play a key role in this phase. In fact, an improper use of an efficient technology can lead the company not to take advantage of all the benefits of the investment remain not efficient. It should be noted however that a fully successful implementation of a new technology typically involves several months or even years in reaching the right balance state The driver technical support become equally important, especially during the phases of installation and start-up. The suppliers of technology may for example follow the early stages of implementation up to which the company is not fully skilled with its new technology or practice. r In the following table, it is illustrated the correlations between drivers and decision making steps just described.

**Table 14: Effects of drivers on decision making steps**

| | DECISION MAKING STEPS | | | | | |
|---|---|---|---|---|---|---|
| **Drivers** | **1** | **2** | **3** | **4** | **5** | **6** |
| Voluntary agreements | | ● | ● | | | |
| Efficiency due to legal restrictions (reg & stds) | | | ● | ● | | |
| Green image | ● | | | | ● | |
| Long-term energy strategy | ● | | | | ● | |
| Willingness to compete | ● | | | | ● | |
| Management with real ambitions and comm. | | ● | ● | ● | | |
| Staff with real ambitions | ● | ● | | | | ● |
| Increasing energy tariffs | ● | | | | ● | |
| Cost reduction from lower energy use | | ● | | | | |
| Public investment subsidies | | | | | ● | |
| Private financing | | | | | ● | |
| Management support | | ● | | ● | | |
| Technical support | | ● | | ● | | ● |
| External energy audit/sub metering | | ● | | | | |
| Programs of education and training | | | | ● | | ● |
| External cooperation | | ● | ● | | | |
| Awareness | ● | ● | | | | |
| Technological appeal | | | ● | | | |
| Knowledge of non-energy benefits | ● | | ● | | ● | |
| Availability of information | ● | | ● | | ● | |
| Clarity of information | | | | ● | | ● |
| Information about real costs | | | | | ● | |
| Trustworthiness of information | | | ● | ● | | |

## *5.3 Company's areas of interest*

In addition to considering the impact on decision making, we will explore the effect that drivers have within the business areas. We will keep the effects of these separate areas compared to those on the decision-making process considering them as two different attributes according to which classify drivers. This decision is dictated by the fact that, as can be inferred from our definition of drivers, these factors have multiple effects that impact at multiple levels within the organization. Thus the effect seen on a stage of the decision-making chain, derived from a driver, totally differs from the one observed in a particular area of the firm (e.g., technology management). In addition, many beneficial effects that a driver makes into a particular step, for example the increased of awareness, affect the entire company and then the new attribute as a whole. In addition, as will be

shown in the next section it can also find out which is the party involved in the organization having a complete picture of the possible actions to be taken and who act.

**Table 15: Company's areas**

| COMPANY | | | |
|---|---|---|---|
| Technological areas | | Management areas | |
| Crosscutting | Specific | Financing | Operations |

We will show what drivers can act and how they can act in a particular business area. So each driver will be placed I its area also analyzing any correlations between them. Some of them could act on the whole company, others could focus on a specific level of detail such as the area of technology or management.

*Company:* in this area general drivers or those that act indiscriminately on all business are interested, bringing benefits to all sectors. In this cluster we included drivers helping to overcome barriers related to behavior or due to the organization. As said by (Cagno et al., 2013): *"when performing an empirical investigation, each barrier related to the behavior would be repeated for each function within the enterprise, thus increasing the number of barriers at the lowest level of the taxonomy"*; the same happens for drivers. The drivers that affect this level are involved in moving the interest of the firm to the energy topic, increase awareness and thereby sensitize the entire orientation of an organization. A strong impact on this phase can have significant beneficial effects on the efficiency that can become part of the organization's culture up to be regarded as fundamental and useful for the core business.

*Technological/Management areas:* the drivers falling into these areas are targeted for action on specific issues such as the promotion of specific technologies or to facilitate the process of financial evaluation in the management areas. This is the main division used for our classification since usually is the strongest in an industrial organization such as for theory and practice. The management area basically reflects management problems that are encountered in doing energy efficiency such as new practices, the efficient management, alternative mechanisms to reduce waste and consumption or a new vision for the approach to investments. The technological area instead deal with specific technical problems of a company analyzing its inefficiencies in the practical field. It encompasses alternative technologies that can be taken to reduce the inefficiency and therefore the mode of production of a company. The drivers in these categories will take care to move the focus of the staff working on technology or management from business as usual to energy efficiency.

*Lowest level*: drivers within these areas should be analyzed case-by-case. Especially as regards the technology, we can make this difference only analyzing each case by the individual companies. For the management, it is rather easier to understand this classification at the lowest level. This areas will not be developed in detail, as the complexity of the model would become very high to its confirmation that ought to derive from personal interviews. Moreover, for each company this detail would be very different and the results will be not comparable.

Having clear this distinction, the drivers will now be categorized according to the business area and according to those that they influence in the organization. To simplify the categorization, as stated previously two main areas will be considered: the technology management and others. In technology management all aspects of production technology and maintenance are included. It is therefore included the production departments with their employees, maintenance crews and their management and programming. In others, it is included all that is not about the technological aspect, from the office of marketing to investment management and financial management.

It should be noted that most of the drivers fall under “others” and it is due tothe definition of drivers given in paragraph 4.3.1 for which drivers are referred to investments in energy efficiency and thus the valuation of investments and the decision maker are always directly or indirectly involved. The only exception is made for technical support that is only involved in the technical aspect. This does not mean it is not interesting for energy efficient investments, but that affects company only in the technological part of the problem. All aspects related to information and the raise of awareness are drivers that belong to both the areas because the information and the awareness act indifferently in every business sector. Even programs of education and training behaves in this way because programs are aimed at both operational staff and at the highest officers (designers, managers, etc..). The driver staff with real ambitions also impacts for the staff employed in the field of technology and for all the support staff for other activities. The remaining drivers of regulatory and economical nature affect directly other functions of the company and couldl reflect this impact on the technological area with an indirect efect.

### *5.3.1 Who are interested within the company*

A similar differentiation for drivers will now be made to understand who is influenced by the drivers within the company. For ease of analysis, we considered only the management and the staff without considering in detail all the various business functions. Even in this case, it is known that the management is influenced by almost all these drivers. This is because the final decisions will be surely taken at higher levels. The drivers impacting on staff, in addition to staff with real ambitions, are those related to behavior with which operators can affect the efficiency of business practices. This classification highlights the fact for which the highest officers of the company are crucial to arrive at a result of energy

efficiency, because are those responsible for the implementation and decisions about investments. However, the staff also remains influential because its behavior determines the result of the company's business as well as the use of efficient technologies and practices.

## *5.4 Integration of the features of the novel framework*

Given our own definition of drivers for energy efficiency and developed an innovative taxonomy to categorize them, we have classified drivers according to four attributes: nature, targeted barriers, actors responsible for their stimulus internally and externally to the firm, and step of the decision-making processes affected by drivers. The final model thus refers to policies that have an impact on enterprises (Figure 8), and has been shaped according to the suggestions coming from 5 preliminary case studies in manufacturing industries. If the promoter of the policy is the same of the driver, the intermediate step is eliminated and the policy will affect directly the enterprise. In this case, the actor promoting driver coincides with the policy maker. In an attempt to quantitatively evaluate to which extent energy efficiency is hindered by the barriers and how drivers can foster its increase, we have conducted an empirical investigation of 61 manufacturing SMEs in Lombardy, the richest, most developed and most industrialized Italian region.

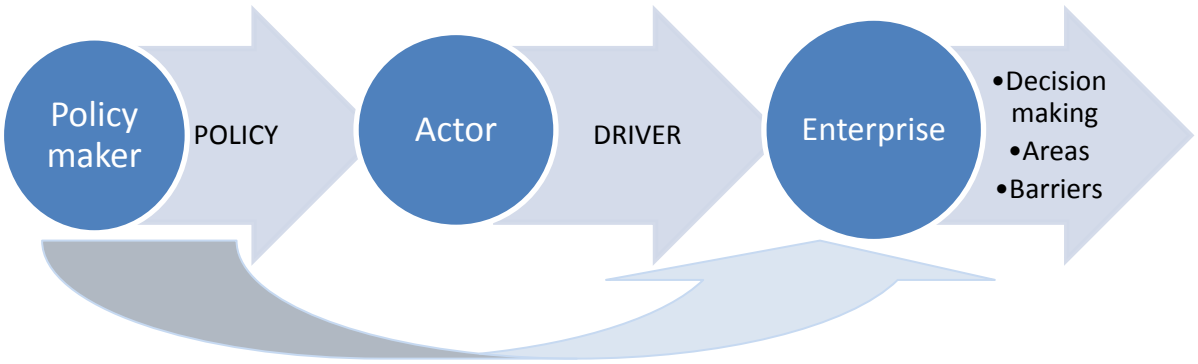



**Figure 9: Final model of the problem**

It will be interesting to understand what are the main drivers, what are the relationships between drivers and decision-making steps, and what should be the insights in future energy efficiency policies.

# Chapter 6

# Research methodology

After having adopted a taxonomy of barriers for empirical investigation and developed an innovative framework of drivers for energy efficiency, the present chapter argues the rationale behind the undertaken research methodology. Following the structure suggested by (Yin, 2003), the discussion will formulate the research questions, then will explain the choice for the case-study methodology and last will detail the research design. After the validation of the proposed model, we have adopted the survey methodology involving a larger sample, as described below.

## *6.1 Research questions*

Having explored the range of measures that deal with energy efficiency problems, we have developed a taxonomy of drivers for energy efficiency. Having provided a clear division between drivers and policies and a clear classification of the former that is missing in literature, the main research questions are:

- What are the main drivers that act on a company and on its decision-making to make them overcome barriers to energy efficiency?
- How can the policy maker or any other external actor act, consistently with the proposed model, to stimulate drivers for energy efficiency considered most important?

## *6.2 Rationale for case study methodology*

The empirical research takes on the multiple-case study methodology for two reasons. First, the three conditions proposed by (Yin, 2003) are met since (1) the nature of the research questions is indeed explanatory, (2) the extent of control over behaviors is very low, and (3) the focus is exclusively on contemporary events. Second, by the definition of multiple-case study, the research intentionally intends to cover not only “the” contextual settings but also “across” these settings in which the phenomenon, i.e., the perception of barriers and drivers, is going to be investigated.

According to (Yin, 2003), three conditions are likely to lead to the use of the case study methodology: the type of research question, the extent of control over behavioral events, and the degree of focus on contemporary events. First, section 6.1 formulates the research questions such that the present investigation takes on explanatory purposes. This is in accordance with the type of research questions that should be posed for a case study. In fact, the questions should be "how" and "why" aiming at being more explanatory than descriptive, i.e., "who", "where", "how many" (Yin, 2003). A part from being "how" questions, the research questions, upon which the following investigation builds, aim at determining whether the barriers and drivers exist, what form they take, and their relative importance within the medium-small and medium-large enterprises. Moreover, the research goal is to assess whether the relative importance vary according to different features of the firms and the energy efficiency measures.

Second, the very low (ultimately absent) control over the behavioral events clearly distinguishes case studies from experiments. In a laboratory setting the experimenter can manipulate behavior directly, precisely and systematically. In contrast, the investigator of attitudes displayed by an industrial sector cannot claim to have control over the behavior of the subjects involved, since the phenomenon and the context are not always distinguishable (Yin, 2003). That is, although we might carefully select each case, we are not able to clearly distinguish whether the importance of a barrier or driver is such because of "real" conditions or because it is faulty "perceived" as such. Therefore, it is utterly impossible to voluntary manipulate the parameters proper of each unit of analysis.

Third, the focus should be mostly on contemporary as opposed to historical events. Contemporaneity of our investigation is straightforward since we are interested in the current barriers that enterprises are facing and in the drivers to overcome them. Furthermore, the case study methodology bear on the use of contemporary sources of evidence, that is, direct observation through interviews of persons involved.

Last but not least, prior to any data collection, it is appropriate to deliberately choose the design variant between single- or multiple-case study (Yin, 2003). The research adopts the multiple-case variant since it is of primary interest to analyze the phenomenon across the contextual settings (Baxter & Jack, 2008); therefore, 5 case-studies are collected. In general, criticisms about single-case studies usually reflect fears about the uniqueness or artificial conditions surrounding the case. Indeed, the main advantage of a multiple-case study design is that it allows to analyze within each setting and across setting, giving evidences considered more robust and reliable, although the contexts of cases are likely to differ to some extent (Yin, 1994).

## *6.3 Research design*

As (Yin, 2003) pointed out and (Baxter & Jack, 2008) detailed, the fundamental steps for a good case study have to be the following:

- formulate the research questions (presented in section 6.1);
- state the unit(s) of analysis (presented in the next section);
- establish the boundaries for the research scope (presented in the next section);
- formulate a conceptual framework giving criteria for interpreting the study's findings (partially presented in Chapter 3 and 4, recalled later in section 6.3.3);
- develop a case-study protocol for data collection (presented in the last section).

Then it will be explained in detail the sample under analysis with the survey methodology and how interview and analysis of results have been conducted.

A survey is a systematic method of collecting data from a population of interest. It tends to be quantitative in nature and aims to collect information from a sample of the population such that the results are representative of the population within a certain degree of error. The purpose of a survey is to collect quantitative information, usually through the use of a structured and standardized questionnaire that minimize interviewer bias. Questions are asked of various members of the group in exactly the same way, within a relatively short time frame. It is appropriate for measuring people perceptions, opinions, knowledge, attitudes, behavioral intentions, and behavior using primarily closed-ended questions. Surveys can be completed by telephone, mail, fax, or in-person. They require some statistical knowledge, sampling and other specialized skills to process and interpret results. It is more difficult to collect a comprehensive understanding of respondents' perspective (in-depth information) compared to in-depth interviews or focus groups. We decided to conduct telephone interviews that present the following advantages: it is possible to achieve high response rates; interviewers are able to document characteristics of non-respondents and reasons for refusal; the amount of non-response to questionnaire items can be minimized; able to obtain results quickly; less costly than face to face interviews (but more expensive than mail surveys). Long and/or complex questions should be avoided, as it is difficult for respondents to retain the questions and response categories (THCU, 1999).

### *6.3.1 Unit of analysis : The Lombardy's manufacturing sector*

The Lombardy region is of great interest from an economic point of view since it produces more than 20% of the national gross domestic product (GDP), accounting for 320 of the 1520 billion Euros of Italy (EUROSTAT, 2012). Moreover, Lombardy's GDP per capita is 33% higher than the EU27's (EUROSTAT, 2012). Second, the Lombardy's manufacturing sector employs nearly 1 million people accounting for a quarter of the people employed within the

sector nationally (ISTAT, 2011). Third, the primary metal manufacturing and the machinery and equipment manufacturing can be considered the core activities within the manufacturing sector since they represent the primary source of employment both for the Lombardy region and the Brescia province as well (ISTAT, 2011). Five structured personal interviews were conducted to have a feedback on the proper functioning of the model, and their structure will be described in detail below. Then, we have conducted structured phone interviews with 61 companies to obtain data and to make quantitative evaluations with the survey methodology.

### *6.3.2 Boundaries for investigation of the barriers and drivers*

On the road to a complete design of our study, we have formulated the research questions and stated the unit of analysis, thus, it is time to set boundaries for the study. (Baxter & Jack, 2008) assert that: *"One of the common pitfalls associated with case study is that there is a tendency for researchers to attempt to answer a question that is too broad or a topic that has too many objectives for one study."* So, in order to avoid this problem, we will establish the boundaries for the investigation of the phenomena of interest, i.e., the barriers to and the drivers for energy efficiency.

#### *6.3.2.1 Boundaries of barriers*

The boundaries of barriers that are going to be analyzed are utterly straightforward, given the thorough taxonomy for empirical investigation adopted in Chapter 3. What needs to be specified here is the choice to evaluate "perceived" barriers only, although both "real" and "perceived" values contribute to determine the full picture of the barriers (Andrea Trianni et al., 2013). The choice is substantially borne by a theoretical reason and a practical constraint. On the one hand, the theoretical reason comes from classic arguments of the marketing research. In fact, it is commonly recognized that understanding the impact of perceived value on consumers is more directly relevant to outcomes and energy efficiency customers are more likely to adopt energy efficiency measures on their perception of the value of the barriers rather than after a formal evaluation of these. On the other hand, privacy warranties on sensitive data restrain the range of the empirical investigation. If the perceived values can be obtained by asking directly one or more questions, the real values are instead obtained through gathering several data about practices and behaviors on investment processes. It is apparent that gathering the real values could not be so straightforward, requiring, for a single barrier, several data and/or information, not always obtainable and/or derivable. Therefore, the research is restricted to the perceived barriers through questions asked to the managers of the firms. In addition, since the barriers are not the main focus of this study but are of interest to draw interesting conclusions about the drivers, it was decided to group them into macro-areas. So we will divide them into seven areas: economic, behavioral, organizational, competences-related, lack of awareness, technology-related and information.

#### *6.3.2.2 Boundaries of drivers*

The drivers proposed belong to three main categories, namely: regulatory, economical and informative. Any type of action that does not fall under these categories has not been taken into account. Drivers have an impact in the company changing its processes and management systems, and the actors of each firm are involved in only few decision phases with precise tasks that will be set out in detail in the results. It is important to underline that it has been explored the industry sector while there is no references to other branches, such as residential, transport and buildings, in which drivers can act.

### *6.3.3 Conceptual framework for interpretation of results*

The case study inquiry benefits from prior development of theoretical propositions to guide data collection and analysis. This point clearly distinguishes the case study methodology from a "qualitative research" which attempts to avoid prior commitment to any theoretical model (Yin, 2003). Theory development does not only facilitate the data collection phase, it also sets out the level of "analytic generalization", as opposed to "statistical generalization" – less relevant, for doing case studies (Yin, 2003).

In accordance with other contributions, our main proposition states that energy efficiency within enterprises, specifically of the Lombardy's manufacturing sector, is inhibited by various type of barriers. So we want to understand what internal factors may promote energy efficiency and help to overcome these barriers. Consequently, it is important to understand who are the actors that can stimulate drivers and what is their nature. Furthermore, the nature of the driver is inherent in the company of his perception and helps us understand how the driver is perceived. The proposed model of drivers, that includes also the relevant actors for their stimulus, must therefore be validated.

Therefore, we have conducted structured personal interviews with four enterprises from the Lombardy's manufacturing sector and one from Sicily's one. This preliminary set of interviews was conducted in order to have a feedback on the proper functioning of the model, and their structure will be described in detail below. The decision-making model, with the six steps proposed, fits well within medium and large companies, whereas in the small enterprises the decisions are typically taken by a single person (the holder), and the division becomes less clear. Despite this, for the model validation, two small companies were also included for not neglecting these realities in the sample. Then, we have conducted structured phone interviews with 61 companies to obtain information about perceived barriers and drivers for overcoming them.

### *6.3.4 Case study: the structured personal interviews*

The interviews were conducted at the headquarters of the various companies, with the exception of the Sicilian company whose interview was conducted by telephone, and carried out in Italian. The referents were plant managers for medium and large companies and owners in the case of small firms. The choice of the level of the interviewee is obviously targeted to the fact that the corporate knowledge is high and then the feedback will be significant. Each interview lasted about 1 hour.

The interviews consisted of the open questions, shown in table 16 and 17, to frame the company and the respondent, and to understand the perception about energy efficiency. Interviews used a standard question guide to ensure adequate coverage of the topic, and this technique does not utilize rigid questions but encourages more natural discourse between informant and researcher (Hausman, 2005). Then, following a phenomenological focus, interviews proceeded based on the topics introduced by the informant, as recommended by (Thompson, 1997). So, we got more specifically into the model and for each decision-making step it has been asked to assess barriers and drivers making a distinction between management and staff. Finally, to complete the validation of the hypothesized model, we asked what was the nature of the proposed drivers and who would be the actors for their stimulus. The goals were: to confirm the model and to illuminate key drivers for each company that influence the ongoing of energy efficiency investments. Data were collected and in some case it was possible to make a short tour of the plants guided by the interviewee.

**Table 16:Interview questions in their order of presentation**

| Questions for personal interviews |
|---|
| ➢ Number of employees? |
| ➢ What are the energy costs per year (electricity, gas, etc.)? |
| ➢ What is the on average the annual turnover? |
| ➢ What's about the corporate organization? |
| ➢ What's about the type of products manufactured and the production process? |
| ➢ Do you make research and development? |
| ➢ Do you have environmental certifications? If yes, how the interest was born? |
| ➢ Is there someone within the company that deals with energy efficiency? Have you referred to consultants? Are you part of some industry association? |
| ➢ Do you make awareness courses for staff on energy? |
| ➢ Have you recently changed machines? If so, why? What is the policy of replacing machinery? |
| ➢ Have you recently made changes or substitutions to the service systems (lighting, compressed air, heating and air conditioning, etc.)? |
| ➢ What are the practices to acquire new technologies? |

### *6.3.4 Survey: the structured phone interviews*

This type of interviews was used to collect data of the main perceived barriers and drivers by companies. As stated previously, it was decided not to ask the barriers individually but grouped into seven macro-areas, for going then deeper into the issue relating to drivers which instead have been listed and explained one by one. Referring to the International Standard Industrial Classification of all Economic Activities (ISIC) (ATECO, 2007), Lombardy's industry focuses on manufacture of non-metallic mineral products (C23), manufacture of basic metals (C24), manufacture of fabricated metal products (C25), and manufacture of machinery and equipment (C28). We have taken into account medium-small enterprises (MSEs), with a number of employees between 50 and 99, and medium-large enterprises (MLEs), with a number of employees between 100 and 250. The investigation considered 61 enterprises (31 MSEs and 30 MLEs) located in the Lombardy region of Italy and indentified

via AIDA database. From this database we have obtained some information about the companies, such as number of employees, sector and province in which the production site is located. Structured interviews were conducted over the telephone with the person in charge of investments and the general purpose of the research was explained. The total duration of the phone call with the designed person was about ten minutes, in which the interviewee was asked to complete a short, guided questionnaire which investigated his/her view of the barriers and of the drivers which do or would facilitate the adoption of energy-efficient technologies and practices in his/her firm. The questions were scored on a 4-point Likert scale which ranged from 1 ("not important") to 4 ("very important").

About 430 companies were contacted and only 61 have shown a willingness to make a telephone interview, so that the response rate was 14.25%. The following graphs show the composition of the sample analyzed.

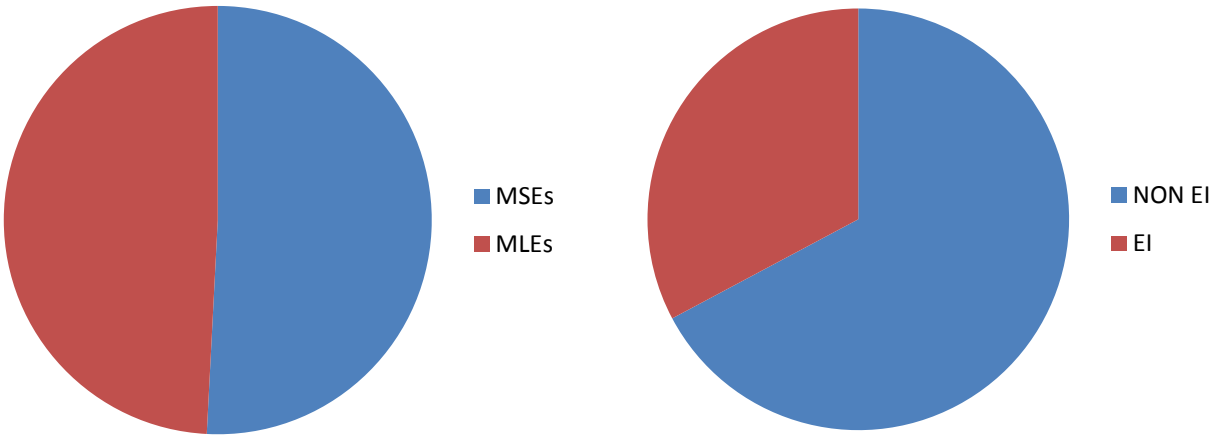



**Figure 10: Subdivision of the sample**

Since the analysis was built on a relatively small number of firms, only propositions derived from the data are presented with suggestions for future testing, rather than using the data for both theory development and testing, as suggested by (Strauss & Cobin, 1994). Below we show the tables used to gather the results from the telephone interviews.

