POLITECNICO DI MILANO

Facoltà di Ingegneria Industriale

Corso di Laurea Magistrale in Ingegneria Gestionale

Energy Management practices: a novel characterization framework and empirical investigation among Swedish enterprises

Relatore: Prof. Enrico Cagno

Correlatori: Prof. Patrik Thollander

Ing. Andrea Trianni

Tesi di Laurea Magistrale di:

Silvia Marconi

Matricola: 783168

Anno accademico 2012/2013

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Energy Management is considered a very important issue in policy makers' energy efficiency agendas. Nonetheless, the debate on Energy Management is quite open, and much more still needs to be done. In the literature, Energy Management is dealt with as a complex topic, analysed from different perspectives, and there does not seem to be a cohesive definition. It seems rather interesting to study Energy Management at an intermediate level, as result of defined strategies and policies of the corporate strategy, and as enabler to energy efficiency improvements at the lowest level. Indeed, we can see that at the intermediate level energy management practices – expressed as procedures and activities – are placed, thus supporting an enterprise to achieve effectively the planned energy efficiency results As a result, positioning Energy Management at this intermediate level, cannot be considered as an exclusive matter of technical settings: management and organization-related aspects are equally fundamental.

The work then aims at assessing the whole enterprise in the context of energy management, in order to have an understanding of its approach in this field. It is possible to study the maturity level of the practices' implementation within the industry. *(Assessment scope).*

Moreover, the evaluation can support an enterprise to investigate which practices are more suitable and advisable according to its specific characteristics, other than helping to understand how these could be further improved. *(Directing scope).*

In order to achieve the aforementioned goals it is necessary to create a *novel characterization framework*, able to understand the most important characteristics of energy management practices through a comprehensive literature review. The new characterization framework of energy management practices will then be tested and applied to a significant sample of companies, representing the manufacturing sector in Sweden.

KEYWORDS: energy efficiency, energy management, energy management practices, novel characterization framework for energy management practices.

ABSTRACT IN ITALIANO

Nell'ambito delle politiche sull'efficienza energetica, l'Energy Management è considerato un tema di grandissima attualità e ricopre un'importanza cruciale. Nonostante ciò il dibattito in merito è ancora aperto, tanto che la letteratura non ha tuttora espresso una definizione univoca, e molto può essere ancora studiato. Può quindi risultare interessante studiare l'Energy Management dal punto di vista della gestione complessiva, considerandolo sia come il risultato di determinate politiche figlie di una strategia corporate, sia in quanto attivatore di interventi finalizzati a migliorare il livello di efficienza all'interno dell'azienda. Le pratiche di Energy Management - concretamente, procedure e attività - si collocano quindi ad un livello intermedio tra visione strategica aziendale e operatività e supportano l'azienda nel raggiungimento degli obiettivi di efficienza definiti a monte.

In questo modo l'Energy Management non interessa solo aspetti tecnici o tecnologici ma afferisce anche alla sfera gestionale, umana e organizzativa.

Il presente studio si pone dunque come obiettivo la valutazione dell'impresa rispetto alle scelte compiute in materia di Energy Management, data la possibilità di rilevare all'interno del settore industriale la situazione AS-IS di implementazione di tali pratiche *(fase di valutazione)*.

I risultati della valutazione si rivelano poi utili per identificare le pratiche più idonee, realizzabili sulla base di specifiche caratteristiche, e più in generale permettono all'azienda di orientare le scelte tese al miglioramento dell'efficienza energetica e tradurle in azioni *(fase di orientamento)*.

Per poter raggiungere gli obiettivi sopradescritti si rende quindi necessaria la creazione di un nuovo modello di classificazione e caratterizzazione delle pratiche di Energy Management, definito a seguito di un'esaustiva revisione della letteratura in merito. Tale modello verrà poi testato e applicato ad un significativo campione di aziende rappresentative del settore manifatturiero in Svezia.

Chapter 1

Introduction

1.1. World energy consumption and outlook

It is recognized that World Energy Consumption has a great effect on humanity's social-economical-political sphere. Institutions such as the International Energy Agency (IEA), the U.S. Energy Information Administration (EIA), and the European Environment Agency are responsible for the periodic collection and publication of energy data. Analysing the World Energy Consumption helps to understand the general trends and patterns, which could frame current energy issues and encourage actions towards collectively useful solutions. The last International Energy Outlook (European Commission, 2013) considers increased world consumption of marketed energy from all fuel sources through 2040 (see Figure 1).

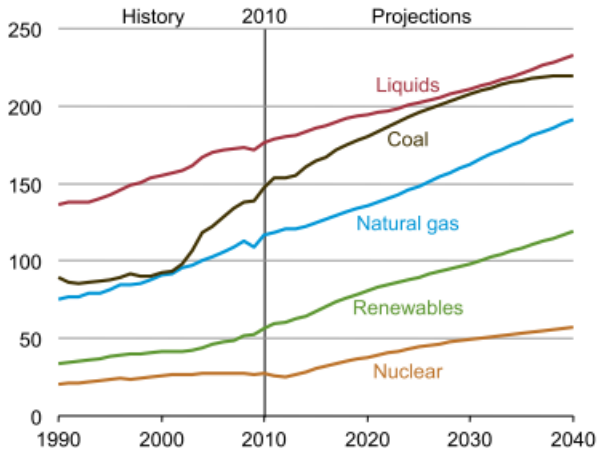


Figure 1. World energy consumption by fuel type, 1990-2040 (quadrillion Btu) (Energy Information Administration, 2013)

According to the Annual Energy Outlook (U.S Energy Information Administrad, 2013), fossil fuels remain the dominant sources of primary energy in the Reference Scenario, accounting for more than three-quarters of the overall increase in energy use between 2007 and 2030. However the liquids share of world marketed energy consumption drops from 34% in 2010 to 28% in 2040, since projected high world oil prices lead to switch away from liquid fuels when feasible.

Considering renewable sources and nuclear power, in the report is affirmed that they are the fastest growing sources (Energy Information Administration 2013).

From the point of view of the consumption by region, the EIA2013 provides the historical trend and the projections until 2040 (U.S Energy Information Administrad, 2013) (see Figure 2).

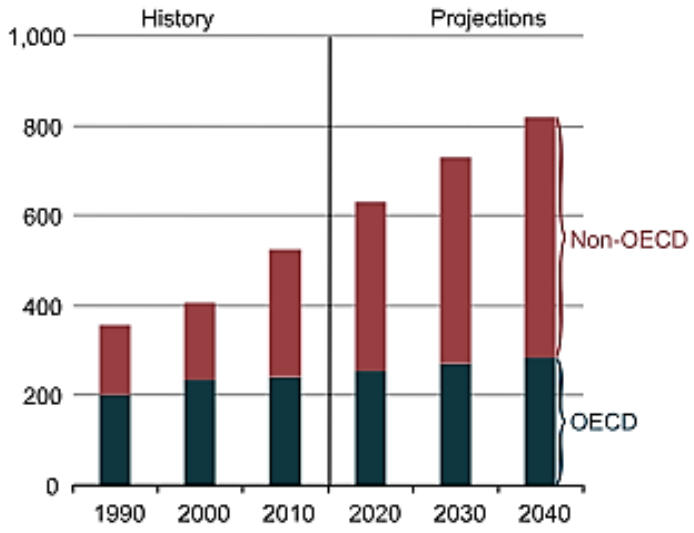


Figure 2. World energy consumption, 1990-2040 (quadrillion Btu) (Energy Information Administration, 2013)

Organization for Economic and Development (OECD) member countries are more advanced energy consumers. Energy demand in the OECD economies grows slowly over the projection period, with an average annual rate of 0.6%. In these regions the rate of growth varies but is actually slow in comparison with the emerging economics of the non–OECD countries like China, Africa and the Middle East. The fastest rates of growth are projected for the latter countries with a GDP (gross domestic

product, expressed in purchasing power parity terms) increasing by 4,7% per year, whereas the GDP of the OECD regions grows at slower rate, 2,1% per year. The result is that the energy consumption in the non-OECD emerging economies increases of 2,3 percent per year, on average.

The reason is that developing non-OECD economies have led the global recovery from the 2008-2009 crisis.

Among the key world emerging countries, China and India continue to run both world economic development and energy demand growth: their share of world energy consumption has increased significantly, and it is predicted to weight for about 31% in 2035. Similarly energy demand in the Middle East increases by 77% over the projection period.

In an analysis by sectors, among residential and commercial buildings, industrial, and transportation, the Key World Energy Statistics (Internationa Energy Agency, 2013b) recognizes the consumption's shares by each sectors (see Figure 3.1; 3.2; 3.3; 3.4;).