**Table 17: Evaluation table for barriers**

| | Score (1-4) | | | | | |
|---|---|---|---|---|---|---|
| **Barriers** | Co. 1 | Co. 2 | Co. 3 | Co. 4 | Co. 5 | Co. 6 |
| Economic barriers | | | | | | |
| Behavioral barriers | | | | | | |
| Organizational barriers | | | | | | |
| Barriers related to competences | | | | | | |
| Lack of awareness | | | | | | |
| Technology-related barriers | | | | | | |
| Information barriers | | | | | | |

**Table 18: Evaluation table for drivers**

| | Score (1-4) | | | | | |
|---|---|---|---|---|---|---|
| **Drivers** | Co. 1 | Co. 2 | Co. 3 | Co. 4 | Co. 5 | Co. 6 |
| Voluntary agreements | | | | | | |
| Efficiency due to legal restrictions (reg. and stds) | | | | | | |
| Green image | | | | | | |
| Long-term energy strategy | | | | | | |
| Willingness to compete | | | | | | |
| Management with real ambitions/comm. | | | | | | |
| Staff with real ambitions | | | | | | |
| Increasing energy tariffs | | | | | | |
| Cost reduction from lower energy use | | | | | | |
| Public investment subsidies | | | | | | |
| Private financing | | | | | | |
| Management support | | | | | | |
| Technical support | | | | | | |
| External energy audits/submetering | | | | | | |
| Programs of education and training | | | | | | |
| External cooperation | | | | | | |
| Awareness | | | | | | |
| Technological appeal | | | | | | |
| Knowledge of non-energy benefits | | | | | | |
| Availability of information | | | | | | |
| Clarity of information | | | | | | |
| Information about real costs | | | | | | |
| Trustworthiness of information | | | | | | |

## *6.4 Confirmation of the model*

During this phase a sample of 5 companies was selected: 1 large, 2 medium and 2 small. The diversity of the sample is mainly due to the fact that we want to explore the industrial landscape at 360 degrees to understand and analyze any differences. So, after a brief description of the companies and reporting the results of each interview, we will try to define what are the most important barriers and drivers for each of them.

### *6.4.1 Analyzed companies*

#### *6.4.1.1 ISEO Serrature s.p.a.*

| | |
|---|---|
| **Name** | ISEO Serrature s.p.a. |
| **Location** | Northern Italy, Lombardy, Pisogne (BS) |
| **Grade of the interviewee** | Chief operation officer (COO) |
| **Dimension (n° of employees in Italy)** | Large (300 and more) |
| **Annual turnover** | 65 million €/year |
| **Consumption of Energy (% on annual turnover)** | 600000€/year (0.92%) |
| **Existent Certification** | UNI EN ISO 9001 (quality)<br>UNI EN ISO 14001 (environment)<br>OHSAS 18001 (safety) |

ISEO Serrature s.p.a. is a large Italian company that was founded in 1969 by Giuseppe Facchinetti; it started producing locks, cylinders and padlocks in Pisogne on the Lake Iseo, from which it takes its name. In 1998 it was created the “Iseo Group”. The growth strategy focuses on two key elements: the size, because in a competitive market makes the difference and the human factor: it is the spirit of enterprise that creates, develops and brings to life a group. This opens up new perspectives to the international presence of Iseo through the offices of the Group operating in Europe, the Middle and Far East, Latin America and since 2009 in China.

The interview was conducted at the headquarters in Pisogne (BS) with the chief operation officer, graduated in electrical engineering and in the group from 12 years after an experience of 4 years in a steel mill where he was head of production.

The Italian factory has more than 300 employees and a turnover of 65 million € per year. The annual energy costs amount to about 600000 €/year thus having a ratio of 0.92% within the turnover. So this company can be classified as non energy intensive. Inside the factory there are all the usual divisions of a manufacturing company by the commercial, marketing to production and technical department. There is an array structure for the

management as the director of the Italian factory is also responsible for other sites also non-Italian. The production takes place on order and a few standard parts are kept in stock.

The company is certified according to the UNI EN ISO 9001, which is required to participate in tenders for public procurement of production. There are also two other certifications: an environment certification (UNI EN ISO 14001) and one concerning the safety (OHSAS 18001). These have been obtained as a result of decisions of senior management to ensure safety in the workplace and in the background for marketing strategies. Recently, the company began to look toward energy efficiency and the first divisions that will deal with the theme are starting to appear. The company's policy then tend to allocate funding to the issue and there is already an internal service that takes care of security and environment. It have been recently installed photovoltaic panels that generate a peak power of 170 kW and parallel to the production plants some systems have arisen to monitor the consumption of energy. In addition there is presence of sub metering as regards analysis of noise, temperature and brightness to ensure the correct functioning of the equipment and comfort of operators.

The company provides training courses for personnel raising their awareness on safety and on environmental issues. This courses are internally organized and structured according to various steps taking place during the period of stay in the company of the resources. ISEO also has a research and development center located in a separate branch away from the main unit in which they focus on product innovation. The process does not undergo specific changes but is closely monitored and supervised by the technical office. The policy of replacing machinery does not provide a predetermined criterion and is not based on the useful life. There are in fact some old machineries on which is made forecasted scheduled maintenance and a strict control over the production tolerances as well as the continued operations for their safety.

Replacement and control will be based on an approach targeted to production rather than consumption. Any investment that comes into the energy concept is evaluated through specific simulations on the impact it has on the cost of the final product. So there is a balance between productivity and energy efficiency investment that has not always been taken to choose the most efficient if not properly justified from the economic-productivity point of view.

*Analysis of the responses on decision making*

Step 1: Awareness

The contact person for the company highlighted the importance of information barriers, such as the main solution has been identified the availability of information as well as knowledge of non-energy benefits. In addition, the respondent pointed out that the quality of information is a prerequisite. Having thus mentioned indirectly the driver

trustworthiness of information. Moving on to the behavioral barriers are not considered as important drivers long term energy strategy or green image but rather for both management and staff the awareness is important. In fact, at this point in the interview the director has emphasized that it is necessary to transmit to personnel ethical values for their behavior to ensure that this step of decision-making functions to the fullest. The same considerations can be applied with regard to barriers related to awareness and the corresponding drivers (awareness and staff with real ambitions). In particular for the analyzed case, the green image is not a particularly important driver because the type of product means that the environmental image in not important for its business and therefore not recognized by customers. A strong stimulus with regard to the management for overcoming behavioral barriers is the increase in energy tariffs. Organizational barriers are not considered highly accidents on this step even make a contribution. In particular, in this case the only incentive for management may be the desire to compete, while on the staff weigh particularly personal ambitions.

Step 2: Needs and opportunity identification

At this stage of the decision-making chain, the Director highlighted the importance of data quality to the point that recently the company has installed devices (panels), which detect and store on time consumption. This makes us understand how lack of sub-metering can be a barrier to the extent that a company tries to find inefficiencies and trying to figure out where to intervene. With regard to this has been provided a high rating to driver such as technical support, external energy audits and external cooperation for behavioral barriers and those related to competences. The management support is not considered a key driver and this was explained by the fact that in the early stages of the decision flow is preferred not to have a support but act also from the inside for confidentiality. With regard to behavioral barriers, he has place no emphasis on cost reduction from lower energy use and voluntary agreements because the company does not consider energy-intensive and therefore the cost of energy does not affect much on the final product. Moreover the company prefer not to trade with any other actor in the chain, nor even with competitors. Finally, it was underlined how in this market there is no benchmarking to make a comparison with competitors, so that only the suppliers and trade associations are considered valid and reliable.

Step 3 : Technology identification

With regard to the technological barriers, which are the main with those related to information, it has been provided a low grade to the driver external cooperation. This is because this phase is kept internal to confidentiality and instead is made a comparison between the various technology providers evaluating various alternatives. When the company tries to evaluate proposals from various suppliers, it requires strong reliability of the information. If it deals with historical suppliers reliability of information is guaranteed,

and when new suppliers come into play, the company tries to visit their factories and analyze old projects to make themselves accountable for their actions and to understand their background. Are therefore very important drivers such as availability of information and knowledge of non-energy benefits. With regard to the latter, at this stage the knowledge of these benefits is used by the company to make a simulation to reach a compromise between efficiency and productivity of the investment. Based on the results will then make the final choice. The driver technological appeal is not considered absolutely relevant for the identification of technologies. As solutions to the barriers of information it is also pointed out the driver efficiency due legal restriction for both management and staff because the rules and regulations require to get the information needed to comply with them. It is not given importance to drivers as voluntary agreements, external cooperation or knowledge of non-energy benefits to overcome such barriers. The regulative driver is considered of primary importance to overcome barriers to behavior together with those of reliability information.

Step 4: Planning

At this stage, information, organizational and related to competences barriers are a real obstacle to both management and staff. According to our interlocutor it is very important to have clear information especially when investment in new technologies and practices for energy efficiency involve huge amounts of money. This phase also provides that the design team is involved from the plant manager to plan the job. In this regard, training courses are delivered according to the budget or if a request came from the staff.

Step 5: Financial analysis and financing

The main barriers were identified in the economic and those related to information. A minus point was given wings behavioral barriers. For monetary problems all drivers offered are important results in less than cost reduction from lower energy use that is not considered useful to overcome economic barriers. In particular, there has been made an example concerning the installation of solar panels that would not be successful if it were not for government subsidies. For information barriers, knowledge of non-energy benefits is not considered at all important in this decision-making step but rather are the details on the actual costs and their availability. The drivers related to information are classified with high scores to overcome behavioral barriers for which there are not considered instead drivers as green image and long term energy strategy. Even at this stage it is stressed the importance of the driver increased energy tariffs to overcome economic barriers and behavioral ones.

Step 6 : Installation start-up and training

For this last decision making phase it was confirmed the presence of organizational and relating to competences barriers. In particular for the first the respondent stressed the

importance of management stating that is fundamental to the sponsorship of the intervention. Are therefore important drivers such as management with real ambitions and commitment and clarity of information. With regard to skills instead emphasis was placed on drivers that affect the staff because then it will be the end-user of the investment. So the primary importance lies in drivers such as technical support and programs of education and training.

Analysis of internal nature of drivers

From the interview it was confirmed the nature of drivers that were analyzed. About voluntary agreements has not been given a definite answer. The only addition that was made is about the drivers management and staff with real ambitions. The respondent did not in fact excluded this drivers from being of regulatory nature in regard of rules of behavior. In particular, having a management with real ambition and commitment could bring in new standards that staff should follow.

Analysis of actors stimulating drivers

Wanting to verify our model in its entirety, we asked the manager to highlight the actors that stimulate drivers proposed. Many of his answers were in line with what was assumed in the model except for some aspects that we illustrate below. One difference is the driver management support that according to the interviewee may result from IAGs. This could be due to the fact that the company in question has close links with the trade associations and trusts them. It was pointed out that the technical support can also result from energy suppliers. Program of education and training could come indirectly from the government passing through the IAGs. For the driver external cooperation actors such as energy suppliers and manufactures appeared. Finally, regarding awareness, availability of information, clarity of information, information about real costs and trustworthiness of information, the contact person has explicitly said that *"when the government gives information, it only want to put obligations."*

*6.4.1.2 Italian Gasket s.p.a.*

| | |
|---|---|
| **Name** | Italian Gasket s.p.a. |
| **Location** | Northern Italy, Lombardy, Paratico (BS) |
| **Grade of the interviewee** | Plant manager, responsible for the maintenance, holder manager |
| **Dimension (n° of employees in Italy)** | Medium (110) |
| **Annual turnover** | 22 million €/year |
| **Consumption of Energy (% on annual turnover)** | 665000 €/year (3%) |
| **Existent Certification** | UNI EN ISO 9001 (quality)<br>UNI EN ISO/TS 16949 (quality)<br>UNI EN ISO 14001 (environment)<br>OHSAS 18001 (safety) |

Italian Gasket was founded in 1984 and obtained in Italy a turnover of 25 million € with 150 employees. It produces technical rubber items (nearly more than 500 mil-lion of pieces) for example: muffs, caps, fairleads, pipettes, little stoppers, frames, bellows, o-rings which are produced with different raw materials as elastomers, thermoplastics (TPE), bi-components and overprinted items. Moreover, linking together different technologies, assemblages can be realized, too. Since 2005 Italian Gasket is also present with proper production trading units in Slovakia (Bratislava) and in China (Shenzhen) to give a better service to the customers there located. A new settlement in North Romania is in phase of optimization. Italian Gasket supplies markets which need a high qualification: besides the main automotive sector it supplies also the pneumatic, household and medical sectors, etc. The company presents itself as energy intensive having an incidence of 3% of the energy costs on turnover.

The interview was conducted at the headquarters in Paratico (BS) with the plant manager graduated in aerospace engineering, the responsible of the maintenance and the holder.

The production is organized by departments, separating the presses, ovens, washing and areas of testing and checking. The production takes place in large numbers when a contract come in by the customer. Once the order is received, it is inserted in the database that generates a proposal for a production. After being confirmed is buying the rubber compound (raw material) that is weighed, checked in the laboratory and brought into production. In the press department the mold is prepared, heated and then the rubber is molding. Depending on the type of product the printout is deburred by hand or automatically and then sent to ovens, to treatment with nitrogen or both. Is then carried out a washing with sand and treated with chemical processes of Teflon, chrome-plating or

chlorination always depending on the type of piece. These treatments as well as any manual deburring are made by third parties outside. At the end on all the pieces is made a manual selection, tape, or automatic and a final quality testing before being packed and shipped.

The company has various certifications regarding the quality, environment and safety. Italian Gasket has as first aim the customer's satisfaction and to reach this target has arranged a quality system, certified according to the Automotive International Standard ISO/TS 16949. Their main customers are the German car manufacturers, large multinational companies who make quality audits and certify Italian Gasket for both the product and the process. As stated by the respondents, the two certifications related to environment and safety have been achieved in order to have a plus for customers, i.e. to increase the green image of the company in an international context.

Italian Gasket benefits from external consultants as Regesta Italy or Retaurus but does not use their services relating to energy efficiency. Studies that have been conducted revealed the opportunity to install a solar system but it was not considered appropriate by management. It have been showed that there is not an internal policy for allocating funds to address energy problems. Interview arose a problem with the sub metering in the production department. In this regard the responsible for the maintenance is trying to move toward these practices suggesting it to the management.

The company organizes internal training of staff in relation to safety, but nothing regarding awareness of energy issues. Research and development is not particularly articulate as the production includes thousands of pieces. They cannot be experts of each product and the innovation is carried out on the product and the process for each specific job. For each order is then evaluated the possibility of complete innovation. Lately have been made investments for the replacement of machinery such as a new compressor a new electrical press. Regarding the latter replacement is being made for relevant energy saving provided that the new machine. The complete electrical operation allows to save on the hydraulic circuit (80 liters of oil in less) and on the maintenance of the equipment (60% in less than preventive maintenance). In addition, the power consumption amounts to 7 kW against the old presses that consume from 20 up to 35 kW. However, asking the question about what criteria should be adopted for the substitution of machines the production manager said: *"For us, the age dictates law but the new generation of machines are driven by energy efficiency"*.

We also asked if in recent years they have made some investments in energy efficiency related to utility systems, and we were told that within the production department (where there are at least 34 presses working at about 200°) an air conditioning system of the latest generation with the heat exchanger to water was installed on the request of the

responsible for the maintenance. It proved to be very efficient in terms of performance and consumption.

*Analysis of the responses on decision making*

Step 1: Awareness

The contact person for the company highlighted the importance of information barriers, such as the main solution has been identified the availability of information as well as knowledge of non-energy benefits. Relating to information we have been told as magazines on the topic are non-existent and in few exhibitions fairs is said a few things about energy efficiency. It was also apparent that the do not know of any funding or financial support for these types of investments that could increase the awareness on this issue. The behavior and organizational barriers were evaluated with a lower score. The main drivers to overcome them have been recognized in a team with real ambition growth of awareness and green image in the market. In addition, the respondents argue that a long-term energy strategy is one of the main solutions to these problems as an alignment of all company positions is crucial. A boost to the competition it has not been classified as an important factor for this level of problems. Finally, it was confirmed the importance of the problems of awareness and the strength of their drivers. Regard to this the holder said that: *"With regard to this step, it is hard to think on these problems when taken from the daily routine".*

Step 2: Needs and opportunity identification

At this stage they have confirmed the existence of barriers related to competences and awareness, arguing that they have a very significant importance for both management and staff. For barriers related to competences, the respondents stressed the importance of technical support and management support arising from IAGs. It has also highlighted the importance of program of education and training, that we have not covered, both for management and staff and to a lesser extent the possibility of using external energy audits. External cooperation with competitors and suppliers prove to be of little interest in this phase, as explicitly stated by the respondents: *"It is difficult at this stage that skills come from outside."* For barriers related to awareness, the same holds true for external cooperation, while they have shown that drivers such as management and staff with real ambitions are the drive motor, as showed by the responsible for the maintenance. Finally, respondents did not give much importance to behavioral barriers, while not neglecting their existence they have been given a low score of 2 out of 4.

Step 3: Technology identification

In this phase technological problems are the main ones. Interview drivers that turn out to be stronger the availability of information and knowledge of other benefits in addition to

energy. External cooperation and technological appeal are not considered significant. Regarding the problems of information, therefore, the legal restrictions are added as an important factor in addition to the driver already cited previously. It was emphasized at this point the importance of the reliability of the source and the plant manager said: *"We will not take anything to closed package."* If it deals with historical suppliers reliability of information is guaranteed, and when new suppliers come into play, the company tries to visit their factories and analyze old projects to make themselves accountable for their actions and to understand their background. The same drivers have an impact on both the management on staff. Compared to the proposed model another time behavioral barriers are not recognized as particularly important to this step decision-making.

Step 4: Planning

In the fourth stage of action planning, respondents gave little value to information barriers (score of 2 out of 4), arguing that it is difficult to have problems of this nature once you get to this step, especially because *"suppliers must provide all in the package."* The organizational problems were deemed important enough (with a score of 3 out of 4) showing that, in line with the drivers that we have proposed, obligations from the government and management with real ambitions represent strong incentives to overcome these barriers. Finally, barriers related to competences proved to be very important for both management and staff, confirming the proposed drivers such as technical support, management support and especially programs of education and training. However, it should be noted that, as repeatedly stressed by the plant manager, the staff in the company is very competent, ambitious and in line with management's objectives.

Step 5: Financial analysis and financing

The main barriers identified in this step of the decision-making are the economic and informative ones. With regard to the first, all proposed drivers have obtained a score between 3 and 4 (on a scale from 1 to 4). The only driver not considered important is Increasing in energy tariffs. It was underlined again the importance of driver related to information like knowledge of non-energy benefits, availability of information and information about real costs. These are considered important both to overcome economic barriers as informative. Despite having confirmed their presence, has not been confirmed a great importance of behavioral barriers (score 2 out of 4), justifying the fact by saying that once you get to this decision point should no longer occur such problems. This probably reflects possibly dynamics of the company such that it is considered that once reached this stage of an investment a certain type of problem does not exist. In fact, shortly after the holder interviewed said that at this point it is possible that it is not even made a careful and stringent financial analysis to reduce the deadlines. This is made because: *"you strongly believes in the investing that you are taking".*

Step 6: Installation start-up and training

For this last decision making phase, it was confirmed the presence of organizational and relating to competences barriers. In particular for the first, the respondents stressed the importance of management stating that it is fundamental for the sponsorship of the intervention. Are therefore important drivers such as management with real ambitions and commitment and clarity of information. With regard to skills instead emphasis was placed on drivers that affect the staff because then it will be the end-user of the investment. So the primary importance lies in drivers such as technical support and programs of education and training.

Analysis of internal nature of drivers

From the interview it was confirmed the nature of drivers analyzed. However there was some exception to what is contained in the model. In particular, three differences have emerged. Firstly, management and staff with real ambitions are not excluded from being of regulatory nature in regard of rules of behavior. In particular, having a management with real ambition and commitment could bring in new standards that staff should follow. Secondly, the driver increased energy tariffs was identified informative in nature rather than economic. This is probably because it was perceived as an information driver and the money such an effect that has been seen as a result of the availability of these information. Finally, green image has been classified under regulatory nature but having also nuances of information character.

*Analysis of actors stimulating drivers*

In the final part of the interview, we asked what are the actors that stimulate the drivers proposed. In general, the responses were in line with our model, pointing out, however, some differences that are the result of their corporate culture. In fact, it was found that the two most important players are the government and the company itself, since only they truly believe in the potential of energy efficiency projects. Of great importance, although a bit less than the previous actors, are also the local industrial unions who know the local situation and the territory. This applies in general, but especially for drivers related to information. Another aspect that has come to light is the fact that the company does not consider as a reliable channel that related to energy suppliers because, according to them, there would be a conflict of interest. This is true to a lesser extent also for technology suppliers. Technical support, management, programs of education and training and external cooperation are welcome if they are organized and conducted by IAGs, but it was also highlighted how is important a contribution by universities, as stated by the holder: *"Universities do a free and real research."* The company said they knew ESCOs, even if they do not consider them as reliable authorities for the same reasoning seen before about energy and technologies suppliers. Finally, it was confirmed during the interview how the

company is in a good position in the market that does not need to compare itself with concurrent or deal with allies. In fact, as mentioned previously, the company enjoys a great prestige abroad and is an important supplier for big German car manufacturers.

*6.4.1.3 Scaccabarozzi Isidoro s.n.c.*

| | |
|---|---|
| **Name** | Scaccabarozzi Isidoro s.n.c. |
| **Location** | Northern Italy, Lombardy, Olginate (LC) |
| **Grade of the interviewee** | Holder |
| **Dimension (n° of employees in Italy)** | Small (4) |
| **Annual turnover** | 600000 €/year |
| **Consumption of Energy (% on annual turnover)** | 30000 €/year (5%) |
| **Existent Certification** | None |

The Scaccabarozzi Isidoro s.n.c. is a company that has its roots in the history of Italy of the 50s in full economic, industrial and cultural development. The founder Isidoro has transmitted to the son Franchino creativity and talent, following the same values with great commitment and vehemence, to provide solutions and cutting edge skills, able to advise, support and materialize the needs of customers. The company is a small manufacturing company that operates in the field of precision mechanical machining. The fleet of machines covers a production area of 1200 square meters, is made up of machine tools (CNC lathes) with great versatility, and allows to provide customers with different types of machining by removal of swarf. The machining is always on the customer's specifications and the production varies from small to medium quantities of parts. The production takes place on order and the department is organized as a job shop in a single building. Energy costs cover a share of 5% of sales so we can classify them as energy intensive. The interview was conducted at the headquarters in Olginate (LC) with the holder who is a mechanical expert.

The company does not have any type of certification regarding to the quality or regarding to other issues such as safety or the environment. The fact of not being certified has been explained saying that it is no important for the market in which they operate. No one inside the company is in charge of energy issues and there is not an awareness of the topic. The change of equipments is not designed with the aim of making energy efficiency but rather with the objective of increasing productivity and precision of the machine. The criteria for a change are then determined according to the obsolescence of the machines. Also sometimes do not take place a replacement of machinery but it is tried to intervene with the replacement of small parts, such as the motor or the inverter, aiming at improving the performance.

Training courses for personnel are organized by external bodies and are used to update the operators only about the proper use of the equipment. The Scaccabarozzi Isidoro is part of Confartigianato that provides basic information and not specific ones to the business. In departments there is no any type of sub metering and it has not been implemented any investment in energy efficiency nor for plants nor for auxiliary services or for way to work.

*Analysis of the responses on decision making*

Step 1: Awareness

For this first step the proposed barriers were confirmed by the interviewed and they all received high scores. Organizational barriers are not specific to this reality in which the owner combines all the functions of the decision-making process and does not take advantage of any employee. With regard to the problems of information knowledge of non-energy benefits and the availability of information received high scores. It was also stressed the importance that the information is reliable. For behavioral problems as well as those of awareness, the green image is not a strong driver for the respondent who has assigned to it the minimum score. It is not considered particularly important for the barriers of behavior also the improved competition. Drivers that have been identified to overcome these problems are: increasing energy tariffs and awareness both estimated with the maximum score, although the respondent does not show much inclination to the theme by stating that: *"If a machine consumes a lot but allow to make more money, that's fine".*

Step 2: Needs and opportunity identification

In this step barriers related to competences and awareness are considered particularly important. The main drivers to solve these problems are respectively technical and management support and management with real ambition. The availability of external energy audit and external cooperation for both barriers are not considered important. This latter aspect was justified by the fact that there is not a cooperation with the industry as it is too large the sample and in this time the competition is the host. It was also confirmed the existence of behavioral problems recognizing as key solutions: management with real ambition, management support and cost reduction from lower energy use. Once again, external energy audit are not considered influential and even fewer voluntary agreements.

Step 3: Technology identification

For the third step, technological barriers and those related to information were assessed most important. With regard to the first, major drivers recognized were the availability of information, knowledge of non-energy benefits and the technological appeal. This last aspect is in this case more than the aesthetics of the machine but rather is related to systems it may have to keep it clean and tidy for showing it "good" within the department.

Also in this step external cooperation is not considered important. Turning to the problems of information all drivers proposed have been recognized as important except voluntary agreements and the external cooperation. Particular emphasis has been placed on the trustworthiness of information considered particularly important at this point. The respondent has shown little confidence in those who provide information for personal profit and say that: *"You must not trust people who want to sell you a machine at all costs, only 20% of what they say is reliable".* Possible behavior problems were also recognized even if they are considered not to be particularly important, and the interviewee gave it a low score (2 out of 4).

Step 4: Planning

In the planning phase, the respondent argued that problems related to information, organizational issues and problems related to the company's own skills exist and vary according to the context and company size. With reference to this reality of small company and with a small staff, he argued that these problems are not very present in his company, providing thereby a value of importance of 2 out of 4.

Step 5: Financial analysis and financing

Even the financial analysis is of course carried out only by the owner. He identifies as the most important barriers the economics ones and even their drivers were considered useful to overcome them. The only one that has received a low score (less than 3) is information about real cost that is not considered particularly important at this stage to overcome economic problems but rather for those of information. In fact, information barriers are also considered important as well as drivers that provide information, knowledge of non-energy benefits and real costs. Once again the barriers of behavior have been identified as real but it was given a low importance by stating that in this little reality when you decide to make an investment, it is completed very quickly and therefore at this point there are no fundamental barriers like these ones.

Step 6: Installation, start-up and training

In this step, organizational barriers and those related to competences were considered very important, yielding a value of 4 out of 4. The solutions to these problems have been greatly appreciated, namely: management with real ambitions and clarity of information for organizational barriers, technical support and program of education and training for the barriers related to competences. Unlike previous 5 steps, in the last stage of installation, start-up and training it was made a clear distinction between management and staff just because, at this stage, the staff becomes more involved and start getting familiar with new equipments. In this case, the owner of the company said that the staff does not create particular problems at the organizational level, while it becomes important with regard to

the problems related to skills. In fact, for the respondent is important that suppliers and installers place alongside staff to provide information and advice for a correct and optimal use of facilities. Finally, it was emphasized that it is important to do updating courses outside, but every company has to arrange courses within because *"those who work on the equipment shall know everything."*

*Analysis of internal nature of drivers*

The respondent did not show major differences compared to that proposed by our model and the nature of the drivers was confirmed in its full.

*Analysis of actors stimulating drivers*

For the verification of the actors that should stimulate drivers proposed, there were no problems, confirming our hypothesis. However, there were some considerations that may arise from the fact that the company operates in a small and non-international context. For example, the government, whether central or local, is not considered up to understand what are the real business problems of these local entities, and the energy suppliers do not give any benefits "because there is a strong conflict of interest." Instead, manufacturers, technology suppliers and installers are considered the most important players especially because they are already classified by the company, being historical and having already made several deals with them in the past. ESCOs were not known by the respondent, but once explained who they are, how they work and what they do, they have been deemed as possible actors that can provide important assistance.

#### *6.4.1.4 SO.PET. s.r.l.*

| | |
|---|---|
| **Name** | SO.PET. s.r.l. |
| **Location** | Southern Italy, Sicily, Geraci Siculo (PA) |
| **Grade of the interviewee** | Holder |
| **Dimension (n° of employees in Italy)** | Small (6) |
| **Annual turnover** | 1800000 €/year |
| **Consumption of Energy (% on annual turnover)** | 160000 €/year (9%) |
| **Existent Certification** | None |

The company SO.PET. SRL, located in Geraci Siculo (PA), operates since 1995 in the field of blow molding of PET preforms (polyethylene-terephthalate) of any weight and size, for the realization of containers for oil, wine, water and drinks. Currently it occupies 6 employees, and it has recently moved into a new industrial building with two floors for a total of 1600 square meters. The company aims to meet the needs of containers in pet in the Sicilian and Calabrian market, and has optimized resources and production time by offering competitive

products, which have gained market share increasingly significant. The production areas have highly skilled technicians, are robotized and employ computerized production lines, maintaining the highest standards of quality.

Regarding the production process, the company buys the PET preforms, which are then heated with ovens and blown with air at 30 bar with blowing machines. The production takes place on order. Energy costs cover a share of 9% of sales, so we can classify it as an energy intensive company. The interview was conducted by telephone with the company owner who is an engineer.

The company does not have certifications regarding the quality, nor even for the safety and environment, but they are working to acquire the ISO 9001. No one inside the company is in charge of energy issues but there is awareness of the topic by the holder that wants to move in that direction. In fact, he has tried to install solar panels, even if they have proved not sufficient to meet the power required due to the fact that the available surface is not large enough. The change of equipments is not designed with the aim of making energy efficiency but rather with the aim of increasing productivity, also because, as pointed out by the owner, *"everything goes by itself: any new system nowadays is designed to consume little energy."* The criteria for a change are then determined according to the obsolescence of the machineries.

Training courses for personnel are organized by external bodies and are used to update the operators only about the theme of safety. The SO.PET. SRL is part of Confindustria Sicilia that provides basic information. In departments there is no any type of sub metering and it has not been implemented any investment in energy efficiency nor for plant, nor for auxiliary services or for way to work.

*Analysis of the responses on decision making*

Step 1: Awareness

For the first step, the proposed barriers were confirmed by the interviewed. Organizational barriers are not specific to this reality in which the owner combines all the functions of the decision-making process and does not take advantage of any employee. With regard to the problems of information, knowledge of non-energy benefits and the availability of information received high scores. It was also stressed the importance that the information is reliable. For behavioral problems as well as those of awareness, the green image is a strong driver for the respondent who has assigned to it the maximum score. It is not considered particularly important for behavioral barriers the driver long-term energy strategy. Drivers identified to overcome these problems are: increasing energy tariffs, willingness to compete and awareness.

Step 2: Needs and opportunity identification

In this step barriers related to competences and awareness are considered particularly important. The main drivers to solve these problems are: technical support, management support and external cooperation for barriers related to competences (because, as pointed out by the holder, *"we are not so equipped from this point of view"*); management with real ambition and external cooperation for the barrier awareness. External energy audit are not considered so important, because they do not know someone who is really competent to perform certain assessments. It was also confirmed the existence of behavioral problems recognizing as key solutions: management with real ambition, management support, awareness and cost reduction from lower energy use. Once again, external energy audit are not considered influential and even fewer voluntary agreements.

Step 3: Technology identification

For this step, technological barriers and those related to information were assessed as the most important. With regard to the first, major drivers recognized were the availability of information, knowledge of non-energy benefits and external cooperation. Little importance was given to technological appeal. Turning to the problems of information all drivers proposed have been recognized as important, except voluntary agreements. Particular emphasis has been placed on the trustworthiness of information considered particularly important at this point, as stated by the holder: *"At this point it is necessary to deal with people who are serious and reliable."* Possible behavior problems were also recognized even if they are considered not to be particularly important in this phase.

Step 4: Planning

In the planning phase, the respondent argued that problems related to information, organizational issues and problems related to the company's own skills exist and vary according to the context and company size. With reference to this reality of small company and with a small staff, he argued that these problems are not very present in his company, providing thereby a value of importance of 2 out of 4. These considerations are in line with the statement made by the company Scaccabarozzi Isidoro s.n.c.

Step 5: Financial analysis and financing

The financial analysis is carried out only by the interviewed. He identifies as the most important barriers the economics ones and even their drivers were considered useful to overcome them. The only one that has received a low score is information about real cost that is considered important only for problems related to information. In fact, information barriers are also considered important as well as drivers such as availability of information, knowledge of non-energy benefits and information about real costs. Once again, behavioral

barriers have been identified as real but it was given to them a low importance (score of 2 out of 4) stating that: *"When I decide to make an investment, I carry it to completion in the shortest possible time."*

Step 6: Installation, start-up and training

In this step, organizational barriers and those related to competences were considered very important. The same applies to the drivers affecting these problems: management with real ambitions and clarity of information for organizational barriers, technical support and program of education and training for the barriers related to competences. Also in this interview and unlike previous 5 steps, in the phase of installation, start-up and training it was made a clear distinction between management and staff. This is due to the fact that, at this stage, the staff becomes more involved with new equipments. As stated by the interviewed, the staff does not create particular problems at the organizational level, while it becomes important with regard to the problems related to competences.

*Analysis of internal nature of drivers*

The respondent has not detached at all by our hypotheses and the nature of the drivers was confirmed in its full.

*Analysis of actors stimulating drivers*

The interviewee has highlighted the same actors proposed by us for the stimulation of the drivers. However, some considerations were made about some of the actors: these considerations are the result of the company past experience and could relate to the context in which it operates. For example, the government, can be considered a very important actor to stimulate many drivers even though *"up to now it has not done anything"*, and the energy suppliers do not give any benefits *"because there is a strong conflict of interest."* Instead, manufacturers, technology suppliers and installers are considered the most important players, especially the historical ones with whom they have made a number of business in the past. ESCOs were not known by the respondent, but once explained who they are, they have been deemed as possible actors that can provide important assistance. Finally, it emerged from the conversation that the holder has full confidence in IAGs because *"people who work in are very familiar with the reality faced by businesses today"*, as stated by him.

*6.4.1.5 Ernesto Malvestiti s.p.a.*

| | |
|---|---|
| **Name** | Ernesto Malvestiti s.p.a. |
| **Location** | Northern Italy, Lombardy, Muggiò (MI) |
| **Grade of the interviewee** | Maintenance responsible |
| **Dimension (n° of employees in Italy)** | Medium (240) |
| **Annual turnover** | 57 million €/year |
| **Consumption of Energy (% on annual turnover)** | 1610087€/year (2.82%) |
| **Existent Certification** | UNI EN ISO 9001 (quality)<br>UNI EN ISO/TS 16949 (quality)<br>UNI EN ISO 14001 (environment) |

Since its foundation in 1945, E. Malvestiti s.p.a. has been a world leader in the high precision die-making industry or blanking and in the production of blanked pieces. The company has two locations, one in Cinisello Balsamo and another in Muggiò. In the first, it is present the head office and the designing and making of dies (carbide steel dies for magnetic laminations, dies for fine blanking, progressive dies). The second instead is the production site of blanked parts: traditional progressive and transfer blanking, fine blanking, blanking of magnetic laminations. In addition, it can supply finished parts after deburring, surface heat treatment, co-molding and assembly. The interview was conducted at the site of Muggiò with the technical manager of maintenance.

In the Muggiò site, the production takes place on order and is organized by departments with work centers or mini-lines consisting of two or three machines. Everything is included in the two sheds: in one there are presses and automated work centers and in the second we find the warehouse, a logistics center, a department of special presses and the control of the quality by hand piece by piece. After a short tour of the plant, it was able to observe how the departments were clean and tidy, showing great professionalism in the work. There is not a department concerning the research and development of the product, but in small part there is an interest with regard to the improvement of the construction process of the molds. Within the production area there is no framework for sub-metering, and there are not future plans for their installation.

E. Malvestiti uses quality system certified in compliance with ISO 9001 and ISO/TS 16949 requirements. This latter certification relates to the automotive industry and covers the principal European and American standards. The heart of the quality system is a highly efficient “quality control” organization which, in order to guarantee the products, has advanced and modern instrumentations. There is also the ISO 14001 environmental certification that the company has decided to get for internal reasons and, apparently, also for the image. In addition, there are plans to acquire OHSAS 18001 safety certification

because Ernesto Malvestiti believes that their added value is the staff, and therefore it is necessary to ensure optimal working conditions for employees. These certifications are also necessary for some customers, especially foreigners customers who are very sensitive to certain issues, such as the quality and the environment.

With regard to energy efficiency, the company has not an internal division that deals with the topic, but relies on external consultants and engineering studies. The Malvestiti s.p.a. is associated with Confapi but the information they receive are not particularly useful, and the association is not very related to operational efficiency. The only help that has been emphasized by the IAG is a strong support in 2000 when the company entered in the consortium of free market for electricity, which was then gradually abandoned by purchasing power independently. The staff receives training on safety and awareness on environmental issues, in particular the latter aspect is addressed with regard to the disposal and recycling of industrial waste.

The replacement of machines is mainly based on two fundamental criteria that are: technology development and age. The replacement is then dictated by innovation and time, and in the production departments old machinery are still present. Lately, they have been replaced many compressor motors favoring those with high energy efficiency, but the respondent admitted that he was not a project for efficiency but rather it was a chance. Regarding other possible investments in energy efficiency, lighting designs and a new air conditioning system have been developed. In fact, by the need to maintain an adequate temperature technique in the production department, an air conditioning system designed to be as efficient as possible has been installed. It is also planned for next year to make a total coverage of the perimeter walls with a coat to bring the building to an A energy class. For the same building, it is also planned to cover the roof with solar panels for the production of electricity. On an experimental basis in the plant of Muggiò, LED lamps were inserted and they are testing their effects and benefits to complete the project in the other shed.

*Analysis of the responses on decision making*

Step 1: Awareness

The person interviewed recognized the importance of information and awareness barriers and the drivers proposed to overcome them have been confirmed. The increase in energy prices was also highlighted as one of the strongest drivers because the company is often very careful to reduce fuel consumption, as well as willingness to compete in a market that is seeing the entry of competitors threatening, such as China. The fact that efficiency can make to improve the position in the market is therefore seen as one of the key points for

awareness. The lowest score (2 out of 4) was attributed to organizational barriers deemed unimportant to the capture of awareness on energy efficiency, but recognized however present. In this step, it was recognized the presence of the management, but no attention has been paid to the staff.

Step 2: Needs and opportunity identification

In this phase, the main barriers are behavioral and those related to awareness. If for the latter class all drivers proposed have been recognized as important, for the first one voluntary agreements and management support have obtained a low grade. This latter driver in particular has not been recognized as very important as the interviewee said that management finds support from a comparison with the staff and therefore remains an internal matter. Since the latter can be seen as a staff with real ambition and awareness of staff, all these drivers are equally important to overcome these problems. A less vote was provided to barriers relating to competences considered however important. Best drivers have been identified in external energy audit and external cooperation: in fact, during the interview it was noted that for Malvestiti there is a strong cooperation with their customers. The management and technical support are also considered as candidates drivers and in particular the latter could act on the skills of the staff to a greater extent than the external cooperation. Finally, the maintenance manager has revealed that they benefit from external audit that are often related to technical support and have the appropriate competences in this field, stating: *"it is necessary that there is someone who is knowledgeable".*

Step 3: Technology identification

Technology-related and information barriers were recognized the main barriers. The drivers that have obtained a higher score to overcome the first are availability of information and knowledge of non energy benefits, while there is one point less for external cooperation and a very low score for technological appeal. Also with regard to problems of information, it was attributed the maximum score to availability of information and trustworthiness of information. In addition in order to have their historic suppliers, the company carries out internal audits to new sources using a variety of methods from media to online research. Behavioral barriers have received a score of 2 out of 4 as the interviewee said that they could occur but it is usually found a compromise inside for the problem solution. When asking about the division between staff and management we were told that: *"The staff proposes and the management decides",* thus highlighting the contribution of staff in the overcoming of barriers.

Step 4: Planning

The main barriers identified are those relating to the powers and all the drivers were recognized as important. The only difference was made between programs of education and training and management or technical support because, in this last case, there are more benefits than a theoretical training course. A vote less has been attributed to organizational barriers that are not considered a priority issue. Nevertheless high scores were given to its relative drivers. Information barriers received a low score (2 out of 4) because not considered important in this phase but rather in those initial.

Step 5: Financial analysis and financing

Information barriers have not been recognized as particularly important as they have little weight on the financial analysis and everything should now be known. Obviously, economic barriers are fundamental, and every proposed driver has received the maximum score, except availability of information and knowledge of non-energy benefits that received 3 out of 4. Nevertheless the respondent has admitted that this is not a problem for them and they have never benefited from funds. Behavioral barriers have received a score of 3 out of 4, and the most important drivers are those related to information and willingness to compete.

Step 6: Installation start-up and training

For this last step, it was confirmed the presence of organizational and competences-related barriers. In particular for the first one the respondents stressed the importance of management, fundamental to the sponsorship of the intervention. Then, drivers such as management with real ambitions and commitment and clarity of information are of particular importance. With regard to skills instead, emphasis was placed on drivers that affect the staff because then it will be the end-user of the investment. So the primary importance lies in drivers such as technical support and programs of education and training, in which another time the latter is considered less important than the first because of its theoretical character.

*Analysis of internal nature of drivers*

The respondent did not show differences from our model and the nature of the drivers was confirmed in its full.

*Analysis of actors stimulating drivers*

In the final part of the interview, we asked what are the actors that stimulate the drivers proposed. In general, the responses were in line with our model, pointing out, however, some differences that are the result of their corporate culture. For drivers related to information the main actors have been recognized in technology providers. Immediately following, trade associations and consultants were recognized as very important. Another important aspect is the fact that the company considers as a reliable channel that related to energy suppliers. In fact, the firms is developing a relationship with a supplier of electricity to carry on the project of replacing lamps and switch to LED lighting. With regard to competitors or allies, it was not given an opinion because they are leaders in their field, and Italians and Europeans competitors are few. Technical support, management and programs of education and training are welcome if they are organized and conducted by IAGs, showing a mistrust towards ESCOs.

### *6.4.2 What change for the proposed model?*

The proposed model was confirmed by the companies interviewed. As noted above, the difference in the decision making process proposed is evident depending on the firm's size. In the case of medium and large enterprises, the logical chain was confirmed in every case and we can feel it appropriate for analysis. For small companies, the subdivision does not exist but the model proposed was presented to have an opinion and was validated. Then, barriers and drivers were confirmed, and the only deficiency, stressed by all the respondents, is the presence of the driver trustworthiness of information to overcome the information barriers. Initially, this driver was not included because we thought that the availability of information was more important than reliability in the first step. During the interviews it was stressed that often information exist but they are not taken into account because there is not a trust in the source of them. This fact sheds light that it is necessary to have reliable information because they are considered valuable to raise awareness on the energy efficiency issue. One of the major difficulties encountered in the process of the interview was to enforce the division between management and staff. Often the discourse collapsed in general and the threat was to lost this distinction; so, stressing this point, some interesting considerations were found. Starting with the first step of decision-making, it is noted as the distinction is less clear for the awareness. In fact, some companies have assigned scores both for management and staff, while others, such as the Malvestiti s.p.a., have said that the awareness can derive only from management. Our opinion is similar to the last because we believe that if the knowledge is not first of all rooted in the highest levels, the company can never be embarked on a path towards energy efficiency. About the research of needs and inefficiencies, instead, the staff seems to acquire more importance being able to support the management. This aspect was confirmed by Italian Gasket s.p.a. in which the maintainer was the promoter of relevant investments. The same applies to the

following step, technology identification, for which the respondent of Malvestiti s.p.a. stated that: "*The staff proposes and then the management decides."* For the planning of the intervention, the management has the leading role and the staff is asked to obtain information to have an overall view widest as possible of the problem. Reached the fifth step, financial analysis and financing, all respondents said that only the management has an important role while the staff do not have any kind of influence. With regard to the installation and start-up, every company interviewed showed that there are two different roles for management and staff: the management has to solve organizational problems while the staff has to deal with technical skills. From this point of view the difference between small and medium-large enterprises lies in the fact that the collaboration and the correlation between the two roles seems to take greater place in a hierarchical structure rather than in a small company where all decision-making powers are in the hands of one person. In this regard, the referent of the SO.PET. s.r.l. has said: *"I take decisions and staff must follow to the letter what I say*".

In conclusion, the initial model was revised adding the driver trustworthiness of information in the first step of decision-making and maintaining the division between management and staff only in steps 2,3,4 and 6.

# Chapter 7

# Main findings

In the first part of this section, we will show the results from personal interviews conducted to confirm our own model, and then the results from phone interview for the evaluation of drivers perceived by enterprises.

## *7.1 Results from personal interviews*

Interesting results can be drawn for every firm interviewed. The results are particularly interesting given the long duration of the interview in which it was possible to ask for opinions and insights on targeted topics. Furthermore, in some cases, it was possible to visit the production department, realizing the current state of the firms and the way they operate.

*ISEO Serrature s.p.a.*

After the analysis of the results obtained from the interview, it can be seen as the drivers that are very important for the company are: efficiency two to legal restrictions, awareness, availability and clarity of information and trustworthiness and management and staff with real ambitions. Moreover, problems of economic nature have not arisen. The barriers for energy efficiency in overall do not seem to be a monetary problem for this firm having a strong market position and so not addressing these difficulties. Rather, it was repeatedly emphasized the importance of a corporate culture that leads to the theme of ambition and awareness to employees. Finally, it is emerged that the company moved in the last period to a road that leads to energy external audits. However, managerial support also via consultants is not considered as an important factor preferring to act internally. Instead, it is seen as a key factor the collaboration with suppliers of energy or technology and thereby the driver technical support. It is interesting to note that ESCOs are not considered as actors for the stimulation of drivers. This is probably due to the fact that there is no complete trust in these companies, not considered useful to achieve energy efficiency.

*Italian Gasket s.p.a.*

Analysis of the data obtained from the interview shows that the most critical drivers for this firm are: public investment subsidies, private financing, management with real ambitions and all related to information. With regard to the economic aspect, the company has a strong market position but having never made investments in energy efficiency the economic aspect could help a lot to move in this direction. In fact, it was highlighted that a lack of information about these funding programs exists in the early part of the decision making. The staff seems to be motivated: in fact, the head of maintenance showed his enthusiasm and willingness to propose new amendments. During the interview we noted that energy prices are almost comparable to the cost of the staff and how the old machines consume disproportionately compared to new equipment on the market. With regard to the safety and cleanliness instead there is a commitment involving the whole company. During a short trip in the production department, we noted in fact many signs of warnings on the machineries and an environment clean and comfortable. Each worker is responsible for his machine and the adjacent area, and after each operation that produces wastes the same are cleaned up immediately.

*Scaccabarozzi Isidoro s.n.c*.

After the interview with the owner of Scaccabarozzi Isidoro, it was found that the most important drivers are: awareness, public investments subsidies, and management with real ambitions and commitment. The awareness is the most important since there has been a very low sensitivity to the issue. The awareness can move their consciousness through an interest that, if not totally, at least in part is necessary to make small interventions regarding energy efficiency. Furthermore, in addition to the economic problem that could be overcome with public subsidies, in this small business it is essential an ambitious management. This is a crucial point since all decisions are made by a single person and the staff does not have any kind of influence with regard to any type of investment. It is important to note that organizational barriers were not recognized during this interview as a small business like this does not address this type of problems as the decision maker is unique. We cannot therefore manifest barriers such as divergent interests, complex decision chain or low status of energy efficiency due to lack of power. In addition, drivers are applied primarily to managers, and staff can be influential only in the last step of decision-making which deal with installation, start-up and training. From these final considerations it can be seen as the interview then undergo a special adaptation when facing small businesses.

*SO.PET. s.r.l.*

After the interview with the owner of SO.PET. s.r.l., it was found that the most important drivers are: awareness, drivers of information, public investments subsidies, private

financing and management with real ambitions and commitment. The awareness and drivers of informative nature are necessary to make interventions regarding energy efficiency. Furthermore, public subsidies and private financing represent a tool to accomplish the investment and are essential for small businesses. An ambitious management is essential, but it must be remembered that in small enterprises all decisions are made by a single person and the staff does not have any kind of influence with regard to any type of investment. For this reason, organizational barriers were not recognized so important during this interview, as found also in the interview made to Scaccabarozzi Isidoro enterprise. In fact, barriers such as divergent interest, complex decision chain or low status of energy efficiency due to lack of power, do not occur in these cases. Finally, drivers are applied primarily to managers and staff can be influential only in the last step of decision-making.

*Ernesto Malvestiti s.p.a.*

The drivers that certainly can have a great impact on Malvestiti s.p.a. are: increasing energy tariffs, efficiency due to legal restriction and management with real ambition and commitment. The problem of funds is not important, given their strong market position and due to the fact that the energy issue is entering into the corporate culture. A strong push towards energy efficiency could come from the increase in energy tariffs since, as it has been confirmed, they are very careful in reducing consumption. The theme of energy remains in the background, but core business remains the primary objective for investing.

## *7.2 Results from phone interviews*

Below we show the results from phone interviews focusing first on the total sample and then on the various clusters. In particular, subdivisions relate to: medium-small enterprises (MSEs) and medium-large enterprises (MLEs), energy intensive companies (EI) and non-energy intensive companies (NEI), and companies of Brescia (BS) and companies not located in Brescia (No BS). In each section, we will emphasize the most important barriers and drivers, making a comparison with the results reported in the literature, and then we will analyze the correlations between the barriers and the correlations between the drivers. In the latter case, the correlations that are greater than 0.7 will be highlighted in red while those between 0.60 and 0.69 in yellow (we have chosen these numerical thresholds because of the complexity of the phenomenon and the high uncertainty). At the end of each section the results on decision making are finally presented, highlighting what are the main drivers, what is their effect on the barriers, what are the actors that can stimulate these forces and in which way they can act.