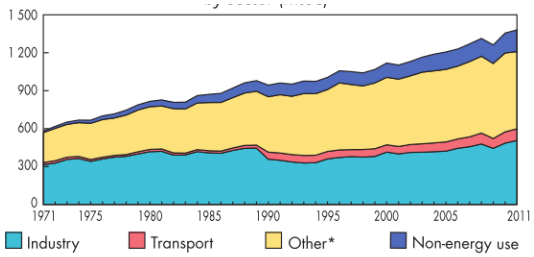


Figure 3.1. Total natural gas consumption, 1971-2010 (IEA, 2013) (Mtoe)

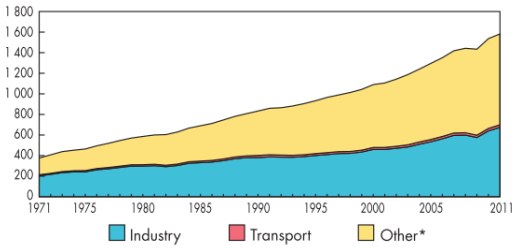


Figure 3.2. Total oil consumption, 1971-2010 (IEA, 2013) (Mtoe)

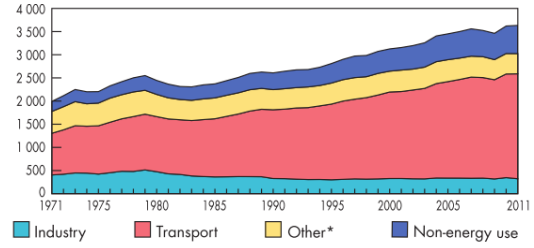


Figure 3.3. Total coal consumption, 1971-2010 (IEA, 2013) (Mtoe)

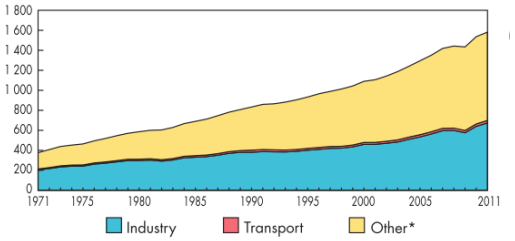


Figure 3.4. Total electricity consumption, 1971-2010 (IEA, 2013) (Mtoe)

Worldwide, industrial energy consumption grows from 200 quadrillion Btu in 2010 to 307 quadrillion Btu in 2040 in the Reference Case. Non-OECD economies account for about 86% of the world increase in industrial sector energy consumption unlike the OECD countries, characterized by a smaller percentage due to the on-going transition from manufacturing economies to service ones and the slow projected growth.

The transportation sector is second only to the industrial sector in terms of total end-use energy consumption. The transportation share of world total liquids consumption increases from 55% in 2010 to 57% in 2040 in the IEO2013.

The liquid flues still dominate in this sector, whereas the natural gas source is more competitive than oil and it is used mostly in electric power generation and industry. Coal consumption had a reduction before year 2000, but it has started to grow fast until 2008 and the increase is mostly due to the China's growth in energy demand.

In the end electricity is the world's fastest-growing form of end-use energy consumption. As the IEO2013 states, world net electricity generation increases by 93%, from 20.2 trillion kilowatt-hours in 2010 to 39.0 trillion kilowatt-hours in 2040. Moreover the growth of electricity demand in the OECD countries, where electricity markets are well established, is slower than in the non-OECD countries, where nowadays still many people do not have an easy access to electricity.

With reference to the World Energy Outlook (US. Energy Information Admnistration, 2009) a further consideration is that these general trends would lead to a fast increment in the concentration of greenhouse gases in the atmosphere. This concentration will result in the global average temperature rising by up to 6°. Hence the enormous climatic change and damage to our world are evident consequences.

If the current energy path remains intact, without any improvement, the consequences for climate conditions and energy security will be alarming and the society will have to face a worldwide challenge.

1.2 Swedish energy consumption and outlook

The country under study in this dissertation is Sweden, the fourth-largest country in the European Union. Its economy has withstood many effects of the recent global financial and economic crisis. Sweden, as one of the most powerful countries in EU, has leading engineering and manufacturing segments: motor vehicles, telecommunications, pharmaceuticals, industrial machines, precision equipment, chemical goods, home appliances, forestry, iron and steel. The Swedish industry consists of about 59.000 companies.

Within these sectors pulp and paper industry is the sector that uses the most energy. As stated by (Patrik Thollander, 2008), they account for 51% of the energy used within industry and steel industry, which is another energy-intensive sector, accounts for 21%. These sectors are responsible for two-thirds of the total energy use within industry during 2011. The chemical industry accounts for 6% of industrial energy use and the engineering industry, although not energy intensive, nevertheless accounts for 7% of total energy use in industry, as result of its high proportion of Sweden's total industrial output. A representation of this partition is shown by (B. Johansson, Modig, & Nilsson, 2007) (see Figure 4).

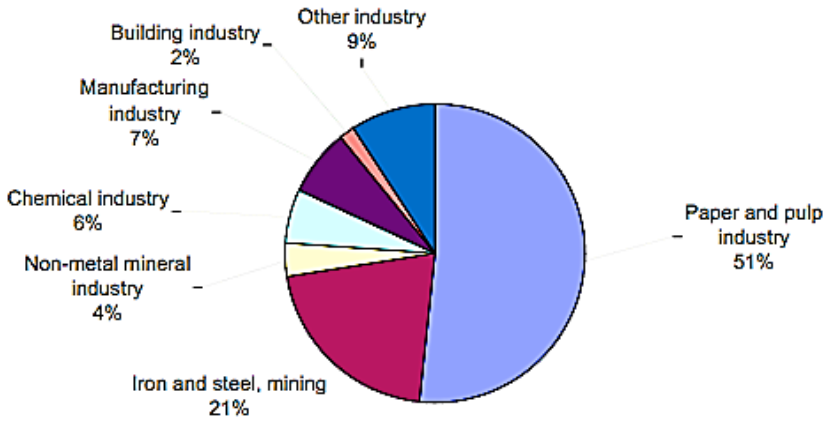


Figure 4. Industrial energy use divided among sectors (Johansson et al., 2007)

Thanks to the report Energy In Sweden (Swedish Energy Agency, 2012a) it is easy to have a comprehensive collection of data and the last detailed available summary of the energy supply and energy use in 2010 is shown in the figure below (see Figure 5).

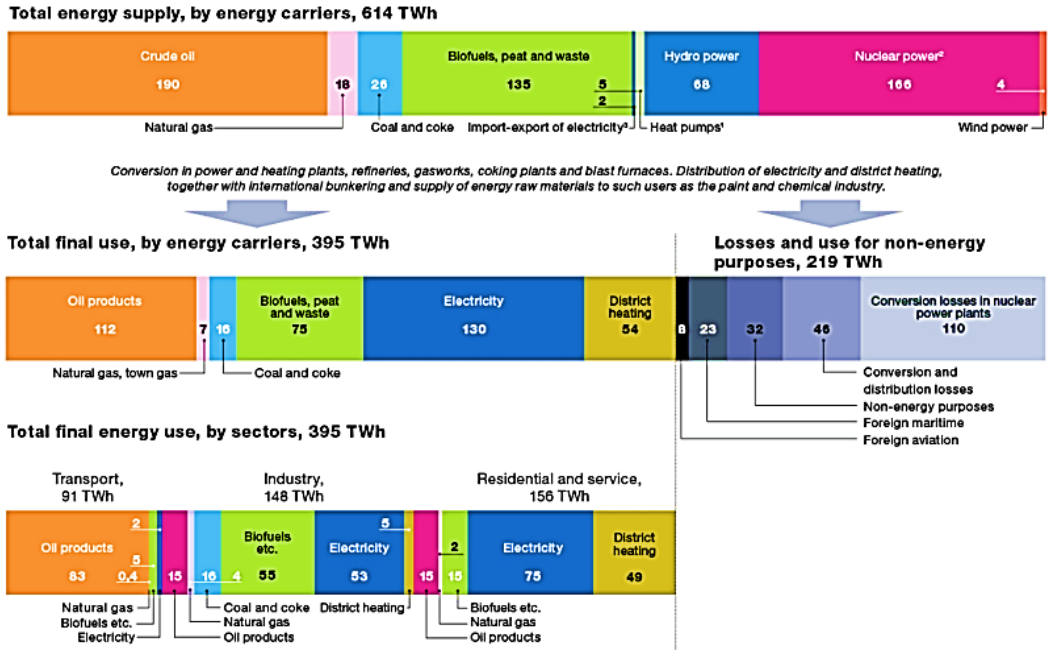


Figure 5. Energy supply and energy use in Sweden in 2010 (TWh) (Swedish Energy Agency, 2012a)

As shown, the shares of each type of fuels are represented and also the parts of the total energy supply, which are lost and used for non- energy purposes that is 36% of the TPES. Moreover, analysing the energy use by sector, most of the energy in industry comes from biofuels (37%) and electricity (36%). The electricity dominates also the residential sector (48%), whereas in the transport one the oil products are the most important resources (91%). This is in line with the worldwide considerations made by the World Energy Outlook.

In the industry sector a progressive replacement of fossil fuels as primary energy source by nuclear and hydro power plants has started since 1970, in connection with the oil crises of the 1970s. Nuclear and hydro power make available 90% of the total electricity generation (Stenqvist & Nilsson, 2011). The imperishably low electricity

process influenced domestic enterprises to favour electricity instead of other energy sources (Patrik Rohdin, Thollander, & Solding, 2007) (see Figure 6).

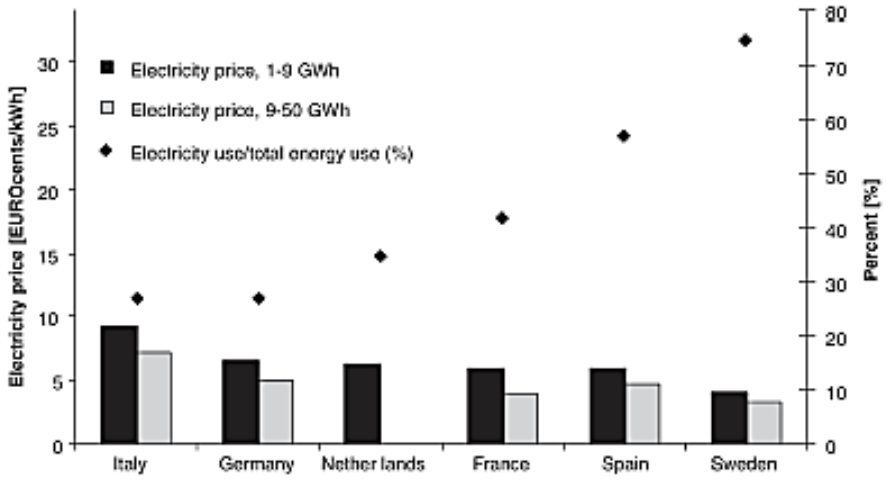


Figure 6. Comparison of the average electricity price and the ratio of electricity use to total energy use of the foundry sector in the selected countries in Europe (Rohdin, et al., 2007)

In 1996 began the liberalisation of the European electricity market, resulting in an increase of prices. The negative effect applies mostly to electricity prices of Swedish industry, used to the lowest electricity prices in Europe (P. Thollander, Svensson, & Trygg, 2010).

Higher energy prices together and a higher use of electricity than other European countries could pose a threat to industrial activity and the international competitiveness of export oriented companies, which relied on low-priced electricity (Patrik Rohdin et al., 2013). In the end, higher energy costs have a bad impact on results, influencing the production (ECON, 2003).

According to Energy Policies of IEA countries (Internationa Energy Agency, 2013a) in 2011 Sweden's total primary energy supply (TPES) was 48.9 million tonnes of oil equivalent (Mtoe) (that is the equivalent of 569TWh).

Fossil fuels, oil, coal and natural gas represented 31,8% of TPES in 2011 and Sweden is the IEA member country with the lowest share of fossil fuels in its energy mix.

The coal share accounted for 4,1% and natural gas for 2,4% compares to the IEA average of 20% and 25% respectively. Nuclear is a large contribution to the Swedish electricity mix. Thanks to many natural resources and efficient long-term policies about renewable energy, Sweden is on the third-highest level among IEA members in term of the share of renewable energy in TPES (see Figure 7).

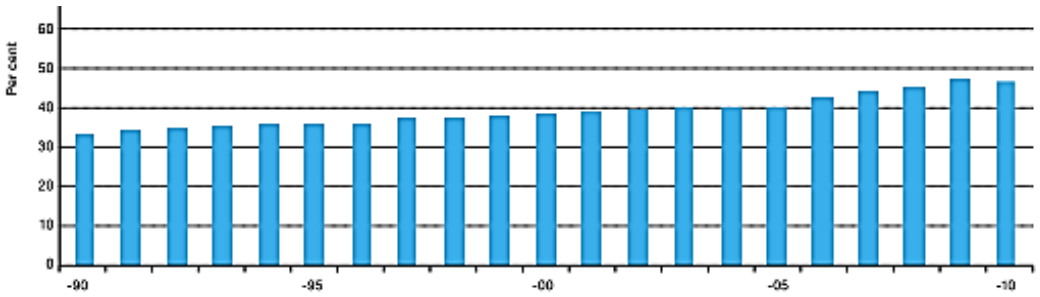


Figure 7. Proportion of energy use in Sweden from renewable sources 1990-2010 (Swedish Energy Agency, 2012a)

With reference to the electricity certificate system (Swedish Energy Agency, 2012b), the goal for the future is to increase by 2020 the production of electricity from renewable sources by 25TWh relative to production in 2002. The certificate system, which run until 2035, is supposed to help Sweden to achieve a more ecologically sustainable energy system.

Regarding other projections for the future made by the Swedish Energy Agency, the total final consumption is supposed to increase by 10,4% in 2020, with most of the increment due to the industry sector. Than consumption growth will slow to 1,8% over the next years to 2030. Industry consumption is expected to grow by 28,5% until 2030, but it will be compensated by lower consumption in the commercial sector, actually thanks to future energy efficiency achievements.

1.3 Energy efficiency – an industrial perspective

As already affirmed by IEO2013 (European Commission, 2013), the industrial sector uses more energy than other end-use sectors, consuming about one-half of the whole

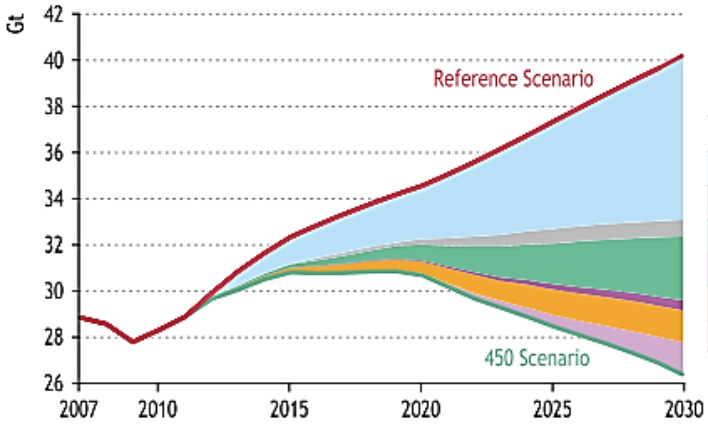
provided energy. The industrial sector counts a widespread set of industries: manufacturing, like food, paper, chemicals, refining, iron and steel, nonferrous metals, non-metallic minerals and nonmanufacturing, like agriculture, mining, construction. In the IEO2013 Reference Case energy consumption in the industrial sector is supposed to grow from 200 quadrillion Btu in 2010 to 307 quadrillion Btu in 2040, with an increasing average of 1,4% per year. Most of the increase in industrial sector energy consumption is in the non-OECD: the rate of growth here is an average of 2,3% per year, compared with 0,4% in the OECD. The non-OECD countries will account for 72% of world total delivered energy consumption in 2040.
The difference in the growth rates is due to the development of individual countries. When developing countries achieve higher levels of economic development, their economies tend to become more service-oriented, as is happening in many OECD countries. Another reason could be the fact that OECD countries generally have more energy-efficient industrial operations. That is why industrial energy intensity, expressed as the amount of energy used for a unit of economic output[1] (Prindle, Zarnikau, & Allis, 2010) in the non–OECD countries is double than in OECD countries. Energy intensity is often correlated to the GDP-Gross Domestic Product-when the analysis is about the economic growth of a country (Piglia, 2012).
Because of the projected increasing energy use, mostly in the industrial sector, the world is facing the challenge of climate change. Continuing on current path, without promoting new policies, it would mean an increasing dependence on fossil fuel and wasteful of energy. The consequence is a concentration of greenhouse gases in the atmosphere in excess of 1000 part per million (ppm) of CO_2 equivalent[2]. The result of the Reference Scenario, which considers all the current relevant policies but not potential future policies or targets, will certainly be a large increase in global temperature (+6°C). because of this situation the world's governments agreed to limit global temperature increase to 2°C. In order to achieve this aim, the concentration of greenhouse gases has to be stabilized at 450 ppm CO_2 equivalent:

[1] Energy intensity is often correlated to the GDP-gross domestic product when the analysis is about the economic growth of a country, given the strong correlation. (Piglia, 2012 da inserire)
[2] Carbon dioxide equivalent (CO2 168 -eq) is a measure used to compare and combine the emissions from various greenhouse gases, and is calculated according to global-warming potential of each gas.

this corresponds to the so called 450 Scenario. Undertaking the aforementioned path requires a deep and fast transformation of the production and use of energy.

1.3.1 Energy efficiency definition

With reference to different studies, as (Enrico Cagno & Trianni, 2012a; Gielen & Taylor, 2007; Jaffe & Stavins, 1994; Palm & Thollander, 2010; Patterson, 1996; Prindle et al., 2010; Tanaka, 2011), the major contribution to CO_2 emissions reduction in 2030 is end-use efficiency, mostly the *industrial energy efficiency*, since industry, together with transportation, is the highest energy-using sector in the world. If the road to energy efficiency is chosen, it could be responsible for more than half of the total saving by 2030 (see Figure 8).



	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 8. World energy-related CO2 emission savings by policy measure in the 450 Scenario (IEA, 2009)

It is clear that energy efficiency is now the best solution and has become relevant in the policy agenda of many countries.

Based on the opinion of (Prindle et al., 2010): "*Energy efficiency is a low-cost, rapidly deployable, and large-scale energy resource. Reducing growth in energy demand is essential to any clean energy strategy: without efficiency advances, clean energy supplies might not keep up with demand, and carbon emissions could continue to grow*"

The importance of energy as a policy objective concerns industrial competitiveness and energy security benefits, as well as environmental benefits such as reducing CO_2 emissions.

There are lots of energy efficiency definitions, since it is a generic term and there is not a unique quantitative measure of it. In general "energy efficiency means a lower energy use to produce the same amount of services or output" (Patterson, 1996), hence the simple ratio is: *Useful output of a process/Energy input into a process*.

Indicator for energy efficiency are important in order to compare countries, industries, sectors, etc., and to assess different efficiency measures also in the formulation of energy policies.