### *7.2.1 Analysis of the total sample*

#### *7.2.1.1 Analysis of barriers*

In table 19, we have ranked the barriers according to their average score, presenting several interesting results.

**Table 19: Perceived barriers - Total sample (61)**

| Barriers rank | | Average score |
|---|---|---|
| **1** | Economic | 3,20 |
| **2** | Behavioral | 2,60 |
| **3** | Lack of awareness | 2,57 |
| **4** | Related to competences | 2,42 |
| **5** | Information | 2,35 |
| **6** | Organizational | 2,30 |
| **7** | Technology-related | 2,27 |

The overall results from the questionnaire show that economic barriers constitute by far the largest barriers to energy efficiency, confirming the findings of (Rohdin et al., 2007) and (Thollander & Ottosson, 2008). In second place we found behavioral barriers suggesting that other priorities or lack of interest in relation to the theme of energy problems are particularly felt by companies. This aspect is further supported by the fact that in the third position we find lack of awareness, with an average score of 2.57, leading companies to neglect the issue of energy efficiency. In fourth place we find the barriers related to competences, with an average score of 2.42, and the reason could be due to the fact that we are asking for perceived barriers. Given the nature of the companies explored, it seems reasonable that organizational barriers are classified as very low (average score of 2.30). In fact, they are not particularly structured organizations and often one person holds many roles, reducing thereby the probability of encountering these types of problems, as confirmed by the study of (A. Trianni & Cagno, 2012). In addition, information and technology-related barriers are perceived to be low due to the fact that we are exploring barriers grouped in macro-areas, and firms have responded by saying that they know what are the available technologies on the market and that they receive a satisfactory amount of information. It is likely that a more detailed analysis of these problems will give rise to interesting aspects that are not covered by this study.

#### *7.2.1.2 Analysis of drivers*

In table 20, instead, we have ranked the drivers according to their average score, presenting several interesting results.

**Table 20: Perceived drivers - Total sample (61)**

| Drivers rank | | Average score |
|---|---|---|
| **1** | Information about real costs | 3,60 |
| **2** | Trustworthiness of information | 3,53 |
| **3** | Public investment subsidies | 3,52 |
| **4** | Clarity of information | 3,52 |
| **5** | Awareness | 3,35 |
| **6** | Knowledge of non-energy benefits | 3,33 |
| **7** | Availability of information | 3,32 |
| **8** | Private financing | 3,28 |
| **9** | Long-term energy strategy | 3,22 |
| **10** | Cost reduction from lower energy use | 3,22 |
| **11** | Technical support | 3,20 |
| **12** | Management with real ambitions/comm. | 3,17 |
| **13** | Increasing energy tariffs | 3,15 |
| **14** | Management support | 3,15 |
| **15** | Staff with real ambitions | 3,03 |
| **16** | Efficiency due to legal restrictions | 3,00 |
| **17** | Voluntary agreements | 2,90 |
| **18** | Green image | 2,82 |
| **19** | Willingness to compete | 2,78 |
| **20** | External energy audits/sub metering | 2,77 |
| **21** | Programs of education and training | 2,75 |
| **22** | External cooperation | 2,52 |
| **23** | Technological appeal | 1,80 |

The four most important drivers – i.e., information about real costs, trustworthiness of information, public investment subsidies and clarity of information with scores of 3.60, 3.53, 3.52 and 3.52 respectively – point out different aspects perceived as being very important.

Although information barriers were not considered to be particularly important (in fifth place), the most important driver is information about real costs. This is because companies want to have as much information as possible to reduce hidden costs, that is, to avoid costs related to gathering, processing and analyzing of information. Obviously, the information that companies want to receive must be reliable and this is underlined by the high importance given to the driver trustworthiness of information. The importance of the driver clarity of information (average score of 3.52) suggests that they are not standardized. A standard presentation in order to increase the clarity, therefore, appears to be a strong push towards energy efficiency investments. This means less time-consuming to analyze the flow of information that companies receive. Often brochures and information files are too much complex and long, so that companies do not consider them. The primary

importance of these information drivers turns out to be a new result compared to those found in the literature, often considering the economic drivers more important, such as in the studies of (Andrea Trianni et al., 2013) and (de Groot et al., 2001). Noting that other drivers of the informative family have received a low score, it is clear that for enterprises the content and the form of information are very important.

Public investment subsidies is in 3rd place because it represents a driver according to which the company receives money for free, while private financing, in 8th place, presupposes a greater effort by the company that will have to pay back the capital received within a specified period and with interest rates. However, both are perceived as important (average score greater than 3.25) and therefore they are classified in the high-end.

Awareness is another informative driver considered to be very important with an average score of 3.35. Since this is a driver that can be stimulated for example by IAGs through sensitization campaigns, it is once again emphasized the importance of receiving information from the outside. In addition, it is also confirmed that it is not important to receive information about skills or technical data but rather generic ones. Even knowledge of non-energy benefits has been classified as particularly important. The knowledge of benefits such as safety or quality, resulting from EE investments, seems to be regarded positively by the companies. In this case, the information is linked to other themes highlighting how fundamental are other aspects beyond the energy savings for the acceptability of energy efficiency investments.

We found that long-term energy strategy and staff with real ambitions are not the main drivers, ninth and fifteenth respectively in the ranking. This is in contrast with the results of (Rohdin et al., 2007), focusing on Swedish foundry industry, and (Thollander & Ottosson, 2008), exploring the Swedish pulp and paper industry. This is due to the fact that the samples of (Thollander & Ottosson, 2008) and (Rohdin et al., 2007) refer to large corporations with greater visibility than SMEs. In fact, with regard to small- and medium-sized enterprises, practices related to long-term energy strategy are not part of their culture. Furthermore, the current economic crisis in the analyzed sector is not conducive to the ambition and commitment to the theme but rather to problems for the survival of the company on the market. In addition, it is likely that many firms feel to have already a staff very sensitive with respect to the issue of energy efficiency.

External cooperation is one of two drivers with the lowest score, under 2.60. Probably, enterprises distrust other actors to form a relationship. Reasonably, technological appeal is the last driver with an average score of 1.80. This is due to the fact that a machinery aesthetically beautiful does not influence business decisions, especially in a period in which many companies face serious problems that force them to focus the attention on productivity and economic factors rather than on less relevant factors. In addition, the

analyzed sample does not have an external visibility so as to consider this factor as important.

*7.2.1.3 Analysis of driver's families*

The results of the drivers grouped into families are shown in table 21.

**Table 21: Drivers grouped in families - Total sample (61)**

| Drivers rank | | Average score |
|---|---|---|
| **1** | Economic | 3,16 |
| **2** | Information | 3,07 |
| **3** | Regulatory | 2,98 |

We note that economic drivers dominate over others, followed by information drivers, and by those belonging to the regulatory category that probably does not stimulate the interest of companies, because every firm tries to get an economic return from any investment very close.

*7.2.1.4 Correlation analysis*

Among the barriers, grouped into macro-areas, there is only one correlation (value equal to 0.62) between technology-related barriers and information barriers (see table 22). This may be due to the fact that knowledge of new technologies on the market is hindered by problems related to the availability of information.

**Table 22: Correlation between barriers - Total sample (61)**

| TOTAL SAMPLE | Economic | Behavioral | Organizational | Related to competences | Lack of awareness | Technology related | Information |
|---|---|---|---|---|---|---|---|
| Economic | 1,00 | 0,25 | 0,12 | 0,04 | 0,04 | 0,19 | 0,22 |
| Behavioral | | 1,00 | 0,04 | 0,19 | 0,06 | 0,27 | 0,21 |
| Organizational | | | 1,00 | 0,24 | 0,08 | 0,25 | 0,04 |
| Related to competences | | | | 1,00 | 0,22 | 0,43 | 0,32 |
| Lack of awareness | | | | | 1,00 | 0,05 | 0,09 |
| Technology-related | | | | | | 1,00 | 0,62 |
| Information | | | | | | | 1,00 |

Observing the correlation matrix, we can see how the three families of drivers remained independent of each other. Within each family, we note that some factors are correlated,

showing interesting results. Management with real ambitions and commitment is strongly correlated with staff with real ambitions, with a value of 0.89. This is because all the surveyed companies consider important the energy efficiency theme stating also that the effort to change the status of a company is to be made by top management, which gives a boost, as well as by all the staff that can give a great contribution. A correlation exists also between public investment subsidies and private financing because the economic aspect is very critical for companies, especially in this period of difficulty. Another strong correlation (value equal to 0.78) exists between management support and technical support, because the top management considers any help from the outside useful to take care of all paperwork and to follow a project from the beginning to the end, without forgetting that this aspect should be accompanied by a technical support useful for the staff to implement new practices or to use in the most efficient way new machineries. Management support is also correlated, unexpectedly, with external energy audits / submetering, with a value equal to 0.62. In fact, it would seem more intuitive associate external energy audits / submetering with technical support in order to assess in the best way inefficiencies and opportunities. Probably, the companies expect from energy audits also aids of managerial nature. Finally, there are correlations between information drivers due to the fact that companies perceive as important the drivers availability of information and information about real costs, stressing however that these must be clear in order to avoid possible misunderstandings, and reliable since in many cases investments require a lot of money.

**Table 23: Correlation between drivers - Total sample (61)**

| TOT. SAMPLE | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | D16 | D17 | D18 | D19 | D20 | D21 | D22 | D23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D1 | 1,00 | 0,34 | 0,36 | 0,07 | 0,04 | 0,06 | 0,08 | 0,22 | 0,02 | 0,51 | 0,45 | 0,20 | 0,10 | 0,20 | 0,08 | 0,35 | 0,13 | 0,24 | 0,37 | 0,37 | 0,12 | 0,09 | 0,12 |
| D2 | | 1,00 | 0,30 | 0,29 | 0,05 | 0,21 | 0,11 | 0,13 | 0,02 | 0,18 | 0,13 | 0,21 | 0,12 | 0,10 | 0,00 | 0,24 | 0,03 | 0,14 | 0,20 | 0,22 | 0,04 | 0,19 | 0,07 |
| D3 | | | 1,00 | 0,02 | 0,10 | 0,03 | 0,01 | 0,13 | 0,02 | 0,16 | 0,24 | 0,37 | 0,27 | 0,35 | 0,07 | 0,29 | 0,19 | 0,17 | 0,42 | 0,10 | 0,13 | 0,16 | 0,08 |
| D4 | | | | 1,00 | 0,22 | 0,18 | 0,15 | 0,21 | 0,02 | 0,07 | 0,08 | 0,05 | 0,04 | 0,00 | 0,12 | 0,15 | 0,04 | 0,34 | 0,04 | 0,13 | 0,09 | 0,07 | 0,06 |
| D5 | | | | | 1,00 | 0,24 | 0,16 | 0,05 | 0,16 | 0,19 | 0,10 | 0,13 | 0,14 | 0,06 | 0,20 | 0,02 | 0,09 | 0,04 | 0,15 | 0,10 | 0,10 | 0,14 | 0,06 |
| D6 | | | | | | 1,00 | 0,89 | 0,04 | 0,02 | 0,40 | 0,34 | 0,01 | 0,00 | 0,14 | 0,22 | 0,15 | 0,01 | 0,02 | 0,09 | 0,08 | 0,01 | 0,07 | 0,02 |
| D7 | | | | | | | 1,00 | 0,02 | 0,01 | 0,42 | 0,35 | 0,03 | 0,03 | 0,14 | 0,23 | 0,11 | 0,03 | 0,03 | 0,04 | 0,09 | 0,07 | 0,19 | 0,04 |
| D8 | | | | | | | | 1,00 | 0,24 | 0,06 | 0,05 | 0,09 | 0,23 | 0,08 | 0,06 | 0,12 | 0,03 | 0,14 | 0,16 | 0,10 | 0,04 | 0,04 | 0,04 |
| D9 | | | | | | | | | 1,00 | 0,02 | 0,16 | 0,10 | 0,20 | 0,03 | 0,24 | 0,17 | 0,17 | 0,06 | 0,01 | 0,26 | 0,38 | 0,38 | 0,46 |
| D10 | | | | | | | | | | 1,00 | 0,79 | 0,09 | 0,05 | 0,17 | 0,11 | 0,23 | 0,09 | 0,02 | 0,09 | 0,00 | 0,09 | 0,08 | 0,10 |
| D11 | | | | | | | | | | | 1,00 | 0,10 | 0,05 | 0,27 | 0,06 | 0,20 | 0,07 | 0,03 | 0,17 | 0,01 | 0,12 | 0,11 | 0,07 |
| D12 | | | | | | | | | | | | 1,00 | 0,78 | 0,62 | 0,31 | 0,37 | 0,23 | 0,18 | 0,32 | 0,37 | 0,38 | 0,30 | 0,39 |
| D13 | | | | | | | | | | | | | 1,00 | 0,58 | 0,10 | 0,35 | 0,14 | 0,07 | 0,29 | 0,41 | 0,49 | 0,42 | 0,48 |
| D14 | | | | | | | | | | | | | | 1,00 | 0,36 | 0,38 | 0,27 | 0,22 | 0,40 | 0,29 | 0,33 | 0,27 | 0,28 |
| D15 | | | | | | | | | | | | | | | 1,00 | 0,31 | 0,13 | 0,18 | 0,00 | 0,12 | 0,13 | 0,03 | 0,14 |
| D16 | | | | | | | | | | | | | | | | 1,00 | 0,10 | 0,37 | 0,10 | 0,23 | 0,22 | 0,17 | 0,25 |
| D17 | | | | | | | | | | | | | | | | | 1,00 | 0,01 | 0,10 | 0,09 | 0,00 | 0,01 | 0,03 |
| D18 | | | | | | | | | | | | | | | | | | 1,00 | 0,33 | 0,13 | 0,05 | 0,03 | 0,08 |
| D19 | | | | | | | | | | | | | | | | | | | 1,00 | 0,17 | 0,29 | 0,30 | 0,24 |
| D20 | | | | | | | | | | | | | | | | | | | | 1,00 | 0,70 | 0,55 | 0,70 |
| D21 | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,77 | 0,96 |
| D22 | | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,76 |
| D23 | | | | | | | | | | | | | | | | | | | | | | | 1,00 |

*7.2.1.5 Analysis of decision-making*

In this section, using the results of the intensity of barriers and drivers, we will apply the model developed in Chapter 5 in order to analyze the impact on corporate decision-making. It will be analyzed each step in relation to the existing barriers, the major drivers that affect it, the effects deriving from drivers and the actors that could activate them. It should be noted that the barriers intensity is the same for each decision-making step because, given the nature of phone interviews, we have not been able to do this analysis in depth as it was possible for the personal interviews. To lighten the writing, each driver will be cited according to its number and each number is preceded by the letter R, E or I, (Regulatory, Economical or Informative respectively), depending on the nature of the driver, as shown in the following table.

**Table 24: Numbering of drivers**

| Number | Driver |
|---|---|
| **R.1** | Voluntary agreements |
| **R.2** | Efficiency due to legal restrictions (reg. and |
| **R.3** | Green image |
| **R.4** | Long-term energy strategy |
| **E.5** | Willingness to compete |
| **E.6** | Management with real ambitions/comm. |
| **E.7** | Staff with real ambitions |
| **E.8** | Increasing energy tariffs |
| **E.9** | Cost reduction from lower energy use |
| **E.10** | Public investment subsidies |
| **E.11** | Private financing |
| **I.12** | Management support |
| **I.13** | Technical support |
| **I.14** | External energy audits/sub metering |
| **I.15** | Programs of education and training |
| **I.16** | External cooperation |
| **I.17** | Awareness |
| **I.18** | Technological appeal |
| **I.19** | Knowledge of non-energy benefits |
| **I.20** | Availability of information |
| **I.21** | Clarity of information |
| **I.22** | Information about real costs |
| **I.23** | Trustworthiness of information |

Step 1: Awareness

From the theoretical model developed, the acting drivers in this step are: R.3, R.4, E.5, E.6, E.7, E.8, I.17, I.19, I.20, I.23. From the empirical investigation results that drivers I.23 and I.17 are particularly strong. The driver I.23 impacts on information barriers that are perceived as being not particularly important (average score of 2.35). Since this driver has an average score equal to 3.53, we can say that its activation could eliminate the information problems breaking down this barrier. The driver I.17 has instead a score of 3.35 and could affect the barrier lack of awareness (average score of 2.57). Behavioral barriers, that are very important at this stage (average score of 2.60), will not be torn down but only reduced by drivers R.4 and E.6, which are middle-ranked. However, considering the dynamics of the drivers, we can say that awareness is the key point of consciousness about the problem and therefore behavioral problems may be deleted over time. Organizational barriers, with a low average score (2.30), are faced by drivers with a medium average score such as long-term energy strategy (3.22), green image (2.82), and willingness to compete (2.78), so it is plausible to consider the strong attenuation or the complete elimination of these barriers. Therefore, in order to overcome the barriers of this step, the main drivers are awareness and trustworthiness of information. For increasing awareness, certified bodies outside to the company become important especially if a relationship of trust between them and the company arises. As shown by personal interviews, each company want to interface itself with associations trustable and competent, which know the geographical area and the socio-economical context in which the company operates. We identify these players in industry associations and local governments. We must not forget that a company trusts in its suppliers and installers, so information campaigns that act on these sources of information are fundamental. In order to increase the awareness, the policy makers should therefore act on these external actors and not only on the companies. Each case requires, however, a more detailed study and further research should be developed to search for sources which are deemed more competent and trusted by companies.

Step 2: Needs and opportunity identification

From the theoretical model developed, the acting drivers in this step are: R.1, E.6, E.7, E.9, I.12, I.13, I.14, I.16, I.17. From the empirical investigation results that driver I.17 is the strongest. This driver, with a strength of 3.35, is the last of high ranked drivers and has a strong action against the barrier awareness and against the behavioral ones. All other drivers that work together to overcome these last barriers obtained a medium or even low score, so it is not plausible to consider their complete elimination only with the help of this driver. Barriers related to competences with an average score of 2.42 are faced by drivers classified as medium or low (I.12, I.13, I.14 and I.16 with average scores of 3.15, 3.20, 2.77 and 2.52 respectively). It is reasonable to think that these barriers will certainly be reduced. When questioned about the skills necessary to identify the needs and opportunities, the

respondent seemed unwilling to admit a lack of competence, due probably to the fact that we are asking for perceived drivers. It is therefore very likely that there is a potential overestimation of the internal organization competences. This consideration stresses the fact that this preliminary analysis highlights the need to understand in more detail the actual competences for the evaluation of inefficiencies. If it were possible then to measure the level of internal competence, it could radically change the importance of drivers related to external skills. At this point, the company would consider external competences important factors to overcome the problems that have been demonstrated. From the bottom vote provided to the driver external energy audits (2.77), it seems that companies are stubborn to seek outside for fear of disclosing sensitive data, and then for reasons of confidentiality. Policy makers should promote audits made by external certified sources released to business solutions such as university researchers.

Step 3: Technology identification

From the theoretical model developed, the acting drivers in this step are: R.1, R.2, E.6, I.16, I.18, I.19, I.20, I.23. From the empirical investigation results that drivers I.19, I.20 and I.23 are particularly strong with average scores of 3.33, 3.32 and 3.53 respectively. Technology-related barriers are the lowest ranked as revealed by the experimental results (average score of 2.27). Being struck by two drivers classified as medium-high (I.19 and I.20) and the two lowest ever (I.18 with a score of 1.80 and I.16 with a score of 2.52), it seems that there is a good chance that these problems could be easily overcome activating the strongest drivers. The driver I.23 impacts on information barriers that are perceived as being not particularly important (average score of 2.35). Since this driver has a strength equal to 3.53, we can say that its activation could eliminate the information problems. In addition, it is coupled with medium-high drivers such as I.19 and I.20, so the result could be more effective. Behavioral barriers, perceived as high, are addressed by two medium-high drivers such as I.19 and I.23, by the medium driver management with real ambitions and commitment with an average score of 3.17, and by others medium-low drivers such as R.1 (average score of 2.90), R.2 (average score of 3.00) and I.16 (average score of 2.52) . Another time, it seems difficult eliminate the behavioral barriers, and the most convenient choice falls on the drivers related to information. In fact, if you give reliable information that demonstrate the cost-effectiveness of an investment, these problems can be easily overcome. However, the driver E.6 (management with real ambitions and commitment) should not be overlooked, and further research are needed to better explore this field since in this study the barriers have been explored by macro-areas, when in reality the complexity of each one is greater. Nevertheless, relying on the five explorative cases where it was possible evaluating the impact of each driver on a single barrier in the context of the specific decision-making step, the driver efficiency due to legal restriction assumes particular importance. In the empirical analysis, it has not been possible to achieve this level of detail and the analysis was limited to the general case. However, the imposition of

energy standards that can put out of the market some of the inefficient technologies, coupled with the knowledge of non-energy benefits (as it emerges from empirical results), could help more strongly to overcome the problems of this step. So, solutions to the barriers of this step may come from outside: in particular, suppliers and manufacturers could provide information on energy-efficient technologies which do not concern only the energy aspect but also other benefits such as security or quality; government, instead, could impose standard to avoid the availability of inefficient technologies.

Step 4: Planning

From the theoretical model developed, the acting drivers in this step are: R.2, E.6, I.12, I.13, I.15, I.21, I.23. From the empirical investigation results that drivers I.21 and I.23 are particularly strong. The information barriers (average score of 2.35) appear to be completely eliminated as well as organizational ones (average score of 2.30). These latter are addressed by a medium driver (E.6) and a low ranked driver (R.2). However, management with real ambition seems to be positive for these barriers. Barriers related to competences are also classified as low (average score of 2.42) and drivers able to overcome them are medium or low. So they can be strongly reduced, even not completely overcome, by the driver (I.15) classified as low with an average score of 2.75. Nevertheless, the attenuation can be at least satisfactory since technical support, which is medium ranked with a score of 3.20, can lead to good results when applied to this step. Once again, drivers cited can be stimulated by external actors, such as industry associations that can provide useful information as well as technical and managerial support. In particular, for this step and for the following concerning the economic aspect, ESCOs may play a fundamental role. In analyzing ESCOs, we should take into account several factors and aspects that prevent their seizure of power, but these are not the subject of this study. Another aspect definitely to be taken into account in the evaluation of any difficulties and possible solutions for the stage of planning, is represented by unexpected delay times. Policy makers could consider the effects that these interventions have on companies in terms of disruptions. To minimize these effects, specific interventions should be studied for having a minimal impact on the planning and for acting also on the information, their clarity and on the intervention implementation time.

Step 5: financial analysis and financing

From the theoretical model developed, the acting drivers in this step are: R.3, R.4, E.5, E.8, E.9, E.10, E.11, I.19, I.20, I.22. From the empirical investigation results that drivers I.22 and E.10 are particularly strong (average score of 3.60 and 3.52 respectively). The driver I.22 impacts on information barriers that are perceived as being not particularly important. Since this driver has a great strength, we can say that its activation could eliminate the information problems breaking down this barrier. In addition, it is coupled with I.19 and I.20 that are medium-high ranked drivers. The main problems of this step, which are also

the barriers with the highest average score (3.20), are the economic ones. They are faced by powerful drivers such as public investment subsidies and information about real costs. Moreover, a variety of high-ranked drivers such as E.9, I.19 and I.20 (average score of 3.22, 3.33 and 3.32 respectively) impact on these barriers. Therefore, we can say that if the main drivers were activated these problems could be overcome completely. Behavioral barriers are classified as second in the experimental analysis (average score of 2.60), and are faced by drivers of medium (R.4 with a score of 3.22) or medium-low (R.3 with a score of 2.82 and E.5 with a score of 2.78) strength, except those linked to information. So these barriers could only be attenuated and not fully overcome. The main drivers in this step are in the hands of external entities such as government or financial institutions. The government should raise the awareness of the banks to stimulate them in providing favorable conditions to companies for their investments in energy efficiency. Promote studies for the understanding of costs and actual savings increases the net present value (NPV) earned by the company in evaluating the investment. This also increases the profitability for the banks that grant a loan for an investment that will be profitable and so less risky. Moreover, it is important to simplify the access to credit by minimizing the bureaucratic processes: in fact, one of the biggest problems for Italian companies is related to the application for the competition notices that will allow the access to grants or loans on more favorable terms.

Step 6: Installation start-up and training

From the theoretical model developed, the acting drivers in this step are: E.6, E.7, I.13, I.15, I.21. From the empirical investigation results that the driver I.21 is the strongest, for reducing organizational barriers. However, management and staff with real ambitions are also of great importance, classified as drivers of medium intensity with an average score of 3.17 and 3.03. Since organizational barriers are classified as low, we can say that the drivers responsible for their removal will be successful. With regard to competences, there may be more problems because of the low confidence in program of education and training, but technical support may have a good effect. So it can be stated that their attenuation may be at a satisfactory level. To enable the drivers necessary to overcome the barriers of this step, it is necessary to have management and staff competent and inclined towards the energy theme. In addition, each company should create an history of the adopted procedures, maybe useful for future applications. The historian would be helpful to standardize complex procedures addressed for the first time and to evaluate the intervention just made. Policy makers could certainly promote training courses that make clear the use of new technologies and the implementation of efficient practices.