1.3.2. Energy benefits and non-energy benefits

As already stated, the main energy benefit obtained through the implementation of energy efficiency measures is the decrease of energy consumptions (Tonn & Martin, 2000). A further result is the improvement of energy security (Patterson, 1996).

Nevertheless the full spectrum of benefits that can be achieved thanks to energy efficient technologies and practices is not fully appreciated as stated by (E. Cagno, Worrell, Trianni, & Pugliese, 2012).

Experience shows that energy efficiency non energy benefits often exceed the value energy savings, so they should be viewed more correctly as part of the total benefits, rather than the only result (Pye & McKane, 2000). Companies can save direct costs of energy resources, as well as reduce disposal costs, avoid fines, minimize bad publicity, enhance productivity and improve workplace conditions. Thanks to some case studies conducted by (Pye & McKane, 2000) within US industry, some potential benefits beyond energy savings are identified: increased productivity; reduced costs of environmental compliance; reduced production costs (labour, operations, maintenance, raw material); reduced waste disposal costs; improved product quality; improved capacity utilization; improved reliability; improved worker safety.

In order to make decisions about investments in efficiency, the management should understand and be aware of all the costs and benefits associated with the energy

efficiency measures: the focus on energy efficiency may not cost so much if the non-energy benefits are included (Boyd & Pang, 2000).

In the work of (Worrell, Laitner, Ruth, & Finman, 2003), the set of non-energy is organized in five groups: reducing waste, lowering emissions, improving operation and maintenance, increasing production and product quality, improving working environment. In the Table 1 this categorisation in presented; the "other" category includes other worthy benefits, which are outside the others groups.

The evaluation of productivity benefits certainly influences the assessment of the energy-efficiency potential. In general, if the productivity benefits are not considered the result can be an underestimation of the cost-effective savings potential.

Waste	Emissions	Operation and maintenance
Use of waste fuels, heat, gas	Reduced dust emissions	Reduced need for engineering controls
Reduced product waste	Reduced CO, CO2, NOx, SOx emissions	Lowered cooling requirements
Reduced waste water		Increased facility reliability
Reduced hazardous waste		Reduced wear and tear on equipment/machinery
Materials reduction		Reductions in labor requirements
Production	**Working environment**	**Other**
Increased product output/yields	Reduced need for personal protective equipment	Decreased liability
Improved equipment performance	Improved lighting	Improved public image
Shorter process cycle times	Reduced noise levels	Delaying or Reducing capital expenditures
Improved product quality/purity	Improved temperature control	Additional space
Increased reliability in production	Improved air quality	Improved worker morale

Table 1. Non-energy benefits form efficiency improvements (Worrell et al., 2003)

An interesting point of view is the one of (Cooremans, 2011), who points out the contribution to competitive advantage of energy efficiency investments. The three dimensions of competitive advantage are: value, costs and risks. The numerous non-energy benefits described by (Worrell et al., 2003) could be integrated into the competitive advantage conceptual framework, as they have influence on increased value, reduced costs and reduced risks.

In conclusion (Bunse, Vodicka, Schönsleben, Brülhart, & Ernst, 2011a) propose a summary of the contribution of energy regarding the three main aspects of sustainable manufacturing industry: environmental, economic and societal aspects.
The framework (Figure 9) underlines the role of energy efficiency as a necessary contribution to all the aforementioned aspects in the society.

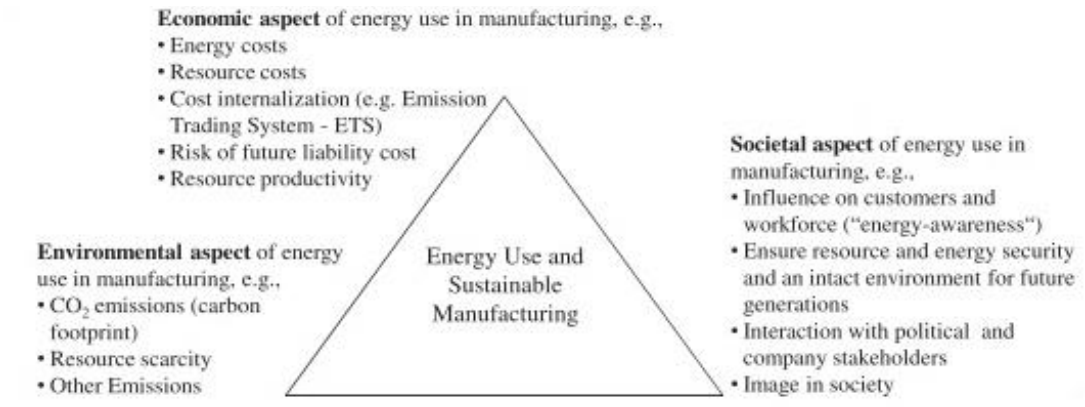


Figure 9. Contribution of energy efficiency to the three main aspects of sustainable manufacturing (Bunse et al., 2011a)

1.4 The energy efficiency gap

After the previous description of the general concepts about energy efficiency, there is still a great debate in the literature. With reference to (Pelenur & Cruickshank, 2012), experience and empirical data show that the adoption rate of energy efficiency measures is not satisfactory, a phenomena called the "Energy Efficiency Gap" or "Energy Efficiency Paradox".

The Energy Efficiency gap is *"the gap that exists between the current or expected future energy use, and the optimal current or future energy use"* (Jaffe & Stavins, 1994). The term "paradox" is used in order to indicate the gradual diffusion of apparently cost-effective energy efficiency technologies and measures. The existence of barriers to energy efficiency explains the gap.

For OECD countries the lost due to the gap is supposed to be 30% of the total potential energy savings. In scientific literature the energy efficiency gap has been analysed with regards to several different economic theories and social sciences, as for example neo-classical economics[3], behavioural economics[4], institutional economics[5], sociology and psychology[6]. The starting position of many studies is that real markets are characterised by several market failures, which create barriers for energy efficiency.

From an economic perspective, (Jaffe & Stavins, 1994) argue that Energy Efficiency Gap is due to market failures, like lack of transparent information, and non-market failures, such as the transaction costs of adopting new technologies. Also (Weber, 1997) identifies four types of obstacles: institutional barriers, market barriers, organizational barriers and behavioural barriers

As already stated, the existence of barriers to energy efficiency commonly explains the gap, but it is not realistic to overcome all barriers at any costs. It is important to recognize that the intervention costs have not to exceed the benefits (Patrik Thollander, 2008). Overcoming the barriers, different potentials of energy efficiency can be reached and these are summarized in Figure 10 (Jaffe & Stavins, 1994).

The Figure shows different views of the efficiency gap that correspond respectively to distances between each of the plateaux and the horizontal axis, the baseline or business as usual energy efficiency level.

[3] "Neo-classical theory identifies several market failures, which inhibit the efficient function of the market" (Eto et al., 1996).

[4] "Behavioural economic theory examines the decision making process in economy. It is analysed why individuals, who should make rational decisions, often act irrational" (Dowlatabadi, et al., 2007).

[5] "Institutional economic theory examines the impact of organisational structures on decision-making processes (e.g. political authorities or companies)" (Sorrell, 2003).

[6] "Sociology and psychology focus on actual decision making of individuals within an organisation" (Stern, 1986).

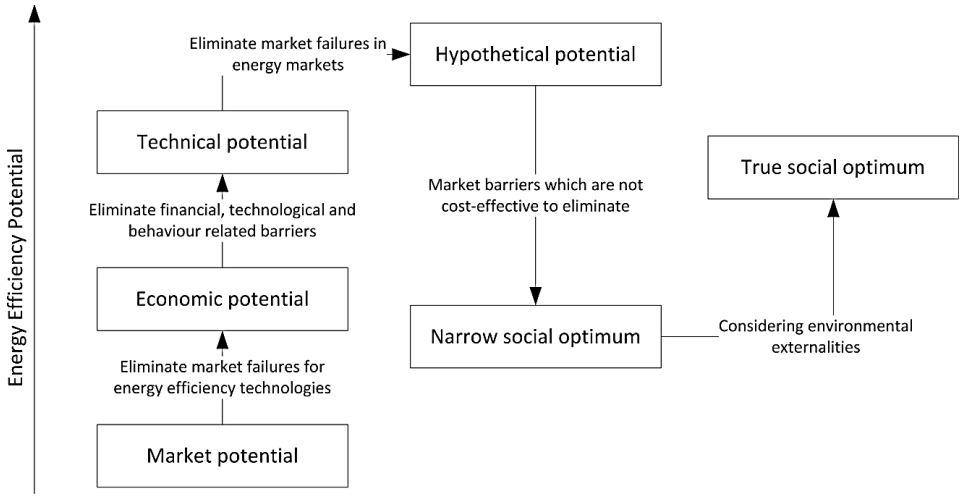


Figure 10. Energy efficiency gaps (Jaffe & Stavins, 1994)

In these analysis the economic potential represents the degree of energy efficiency achievable if market failures in the energy technology market are eliminated. The scenario, in which non-market failures are removed, is considered the technical potential. The highest level is the hypothetical potential, in which there are not any market failures: it could be possible if the government were supposed to overcome all market barriers. This is not a reasonable assumption. Therefore to reach the narrow social optimum, at a lower level, some barriers should be included again: those whose costs of exclusion would be greater than the desirable benefits. In the end, the true social optimum embraces the additional energy conservation if the environmental effects of energy generation and use are internalized.

1.5 European key energy policies

As the world energy trends show, the situation related to the consumption is supposed to become even more critical. For this reason the involvement in energy field of the European Community becomes necessary. The EU should play a global leading role: an effective decision maker able to manage climate change, to face up to the challenge of energy security and to make the European economy an example for sustainable development. The European Commission's proposals and policies should

aim to change the future energy paths. The most important initiatives are presented in this paragraph.

The agreement by March 2007 to set precise targets, was an important symbol of the Europe's commitment (European Commission, 2008). The European Council established the so-called **20-20-20 targets** (Patrik Rohdin et al., 2013), a program that includes two key objectives:

- a reduction of at least 20% in greenhouse gases (GHG) by 2020;
- a 20% share of renewable energies in EU energy consumption by 2020;

Energy efficiency is central in the EU's 2020 strategy, since it is one of the most cost-effective ways to enhance security of energy supply and to reduce emissions. Energy efficiency, as already said, can be considered as the biggest energy resource. With reference to (European Commission, 2011) the European countries have to introduce energy efficiency policies and measures in order to reach the 20% target. Therefore, **National Energy Efficiency Action Plans** (NEEAPs) have provided the framework for energy efficiency policy development in end-use sectors.

This plan was established under the **Energy Services Directive (ESD)**: introduced in 2006, it sets out a 9% energy-savings target (Directive 2006/32/EC). The ESD includes a lot of activities and services, such as the availability of energy audits for SMEs (small and medium enterprises), financial incentives for the adoption of energy efficiency measures (European Commission, 2011).

Another international energy policy approved by the EU's member states is the **European Emission Trading Scheme (ETS).** The first period of application was from 2005 to 2007 but it was lately extended for the years 2008-2012. With the ETS the level of CO_2 within the EU has been restricted.

After this brief description of the main energy policies, it is useful to investigate which political interventions occur in Sweden, the country focus of my research.

1.6 Swedish energy key policies

To understand how Sweden deals with the energy issue a quick analysis of the policy scenario could be noteworthy. Within the energy sector Sweden has a lot of directives, regarding the environmental, the competitiveness and long-term stability question. The majority of them is based on fixing targets to be achieved by 2020, supporting the objectives of the EU Commission. Thus it could be said that the Swedish energy policy is well harmonised within the EU.

The Energy Policies report of IEA countries (Internationa Energy Agency, 2013a) provides a list of the most relevant policies in the Swedish scenario:

- Short-to medium-term targets for 2020
- The long-term priorities
- Action plan for renewable energy
- Action plan for energy efficiency
- Nuclear replacement
- Climate change adaption
- Energy markets and consumers
- Climate taxation reform
- Research and innovation for a sustainable energy system

After this general presentation of the most important policies, the final analysis that could be conducted is the one related to the policy measures affecting the use of energy by industries.

The main policies influencing the industrial sector are: energy and carbon dioxide taxes together with the EU Emission Trading System for trading emission rights (Swedish Energy Agency, 2012c), the Programme for Electrically Intensive Industry (PFE), the electricity certificate system, the environmental framework code and the energy audit checks.

As stated in the report from the Swedish Energy Agency and the Swedish Environmental Protection Agency, **the Emissions Trading System Directive** manages the trading of emission rights in industry. The aim is to lower greenhouse gas emissions at minimum cost.

The second important measure is related to **energy and carbon dioxide tax**: the former one is based on the energy content of fossil fuels and on electricity use, while the latter is paid per emitted kilogram of carbon dioxide from almost all fuels Moreover there is a further tax on coal, peat and oil.

In 2005 Sweden introduced a voluntary agreement called **Programme for Energy Efficiency in Energy Intensive industries (PFE)**, which became very popular. The goal of the PFE is to improve the competitiveness of Swedish energy intensive industries and to achieve the goals of improving energy efficiency (Stenqvist & Nilsson, 2011). The quantitative aim is to get an energy efficiency improvement at least equal to the effect of the electricity tax.

The main support for companies joining the PFE is a financial incentive in form of a tax exemption. During the period of membership,5 years, companies do not pay the electricity tax of 0.55 €/MWh. The PFE affects energy intensive manufacturing industries, which utilise electricity as major energy source in their production processes. Companies willing to join the agreement must have energy cost of at least 3% of the production value or paying emission taxes of at least 0.5% of their value added (Rezessy & Bertoldi, 2011). In the first period 110 companies participated in the PFE (Swedish Energy Agency, 2011).

The first agreement period ended in 2009, thereafter the agreement was extended for other five years. The estimated reduction of 0.6 TWh per year was exceeded by a total reduction of 1.45 TWh per year (Swedish Energy Agency, 2011). (Stenqvist & Nilsson, 2011) analyse the estimated impact of 101 companies as percentage of avoided electricity use compared to the baseline, that is the electricity demand, 30 TWh, in 2004 (see Figure 11).

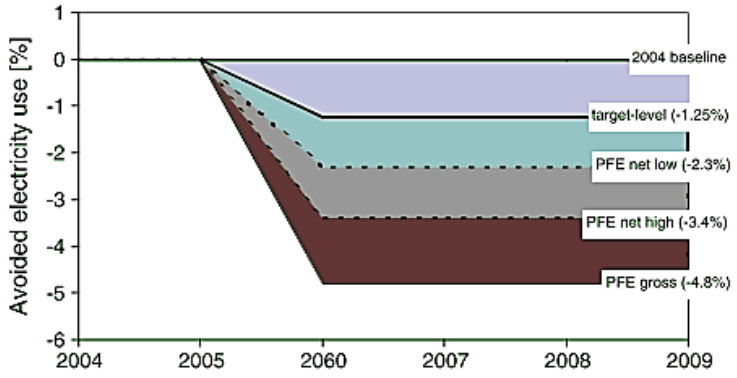


Figure 11. Avoided electricity consumption form PFE measures compared to the 2004 baseline (Swedish Energy Agency, 2007, 2011)

In regard to the **Electricity Certificate System** it is a market-based support system concerning the increase of the electricity production from renewable source by 2020. The electricity certificate system is designed to support the construction of new plants for the production of electricity.

Another mentioned policy measure is the **Swedish Environment Framework Code** (Ministry of the Environment, 2013): it is the first integrated set of environmental legislations in Sweden. The purpose of the Code is to promote a sustainable development assuring a healthy and sound environment for present and future generations. In detail it requires all industrial production to use the best possible technology and to make efficient use of energy. The implication is that companies need to become aware of how they use energy, in order to identify the possible potentials for improvements and then implement saving energy measures.

The last measure is the **Energy audit checks,** a public support for companies that wish to map their energy use. The support consists of encouragement actions and awareness creation of energy efficiency improvement potential.
The system covers 50% of the cost of an energy audit, with a maximum of SEK 30000 (EUR 3360) and is available to companies using more than 500MWh of energy per year.

Several energy-related macro environmental factors affecting the Swedish industry have been presented in order to provide a holistic understanding of their current situation (see Figure 12).

The conclusion of this overall overlook is that energy efficiency is identified as a key success factor to face these challenges.

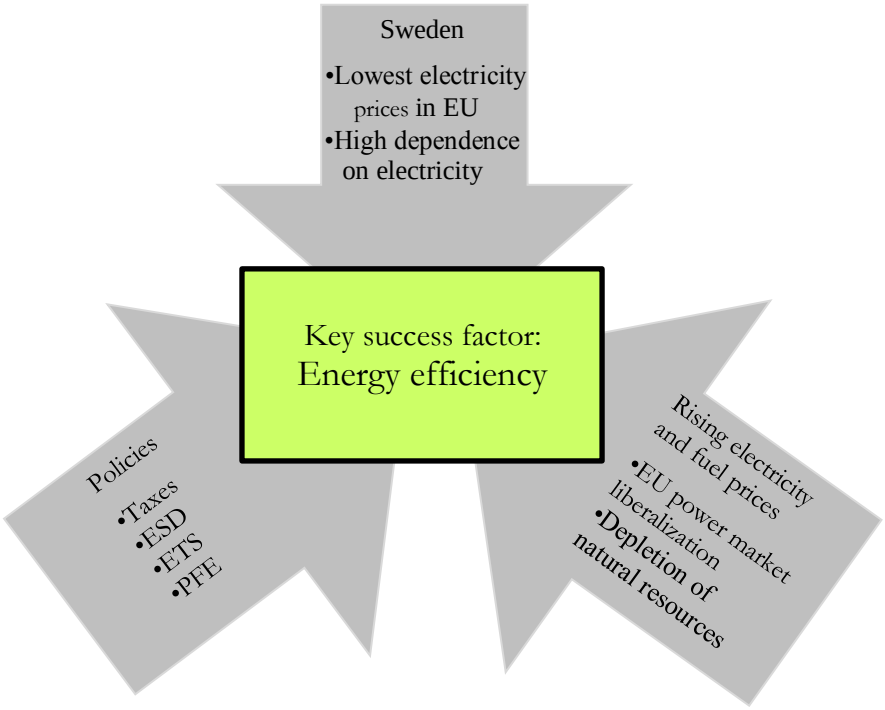


Figure 12. The link between Energy Efficiency and Energy Management

In the previous introduction the concept and the importance of energy efficiency have been properly highlighted. Now the missing step is the existing link between energy efficiency and the focus of this dissertation: the Energy Management.

Although there exists a great volume of literature on energy efficiency, there are fewer reviews on the Energy Management potential.