### *7.2.2 Analysis by firm size*

#### *7.2.2.1 Analysis of barriers*

**Table 25: Perceived barriers - Clusters by firm size**

| Barriers<br>No. of Enterprises | Average score<br>61 | MLEs<br>30 | MSEs<br>31 | Δ(MLEs-tot. sample)% | Δ (MSEs-tot. sample)% | Δ (MLEs-MSEs)% |
|---|---|---|---|---|---|---|
| Economic | 3,20 | 3,48 | 2,93 | 0,28 | 0,27 | 0,56 (•) |
| Behavioral | 2,60 | 2,48 | 2,71 | 0,12 | 0,11 | 0,23 |
| Organizational | 2,30 | 2,21 | 2,39 | 0,09 | 0,09 | 0,18 |
| Related to competences | 2,42 | 2,41 | 2,42 | 0,00 | 0,00 | 0,01 |
| Lack of awareness | 2,57 | 2,38 | 2,75 | 0,19 | 0,18 | 0,37 |
| Technology related | 2,27 | 2,24 | 2,29 | 0,03 | 0,02 | 0,05 |
| Information | 2,35 | 2,38 | 2,32 | 0,03 | 0,03 | 0,06 |

**Note: Meaningfulness of Δ: (••) more than 20%; (•) between 15% and 20%; (no dots) less than 15%.**

From the differentiation between medium-large and medium-small enterprises, we can see that all kinds of barriers do not undergo significant differences from the overall sample. The only notable difference exists between the clusters: in particular, the economic barriers undergo a significant difference exceeding 15% of the whole sample average. (Patrik Rohdin et al., 2007) claim that economic barriers are the most important to both the size, and this result has also emerged from our analysis. Nevertheless, our study shows that medium-small companies are affected to a lesser extent from economic problems compared to the medium-large ones. This unexpected result seems to find a plausible explanation through a more detailed analysis of the sample investigated. On the one hand, indeed, we can reasonably suppose that we have interviewed several MSEs with a high level of performance, therefore not suffering from economic barriers, but still considering economic drivers as important, due to the contingent economic and financial crisis. On the other hand, we can find some enterprises that, although judging economic barriers of particular importance, do not believe drivers such as public subsidies or private financing are able to overcome them. This is even more critical, as it may reflect a loss of trustworthiness towards the support coming from political institutions. Another difference that can be observed (less than 15%) regards the barrier lack of awareness more important for medium-small companies (score 2.75) compared to medium-large (score 2.38). This makes us think that the greatest difficulties are encountered by companies with limited resources such as the medium-small, as suggested by (Hasanbeigi et al., 2010). Finally, we note that there are not important differences between clusters and the whole sample

regarding barriers related to competences, related to technologies and related to information. This latter, in particular, is in disagreement with the study of (de Groot et al., 2001) for which *"the information gap is particularly large in small firms facing limited competition and spending relatively little on investments."*

*7.2.2.2 Analysis of driver*

Drivers of informative nature are top rated by both the clusters. The second most important driver is public investment subsidies, and it is important to note that it is not immediately followed by private financing. (Pimenova & Van der Vorst, 2004) in their study showed that financial support has been ranked as the second greatest driver, but (Parker, Redmond, & Simpson, 2009) pointed out that for MSEs the types of these incentives are important. In fact, confirming our result, public subsidies are better seen than private financing, and this insight is confirmed both for MSEs and MLEs. Each cluster differs from the total sample for the driver efficiency due to legal restriction (less than 15%) and in particular the biggest difference is between the two clusters with a deviation greater than 20% of the average of the whole sample. MSEs give a low priority to this driver, and the explanation can be found in the article of (Parker et al., 2009) for which the ineffectiveness of regulations is probably due to the fact that these restrictions are perceived as a business threat or there is no awareness of regulations. This latter aspect in particular can be seen from the results of drivers grouped into families (table 27) in which the most significant difference occurs just in correspondence of the regulatory actions that are classified by MSEs as the lowest, with a significant difference between the two clusters very close to 15%. Moreover, given the different social visibility of the two clusters, rules and regulations will surely have a greater effect on larger companies that are exposed to greater visibility. The second most important difference between medium-small and medium-large concerns the driver green image, in which the MLEs attribute an average score of 3.03 with a difference from MSEs by more than 15%. This is confirmed by the study of (Hasanbeigi et al., 2010) asserting that: *"having a good image is of even more importance for big companies and corporations."* Although it does not exceed the 15%, another difference appear between the two clusters for the driver external cooperation. In this regard MLEs consider it as less important than medium-small ones. This seems to reflect the will of medium-small businesses to create their own network aimed at sharing resources to improve efficiency. This research is stimulated by the fact that these companies do not possess the resources to address specifically energy efficiency. Implications for policy makers could be to set up a collective and common energy manager for the entire network of companies. So a medium-small company could definitely benefit from a partnership to a greater extent. The same result is confirmed by the study of (Aflaki et al., 2012) for which cooperation possibly also with ESCOs can support MSEs in implementing energy efficiency projects.

**Table 26: Perceived drivers - Clusters by firm size**

| Drivers<br>No. of Enterprises | Average sc<br>61 | MLEs<br>30 | MSEs<br>31 | Δ(MLEs-sample)% | Δ (No SMEs-sample)% | Δ (MLEs-MSEs)% |
|---|---|---|---|---|---|---|
| Voluntary agreements | 2,90 | 3,03 | 2,77 | 0,13 | 0,13 | 0,26 |
| Efficiency due to legal restrictions | 3,00 | 3,41 | 2,60 | 0,41 | 0,40 | 0,81 (••) |
| Green image | 2,82 | 3,03 | 2,61 | 0,22 | 0,21 | 0,43 (•) |
| Long-term energy strategy | 3,22 | 3,34 | 3,09 | 0,13 | 0,12 | 0,25 |
| Willingness to compete | 2,78 | 2,69 | 2,87 | 0,09 | 0,09 | 0,18 |
| Management with real ambitions/comm. | 3,17 | 3,21 | 3,13 | 0,04 | 0,04 | 0,08 |
| Staff with real ambitions | 3,03 | 3,07 | 3,00 | 0,04 | 0,03 | 0,07 |
| Increasing energy tariffs | 3,15 | 3,14 | 3,16 | 0,01 | 0,01 | 0,02 |
| Cost reduction from lower energy use | 3,22 | 3,14 | 3,29 | 0,08 | 0,08 | 0,15 |
| Public investment subsidies | 3,52 | 3,52 | 3,52 | 0,00 | 0,00 | 0,00 |
| Private financing | 3,28 | 3,31 | 3,26 | 0,03 | 0,03 | 0,05 |
| Management support | 3,15 | 3,14 | 3,16 | 0,01 | 0,01 | 0,02 |
| Technical support | 3,20 | 3,14 | 3,26 | 0,06 | 0,06 | 0,12 |
| External energy audits/sub metering | 2,77 | 2,76 | 2,77 | 0,01 | 0,01 | 0,02 |
| Programs of education and training | 2,75 | 2,66 | 2,84 | 0,09 | 0,09 | 0,19 |
| External cooperation | 2,52 | 2,38 | 2,65 | 0,14 | 0,13 | 0,27 |
| Awareness | 3,35 | 3,28 | 3,42 | 0,07 | 0,07 | 0,15 |
| Technological appeal | 1,80 | 1,90 | 1,71 | 0,10 | 0,09 | 0,19 |
| Knowledge of non-energy benefits | 3,33 | 3,34 | 3,32 | 0,01 | 0,01 | 0,02 |
| Availability of information | 3,32 | 3,34 | 3,29 | 0,03 | 0,03 | 0,06 |
| Clarity of information | 3,52 | 3,48 | 3,55 | 0,03 | 0,03 | 0,07 |
| Information about real costs | 3,60 | 3,59 | 3,61 | 0,01 | 0,01 | 0,03 |
| Trustworthiness of information | 3,53 | 3,48 | 3,58 | 0,05 | 0,05 | 0,10 |

**Note: Meaningfulness of Δ: (••) more than 20%; (•) between 15% and 20%; (no dots) less than 15%.**

### *7.2.2.3 Analysis of driver's families*

As already mentioned in the analysis of individual drivers, medium-small firms perceive as less important drivers of regulatory nature.

**Table 27: Perceptions of drivers grouped into families - Clusters by firm size**

| Drivers family<br>No. of | Average<br>61 | MLEs<br>30 | MSEs<br>31 | Δ(MLEs-sample)% | Δ(MSEs-sample)% | Δ (MLEs-MSEs)% |
|---|---|---|---|---|---|---|
| Regulatory | 2,98 | 3,21 | 2,77 | 0,22 | 0,22 | 0,44 |
| Economic | 3,16 | 3,15 | 3,18 | 0,01 | 0,01 | 0,02 |
| Information | 3,07 | 3,04 | 3,10 | 0,03 | 0,03 | 0,06 |

**Note: Meaningfulness of Δ: (••) more than 20%; (•) between 15% and 20%; (no dots) less than 15%.**

### *7.2.2.4 Correlation analysis*

**Table 28: Correlation between barriers - MLEs**

| MLEs | Economic | Behavioral | Organizational | Related to competences | Lack of awareness | Technology related | Information |
|---|---|---|---|---|---|---|---|
| Economic | 1,00 | 0,37 | 0,21 | 0,09 | 0,09 | 0,08 | 0,42 |
| Behavioral | | 1,00 | 0,32 | 0,30 | 0,05 | 0,39 | 0,23 |
| Organizational | | | 1,00 | 0,24 | 0,01 | 0,25 | 0,06 |
| Related to competences | | | | 1,00 | 0,07 | 0,60 | 0,32 |
| Lack of awareness | | | | | 1,00 | 0,11 | 0,10 |
| Technology related | | | | | | 1,00 | 0,63 |
| Information | | | | | | | 1,00 |

**Table 259: Correlation between barriers - MSEs**

| MSEs | Economic | Behavioral | Organizational | Related to competences | Lack of awareness | Technology related | Information |
|---|---|---|---|---|---|---|---|
| Economic | 1,00 | 0,13 | 0,01 | 0,17 | 0,10 | 0,28 | 0,14 |
| Behavioral | | 1,00 | 0,35 | 0,04 | 0,03 | 0,12 | 0,21 |
| Organizational | | | 1,00 | 0,23 | 0,13 | 0,24 | 0,15 |
| Related to competences | | | | 1,00 | 0,41 | 0,22 | 0,32 |
| Lack of awareness | | | | | 1,00 | 0,02 | 0,10 |
| Technology related | | | | | | 1,00 | 0,62 |
| Information | | | | | | | 1,00 |

The analysis of correlation between the barriers show that there is a correlation for MLEs between barriers for technology, and those relating to the competences. We note that it is a matter of borderline significance and in any case is probably due to the fact that considering themselves competent in evaluate EE investment companies emphasize that appropriate technologies are on the market and they are able to find these. It is known instead as for both clusters barriers relating to the technologies are correlated with those of information. This suggest that the low perception of a technology on the market may be linked to the lack of information. Nonetheless the correlation remains of medium intensity.

By analyzing the correlation table of the drivers (in appendix B) for medium-large companies are immediately noticeable the strongest correlations that exceed the threshold of 0.7. As expected the driver due to the flow of information are strongly correlated with each other. This is due to the fact that if a company believes it is important the availability of the information wants to get clear, accurate and reliable and they are the most complete are possible. Another strong correlation (0.74) is observed between the driver technical support and management support. This result may suggest the fact that a company receives a management support for an investment wants to maintain this help even on the technical side connected. Two other results are expected correlations between public subsidies and private investment financing and management with real ambition and staff with real ambition. This latter means that ambition and the commitment to the issue is known to take place at all levels of the company. Then there is a correlation of average intensity between the drivers public investment subsidies, private financing and voluntary agreements. This aspect was not known for the medium-small companies and in fact they perceive the driver voluntary agreement to a lesser extent by the MLEs showing a difference on the other cluster that is very close to the 10% level of significance. We can therefore assume that, since the two economic drivers in question are perceived in the same way by both MSEs this latter MLEs see these voluntary agreements in a way to gain also economic benefits. The same correlation between the two economic drivers and management with real ambition and commitment could be explained by the dynamics of the drivers. Or in the minds of those who respond to the interview the economic incentive can be seen as a boost to the' ambition and the commitment of the management. The fact that there is a ligament also with the driver staff with real ambition is a consequence of the strong correlation of the latter with driver management with real ambition and commitment shown above.

In the case of MSEs are confirmed all the strong correlations analyzed above with the only difference that the one linked to incentives is not stronger but becomes of average intensity. There is indeed a greater difference than the MLEs between the score at the level of public investments subsidies and private financing giving further confirmation to the discoveries of (Parker et al., 2009). Come to light then two other strong correlations. The first relates to external energy audit that turns out to be strongly correlated with

management support and technical support. This may suggest that these external audits by the medium-small enterprises are expect also to provide important tips over how to deal with these issues from both a technical and managerial point of view. The second is always about external energy audit but this time referring to clarity and trustworthiness of information. This result may mean that form the external audits a MSEs expect to receive clear and reliable information, therefore considering it a strong tool also for finding the needed information. Finally, we note a medium correlation between the driver cost reduction from lower energy use, clarity and trustworthiness of information and information about real cost. These are correlations of low value (0.6, 0.61 and 0.63) and appear to mean that as the fact of cost reduction for the reduced use of energy should be certified and that this information has to comes clearly for the related technology or practice. Furthermore, the fact of the cost reduction may be connected to receiving information about the real costs of a technology and therefore it is easy to understand the correlation with the driver information about real costs.

*7.2.2.5 Analysis of decision making*

Analyzing the decision-making process of companies broken down by size we note that in MSEs are not shown major differences compared to the total sample and the main changes are related to the MLEs. In particular, for the first step the driver green image is felt most important (average score of 3.03 vs 2.82 for the total sample). This suggests that a company with greater visibility can leverage the fact of the environmental image to ensure that awareness to the subject of energy will increase. This contributes to the elimination of behavioral barriers that even for the cluster of MLEs are considered as the second most important (average score of 2.48). The co-operation of this driver with the awareness is therefore essential for the elimination of these barriers which will then be more easily removed for companies of larger size. Another significant difference resulting from the analysis for size concerns regulatory drivers. In this case the responses of medium-large companies align more closely with those derived from exploratory cases confirming the importance of efficiency due two legal restriction that acts primarily to the steps 3 and 4. The observations made for the total sample with respect to the imposition of standard and putting out of the market inefficient technologies seem to have a stronger impact on larger companies. This aspect suggests how regulations have a positive effect on the research of technologies and planning to keep them within certain criteria addressed for efficiency. Concerning all other decision step or 2, 5 and 6 are not highlighted particular differences from the total sample; therefore are valid all the considerations made in paragraph 7.2.1.5.

### *7.2.4 Analysis by firms' energy intensity*

#### *7.2.4.1 Analysis of barriers*

As mentioned before, we have focused on energy intensive companies (ISIC C23 and ISIC C24), where the cost of energy has a significant influence on turnover, and on non energy intensive companies (ISIC C25 and ISIC C28).

**Table 30: Perceived barriers - Cluster by firms' energy intensity**

| Barriers<br>No. Of Enterprises | Average score<br>61 | NEI<br>41 | EI<br>20 | Δ(NEI-sample)% | Δ (EI-sample)% | Δ (NEI-EI)% |
|---|---|---|---|---|---|---|
| Economic | 3,20 | 3,12 | 3,36 | 0,08 | 0,16 | 0,24 |
| Behavioral | 2,60 | 2,56 | 2,68 | 0,04 | 0,08 | 0,12 |
| Organizational | 2,30 | 2,37 | 2,17 | 0,07 | 0,14 | 0,20 |
| Related to competences | 2,42 | 2,41 | 2,42 | 0,00 | 0,00 | 0,01 |
| Lack of awareness | 2,57 | 2,73 | 2,23 | 0,17 | 0,34 | 0,50 (•) |
| Technology related | 2,27 | 2,24 | 2,31 | 0,02 | 0,05 | 0,07 |
| Information | 2,35 | 2,24 | 2,57 | 0,11 | 0,22 | 0,32 |

**Note: Meaningfulness of Δ: (••) more than 20%; (•) between 15% and 20%; (no dots) less than 15%.**

The main barriers for both clusters are economic ones without significantly differ from the entire sample. The first difference (although less than 15%) is found in barrier lack of awareness that is less felt by EI presenting a significant difference from the entire sample. Also, the difference between clusters is significant, and with difference greater than 15% the NEI are affected to a greater extent of this problem. This result may suggest the fact that the non-energy-intensive companies feel better this lack of awareness as the cost of energy is not a major problem. In fact, as suggested (Aflaki et al., 2012): *"energy savings are not significant enough to receive management attention."* Nevertheless, the result for the energy-intensive companies differs from that observed in the study of (Patrik Thollander & Ottosson, 2008) for which barriers of lack of awareness are classified as medium, while here they are low ranked.

*7.2.4.2 Analysis of drivers*

**Table 31: Perceived drivers - Cluster by firms' energy intensity**

| Drivers<br>No. Of Enterprises | Average<br>61 | NEI<br>41 | EI<br>20 | Δ (NEI-sample)% | Δ (EI-sample)% | Δ (NEI-EI)% |
|---|---|---|---|---|---|---|
| Voluntary agreements | 2,90 | 3,00 | 2,70 | 0,10 | 0,21 | 0,31 |
| Efficiency due to legal restrictions | 3,00 | 3,02 | 2,95 | 0,02 | 0,05 | 0,07 |
| Green image | 2,82 | 2,80 | 2,84 | 0,01 | 0,02 | 0,04 |
| Long-term energy strategy | 3,22 | 3,24 | 3,16 | 0,03 | 0,06 | 0,08 |
| Willingness to compete | 2,78 | 2,66 | 3,04 | 0,12 | 0,26 | 0,38 |
| Management with real ambitions/comm. | 3,17 | 3,27 | 2,96 | 0,10 | 0,21 | 0,31 |
| Staff with real ambitions | 3,03 | 3,20 | 2,70 | 0,16 | 0,33 | 0,49 (•) |
| Increasing energy tariffs | 3,15 | 3,12 | 3,21 | 0,03 | 0,06 | 0,09 |
| Cost reduction from lower energy use | 3,22 | 3,02 | 3,61 | 0,19 | 0,39 | 0,59 (•) |
| Public investment subsidies | 3,52 | 3,59 | 3,38 | 0,07 | 0,14 | 0,21 |
| Private financing | 3,28 | 3,34 | 3,16 | 0,06 | 0,12 | 0,18 |
| Management support | 3,15 | 3,07 | 3,31 | 0,08 | 0,16 | 0,23 |
| Technical support | 3,20 | 3,15 | 3,31 | 0,05 | 0,11 | 0,16 |
| External energy audits/sub metering | 2,77 | 2,78 | 2,74 | 0,01 | 0,03 | 0,04 |
| Programs of education and training | 2,75 | 2,71 | 2,84 | 0,04 | 0,09 | 0,13 |
| External cooperation | 2,52 | 2,54 | 2,48 | 0,02 | 0,04 | 0,06 |
| Awareness | 3,35 | 3,41 | 3,22 | 0,06 | 0,13 | 0,20 |
| Technological appeal | 1,80 | 1,93 | 1,54 | 0,13 | 0,26 | 0,39 (••) |
| Knowledge of non-energy benefits | 3,33 | 3,24 | 3,52 | 0,09 | 0,18 | 0,27 |
| Availability of information | 3,32 | 3,39 | 3,17 | 0,07 | 0,15 | 0,22 |
| Clarity of information | 3,52 | 3,44 | 3,68 | 0,08 | 0,16 | 0,24 |
| Information about real costs | 3,60 | 3,49 | 3,83 | 0,11 | 0,23 | 0,34 |
| Trustworthiness of information | 3,53 | 3,46 | 3,68 | 0,07 | 0,14 | 0,21 |

**Note: Meaningfulness of Δ: (••) more than 20%; (•) between 15% and 20%; (no dots) less than 15%.**

Both clusters perceive as the most important drivers those related to the flow of information, in particular information about real costs. It should be noted that the drivers of information (knowledge of non-energy benefits, information about real costs, clarity of information and trustworthiness of information), except availability of information, are considered more important by EI companies. This can be explained by the fact that these companies associated high investment costs for energy efficiency measures and thus prefer to have clear, detailed and reliable if it were decided to make some changes in their

production sites. Immediately followed for the energy-intensive companies is cost reduction from lower energy use with a score of 3.61. As expected this driver is very important for a business in which the cost of energy has a strong influence on the final one. In fact, we do not have a deviation from the total sample that exceeds the 15% of significance but when compared to the non-energy intensive sector (average score 3.02) we arrive at more than 15% of difference. This result was largely borne out by studies in the literature such as (de Groot et al., 2001), (Patrik Thollander & Ottosson, 2008) and (Hasanbeigi et al., 2010). This latter assert that *"the top key driver for energy efficiency improvement mentioned by both industries as well as experts is reducing final product cost by reducing energy cost",* while (Patrik Thollander & Ottosson, 2008) say: *"highest ranked driving force, according to the respondents, was cost reductions resulting from lower energy use…third party financing was ranked low, indicating that this driving force may be of insignificant importance for energy- intensive industries"*. This last statement differs from our results about economic drivers such as private financing and public investments subsidies are classified as medium-high. The driver staff with real ambition is considered more helpful for NEI companies with a significance of about 15%. This could be explained by the fact that the energy intensive are already committed with respect to the subject while maybe in NEI companies there is need for staff with real ambition to bring them to a state of efficiency which otherwise would not be obtained. Still referring to energy intensive companies (Patrik Rohdin et al., 2007) consider it as the second most important driver, while in our case it is classified as of low-average importance. It is also shown a significant difference compared to the cluster of NEI (more than 15%) and compared to the total sample (more than 10%). However the importance of this driver for the non-energy intensive companies was confirmed by the study of (P Rohdin & Thollander, 2006) about the non-energy intensive industries in Sweden. They claim that: *"one driving force in particular that was shown to have an effect on the implementation rate was the existence of people with real ambition within the organization"*. The difference lies in the fact that for them it is a key drivers while for us the keys are those relating to the economic and the flow of information. The difference states probably in the explanation given by (P Rohdin & Thollander, 2006) for the fact that drivers about subsidies are classified as low i.e. that all the companies in their sample are successful companies. Another difference between clusters can be observed for the driver willingness to compete even if it is no significant at the 15% level. EI companies think that giving a competitive character to these investments could help in doing energy efficiency while NEI companies classified it as lower, in fact there is a differences but that not exceed 15%. This is probably another time related to the extent of the cost of energy on the overall cost for a business. This insight finds a confirmation in literature in the work of (Cagno & Trianni, 2012) saying that *"see energy efficiency as a strategic factor that will affect their firm's ability to compete, thus lending the topic increased urgency in the coming years"*. The results confirm previous research performed by (Patrik Thollander & Ottosson, 2008) in their exploration of the Swedish pulp and paper industry, and (Hasanbeigi et al., 2010) regarding Thai cement and textile industry.

It is interesting to note that the driver increasing energy tariffs in not considered so much important also from EI industries (score of 3.21) despite the great energy expenditure. This is in contrast with the studies of (Fisher-vanden, Jefferson, Liu, & Tao, 2002) and (de Groot et al., 2001) which consider it as an important driver. The last significant difference between clusters is for the driver technological appeal. This is another time the lowest ranked driver but NEI industries show a great predisposition for the fashionable technologies. They do not differ from the total sample but the difference with the other cluster has a significance nearly than 20% with an average score of 1.93. Probably, companies focused on the process, like the EI enterprises, rather than the product have no interest in the aesthetics of the machine. In a foundry, for example, the purchase of a machine is according only to its functionality because machineries are specific. In a rather mechanical turning, the machine becomes more generic and easy to replace, and in this case the appeal could become more important.

*7.2.4.3 Analysis of driver's families*

For the families of drivers, it do not notice a significant difference between the cluster and the total sample rather than the fact that for EI companies drivers of regulatory nature are clearly the lowest ranked. For NEI companies instead they receive an average score of 3.02, so they are considered almost as important as those of an informative nature (average score of 3.05).