In practice, improving energy efficiency is often focused on investing in the most efficient available technology (Andrea Trianni, Cagno, & De Donatis, 2014). The potential impact of Energy Management has been neglected for many years, but recently an increasing awareness is growing about this issue (Palm & Thollander, 2010).

In the literature review many authors consider the Energy Management as one of the most relevant means to reach a higher level of energy efficiency in the industry.
Table 2 shows a set of main authors, who relate explicitly Energy Management to Energy Efficiency. In this short literature review the dates of the reports and articles are worthy of notice: the information totally respects the principle of the recentness and this is a demonstration of the late attention to the energy management side of energy efficiency. The concept and the meaning of Energy Management are widely discussed in the next chapter.

Reference	Description
(Bunse et al., 2011a)	Implementing an energy management can be a way to reduce energy consumption and the related CO2 emissions, and this is the purpose of energy efficiency.
(Martin, Muûls, de Preux, & Wagner, 2011)	It is clear the evidence that differences in energy efficiency across firms within a given sector are strongly associated with differences in energy management.
(Ates & Durakbasa, 2012)	Management of the energy has been a subject of interest for all stakeholders as it is considered a significant method of improving energy efficiency and lowering CO2 emissions.
(Backlund, Ottosson, & Broberg, 2012)	Improvements in energy efficiency can be obtained at low cost with energy management.
(Patrik Thollander & Palm, 2012)	An energy management program is a key means by which an industrial company can overcome barriers and improve energy efficiency.
(Drumm, Busch, Dietrich, Eickmans, & Jupke, 2012)	Energy efficiency is presently the most effective and economic lever to sustainably lower energy consumption and energy management systems help to successfully reduce the energy consumption and CO2 emissions.
(Patrik Thollander & Ottosson, 2010a)	Energy management is a means to overcome barriers to energy efficiency.
(Backlund, Ottosson, et al., 2012)	In order to improve energy efficiency and reach the EU: 20- 20-20 primary energy saving target, focus on energy saving potentials from implementing energy management practices in firms is necessary.
(Wai, Mohammed, & Ting, 2011) (Palm & Thollander, 2010)	A long-term program aimed at making the use of energy more efficient is needed. One of the possible solutions is through energy management.
(Palm & Thollander, 2010)	Including Energy Management is of utmost importance for the analysis of future improvements of industrial energy efficiency
(Vikhorev, Greenough, & Brown, 2012)	To improve energy efficiency an organization must adopt procedures, included in energy management.

Table 2. Synthesis of the literature on Energy Management end Energy Efficiency

Chapter 2

Energy Management in Practice

2.1 The concept of Energy Management and critics to the background literature

The end of the previous introduction opens the great debate on Energy Management, which corresponds to the scope of this work. The word "debate" is properly used since it is quite hard to clarify this question and there does not exist a unique and sound theory in the scientific and industrial literature.

Recently, Energy Management has been the subject of considerably increased attention as regards policy formulation (Patrik Thollander & Ottosson, 2010a).

The first step towards an analysis and critics of this issue is to collect the available information. Then the next step will be dedicated to understand the lack of elements in the literature and secondly to point out what could be useful in order to improve the knowledge and the comprehensibility of Energy Management. Increasing the detail in such an analysis could be worthy to mitigate the possible gaps and to realize that much more still needs to be done.

The information sources are identified by searching online databases, like Emerald, Science Direct, Diva Portal, Google Scholar and Governments websites, mostly within Swedish ones. The quality of the information is ensured since it refers to significant academic articles, reports and books.

Moreover a certain attention has to be paid with respect to the recentness of the researches There is only a work, the one of (Caffall, 1995), that is old research, nonetheless it is considered the starting point.

It is particularly interesting to gather and examine what is written about Energy Management. Among the great amount of studies in the energy field, the research into Energy Management has so far been rare (Patrik Thollander & Palm, 2012).

In the following part the idea of Energy Management is exposed. First of all it is mandatory to notice that the proposed comments are wide and not always written as real descriptions: this represents the initial problem.

In order to comprehend what could be improved in this field, the first aim is to try to specify the implicit meaning of each definition and the point of view of the different authors. To this end, attention has been paid towards human and organizational aspects within Energy Management and the relative weights in the descriptions.

- "Energy Management is the proactive, organized and systematic coordination of procurement, conversion, distribution and use of energy to meet the requirements, taking into account environmental and economic objectives" (Association of German Engineers).
- "Energy Management is defined as applying to resources as well as to the supply, conversion and utilization of energy so that least power is expended to achieve worthwhile aims" (O'Callaghan & Probert, 1977).
- "Energy Management is the strategy of meeting energy demand when and where it is needed. It is one of the main functions of industrial management" (Abdelaziz, Saidur, & Mekhilef, 2011).
- "Energy Management in production includes control, monitoring, improvements activities for energy efficiency" (Bunse et al., 2011a).

The aforementioned comments are very broad and they don't say specifically what is Energy Management. The descriptions include the overall view of Energy Management and it is not clear how much is the organizational and human dimension weight with respect to the technological part. It is mainly emphasised the role of streamlining and rationalization of energy resource in a structured way. Even though these descriptions are not comprehensive this last aspect is relevant anyway. In the case of the comment of (Bunse et al., 2011a), for instance the production is mentioned as the only belonging area of Energy Management. This is an extremely limited vision.

- "What many descriptions have in common is the focus on implementation of energy efficient technologies and replacing inefficient equipment. However Energy Management also includes care and maintenance of technology to preserve an efficient operation. It requires continuous work and improvement" (Backlund, Thollander, Palm, & Ottosson, 2012).
- "EM is known as the effective use of energy to maximize profits and to enhance competitive positions through optimisation of energy efficiency technologies in the process and organizational measures. It is regarded as a long-term method of stretching limited energy resources" (Thumann & Mehta, 1997).
- "EM concerns the implementation of new technologies, new materials and new manufacturing process, and the use of new technologies in equipment and materials for business and industry. Managing energy is not a just technical challenge, but one of how to best implement those technical changes with economic limits and with a minimum of disruption" (Turner & Doty, 2007).
- "Energy Management includes both planning of energy efficiency investments as well as care and maintenance of technology to maintain an efficient operation. The key to success for Energy Management is a combination of management and traditional technical energy efficiency measures" (Backlund, Ottosson, et al., 2012).
- "EM had been technology led and therefore located mostly in technical departments which tended to be isolates form mainstream mgmt. Activities need to be in integrated into the management structure" (Ashford, 1993).

In these descriptions the technological point of view remains important even if there is an effort to include something related to the way of working. Energy Management is not only purchasing the best available technologies (BAT) but the authors sustain that there is a need of knowledge and awareness in order to keep up the operations.

- "Energy Management can be defined as the way a company works strategically on energy. Research into energy efficiency has generally focused on technological and systems improvements but it is not enough" (Palm & Thollander, 2010).
- "Effective Energy Management has a strategic dimension. It includes all operational, tactical and strategic decision-making processes that involve or affect

processes and operations regarding energy use" (Rudberg, Waldemarsson, & Lidestam, 2013).

- "It is not only a matter of technical settings: the management and organizational side are also essential aspects. Most of study in the past dealt with highly technical aspects but did not include the comprehensive management aspects of energy" (Ates & Durakbasa, 2012).
- "It is clear the transformation from a rather technical system to a management system with more focus on information, communication and employee involvement. Energy Management is a management system not only a monitoring system" (Christoffersen, Larsen, & Togeby, 2005).
- "Energy Management is becoming a dynamic process where new ideas and knowledge are generated, which in turn, produce additional energy efficiency gains. A comprehensive Energy Management programme is not purely technical and it its introduction also implies a new management discipline" (Kannan & Boie, 2003b).
- "Energy Management is multidisciplinary in nature, and it combines the skills of engineering management and housekeeping" (Murphy).
- "Until recent times Energy Management primarily focused on replacing inefficient equipment. The knowledge gained from many energy efficiency projects is driving a transition from traditional tactical practice to Energy Management strategies. It is a process of continuous improvement" (Gordić et al., 2010).
- "EM has traditionally focused exclusively on technologies that increase the energy efficiency of key energy-consuming processes and equipment but there have always been concerns that traditional deployment practices have not results in consistent and long term energy savings. A strategic approach has the power to increase energy savings above and beyond the savings realized by traditional tactical practices alone" (V. Gorp, 2004).

Here the novelty is the acknowledgement that Energy Management and organizational means have been neglected in the past years. The role of technology is still stressed but is rising the idea that energy has to be treated as a strategic resource.

- "Energy Management is largely about people rather than technology. The approach can be "people-based", but a sound approach in order to succeed will be the combination of both the managerial techniques and some technical measures appropriate to the particular site" (Caffall, 1995).

According to my work, this remains the most important definition of Energy Management because for the first time the human and organizational aspects get more importance than the technical ones. This book is extremely innovative and what it is worthy of notice is the date of this study. From 1995 there haven't been other works, which affirmed so radically that Energy Management has not to be considered only from the technical point of view.

The studies concerning the new energy efficiency technologies and the implementations of the best available technologies (BAT) are very common in the literature but a focus mostly on strategic, organizational and human implications of Energy Management is not still satisfactorily considered, as stated by (Patrik Thollander & Ottosson, 2010a).