**Table 32: Perceived drivers grouped into families - Cluster by firms' energy intensity**

| Drivers family | Average score | NEI | EI | Δ(NEI-sample)% | Δ (EI-sample)% | Δ (NEI-EI)% |
|---|---|---|---|---|---|---|
| No. Of Enterprises | 61 | 41 | 20 | | | |
| Regulatory | 2,98 | 3,02 | 2,91 | 0,03 | 0,07 | 0,11 |
| Economic | 3,16 | 3,17 | 3,15 | 0,01 | 0,01 | 0,02 |
| Information | 3,07 | 3,05 | 3,11 | 0,02 | 0,04 | 0,06 |

**Note: Meaningfulness of Δ: (••) more than 20%; (•) between 15% and 20%; (no dots) less than 15%.**

*7.2.4.4 Correlation analysis*

Referring to the barriers there is nothing to report for the NEI companies, while for the EI there is only a correlation of medium strength between the barriers relating to the competences and lack of awareness. Lack of awareness seems to affect the competences, in particular is plausible to think that a power of awareness to the issue would push for the acquisition of skills.

**Table 33: Correlation between barriers -NEI**

| NEI | Economic | Behavioral | Organizational | Related to competences | Lack of awareness | Technology related | Information |
|---|---|---|---|---|---|---|---|
| Economic | 1,00 | 0,17 | 0,11 | 0,31 | 0,20 | 0,07 | 0,08 |
| Behavioral | | 1,00 | 0,02 | 0,11 | 0,32 | 0,13 | 0,09 |
| Organizational | | | 1,00 | 0,06 | 0,01 | 0,11 | 0,105 |
| Related to competences | | | | 1,00 | 0,26 | 0,23 | 0,22 |
| Lack of awareness | | | | | 1,00 | 0,03 | 0,11 |
| Technology related | | | | | | 1,00 | 0,56 |
| Information | | | | | | | 1,00 |

**Table 34 : Correlation between barriers -EI**

| EI | Economic | Behavioral | Organizational | Related to competences | Lack of awareness | Technology related | Information |
|---|---|---|---|---|---|---|---|
| Economic | 1,00 | 0,20 | 0,11 | 0,33 | 0,05 | 0,10 | 0,13 |
| Behavioral | | 1,00 | 0,01 | 0,33 | 0,45 | 0,24 | 0,28 |
| Organizational | | | 1,00 | 0,05 | 0,29 | 0,50 | 0,19 |
| Related to competences | | | | 1,00 | 0,67 | 0,38 | 0,37 |
| Lack of awareness | | | | | 1,00 | 0,16 | 0,38 |
| Technology related | | | | | | 1,00 | 0,47 |
| Information | | | | | | | 1,00 |

From the correlation of drivers for non-energy intensive companies (table in appendix B) is known as the considerations are the same as those made for the analysis of medium-small enterprises. It is reconfirmed the strong correlations between the information drivers, those related to subsidies, those relating to technical and managerial support and those about people with real ambitions. Another time it is highlights the fact that the company expects from an external energy audit also technical and management support and to receive clear and reliable information even if the correlation becomes of medium entity in both cases. Analyzing the case of energy-intensive companies, it can see correlations between staff with real ambition, voluntary agreements and green image. To get a green picture on the market people with real ambitions are. In case of voluntary agreements, it must to be sure to have the strength and skills to support the agreement. The ambition of those who actually work on machinery plays a fundamental role. We note however that there is a medium-sized correlation between green image and voluntary agreements. Nevertheless the value of the correlation (0.63) is very close to the low threshold, and also these two drivers are not considered to be of primary importance from this cluster. It is

then shown a correlation, always of medium size, between management support and availability, clarity and trustworthiness of information.

*7.2.4.5 Analysis of decision making*

Making a comparison with the total sample and taking into account the most important drivers discussed above, we see now what are the differences that can be highlighted by comparing the sample EI with the NEI one. The driver awareness, relevant for the first two steps, seems to be more appreciated by the sample NEI (average score of 3.41 vs 3.22 for EI firms) because, probably, companies EI believe that the awareness of the energy efficiency importance is already widespread. Drivers of economic nature are on the same level for the two samples, with the exception of willingness to compete and cost reduction from lower energy use that become more importance (difference between the two clusters of about 10% and 15% respectively) for EI firms probably looking more at the costs and considering energy efficiency as a tool to achieve a competitive advantage. So, the driver willingness to compete exceeds a score of 3 for EI companies. In fact, it would definitely help to overcome organizational and behavioral problems in the first decision-making step by bringing a strong commitment to all areas of the company. The transmission of a message that these investments could lead to a competitive advantage may therefore be a key point on which to act for policy makers in relation to EI companies. On the other hand, this driver coupled with cost reduction from lower energy use can help EI companies very strongly in overcoming economic and behavioral barriers related to the financial analysis step. The cost reduction from lower energy use and the willingness to compete would lead the company to analyze these investments in a different light.

## *7.2.5 Analysis by firms' geographical area*

*7.2.5.1 Analysis of barriers*

**Table 35: Perceived barriers - Cluster by firms' geographical area**

| Barriers<br>No. of Enterprises | Average score<br>61 | BS<br>27 | No BS<br>34 | Δ (BS-sample)% | Δ (No BS-sample)% | Δ (BS-No BS)% |
|---|---|---|---|---|---|---|
| Economic | 3,20 | 3,04 | 3,33 | 0,16 | 0,13 | 0,29 |
| Behavioral | 2,60 | 2,70 | 2,52 | 0,10 | 0,08 | 0,19 |
| Organizational | 2,30 | 2,26 | 2,33 | 0,04 | 0,03 | 0,07 |
| Related to competences | 2,42 | 2,15 | 2,63 | 0,27 | 0,21 | 0,48 (•) |
| Lack of awareness | 2,57 | 2,56 | 2,58 | 0,01 | 0,01 | 0,02 |
| Technology related | 2,27 | 2,19 | 2,33 | 0,08 | 0,06 | 0,15 |
| Information | 2,35 | 2,44 | 2,28 | 0,09 | 0,08 | 0,17 |

**Note: Meaningfulness of Δ: (••) more than 20%; (•) between 15% and 20%; (no dots) less than 15%.**

Comparing the companies of Brescia with the whole sample, there is a significant difference between 10% and 15% for the barrier related to competences. In particular, this barrier is less felt by companies of Brescia and this suggests that they have a competent staff able to find inefficiencies in the energy efficiency field. Instead, comparing the sample of Brescia with the non-Brescia one, it is noted for the same barrier that there is a significant difference between 15% and 20%. It is probably for this reason that no-Brescia's firms have given a higher score (average value of 3.27) than companies of Brescia (average value equal to 3.11) to the driver Technical support, even if the analysis does not reveal a significant difference. The fact of the lower weight given to barriers relating to the competences for the companies of Brescia can be reasonably explained by the fact that many of them during the telephone interviews emphasized a collaboration with universities.

*7.2.5.2 Analysis of drivers*

Passing to the drivers, there is a significant difference in the range 15%-20% between the two clusters for the driver External energy audits, more relevant for the cluster of Brescia. It is likely that there is a sort of distrust in the external bodies from the non-Brescia's firms point of view. In fact, we note differences between the cluster, although not exceed 15% of significance for the driver program of education and training. This is most important for Brescia companies highlighting the fact that they are committed for the skills placing greater confidence in any external collaborations to retrieve them.

**Table 36: Perceived drivers - Cluster by firms' geographical area**

| Drivers<br>No. of Enterprises | Average<br>61 | BS<br>27 | No BS<br>34 | Δ(BS-sample)% | Δ (No BS-sample)% | Δ (BS-No BS)% |
|---|---|---|---|---|---|---|
| Voluntary agreements | 2,90 | 2,85 | 2,94 | 0,05 | 0,04 | 0,09 |
| Efficiency due to legal restrictions | 3,00 | 3,11 | 2,91 | 0,11 | 0,09 | 0,20 |
| Green image | 2,82 | 2,93 | 2,73 | 0,11 | 0,09 | 0,20 |
| Long-term energy strategy | 3,22 | 3,22 | 3,21 | 0,01 | 0,00 | 0,01 |
| Willingness to compete | 2,78 | 2,93 | 2,67 | 0,14 | 0,11 | 0,26 |
| Management with real ambitions/comm. | 3,17 | 3,33 | 3,03 | 0,17 | 0,13 | 0,30 |
| Staff with real ambitions | 3,03 | 3,11 | 2,97 | 0,08 | 0,06 | 0,14 |
| Increasing energy tariffs | 3,15 | 3,15 | 3,15 | 0,00 | 0,00 | 0,00 |
| Cost reduction from lower energy use | 3,22 | 3,19 | 3,24 | 0,03 | 0,02 | 0,06 |
| Public investment subsidies | 3,52 | 3,67 | 3,40 | 0,15 | 0,12 | 0,27 |
| Private financing | 3,28 | 3,33 | 3,24 | 0,05 | 0,04 | 0,09 |
| Management support | 3,15 | 3,30 | 3,03 | 0,15 | 0,12 | 0,26 |
| Technical support | 3,20 | 3,11 | 3,27 | 0,09 | 0,07 | 0,16 |
| External energy audits/sub metering | 2,77 | 3,00 | 2,58 | 0,23 | 0,19 | 0,42 (•) |
| Programs of education and training | 2,75 | 2,93 | 2,61 | 0,18 | 0,14 | 0,32 |
| External cooperation | 2,52 | 2,63 | 2,43 | 0,11 | 0,09 | 0,20 |
| Awareness | 3,35 | 3,15 | 3,51 | 0,20 | 0,16 | 0,36 |
| Technological appeal | 1,80 | 1,74 | 1,85 | 0,06 | 0,05 | 0,11 |
| Knowledge of non-energy benefits | 3,33 | 3,30 | 3,36 | 0,04 | 0,03 | 0,07 |
| Availability of information | 3,32 | 3,22 | 3,39 | 0,09 | 0,08 | 0,17 |
| Clarity of information | 3,52 | 3,44 | 3,57 | 0,07 | 0,06 | 0,13 |
| Information about real costs | 3,60 | 3,59 | 3,61 | 0,01 | 0,01 | 0,01 |
| Trustworthiness of information | 3,53 | 3,48 | 3,57 | 0,05 | 0,04 | 0,09 |

**Note: Meaningfulness of Δ: (••) more than 20%; (•) between 15% and 20%; (no dots) less than 15%.**

*7.2.5.3 Analysis of driver's families*

Nothing to report instead with regard to the drivers categorized as: regulatory, economic and information.

**Table 37: Perceived drivers grouped into fimilies - Cluster by firms' geographical area**

| Drivers family | Average | BS | No | Δ(BS-sample)% | Δ (No BS-sample)% | Δ (BS-No BS)% |
|---|---|---|---|---|---|---|
| No. of | 61 | 27 | 34 | | | |
| Regulatory | 2,98 | 3,03 | 2,95 | 0,04 | 0,04 | 0,08 |
| Economic | 3,16 | 3,24 | 3,10 | 0,08 | 0,06 | 0,14 |
| Information | 3,07 | 3,07 | 3,07 | 0,00 | 0,00 | 0,01 |

**Note: Meaningfulness of Δ: (••) more than 20%; (•) between 15% and 20%; (no dots) less than 15%.**

*7.2.5.4 Correlation analysis*

For the correlation between drivers in the sample of companies of Brescia, we see a strong correlation (value equal to 0.84) between management with real ambitions and commitment and staff with real ambitions because, once again, it is believed that it is important not only a push from top management but also the cooperation of all staff (table in appendix B). All the considerations expressed before in the other clusters, apply to correlations between: public investment subsidies and private financing, management support and technical support, technical support and external energy audits, and between drivers related to the availability, clarity, trustworthiness of information as well as information about real costs. We further point out a correlation between management support and trustworthiness of information, and between technical support and clarity of information that, although they are at the limit of the lower threshold (in both the cases the value is equal to 0.61), show that companies are expecting from these types of supports also clear, detailed and reliable information in order to make correct assessments.

In the sample of companies not located in Brescia, we found the same results seen for the sample of Brescia with two differences: in this case, it does not exist a correlation between management support and trustworthiness of information, and between technical support and clarity of information; moreover, there is a correlation between voluntary agreements and public investments subsidies probably because these companies associate agreements with the government with grants.

Nothing to report with regard to the correlations between barriers.

**Table 38: Correlation between barriers - BS**

| BS | Economic | Behavioral | Organizational | Related to competences | Lack of awareness | Technology related | Information |
|---|---|---|---|---|---|---|---|
| Economic | 1,00 | 0,20 | 0,05 | 0,04 | 0,06 | 0,04 | 0,05 |
| Behavioral | | 1,00 | 0,04 | 0,25 | 0,29 | 0,08 | 0,22 |
| Organizational | | | 1,00 | 0,16 | 0,03 | 0,48 | 0,26 |
| Related to competences | | | | 1,00 | 0,52 | 0,52 | 0,56 |
| Lack of awareness | | | | | 1,00 | 0,46 | 0,31 |
| Technology related | | | | | | 1,00 | 0,50 |
| Information | | | | | | | 1,00 |

**Table 39: Correlation between barriers - NO BS**

| NO BS | Economic | Behavioral | Organizational | Related to competences | Lack of awareness | Technology related | Information |
|---|---|---|---|---|---|---|---|
| Economic | 1,00 | 0,27 | 0,19 | 0,01 | 0,12 | 0,36 | 0,34 |
| Behavioral | | 1,00 | 0,11 | 0,19 | 0,12 | 0,40 | 0,20 |
| Organizational | | | 1,00 | 0,30 | 0,18 | 0,10 | 0,13 |
| Related to competences | | | | 1,00 | 0,04 | 0,36 | 0,20 |
| Lack of awareness | | | | | 1,00 | 0,20 | 0,07 |
| Technology related | | | | | | 1,00 | 0,71 |
| Information | | | | | | | 1,00 |

### *7.2.5.5 Analysis of decision making*

Making a comparison with the total sample and taking into account the most important drivers discussed above, we see now what are the differences that can be highlighted by comparing the sample BS with the No BS one. In this first phase of decision making, one of the two drivers stronger, trustworthiness of information, is perceived in the same way by the two samples (BS and No BS), while the other significant driver, awareness, has been considered more important from the sample No BS, with an average score of 3.51 vs 3.15 for the sample BS. In fact, even if not signaled, there is a significant difference of about 10% between the two samples. Probably, companies of Brescia believe that the awareness of the energy efficiency importance is already widespread. Similar considerations apply to the step 2 in which the driver awareness turns out to be stronger. Its activation can eliminate the barrier lack of awareness and, over time, also the behavioral one, because it is likely that who becomes conscious on the theme of energy is brought to change his/her attitude in how he/she operates. Overall, we can say that the drivers of information (knowledge of

non-energy benefits, information about real costs, availability of information, clarity of information, trustworthiness of information), that have a very high weight in the subsequent steps, have the same importance for the two samples. This leads us to say that, as in the case of the total sample, the related barriers of the various steps may be easily overcome. Last small difference appears in the fifth step (financial analysis and financing) in which the sample of Brescia feels more important than the other public investment subsidies (3.67 vs 3.40).

# Chapter 8

# Conclusions

The issue of energy efficiency today is yet vivid and improving energy efficiency has been pointed out as the greatest contributor to energy demand reduction and, in turn, to GHG emissions mitigation. An important breakthrough in the field of environmental and energy policy took place at the European Council meeting of 2007, where ambitious energy and climate change objectives for 2020 were adopted namely: reduce GHG emissions by 20%, increase the share of renewable energy to 20%, and make a 20% improvement in energy efficiency. Nevertheless, with current efforts, the target of improving energy efficiency by 20% is unlikely to be achieved (European Commission, 2010): in fact, most recent projections show only a 10% cut will be reached. Despite the need for increased industrial energy efficiency, several studies indicate that cost-effective energy efficiency measures are not always implemented, which is explained by the existence of barriers to energy efficiency. This concerns all the companies and in particular the small- and medium-sized enterprises (SMEs) which cover a consistent share of energy consumption, are usually less efficient than large enterprises and have received little attention by researcher as well as policy makers. The literature dealing with the study of the mechanisms of barriers proved to be very broad and satisfactory. In fact, several authors have developed taxonomies of barriers from a theoretical point of view and also for empirical investigation. Extending the analysis of the literature for studies that focus on the ways to overcome these barriers, we note the lack of a rigorous taxonomy. Therefore, starting from the few contributions presented in literature, we provided our own definition and we developed a new taxonomy of drivers for energy efficiency. Our framework is characterized by being innovative, rigorous and comprehensive compared to the existent works. In particular, it highlights the difference between policies, affecting the external system in which a company operates, from drivers that act directly inside the organization. We have classified drivers according to four attributes: nature, targeted barriers, actors responsible for their stimulus internally and externally to the firm, and step of the decision-making processes affected by drivers. The new classification of drivers was presented in section 5.1.2, and in the next sections drivers are categorized according to the actors recognized from the literature and responsible for their stimulus and according to the barriers they hit. It is important to be clear about the difference between nature and effect, as for nature we refer to either the result of the driver or the benefits that its implementation can bring to an enterprise. By nature of the driver, indeed, we mean how it

is perceived in, or what kind of change it can bring to the company. Additionally, we have developed a new model for the decision-making process to which reference is made for the classification of drivers. After a literature review we have organized this process through six decision step: Awareness, Needs and opportunity identification, Technology identification, Planning, Financial analysis and financing, Installation start-up and training. The final model thus refers to policies that have an impact on companies through drivers. The policy maker does not always act directly (thus transforming a policy to a driver for an enterprise); instead, various intermediaries of the so-called energy efficiency supply chain, such as financial institutions, IAGs, manufacturers, suppliers, installers, ESCOs, customers, etc., help to spread drivers into the company.

The model has been tested through exploratory studies to find confirmation of our framework and refine some details. We have carried out our model validation in a very broad context, in enterprises with very different characteristics (in terms of sector and firm's size). This has enabled to verify the effectiveness of the proposed model as well as its solidity. During this phase, it was possible to delve deeply into the problem, as each driver has been explored in terms of its impact on every decision-making step and on specific barriers. In addition, the classifications made in relation to their nature and to the actors who are responsible for the stimulation has been confirmed. In conclusion, the developed model has been tested, refined, and then adapted to cover the issue without leaving gaps.
Then we have proceeded with an extensive empirical analysis of our framework. We have decided to investigate the Lombardy manufacturing sector, since this geographical area is strategic for the Italian economy, selecting medium-small (from 50 to 99 employees) and medium-large (from 100 to 250 employees) enterprises from different areas. Our choice towards larger enterprise (although within SMEs) has been made to point out the different issues addressed by our framework, that in smaller SMEs could be condensed in very easy routines by entrepreneurs or firm's owners. The selection of sectors has been focused on four relevant industrial activities in Lombardy, namely: manufacture of non-metallic mineral products (C23), manufacture of basic metals (C24), manufacture of fabricated metal products (C25), and manufacture of machinery and equipment (C28). The companies have been chosen to highlight particular business features through which understand if and how these affect the perception of energy efficiency barriers and drivers. The analysis has also been performed differentiating companies by: size, energy intensity and location. The results were obtained through telephone interviews conducted with holders, managers or other key people responsible of energy-efficient technologies and practices investments. We have decided to ask at first the barriers divided into macro-areas (economic, behavioral, organizational, related to competences, lack of awareness, technology-related, and information) with reference to the studies present in the literature, and then the drivers one by one. This procedure has allowed us to highlight the most relevant issues by enterprises and then to evaluate the possible solutions.

The analysis on the whole sample highlighted the relevance of economic barriers, highlighting that the availability of capital is a key issues to start an investment. In second place, we have found behavioral barriers, suggesting that other priorities or lack of interest in relation to the topic of energy issues are particularly suffered by enterprises. Given the nature of the sample explored, it seems reasonable that organizational barriers are classified as very low. Indeed, in general SMEs are low structured organizations. In addition to that, information and technology-related barriers are perceived to be low. This might be due to the fact that the investigation on barriers has been conducted by macro-areas, and respondents highlight the large amount of information on available technologies on the market. When looking at factors influencing drivers and barriers to energy efficiency, the firm's size seems to affect barriers related to awareness. This might be due to the current situation of the Italian market, in major part populated by the small to medium businesses and suffering from a deep economic and financial crisis. Hence, it is likely that priorities of enterprises are towards keeping the business running, that towards energy efficiency, nonetheless without a clear comprehension of the effective benefits in terms of productivity achievable through energy efficiency. The same difference seems to emerge for the differentiation by energy intensity, for which NEI suffer more from awareness issues. This result appears to be reasonable as EI by their nature have a greater awareness of the issue. The geographical location seems to influence the competence-related barriers. In fact, drivers dealing with skills, as program of education and training and external energy audits, are considered by enterprises located in Brescia as more relevant than for enterprises located in other provinces in Lombardy. This result can be reasonably explained by the fact that many of them emphasized their collaboration with universities and knowledge centers.

The most critical drivers from the experimental analysis turn out to be information about real costs, trustworthiness of information, public investment subsidies, clarity of information, awareness, knowledge of non-energy benefits, availability of information and private financing. Although six out of eight of the most relevant drivers are related to information, economic drivers are still the most predominant in an analysis by categories. This seems to be a plausible outcome, as the economic availability is always an important mean to address an investment. Moreover, this results may suggest that companies want to be provided with all necessary information and be supported by an economic point of view. When looking at the analysis of correlation between barriers and drivers, our investigation revealed usually very low correlation coefficients, thus showing the capability of our model to separate the issues. In very few cases, with respect to information drivers, a higher correlation can be appreciated, suggesting further research to investigate in deeper detail the content and form of information, linking them to specific technology and their suppliers. The limited firm's size of our sample implies that the main intermediaries between the enterprises and its technology suppliers are mainly local installers and suppliers. This is mainly due to a lack of competences and time to cover all aspects

concerning technologies, usually focusing on core production activities. Hence, energy management and control can be considered as peripheral. Therefore, installers and suppliers are responsible to provide technologies as well as the information they possess. This means that enterprises strictly depend on either on their knowledge about existing opportunities, or by their interests in installing one specific technology. Our study has also revealed that interventions need to be studied in detail to minimize externalities paying particular attention to where to act, at the economic engagement, at the total implementation costs (hidden costs) and at the ease of detection of the future benefits. In particular, the studies should be targeted to the characteristics of the investment and the impact they may have within an enterprise, turning all in information to be provided to decision-makers. In doing this, information is recognized to be desired from very trusted sources and customized to the specific case. This means that information does not come from trustworthy sources, and is not directed and designed for businesses. Further studies for a more development of the concept should therefore be targeted to expand these results, in order to understand which are the information that companies consider necessary to decide, which information is provided and how it is provided, exploring the possible misalignment between received and provided information.

Our analysis has also revealed drivers classified as the lowest, namely: technological appeal, external cooperation, programs of education and training and external energy audit. The result for technological appeal seems to be reasonable given the lack of visibility of the sample. The companies surveyed do not have particular reasons to appear in public as trendy or particularly attractive. Regarding the other very low-ranked drivers it seems that enterprises distrust external agencies. These are often thought of as unsuitable or too orientated to their business so that they would not be particularly helpful. In addition it seems that enterprises perceive themselves as sufficiently competent. This could be due to the fact that the questions are related to perceived barriers and is therefore likely to attend an overestimation of capabilities. This preliminary analysis clearly points out the need to understand in more detail the actual competences in the evaluation of inefficiencies. If it were possible then measure the level of internal competence on this issue and that it was clear for the company, it could radically change the importance of drivers related to external skills. At this point, the company would consider external competences important factors to overcome their problems . Useful considerations for policy makers may be on promoting audit made by external certified sources released to business solutions, such as university, thus more likely to be unbiased with respect to interest with respect to specific technologies.

One of the most relevant features of our framework is the capability to evaluate the effect of the drivers on the decision-making process. Given the high importance attached to informative drivers, to the awareness and to subsidies and private financing, it is reasonable that the decision-making steps most affected will be 1 and 5. Regarding the first

step, drivers of information are the most important, and the awareness, being the key point of consciousness about energy efficiency, is reflected by a wider effect contributing to the reduction of many barriers, including the behavioral ones. With regard to step 5, financial analysis and financing, drivers of information are still important, but economic ones become important as well. As it was plausible to expect, especially in this period of crisis, the economic aspect is very important. Public investment subsidies is more relevant because it represents a driver according to which the company could receive capital at lower rate, while private financing presupposes a greater effort by the company that will have to pay back the capital received within a specified period and with market interest rates. As for the other decision-making steps, the sample did not show any particular problem, classifying the relative barriers as usually low. This latter consideration could also be extended to the existing sample, if we were able to measure the real barriers and drivers, showing lack of competences. In conclusion, our analysis revealed that the increase of awareness as well as financial analysis and financial support of the investments have emerged as most critical in the decision-making process to adopt an energy-efficient technology.