In the last few years a change in the way of considering this kind of management has happened, as the previous definitions show, but still a lot needs to be done in order to improve the knowledge and the awareness in the industry. Regarding industrial energy efficiency improvements the potential, that can be achieved through changes in how energy is managed and used, rather than through installation of new technologies is still unexploited (Mckane, 2009).

It is then evident that only upgrading the efficiency of technologies cannot achieve optimal savings, but when this effort is combined with management systems, the results can be significant savings (Scheihing, 2009).

Energy is one of the management resources of a company, and shall be managed and controlled in harmony with the management of other resources.

After these considerations, it is worthwhile to resume the concept of Energy Management in this work*:*

Industrial Energy Management is the practical application of energy management principles and practices across an organisation in a sustainable way. The mere implementation of energy efficiency technological measures as well as the institution of an energy policy within the business strategy is not

sufficient: Energy Management, with its practices, is the result of the policy and the enabler to energy savings and technical interventions. Without the "soft" activities, components of Energy Management, that integrate leadership, governance, and mostly people, the company would not get the best results in energy efficiency and savings.

Considering Energy Management at an intermediate level between corporate policy and operative interventions recall the treatise of (Anthony, 1965). The author created a taxonomy for managerial activity, composed by three parts

- Strategic planning: long-term goals and policies (decisions at a high management level).
- Management control: acquisition and efficient use of resources in pursuit of company's goals (decisions at a middle management level).
- Operational control: efficient and effective implementation of specific tasks, (activities at a low management level).

By (Caffall, 1995) the last comment is that " *you cannot buy world class performance: it can only be achieved through skill and hard work. Companies are still dominated by people, so success will only come from making the technology subservient to them".* This statement agrees with the chapter main argument.

2.1.1 Energy Policy

The adopted definition of Energy Management does not include the energy policy at the business corporate level. The analysis of this issue is not the focus of this work but it is essential to say that the energy policy is necessary in order to manage the energy as the any other resource in the industry.

The energy policy is the company vision regarding future energy use and the term is medium-long. It plays the role of enabler to the Energy Management and then to the process of investments and implementations of technical measures. It is of utmost importance for the success of Energy Management.

As stated by (Patrik Thollander & Ottosson, 2010a) it is significant to note that the energy management goals are on a lower organizational level than business energy strategy or policy.

The energy policy/strategy is considered an important instrument which provides explanation on energy-related plans and priorities (Sorrell & Scott, 2000). It is allow establishing an authority mechanism (Ates & Durakbasa, 2012).

The policy is necessary in order to prioritize on the company strategic and corporate level the energy question and the Energy Management solution (Rudberg et al., 2013). Furthermore one of the Energy Management Handbook, especially the one of (Department of Alternative Energy Development and Efficiency Energy Conservation Center Thailand, 2005), describes five attributes of a successful energy policy:

- Commitment: personal message from top management with a commitment with a regular policy review.
- Thrust: a new and challenging dimension to energy and environment.
- Applicability: instruction on which parts of the organization are covered by the policy.
- Implementation: short and qualitative guidance on how the policy objectives are to be met.
- Review: the acknowledgement on how goals have been achieved.

According to this list it is possible to that the energy policy is a direct input e from the top management and it belongs to of the overall strategy of the company. The energy policy should be simple and easy to communicate (Hrustic, et al., 2011). It should have a high priority with respect to anything else in the energy issue.

Nonetheless the practical activities of Energy Management lead to effective energy saving in a direct or indirect way: the energy policy is necessary but not sufficient.

2.1.2 Energy Management in practice

Energy Management is inspired by and similar to other management systems such as: Environmental Management, Health and Safety Management, Quality and

Production management. Often Energy Management is included in the Environmental Management or linked to Climate Change Management, even if it focuses more on reducing the use of energy rather than reducing emissions of GHG (Möllersten & Westermark, 2001).

All these management standards belong to the family of so-called Rational Models for Decision-making.

These considerations are sustained by (Christoffersen et al., 2005) in a detailed work about energy management in practice in the Danish manufacturing industry. The three authors also present also an interesting analytical framework, which helps to figure out the background variables that affect the work with energy in a company. It is useful to comprehend the general "environment" of Energy Management. As illustrated in Fig 14, energy management in practice will lead to energy savings through a more efficient use of energy, as already mentioned. The factors that contribute to improve the knowledge about Energy Management and then consequently to make it effective, are five:

- *Regulation:* the policy measures in the energy sector together with other environmental instruments can change the behaviour of people towards energy use.
- *External relations:* the impact of the relations is very deep. The network within the same industrial sector as well as within different sectors or companies is important with respect to the transfer of knowledge.
- *Company characteristics:* the Energy Management and in general the energy activities depend on the company's characteristics. Sector, size, kind of processes and energy intensity result very critical.
- *Internal conditions:* these represent maybe the main factors, mostly for the analysis in this work. The internal organisation of the company has a great influence on the energy activities. Two types of attitudes could be identified: proactive and reactive.
- *Energy price:* this is a debatable variable because in the past different scholars sustained that energy prices influenced energy consumption and activities in the industry. But the energy prices cannot totally explain the differences in the effective implementation of Energy Management activities since many studies,

like the survey in the Danish manufacturing sector of (Christoffersen et al., 2005), demonstrate that other factors are decisive.

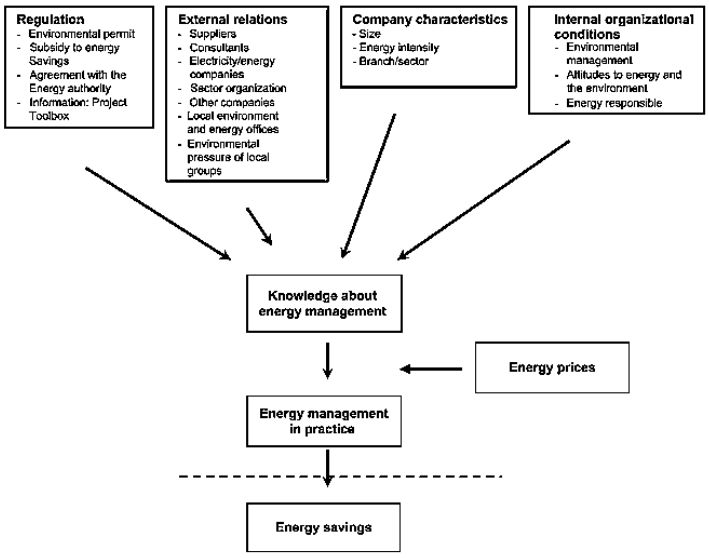


Figure 14. The analytical framework (Christoffersen et al., 2005)

Regarding this famous framework, a comment is that for this dissertation the main factors are internal conditions and external relations: the Energy Management in practise is affected by the internal state and the network with other companies. Here the success is the improved knowledge that allows to establish and then make more effective the Energy Management. As already said, few scientific and empirical researches focus only on these aspects.

2.1.3 The scope of Energy Management

The literature review concerning Energy Management proposes many economic, social, environmental aims; the most relevant and well considered goals are:

- *Improving energy efficiency* (decreasing energy cost and CO2 emissions, reducing energy consumptions and energy intensity, reducing energy requirements per unit of output while holding constant or reducing total costs of producing the output): this is the main scope, already debated. A consequence of the higher

energy efficiency level is enhancing productivity, competitive position, profitability and potential growth (Ates & Durakbasa, 2012; Backlund, Thollander, et al., 2012; Bunse, Vodicka, Schönsleben, Brülhart, & Ernst, 2011b).

- *Overcoming barriers to diffusion of new energy efficiency technologies and assisting the adoption of new technologies*: the Energy Management, with its soft aspects, is an enabler to the effective implementation of technological measures (Backlund, Ottosson, et al., 2012; Patrik Thollander, 2008; Vikhorev, Greenough, & Brown, 2013).
- *Facilitating energy efficiency investment decisions:* the Energy Management helps in the decision making process, since improves the knowledge and information concerning energy in the company (Caffall, 1995; Ates & Durakbasa, 2012).
- *Improving energy efficiency of existing business activity:* in the majority of the cases what is improved in a company is the energy efficiency of existing equipment and processes. With some precautions and small improvements can ne changed the way of working with them, mostly with the effort and commitment of the people (Abdelaziz et al., 2011; Backlund, Thollander, et al., 2012; Christoffersen, Larsen, & Togeby, 2006; Rudberg et al., 2013).
- *Funding investments in energy saving technologies:* a lot of Energy Management no-cost activities lead to earlier savings, which can be used as funding for more expensive investments. It can be created a sort of internal fund with no-cost or measures (Diaconescu, Patrascu, Grogorescu, & Simionescu, 2011; Wai et al., 2011; Caffall, 1995).

2.1.4 The Energy Management System

Regarding Energy Management, the new point of view is that energy has to be considered as important as other resources in the company, and therefore its management has to become a priority.

In the last years the awareness about similarities among different kinds of management has grown. Now it is clear that Energy Management has been inspired by other management guidelines like environmental, health, safety and quality management which all belong to the family of so called '*Rational Models for Decision*

making' (Christoffersen et al., 2005).

Earlier versions of energy management system, e.g. environmental management standard ISO (International Organisation for Standardisation) 14001, were based on this model. First of all it anticipates an explanation of the meaning of "energy management system". According to (Patrik Thollander & Palm, 2012) an energy management system is a "tool for implementing the energy management procedures by which a company works strategically on energy".