The analysis by energy's intensity reveal that drivers such as information about real costs are still important. After that, trustworthiness and clarity of information and cost reduction from lower energy use can be appreciated. Indeed, this driver is very important for energy intensive enterprises, in which the cost of energy has a strong influence on production costs, thus becoming a crucial issue. We have also noted a difference in the driver willingness to compete for the analysis by sector, although the significance did not show to be particularly high. Nonetheless, it is worthy pointing out that this driver has ben considered as of medium-high importance for EI enterprises, whilst presented a very low score for the whole sample. The overall low importance value is probably due to the distribution of the sample, composed by two thirds of NEI companies and only one third of EI ones. Therefore, when clustering by energy consumption, this importance emerges, showing that more energy intensive enterprises are starting to conceive energy efficiency as a competitive factor. Moreover, the awareness of the productivity benefits coming from energy efficiency investments is not rooted yet, showing that energy efficiency is quite conceived in terms of energy savings and not as a strategic factor able to improve firm's competitiveness.

By looking the classification for drivers families, we can observe a very interesting result. Above all, regulatory drivers are the lowest ranked. Following the concept of the carrot and stick of (B. S. Reddy & Assenza, 2007), we note how companies believe that, by forcing regulations, they do not receive a beneficial effect on the implementation of energy efficiency, rather preferring self-motivated and voluntary actions. This result undergoes substantial changes if we focus on the analysis of drivers for companies divided by size. It can be noted indeed how the forces belonging to this category have all received a higher

score from medium-large companies. In fact, the analysis for this cluster reveals that regulatory drivers are on the first place surpassing even the economic ones. This seems a plausible outcome given the different social visibility of the two clusters: rules and regulations will surely have a greater effect on larger companies that are exposed to greater visibility. The other significant difference regards the driver green image that is perceived as more important for medium-large companies. For the policy makers, promoting a market study to demonstrate the importance of being green may shift the focus of the medium-small companies towards energy efficiency.

Our research has opened several points providing interesting suggestions for future research.

It could be interesting expanding the research to the real barriers rather than to perceived interventions, making specific recommendations for policy makers. It is known as a policy based may be more effective when addressing not only the perceived barriers, that are those based on which the decision are taken, but also real barriers, thus giving a picture of the real problems of enterprises. Furthermore, our empirical investigation has been based on the general perception of drivers. Further research could then go with more detail on decision-making and barriers to every step. In doing this, the barriers that have been explored only by macro-areas could be expanded in detail, thus allowing to understand drivers to specific barrier in a given step of the decision-making process.

It would be also interesting to expand the study to understand which areas of the companies are affected by specific drivers. Given the complexity of the problem, we have not been able to go deeper into this issue. However, it seems very interesting to see which divisions and therefore who are directly involved into the company and which benefits can be obtained. It would lead, therefore, to study specific actions to influence their perceptions and make them aware of the importance of efficiency. This aspect is of particular interest for large companies which have a much more complex and articulated structure with respect to SMEs. In addition, our focus has been on the manufacturing sector, and the perception of the drivers remains unexplored for buildings, transport, households, etc.. Future studies could then progress in order to use this taxonomy and test it in other fields, as the drivers have been designed to be adaptable in every field .

During our investigation we focused more on technologies rather than on practices to make energy efficiency. Moreover, we have not considered specific technologies for a particular sector, and it is clear that several alternatives exist. Future research could then be addressed to analyze in detail which drivers are the most suited for specific technologies. Indeed, making a classification of actions or specific interventions would lead to categorize this taxonomy in accordance to another attribute such as for which type of intervention they are designed. In fact, to improve the efficiency of their status, companies do not necessary need to invest capital in a new machinery, but it is possible to adopt actions at

management level to improve the existing equipment. Intervention on the management side may therefore be particularly interesting to be studied, because it would lead to benefits and would not necessarily require a financial commitment. In this regard, it would be useful to provide new ideas on energy management. As the role of energy has become increasingly important over time, energy management has evolved in terms of the required level of detail. This has been further affected by many factors, such as new technologies, the structure of industries, changing economic, environmental and social pressures, the availability of support and changing business strategies. According to some studies, energy management could influence not only energy demand and costs but also the energy-related environmental and social impacts that affect, for example, a company's position in the carbon market, customers' willingness to pay and shareholders' willingness to invest. Other authors such as (Abdelaziz et al., 2011) think indeed that energy management is the strategy of meeting energy demand when and where it is needed. This can be achieved by adjusting and optimizing energy using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems. There are therefore those who associate the energy manager to energy efficiency from a purely technical point of view (Sivill et al., 2012), and others that bind this figure to tasks much wider which also affect corporate strategies (Abdelaziz et al., 2011). Since there are ambiguous and different visions on the figure of energy manager that is becoming more and more widespread, it would be interesting to investigate further in this direction to completely understand what are the tasks and problems that can be addressed by this figure.

Another area in which future research may find ample space it concerns the used sample. Our investigation to validate the framework has been focused on single enterprise, in which we have asked barriers and drivers. Nonetheless, it seems very interesting to understand how expand the analysis also to the other actors involved in the provision of technologies and practices. Indeed, the investigation could look on players such as installers, suppliers, customers, IAGs etc. to understand what is their perception on barriers and drivers. This would enable the comprehension of the mechanisms driving their actions and what they think can help enterprises and be, at the same, time suitable for their business. Starting from this evidence, we could compare the results, assess, characterize and discuss possible misalignments. Doing that would also provide a competitive edge to the taxonomy, that could be further refined according to the further insights.

The analysis of the empirical results allowed us to see that the informative drivers have not received homogeneous scores. Indeed, some drivers can be observed in the highest ranked positions, whilst others are judged as being of low importance. Hence, to fully understand this effect, future research could address the detailed analysis of the categories of drivers. Moreover, also within a given category, attention could be paid in further dividing drivers into sub-categories.. This classification could explain why drivers belonging to the same

subfamily present similar scores in the ranking. Moreover, this level of detail could be particularly useful for studying specific interventions at the policies level.

One issue that our research has opened to new scientific studies regards the understanding of the indirect benefits of these investments. From the analysis of the results we can observe that the knowledge of non-energy benefits is considered a very high driver, and it is an indicator showing that energy efficiency has not been conceived in terms of non-energy benefits. It is clear, therefore, that studies on a strict classification of these benefits would be certainly useful and necessary. In the literature, only few authors such as (Worrell et al., 2003), (Skumatz & Gardner, 2005), (Mills & Rosenfelds, 1996), (Lung et al., 2005) and (Pye & McKane, 2000) have dealt with the issue, but all these studies are based on very few and specific case. Nonetheless, a thorough and complete theoretical framework is missing. With such a categorization, also the investigation on drivers for energy efficiency would obtain benefits, as it would allow to deepen the understanding of, e.g., the driver knowledge of non-energy benefits. Indeed, also policy-makers can receive useful suggestions to understand which aspects deserves more attention and commitment to have a greater impact on enterprises, thus developing more effective policies for energy efficiency.

# APPENDIX

# Appendix A: Literature review of barriers for energy efficiency

| Article | Region | Sector/ Market | Approach to the problem | Main barriers and findings |
|---|---|---|---|---|
| ***Theoretical*** | | | | |
| (Sanstad et al., 1995) | Non specific | All sectors | Economic | The main focus is on the problem of discount rates and criteria for the evaluation of investments in energy efficiency |
| (Nichols, 1994) | USA | All sectors | Economic | The gap can be explained fairly readily if we use some-what higher (though far from irrational) discount rates to compute new adopters' net benefits under the TRC test. |
| (DeCanio, 1993) | USA | EE investments | Socio-behavioral | Internal hurdle rates are often set at for bounded rationality, principal- agent problems, and moral hazard. |
| (Brown, 2001) | USA | Motor driven systems, lighting | Political | Large-scale market failures and barriers prevent consumers in the USA from obtaining energy services at least cost. |
| (Hirst & Brown, 1990) | USA | All sectors | Socio-behavioral | The primary barriers preventing EE interventions include distortions in fuel prices, limited access to capital, supply infrastructure limitations, and information gaps. |
| (Hassett & Metcalf, 1993) | USA | All sectors | Economic | High discount rates attributed to investors making energy conservation investments are not irrational or the result of some market failure. |
| (Sanstad & Howarth, 1994) | USA | EE investments | Technological, Economic | Problems of imperfect information and bounded rationality on the part of consumers, for example, may lead real worm outcomes to deviate from the dictates of efficient resource allocation. |
| (Johnson, 1994) | Non specific | EE investments | Economic | Theory of irreversible investment and extended NPV methods suggest these approaches may offer promise for improving our understanding of energy technology investment decisions. |

| | | | | |
|---|---|---|---|---|
| (Cooremans, 2009) | Non specific | EE investments | Economic | For the success of investments in energy efficiency is important to stress their impact on competitive advantage to highlight the strategic character of these. |
| (Jaffe & Stavins, 1994) | Non specific | EE investments | Economic | Distinction between market failure and non market failure, Identified five separate and distinct notions of optimality. |
| (Carlsmith, Chandler, Machmahon, 1990) | USA | EE investments | Socio-behavioral | The main problems for development of energy efficiency are recognized to be in uncertainty about future fuel prices and about precise future estimates |
| (Golove & Eto, 1996) | Non specific | Lighting, ventilation | Political | Market failure as an explanation of the difference between the current choices in EE. Six types of them are identified |
| (DeCanio, 1998) | USA | EE investments | Economic | Market failure and organizational barriers are identified as the majors problem for the undertake of energy efficiency investments. Are provided insights for future energy policy. |
| (Geller et al., 2006) | OECD countries | EE investments | Technological | Are considerate technological, institutional, and market barriers. It is given a more emphasis on programs and policies to overcome barriers |
| (Patrik Thollander, Palm, & Rohdin, 2000) | Non specific | EE investments | Technological, behavioral | 15 theoretical barriers are divided into three different categories, depending on each barrier's system complexity. |
| (A. K. N. Reddy, 1991) | USA, India | EE investments | Technological | Analysis of aspects of the various sectors that interact and cooperate in achieving energy efficiency. For each field then identifies barriers and actors. |
| (B. S. Reddy & Assenza, 2007) | Non specific | EE investments | Socio-behavioral | New taxonomy of barriers dividing them into three categories, macro meso and micro barriers. |
| (Dilip et al., 1999) | Latin America | Motor driven systems | Economic | 4 categories of market imperfections: information dissemination, burocratic structure and limited scope of attention, return to scale and network externalities, capital market imperfection. |
| (Weber, 1997) | Non specific | EE investments | Socio-behavioral | Barriers and actors: institutional (social approach), market failure, organizational (social system influenced by routines, procedures, organizational structures), behavioral (individuals attitudes) and values for energy conservation. |
| (Walsh & Thornley, 2012) | Western Europe | Heating | Technical | A strategic mapping exercise found barriers relating to location, cost and the availability of infrastructure to be the most significant, augmented by a number of institutional issues relating to company strategy and priority. |

| | | | | |
|---|---|---|---|---|
| (Verbruggen et al., 2010) | Non specific | EE investments | Economic | Extended, and hopefully also clearer, definitions of some major factors and relationships that affect the development and deployment of RE supplies in given energy economies. |
| (Worrell, 1995) | China | EE investments | Technological | Advanced steel-making technologies could reduce the energy intensity dramatically at lower capital and operating costs, while reducing polluting emissions. |
| (Ostertag, 1999) | Non specific | Motor driven, ventilation, compressed air | Economic | Integration of trans costs not always reduce or neutralize the gap (no-regret potential), the result of a systematic integration of this technology costs EE and their respective standard is not yet clearly defined. |
| (Sanstad, Koomey, 1993) | Non specific | EE investments | Economic | Barriers for energy efficiency are influenced by: social factors, behavioral and managerial factors and problems of market structure. (Criticism to Sutherland 1991) |
| (Fleiter et al., 2011) | Western Europe | EE investments | Technological | Despite the evident existence of market failures and barriers for energy-efficient technologies, they are only partly and in a rather aggregated form considered in today's bottom-up models. |
| (E. L. F. de Almeida, 1998) | Western Europe | Motor driven systems | Technological | Although there is a potential for improvement in the EE of electric motors, the market structure and current decision-making practices are obstacles to the accomplishment of this potential. |
| (Unachukwu, 2011) | Nigeria | EE investments | Political, socio-behavioral | There is a need to evolve a national standard and address the barriers to energy efficiency as well as recognize the synergy between EE and renewable energy systems. |
| (Howarth & Andersson, 1993) | Non specific | Building | Economic | Structural characteristics of markets for energy-using equipment may impede the adoption of cost-effective energy-efficient technologies even when markets are competitive. |
| (Cooremans, 2011) | Non specific | All sectors | Economic | For a great success of an EE investments it is fundamental highlight its strategic character. |
| ***Empirical*** | | | | |
| (De Groot et al., 2001) | Western Europe | EE investments | Economic | The most significant barrier is the presence of other investments that are considered the most promising and important. |
| (Da-li, 2009) | China | EE investments | Technical, political | There is a large energy efficiency market potential for ESCOs in China. Presented a series of measures have been put forward for promoting the ESCOs |

| | | | | |
|---|---|---|---|---|
| (Sola & Xavier, 2007) | Latin America | Chemical, paper, food, wood | Socio-behavioral | Human factors are inversely proportional to energy losses, implementation of these factors can contribute to transpose the barriers to improve energy efficiency in organizations. |
| (Worrell et al., 2003) | USA | Iron and steel | Economic | Many industry decision-makers have already discovered the important benefits of energy efficiency technologies as a productivity investment. |
| (Blumstein et al., 1980) | USA | Building | Socio-behavioral | Majors barriers to energy conservation is the lack of a fundamental understanding of the nature of barriers and of systematic methods for evaluating strategies. |
| (Tiedemann, Sulyma, & Resources, 2009) | Canada | Machinery | Technological | Impact evaluation of the Power Smart Partners Industrial program. 4 key lessons. |
| (A. Trianni & Cagno, 2012) | Italy | Iron and steel, textile, plastic, wood | Technological | It is necessary to avoid bundling together SEs, MEs and MLEs, when it is likely not correct. |
| (Chai & Yeo, 2012) | Singapore | Pharmaceutical | Socio-behavioral, political | Close-loop framework to overcome energy efficiency barriers of four stages: motivation-capability-implementation-results |
| (Patrik Thollander et al., 2007) | Sweden | EE investments | Socio-behavioral, technical | The largest barriers in Swedish SMEs is the low priority of EE, to reduce this is necessary a strong public policy intervention targeting this companies. |
| (Tonn & Martin, 2000) | USA | EE investments | Socio-behavioral | First strong step toward the development of a life cycle model of industrial EE decision making. |
| (Palm & Thollander, 2010) | Sweden | Metal | Socio-technical | Actors from different sectors emphasize different barriers to energy efficiency and different reasons why cost-efficient energy efficiency measures are not implemented. |
| (P Rohdin & Thollander, 2006) | Sweden | Manufacturing non-energy intensive | Technical | Environmental Management Systems did not seem to have influenced the implementation rate of energy efficiency measures at the studied sites. |
| (Sardianou, 2008) | Greece | Chemical, metal, machinery, paper, food, textiles | Socio-behavioral | Industry can be encouraged to make energy efficiency investments by providing subsidies or favorable tax treatment. For efficiency improvements industries should be treated in subgroups. |
| (Shi, Peng, Liu, & Zhong, 2008) | China | Chemical, metal, machinery, paper, food, textiles | Political | For cleaner production to thrive in Chinese enterprises, it is necessary remove various regulatory, institutional, market, financial, informational, managerial and organizational barriers. |
| (Hein & Blok, 1995) | Western Europe | All sectors | Economic | For the selected companies the transaction costs mainly consists of information costs, the estimates of these costs is between 3% and |

| | | | | |
|---|---|---|---|---|
| | | | | 8% of the investments |
| (Painuly et al., 2003) | USA, Canada, Korea | Energy sector | Economic, Political | Potential for EE improvement in development countries is >30%, local financing market and ESCOs needs to be developed |
| (Sovacool, 2009) | OECD countries | Energy sector | Socio-behavioral | No single-policy mechanism is a panacea, and until comprehensive policy changes are implemented, renewable energy and energy efficiency will never realize their full potential. |
| (Poputoaia & Bouzarovski, 2010) | Romania | Energy sector | Political | District Heating (DH) sector is affected primary by legal barriers, DH regulation in Romania is still undergoing a process of transition. |
| (Nagesha & Balachandra, 2006) | India | Metal | Technical | Barrier priorities remained identical irrespective of the other dissimilarities between the clusters they belong. |
| (Kounetas et al., 2011) | Greece | EE investments | Economic | The level of information or knowledge acquired by a firm is technology specific. The technology vintage is the key factor determining the heterogeneity. |
| (Patrik Rohdin et al., 2007) | Sweden | Metal | Technical | energy consultants and other energy actors are considered trustworthy by the foundries, and thus may help solve organizational problems. |
| (Schleich, 2009) | Germany | Commercial and service | Economic | Numbers and types of relevant barriers vary across sub- sectors, and most sub-sectors are subject to relatively few of the barriers explored |
| (Patrik Thollander & Ottosson, 2008) | Sweden | Pulp and paper | Technical | This study has show that barriers to and driving forces for energy efficiency are not solely market-related. |
| (Cooremans, 2012) | Western Europe | EE investments | Economic | Energy-efficiency investments are perceived as weakly strategic by companies. This would explain why many energy-efficiency projects remain un-chosen. |
| (Schleich & Gruber, 2008) | Germany | Commerce, service | Techno-economic | Since barriers vary across sub-sectors, policies have to take these differences into account and they should not only target smaller organizations within sub-sectors. |
| (G. Wang, Wang, & Zhao, 2008) | China | Energy sector | Socio-behavioral | Development of relationships among some important barriers to energy saving through the ISM model.(not statistically validated) |
| (Richards, Noble, & Belcher, 2012) | Canada | Energy sector | Technical | A more systems-based approach that integrates investment in renewable energy development identifying and address underlying barriers would result in greater penetration of renewable energy. |
| (Kulczycka & Lipińska, 2003) | Poland | Energy Sector | Political | To liberalize energy market sector there is the possibility of using modern methods of trading but the role of the long-term contract |

| | | | | |
|---|---|---|---|---|
| | | | | is still dominant. |
| (Fleiter, Fehrenbach, Worrell, & Eichhammer, 2012) | Germany | Pulp and paper | Technical | The assessment of cost-effectiveness greatly depends on the discount rate assumed, as well as the shape of the cost curve. |
| (Sturm, Hugenschmidt, Joyce, Hofacker, & Roskilly, 2012) | Western Europe | Brewery | Technical | Efficiency is not a technological problem but a problem of realization of existing and well known measures. |
| (Martinot, 1998) | Russia | Manufacturing | Technical | In Russia many transaction barriers seriously limit investment in these technologies and technology transfer with other countries. |
| (Palm, 2009) | Sweden | Manufacturing | Socio-behavioral | Using lifestyle categories in the analysis of barriers can help in find cost-effective policy tailoring information to SMEs, it is also important for policy maker to divides company in categories. |
| (Painuly, 2001) | Non specific | Energy sector | Technical | Framework for identifying and overcoming barriers to renewable energy technologies (RETs).Measures to overcome the barriers may also be unique to a country/region. |
| (A. T. de Almeida et al., 2003) | Western Europe | Chemical, metal, machinery, paper, food | Technical | Equipment suppliers and other third parties can be used in a coordinated way to “gear up” effort to promote the market transformation of energy-efficient motors and drives. |
| (Massoud, Fayad, El-Fadel, & Kamleh, 2009) | Lebanon | Food | Socio-behavioral | Regulations coupled with appropriate financial incentives should persuade industries to converge to environmental standards. |
| (Zhang, Shen, & Chan, 2012) | Hong Kong | Energy sector | Technical | Valuable reference for Governments, contractors and other stake-holders in other countries in providing insights into their own barriers and possible mitigation approaches. |
| (Kounetas & Tsekouras, 2008) | Greece | Manufacturing | Economic | The firms' decision to adopt an EET is positively related to their profitability, while the diffusion rate of the EET is influenced by specific firm characteristics. |

# Appendix B: Correlation's tables of drivers for clusters

| MLEs | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | D16 | D17 | D18 | D19 | D20 | D21 | D22 | D23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D1 | 1,00 | 0,33 | 0,38 | 0,14 | 0,23 | 0,37 | 0,25 | - | 0,13 | 0,69 | 0,60 | 0,26 | 0,17 | 0,22 | 0,04 | 0,39 | 0,22 | 0,43 | 0,60 | 0,25 | 0,31 | 0,28 | 0,37 |
| D2 | | 1,00 | 0,21 | 0,23 | 0,08 | 0,33 | 0,21 | 0,09 | 0,08 | 0,38 | 0,26 | 0,03 | 0,03 | 0,18 | 0,14 | 0,34 | 0,00 | 0,06 | 0,26 | 0,19 | 0,11 | 0,11 | 0,20 |
| D3 | | | 1,00 | 0,24 | 0,30 | 0,06 | 0,08 | 0,20 | 0,04 | 0,24 | 0,18 | 0,40 | 0,20 | 0,32 | 0,38 | 0,25 | 0,41 | 0,39 | 0,54 | 0,06 | 0,12 | 0,05 | 0,06 |
| D4 | | | | 1,00 | 0,15 | 0,16 | 0,13 | 0,23 | 0,18 | 0,02 | 0,02 | 0,26 | 0,09 | 0,21 | 0,21 | 0,17 | 0,19 | 0,34 | 0,38 | 0,30 | 0,16 | 0,18 | 0,19 |
| D5 | | | | | 1,00 | 0,06 | 0,02 | 0,08 | 0,02 | 0,21 | 0,18 | 0,31 | 0,16 | 0,02 | 0,21 | 0,24 | 0,09 | 0,10 | 0,41 | 0,24 | 0,11 | 0,05 | 0,18 |
| D6 | | | | | | 1,00 | 0,87 | 0,14 | 0,17 | 0,66 | 0,70 | 0,11 | 0,01 | 0,38 | 0,08 | 0,45 | 0,07 | 0,08 | 0,26 | 0,11 | 0,14 | 0,13 | 0,16 |
| D7 | | | | | | | 1,00 | 0,07 | 0,11 | 0,60 | 0,64 | 0,04 | 0,06 | 0,40 | 0,16 | 0,35 | 0,18 | 0,18 | 0,12 | 0,02 | 0,07 | 0,27 | 0,08 |
| D8 | | | | | | | | 1,00 | 0,35 | 0,10 | 0,12 | 0,11 | 0,23 | 0,13 | 0,08 | 0,01 | 0,15 | 0,08 | 0,18 | 0,17 | 0,29 | 0,15 | 0,17 |
| D9 | | | | | | | | | 1,00 | 0,05 | 0,15 | 0,06 | 0,06 | 0,05 | 0,46 | 0,06 | 0,18 | 0,10 | 0,09 | 0,25 | 0,15 | 0,15 | 0,30 |
| D10 | | | | | | | | | | 1,00 | 0,88 | 0,04 | 0,09 | 0,33 | 0,09 | 0,34 | 0,35 | 0,19 | 0,33 | 0,03 | 0,19 | 0,10 | 0,16 |
| D11 | | | | | | | | | | | 1,00 | 0,16 | 0,03 | 0,38 | 0,08 | 0,30 | 0,15 | 0,12 | 0,24 | 0,02 | 0,18 | 0,00 | 0,14 |
| D12 | | | | | | | | | | | | 1,00 | 0,74 | 0,34 | 0,23 | 0,24 | 0,16 | 0,24 | 0,30 | 0,10 | 0,15 | 0,05 | 0,16 |
| D13 | | | | | | | | | | | | | 1,00 | 0,41 | 0,01 | 0,28 | 0,05 | 0,02 | 0,25 | 0,04 | 0,07 | 0,05 | 0,08 |
| D14 | | | | | | | | | | | | | | 1,00 | 0,26 | 0,32 | 0,43 | 0,20 | 0,26 | 0,09 | 0,16 | 0,10 | 0,10 |
| D15 | | | | | | | | | | | | | | | 1,00 | 0,37 | 0,08 | 0,14 | 0,11 | 0,17 | 0,19 | 0,14 | 0,17 |
| D16 | | | | | | | | | | | | | | | | 1,00 | 0,06 | 0,44 | 0,06 | 0,18 | 0,18 | 0,14 | 0,26 |
| D17 | | | | | | | | | | | | | | | | | 1,00 | 0,18 | 0,18 | 0,04 | 0,08 | 0,07 | 0,06 |
| D18 | | | | | | | | | | | | | | | | | | 1,00 | 0,39 | 0,17 | 0,06 | 0,04 | 0,12 |
| D19 | | | | | | | | | | | | | | | | | | | 1,00 | 0,21 | 0,20 | 0,13 | 0,15 |
| D20 | | | | | | | | | | | | | | | | | | | | 1,00 | 0,85 | 0,58 | 0,88 |
| D21 | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,73 | 0,95 |
| D22 | | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,68 |
| D23 | | | | | | | | | | | | | | | | | | | | | | | 1,00 |

| MSEs | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | D16 | D17 | D18 | D19 | D20 | D21 | D22 | D23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D1 | 1,00 | 0,32 | 0,31 | 0,01 | 0,25 | 0,49 | 0,42 | 0,48 | 0,14 | 0,33 | 0,30 | 0,17 | 0,06 | 0,17 | 0,17 | 0,36 | 0,08 | 0,03 | 0,17 | 0,47 | 0,01 | 0,03 | 0,05 |
| D2 | | 1,00 | 0,27 | 0,27 | 0,01 | 0,11 | - | 0,23 | 0,18 | 0,01 | 0,00 | 0,38 | 0,27 | 0,33 | 0,18 | 0,32 | 0,13 | 0,17 | 0,16 | 0,25 | 0,03 | 0,28 | 0,05 |
| D3 | | | 1,00 | 0,23 | 0,04 | 0,02 | 0,08 | 0,04 | 0,07 | 0,08 | 0,29 | 0,37 | 0,37 | 0,39 | 0,16 | 0,41 | 0,04 | 0,08 | 0,33 | 0,12 | 0,15 | 0,25 | 0,14 |
| D4 | | | | 1,00 | 0,31 | 0,19 | 0,16 | 0,21 | 0,11 | 0,13 | 0,17 | 0,10 | 0,13 | 0,19 | 0,06 | 0,18 | 0,07 | 0,32 | 0,25 | 0,01 | 0,27 | 0,24 | 0,24 |
| D5 | | | | | 1,00 | 0,42 | 0,30 | 0,02 | 0,34 | 0,17 | 0,03 | 0,01 | 0,13 | 0,09 | 0,19 | 0,17 | 0,26 | 0,03 | 0,06 | 0,01 | 0,25 | 0,19 | 0,23 |
| D6 | | | | | | 1,00 | 0,91 | 0,08 | 0,17 | 0,09 | 0,04 | 0,11 | 0,00 | 0,07 | 0,37 | 0,16 | 0,09 | 0,13 | 0,06 | 0,24 | 0,13 | 0,03 | 0,08 |
| D7 | | | | | | | 1,00 | 0,05 | 0,12 | 0,20 | 0,04 | 0,09 | - | 0,11 | 0,31 | 0,14 | 0,11 | 0,14 | 0,21 | 0,19 | 0,18 | 0,13 | 0,13 |
| D8 | | | | | | | | 1,00 | 0,08 | 0,28 | 0,26 | 0,08 | 0,23 | 0,03 | 0,05 | 0,23 | 0,09 | 0,22 | 0,15 | 0,35 | 0,17 | 0,05 | 0,23 |
| D9 | | | | | | | | | 1,00 | 0,02 | 0,17 | 0,27 | 0,45 | 0,00 | 0,03 | 0,26 | 0,13 | 0,23 | 0,12 | 0,29 | 0,60 | 0,61 | 0,63 |
| D10 | | | | | | | | | | 1,00 | 0,68 | 0,13 | 0,01 | 0,02 | 0,14 | 0,11 | 0,18 | 0,28 | 0,15 | 0,03 | 0,01 | 0,22 | 0,04 |
| D11 | | | | | | | | | | | 1,00 | 0,06 | 0,07 | 0,17 | 0,05 | 0,10 | 0,27 | 0,06 | 0,10 | 0,01 | 0,08 | 0,20 | 0,02 |
| D12 | | | | | | | | | | | | 1,00 | 0,81 | 0,83 | 0,37 | 0,48 | 0,28 | 0,13 | 0,33 | 0,54 | 0,52 | 0,44 | 0,55 |
| D13 | | | | | | | | | | | | | 1,00 | 0,71 | 0,16 | 0,41 | 0,21 | 0,13 | 0,32 | 0,66 | 0,77 | 0,65 | 0,77 |
| D14 | | | | | | | | | | | | | | 1,00 | 0,45 | 0,45 | 0,14 | 0,24 | 0,51 | 0,43 | 0,45 | 0,39 | 0,41 |
| D15 | | | | | | | | | | | | | | | 1,00 | 0,23 | 0,17 | 0,25 | 0,11 | 0,09 | 0,08 | 0,05 | 0,10 |
| D16 | | | | | | | | | | | | | | | | 1,00 | 0,11 | 0,34 | 0,15 | 0,28 | 0,24 | 0,20 | 0,23 |
| D17 | | | | | | | | | | | | | | | | | 1,00 | 0,15 | 0,04 | 0,19 | 0,05 | 0,06 | 0,09 |
| D18 | | | | | | | | | | | | | | | | | | 1,00 | 0,26 | 0,11 | 0,05 | 0,08 | 0,07 |
| D19 | | | | | | | | | | | | | | | | | | | 1,00 | 0,14 | 0,36 | 0,41 | 0,31 |
| D20 | | | | | | | | | | | | | | | | | | | | 1,00 | 0,62 | 0,53 | 0,59 |
| D21 | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,80 | 0,97 |
| D22 | | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,82 |
| D23 | | | | | | | | | | | | | | | | | | | | | | | 1,00 |

| NEI | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | D16 | D17 | D18 | D19 | D20 | D21 | D22 | D23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D1 | 1,00 | 0,24 | 0,58 | 0,04 | 0,11 | 0,17 | 0,18 | 0,03 | 0,09 | 0,50 | 0,56 | 0,10 | - | 0,19 | 0,03 | 0,16 | 0,04 | 0,19 | 0,49 | 0,09 | 0,14 | 0,05 | 0,10 |
| D2 | | 1,00 | 0,24 | 0,19 | 0,08 | 0,34 | 0,24 | 0,06 | 0,07 | 0,13 | 0,14 | 0,27 | 0,15 | 0,28 | 0,00 | 0,11 | 0,03 | 0,19 | 0,36 | 0,04 | 0,12 | 0,26 | 0,13 |
| D3 | | | 1,00 | 0,02 | 0,18 | 0,00 | 0,05 | 0,08 | 0,13 | 0,21 | 0,30 | 0,36 | 0,25 | 0,38 | 0,09 | 0,42 | 0,18 | 0,26 | 0,51 | 0,12 | 0,17 | 0,19 | 0,15 |
| D4 | | | | 1,00 | 0,50 | 0,40 | 0,40 | 0,07 | 0,11 | 0,09 | 0,01 | 0,08 | 0,06 | 0,09 | 0,21 | 0,22 | 0,04 | 0,46 | 0,06 | 0,20 | 0,19 | 0,16 | 0,16 |
| D5 | | | | | 1,00 | 0,32 | 0,27 | 0,06 | 0,17 | 0,25 | 0,14 | 0,11 | 0,13 | 0,05 | 0,13 | 0,04 | 0,05 | 0,09 | 0,15 | 0,11 | 0,13 | 0,12 | 0,12 |
| D6 | | | | | | 1,00 | 0,93 | 0,18 | 0,01 | 0,33 | 0,17 | 0,07 | 0,08 | 0,13 | 0,12 | 0,10 | 0,01 | 0,11 | 0,08 | 0,19 | 0,18 | 0,09 | 0,15 |
| D7 | | | | | | | 1,00 | 0,16 | 0,04 | 0,37 | 0,22 | 0,08 | 0,07 | 0,09 | 0,09 | 0,09 | 0,03 | 0,12 | 0,01 | 0,24 | 0,22 | 0,19 | 0,19 |
| D8 | | | | | | | | 1,00 | 0,07 | 0,10 | 0,09 | 0,11 | 0,07 | 0,17 | 0,02 | 0,02 | 0,17 | 0,12 | 0,23 | 0,04 | 0,05 | 0,06 | 0,02 |
| D9 | | | | | | | | | 1,00 | 0,02 | 0,23 | 0,15 | 0,26 | 0,12 | 0,29 | 0,05 | 0,19 | 0,07 | 0,01 | 0,42 | 0,39 | 0,36 | 0,41 |
| D10 | | | | | | | | | | 1,00 | 0,78 | 0,15 | 0,08 | 0,19 | 0,18 | 0,03 | 0,13 | 0,10 | 0,08 | 0,09 | 0,06 | 0,23 | 0,04 |
| D11 | | | | | | | | | | | 1,00 | 0,19 | 0,08 | 0,36 | 0,16 | 0,17 | 0,03 | 0,06 | 0,20 | 0,08 | 0,03 | 0,22 | 0,09 |
| D12 | | | | | | | | | | | | 1,00 | 0,73 | 0,65 | 0,49 | 0,54 | 0,28 | 0,26 | 0,26 | 0,44 | 0,50 | 0,35 | 0,52 |
| D13 | | | | | | | | | | | | | 1,00 | 0,62 | 0,24 | 0,49 | 0,12 | 0,10 | 0,22 | 0,57 | 0,63 | 0,48 | 0,62 |
| D14 | | | | | | | | | | | | | | 1,00 | 0,49 | 0,57 | 0,29 | 0,27 | 0,39 | 0,31 | 0,34 | 0,26 | 0,30 |
| D15 | | | | | | | | | | | | | | | 1,00 | 0,42 | 0,16 | 0,26 | 0,08 | 0,23 | 0,19 | 0,05 | 0,21 |
| D16 | | | | | | | | | | | | | | | | 1,00 | 0,02 | 0,39 | 0,15 | 0,17 | 0,18 | 0,17 | 0,17 |
| D17 | | | | | | | | | | | | | | | | | 1,00 | 0,18 | 0,07 | 0,02 | 0,01 | 0,02 | 0,02 |
| D18 | | | | | | | | | | | | | | | | | | 1,00 | 0,36 | 0,08 | 0,09 | 0,14 | 0,10 |
| D19 | | | | | | | | | | | | | | | | | | | 1,00 | 0,22 | 0,25 | 0,25 | 0,20 |
| D20 | | | | | | | | | | | | | | | | | | | | 1,00 | 0,95 | 0,76 | 0,93 |
| D21 | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,80 | 0,97 |
| D22 | | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,81 |
| D23 | | | | | | | | | | | | | | | | | | | | | | | 1,00 |

| EI | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | D16 | D17 | D18 | D19 | D20 | D21 | D22 | D23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D1 | 1,00 | 0,12 | 0,63 | 0,27 | 0,13 | 0,59 | 0,69 | 0,16 | 0,09 | 0,43 | 0,53 | 0,08 | 0,07 | - | 0,08 | - | 0,07 | 0,20 | 0,35 | 0,17 | 0,17 | 0,09 | 0,09 |
| D2 | | 1,00 | 0,23 | 0,01 | 0,03 | 0,09 | 0,30 | 0,01 | 0,27 | 0,15 | 0,04 | 0,13 | 0,13 | 0,17 | 0,28 | 0,35 | 0,16 | 0,17 | 0,12 | 0,33 | 0,33 | 0,37 | 0,32 |
| D3 | | | 1,00 | 0,42 | 0,10 | 0,45 | 0,63 | 0,01 | 0,15 | 0,16 | 0,22 | 0,20 | 0,06 | 0,20 | 0,01 | 0,17 | 0,30 | 0,11 | 0,45 | 0,23 | 0,23 | 0,18 | 0,18 |
| D4 | | | | 1,00 | 0,28 | 0,19 | 0,27 | 0,23 | 0,29 | 0,27 | 0,30 | 0,34 | 0,49 | 0,44 | 0,10 | 0,15 | 0,25 | 0,46 | 0,34 | 0,37 | 0,37 | 0,32 | 0,34 |
| D5 | | | | | 1,00 | 0,10 | 0,15 | 0,37 | 0,50 | 0,09 | 0,10 | 0,07 | 0,12 | 0,18 | 0,27 | 0,02 | 0,29 | 0,17 | 0,14 | 0,15 | 0,15 | 0,21 | 0,11 |
| D6 | | | | | | 1,00 | 0,90 | 0,10 | 0,11 | 0,01 | 0,06 | 0,05 | 0,13 | 0,21 | 0,19 | 0,05 | 0,01 | 0,43 | 0,21 | 0,16 | 0,16 | 0,02 | 0,12 |
| D7 | | | | | | | 1,00 | 0,06 | - | 0,04 | 0,07 | 0,02 | 0,12 | 0,14 | 0,26 | 0,01 | 0,04 | 0,35 | 0,38 | 0,21 | 0,21 | 0,14 | 0,16 |
| D8 | | | | | | | | 1,00 | 0,17 | 0,29 | 0,29 | 0,05 | 0,15 | 0,34 | 0,04 | 0,14 | 0,21 | 0,11 | 0,26 | 0,08 | 0,08 | 0,14 | 0,02 |
| D9 | | | | | | | | | 1,00 | - | 0,16 | 0,08 | - | - | 0,26 | 0,32 | 0,22 | 0,22 | 0,09 | 0,28 | 0,28 | 0,39 | 0,30 |
| D10 | | | | | | | | | | 1,00 | 0,77 | 0,06 | 0,02 | 0,31 | 0,36 | 0,10 | 0,29 | 0,02 | 0,09 | 0,10 | 0,10 | 0,27 | 0,09 |
| D11 | | | | | | | | | | | 1,00 | 0,11 | 0,22 | 0,48 | 0,28 | 0,22 | 0,05 | 0,09 | 0,24 | 0,05 | 0,05 | 0,30 | 0,07 |
| D12 | | | | | | | | | | | | 1,00 | 0,77 | 0,54 | 0,45 | 0,45 | 0,13 | 0,05 | 0,19 | 0,63 | 0,63 | 0,54 | 0,66 |
| D13 | | | | | | | | | | | | | 1,00 | 0,74 | 0,19 | 0,54 | 0,10 | 0,11 | 0,23 | 0,59 | 0,59 | 0,48 | 0,56 |
| D14 | | | | | | | | | | | | | | 1,00 | 0,11 | 0,31 | 0,14 | 0,14 | 0,31 | 0,42 | 0,42 | 0,31 | 0,32 |
| D15 | | | | | | | | | | | | | | | 1,00 | 0,10 | 0,09 | 0,18 | 0,03 | 0,20 | 0,20 | 0,07 | 0,22 |
| D16 | | | | | | | | | | | | | | | | 1,00 | 0,26 | 0,02 | 0,15 | 0,24 | 0,24 | 0,16 | 0,20 |
| D17 | | | | | | | | | | | | | | | | | 1,00 | 0,45 | 0,23 | 0,25 | 0,25 | 0,11 | 0,21 |
| D18 | | | | | | | | | | | | | | | | | | 1,00 | 0,12 | 0,25 | 0,25 | 0,11 | 0,27 |
| D19 | | | | | | | | | | | | | | | | | | | 1,00 | 0,43 | 0,43 | 0,30 | 0,35 |
| D20 | | | | | | | | | | | | | | | | | | | | 1,00 | 1,00 | 0,89 | 0,96 |
| D21 | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,89 | 0,96 |
| D22 | | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,91 |
| D23 | | | | | | | | | | | | | | | | | | | | | | | 1,00 |

| BS | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | D16 | D17 | D18 | D19 | D20 | D21 | D22 | D23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D1 | 1,00 | 0,54 | 0,41 | 0,12 | 0,22 | 0,25 | 0,42 | 0,15 | 0,36 | 0,33 | 0,38 | 0,04 | 0,11 | - | 0,25 | 0,22 | 0,06 | 0,33 | 0,31 | 0,34 | 0,06 | 0,15 | 0,12 |
| D2 | | 1,00 | 0,24 | 0,13 | 0,07 | 0,23 | 0,02 | 0,09 | 0,27 | 0,26 | 0,21 | 0,01 | 0,08 | 0,05 | 0,01 | 0,38 | 0,24 | 0,15 | 0,14 | 0,36 | 0,05 | 0,16 | 0,04 |
| D3 | | | 1,00 | 0,43 | 0,09 | 0,16 | 0,22 | 0,26 | 0,10 | 0,18 | 0,20 | 0,18 | 0,01 | 0,31 | 0,06 | 0,10 | 0,37 | 0,02 | 0,41 | 0,07 | 0,05 | 0,07 | 0,00 |
| D4 | | | | 1,00 | 0,23 | 0,09 | 0,06 | 0,23 | 0,07 | 0,26 | 0,30 | 0,24 | 0,35 | 0,31 | 0,02 | 0,03 | 0,17 | 0,37 | 0,15 | 0,17 | 0,20 | 0,15 | 0,17 |
| D5 | | | | | 1,00 | 0,17 | 0,10 | 0,25 | 0,49 | 0,07 | 0,01 | 0,17 | 0,17 | 0,19 | 0,28 | 0,01 | 0,24 | 0,11 | 0,03 | 0,07 | 0,15 | 0,18 | 0,11 |
| D6 | | | | | | 1,00 | 0,84 | 0,06 | 0,11 | 0,34 | 0,23 | 0,14 | 0,05 | - | 0,51 | 0,06 | 0,02 | 0,22 | 0,09 | 0,15 | 0,18 | 0,08 | 0,15 |
| D7 | | | | | | | 1,00 | 0,07 | 0,04 | 0,27 | 0,22 | 0,20 | 0,11 | - | 0,58 | 0,04 | 0,03 | 0,10 | 0,33 | 0,23 | 0,25 | 0,23 | 0,21 |
| D8 | | | | | | | | 1,00 | 0,05 | 0,07 | 0,16 | 0,11 | 0,07 | 0,12 | 0,04 | 0,02 | 0,16 | 0,14 | 0,04 | 0,15 | 0,04 | 0,14 | 0,00 |
| D9 | | | | | | | | | 1,00 | 0,10 | 0,22 | 0,04 | 0,03 | 0,05 | 0,16 | 0,24 | 0,19 | 0,22 | 0,04 | 0,12 | 0,36 | 0,41 | 0,37 |
| D10 | | | | | | | | | | 1,00 | 0,82 | 0,14 | 0,16 | 0,05 | 0,32 | 0,19 | 0,02 | 0,09 | 0,04 | 0,27 | 0,13 | 0,26 | 0,12 |
| D11 | | | | | | | | | | | 1,00 | 0,03 | 0,09 | 0,15 | 0,27 | 0,26 | 0,18 | 0,10 | 0,12 | 0,09 | 0,00 | 0,31 | 0,08 |
| D12 | | | | | | | | | | | | 1,00 | 0,79 | 0,57 | 0,20 | 0,19 | 0,09 | 0,05 | 0,28 | 0,54 | 0,59 | 0,56 | 0,61 |
| D13 | | | | | | | | | | | | | 1,00 | 0,68 | 0,01 | 0,27 | 0,11 | 0,19 | 0,28 | 0,45 | 0,61 | 0,51 | 0,59 |
| D14 | | | | | | | | | | | | | | 1,00 | 0,17 | 0,04 | 0,19 | 0,15 | 0,37 | 0,40 | 0,38 | 0,36 | 0,31 |
| D15 | | | | | | | | | | | | | | | 1,00 | 0,06 | 0,11 | 0,03 | 0,08 | 0,02 | 0,05 | 0,05 | 0,06 |
| D16 | | | | | | | | | | | | | | | | 1,00 | 0,19 | 0,14 | 0,10 | 0,05 | 0,13 | 0,05 | 0,10 |
| D17 | | | | | | | | | | | | | | | | | 1,00 | 0,26 | 0,17 | 0,18 | 0,26 | 0,14 | 0,23 |
| D18 | | | | | | | | | | | | | | | | | | 1,00 | 0,11 | 0,21 | 0,11 | 0,01 | 0,14 |
| D19 | | | | | | | | | | | | | | | | | | | 1,00 | 0,35 | 0,43 | 0,38 | 0,36 |
| D20 | | | | | | | | | | | | | | | | | | | | 1,00 | 0,65 | 0,65 | 0,62 |
| D21 | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,88 | 0,97 |
| D22 | | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,89 |
| D23 | | | | | | | | | | | | | | | | | | | | | | | 1,00 |

| No BS | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | D16 | D17 | D18 | D19 | D20 | D21 | D22 | D23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D1 | 1,00 | 0,25 | 0,33 | 0,03 | 0,08 | 0,12 | 0,24 | 0,27 | 0,20 | 0,63 | 0,50 | 0,37 | 0,27 | 0,35 | 0,02 | 0,45 | 0,36 | 0,17 | 0,40 | 0,41 | 0,31 | 0,35 | 0,35 |
| D2 | | 1,00 | 0,32 | 0,46 | 0,11 | 0,18 | 0,18 | 0,14 | 0,09 | 0,13 | 0,08 | 0,28 | 0,25 | 0,15 | 0,04 | 0,15 | 0,31 | 0,15 | 0,25 | 0,17 | 0,07 | 0,24 | 0,11 |
| D3 | | | 1,00 | 0,43 | 0,18 | 0,14 | 0,17 | 0,06 | 0,07 | 0,14 | 0,26 | 0,46 | 0,45 | 0,37 | 0,12 | 0,39 | 0,08 | 0,26 | 0,44 | 0,14 | 0,22 | 0,26 | 0,16 |
| D4 | | | | 1,00 | 0,23 | 0,30 | 0,28 | 0,20 | 0,10 | 0,10 | 0,15 | 0,33 | 0,34 | 0,31 | 0,21 | 0,35 | 0,42 | 0,31 | 0,25 | 0,08 | 0,07 | 0,06 | 0,09 |
| D5 | | | | | 1,00 | 0,27 | 0,20 | 0,22 | 0,01 | 0,23 | 0,17 | 0,26 | 0,36 | 0,02 | 0,15 | 0,05 | 0,08 | 0,13 | 0,24 | 0,11 | 0,08 | 0,11 | 0,03 |
| D6 | | | | | | 1,00 | 0,95 | 0,11 | 0,04 | 0,43 | 0,43 | 0,04 | 0,08 | 0,22 | 0,02 | 0,19 | 0,10 | 0,18 | 0,27 | 0,03 | 0,24 | 0,05 | 0,25 |
| D7 | | | | | | | 1,00 | 0,09 | 0,01 | 0,53 | 0,48 | 0,09 | 0,06 | 0,24 | 0,06 | 0,23 | 0,10 | 0,17 | 0,23 | 0,08 | 0,20 | 0,12 | 0,19 |
| D8 | | | | | | | | 1,00 | 0,41 | 0,05 | 0,02 | 0,21 | 0,35 | 0,05 | 0,08 | 0,18 | 0,12 | 0,14 | 0,25 | 0,07 | 0,04 | 0,07 | 0,07 |
| D9 | | | | | | | | | 1,00 | 0,02 | 0,13 | 0,14 | 0,31 | 0,01 | 0,29 | 0,43 | 0,18 | 0,04 | 0,01 | 0,38 | 0,42 | 0,39 | 0,56 |
| D10 | | | | | | | | | | 1,00 | 0,78 | 0,18 | 0,05 | 0,27 | 0,02 | 0,24 | 0,25 | 0,08 | 0,14 | 0,23 | 0,32 | 0,08 | 0,28 |
| D11 | | | | | | | | | | | 1,00 | 0,18 | 0,02 | 0,35 | 0,07 | 0,14 | 0,07 | 0,01 | 0,21 | 0,06 | 0,26 | 0,09 | 0,22 |
| D12 | | | | | | | | | | | | 1,00 | 0,82 | 0,65 | 0,34 | 0,46 | 0,48 | 0,34 | 0,37 | 0,28 | 0,25 | 0,09 | 0,25 |
| D13 | | | | | | | | | | | | | 1,00 | 0,55 | 0,18 | 0,45 | 0,43 | 0,28 | 0,28 | 0,36 | 0,36 | 0,32 | 0,37 |
| D14 | | | | | | | | | | | | | | 1,00 | 0,44 | 0,60 | 0,48 | 0,51 | 0,44 | 0,24 | 0,35 | 0,21 | 0,29 |
| D15 | | | | | | | | | | | | | | | 1,00 | 0,44 | 0,26 | 0,33 | 0,07 | 0,23 | 0,24 | 0,12 | 0,22 |
| D16 | | | | | | | | | | | | | | | | 1,00 | 0,52 | 0,57 | 0,26 | 0,42 | 0,35 | 0,31 | 0,42 |
| D17 | | | | | | | | | | | | | | | | | 1,00 | 0,32 | 0,39 | 0,43 | 0,35 | 0,25 | 0,40 |
| D18 | | | | | | | | | | | | | | | | | | 1,00 | 0,49 | 0,06 | 0,03 | 0,05 | 0,02 |
| D19 | | | | | | | | | | | | | | | | | | | 1,00 | 0,00 | 0,16 | 0,22 | 0,11 |
| D20 | | | | | | | | | | | | | | | | | | | | 1,00 | 0,76 | 0,41 | 0,78 |
| D21 | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,62 | 0,95 |
| D22 | | | | | | | | | | | | | | | | | | | | | | 1,00 | 0,58 |
| D23 | | | | | | | | | | | | | | | | | | | | | | | 1,00 |

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