Hereby, a management system is the "framework that contains the procedures and tools so that an organisation can fulfil its objective regards to energy savings" (Anderson, 2005; UBA, 2010).

Nowadays are available European (EN 16001) and international (ISO 50001) energy management standards. The ISO 50001 is a framework that helps companies to manage their energy systems and better plan energy savings and to reduce pollution as well as costs: these standards can reduce global energy consumption by 60% (International Organization for Standardization, 2011). The ISO 50001 provides the following benefits:

- Resolves energy efficiency problems
- Improves energy usage of energy-consuming assets
- Estimates environmental impact of greenhouse gases
- Improves energy management and communication
- Provides best practices for energy efficiency
- Prioritizes new energy-saving technology
- Improves energy efficiency of supply chains
- Details greenhouse gas reduction plans

The aforementioned standards are based on the *Plan-Do-Check-Act (PDCA) cycle*. Figure15 shows an adapted version of the PDCA cycle and displays its relationship to the central aspects of an energy management system with the final goal to improve energy efficiency.

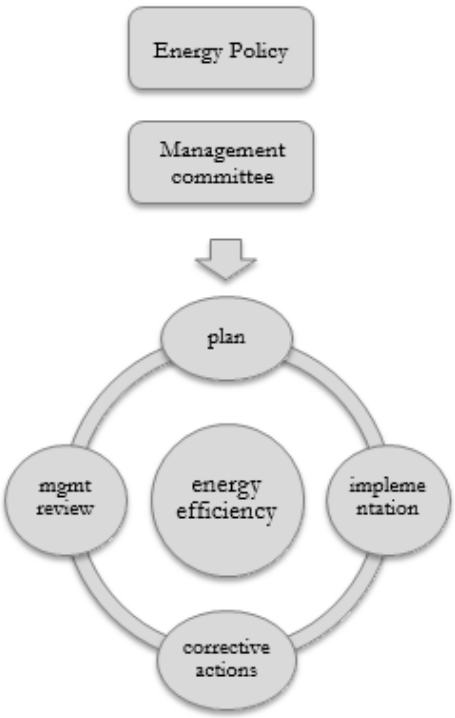


Figure 15. PDCA cycle of an Energy Management System

Above all, energy management systems emphasises that energy efficiency potentials are investigated on a continuous basis and not just the time in which the system is implemented. With respect to the statement of (Christoffersen et al., 2005) it should be underlined that there is no "*one-size-fits-all*" each system is individualised and suited to the specific company. The following part, according to the official report (International Organization for Standardization, 2011) presents a brief description of the requirements of the ISO 50001

Top management commitment. The commitment of the top management to improve energy efficiency is crucial to create credibility and to facilitate the introduction of an energy management system (Smith, et al., 2007). Top management has the task of establishing an energy policy, appointing an energy manager, who is supported by an energy management team, and providing necessary resources (International Organization for Standardization, 2011)

Planning. (Mckane, 2009) states that "in companies without a plan in place, opportunities for improvement may be known but may not be promoted or implemented because of organizational barriers".

The "planning step" includes conducting an energy review, defining a baseline and energy performance indicators and formulating objectives, goals and action plans in form of an energy policy and energy plan (International Organization for Standardization, 2011). The energy policy should be simple and easy to communicate (Hrustic, et al., 2011). It clarifies how the organisation plans to use energy.

Doing. Here the implementation of the energy action plans. In order to successfully achieve the goals defined in the planning stage, ISO 50001 includes six basic modules: training and awareness; communication; documentation; controlling, design; procurement.

Checking. The "checking stage" includes monitoring, measuring and examining the previous defined energy-parameters according to energy policy and objectives (ISO, 2011). These measures have to be conducted regularly. This task is closely related to quality management systems and environmental management systems.

Management-review. Regarding periodical management review, top management evaluates the EMS on a highly aggregated level. The purpose is to verify if the current system is still suitable and effective to achieve the goals and to take actions for improving the EMS and energy efficiency in general.

2.1.5 Barriers to Energy Efficiency and Energy Management

Until now a fundamental issue has not yet been discussed: the barriers to energy efficiency and consequently to energy management. The main definition in the literature is that a barrier to energy efficiency in organizations is "a postulated mechanism that inhibits investment in technologies that are both energy-efficient and apparently economically efficient" (Sorrell, Mallett, & Nye, 2010).

The literature about this issue is wide and an in depth analysis is out of the scope of this work. A brief distinction is among: market related energy efficiency barriers caused by market failure and not caused by market failure (Jaffe & Stavins, 1994;

Palm & Thollander, 2010; Sorrell & Scott, 2000). Table 3 presents a collection of the main barriers in order to resume a part of the literature regarding this issue.

Authors and Year	Sector	Main Barriers
(Reddy & Assenza, 2007)	All sectors	awareness; economic
(Sorrell & Scott, 2000)	Industrial sector	behavioural; organizational; technology related
(Harris, Anderson, & Shafron, 2000)	All sectors	economic; organizational
(de Groot, Verhoef, & Nijkamp, 2001)	Selected industrial sectors	behavioural
Anderson and Newell, 2004	Manufacturing industry	economic
(P Rohdin & Thollander, 2006)	Non-energy intensive manufacturing	economic; organizational ; behavioural
(Nagesha & Balachandra, 2006)	Foundries, bricks and tiles industries	economic; behavioural
(Patrik Thollander, Rohdin, Karlsson, Rosenqvist, & Söderström, 2012)	Foundry industry	economic; technology related
(Sardianou, 2007)	Industrial sector	behavioural; competence related
(Patrik Thollander & Ottosson, 2008)	Pulp and paper industry	economic; technology related; behavioural; organizational
(Schleich, 2009)	Commerce – services	informational; organizational
Muthulingam et al., 2011	Manufacturing industries	economic
(Fleiter, Worrell, & Eichhammer, 2011)	Small industry	economic
(E. Cagno et al., 2012; A. Trianni & Cagno, 2012)	Non-energy intensive manufacturing	economic; technology related
(Walsh & Thornley, 2012)	Non-energy intensive process industry	economic; technology related
Apeaning and Thollander, 2013	Industrial sector	economic
(Kostka, Moslener, & Andreas, 2013)	Small industry	informational
(E. Cagno, Worrell, Trianni, & Pugliese, 2013)	Manufacturing industry	awareness; organizational
(Andrea Trianni, Cagno, & Worrell, 2013)	Foundry industry	economic; organizational; behavioural

Table 3. Synthesis of the literature review on energy efficiency barriers

In this work an already developed taxonomy is used for the empirical investigation. The taxonomy, proposed by (E. Cagno et al., 2013), embraces these barriers:

- *Information barrier*s: these are composed of a set of barriers including both external and internal problems regarding the company due to the flow of information. Examples are: lack of information on costs and benefits, not clear information by suppliers, trustworthiness of the information source, information issues on energy contracts.
- *Economic barrier*s: these barriers are related to the economic evaluation of an energy-efficiency activity. Theoretically some components of this barrier are not

so important with respect to Energy Management, but the organizational and hidden costs still have more weight.

Examples are: low capital availability, investment costs, hidden cost, intervention-related risks, external risks, not sufficiently profitable intervention.

- *Behavioural barriers*: these barriers regard the behaviour of people and decision-makers within the firm and for this reason they can be referred exclusively to internal factors of the company. This is one of the most crucial group of barriers for Energy Management. Examples are: lack of interest in energy-efficiency interventions, other priorities, inertia, imperfect evaluation criteria and lack of sharing the objective.

  Having other priorities is a particularly critical barrier for small and medium companies: often the decision-makers are focused on few core business activities. This is studied in many empirical researches (Enrico Cagno & Trianni, 2012a; P Rohdin & Thollander, 2006; Patrik Rohdin et al., 2007). Regarding inertia, as (Sorrell et al., 2010) point out, "this barrier represents the resistance to change and risk, and the more radical the higher it will be."
- *Organizational barriers*: these barriers descend from the interaction of different functions within a company. For Energy Management the organizational aspect and related obstacles are supposed to be very significant.

  Examples are: low status of energy efficiency, divergent interests, complex decision chain, lack of time, lack of internal control.
- *Barriers related to competence:* specific competences are requires to find the best way to improve energy efficiency. The lack of these competences leads to an incorrect use of energy and therefore makes it harder to achieve the desired objectives..

  Examples are: identifying the inefficiencies, implementing the interventions, difficulty in gathering external and internal competences
- *Awareness barriers*: the area of interest of these obstacles is the ignorance of decision makers on energy efficiency concept and energy management practices, and the complete lack of interest in energy issues.

After this general discussion and explanation of energy efficiency barriers, the obstacles influencing the Energy Management can be recognized. Since the

discussion on Energy Management does not deal with technical problems and solutions, all the barriers related to the technical sphere will be not considered here as real barriers. Only the barriers, which frequently inhibit the organizational ability to manage energy, are taken into consideration.

These are identified by (Brown & Key, 2002) as: lack of organizational commitment, insufficient resources, lack of energy data, shifting priorities, result not sustained and narrow focus (widening the focus and participation in energy management could certainly result in better improvements).

These examples mostly belong to the *organizational, behavioural and information categories*. In this case some barriers like risk and access to capital are no more valid, since the Energy Management activities are almost always no-cost or with short pay-back time. The one that remains is the hidden cost barrier, still influencing the decision-making process regarding Energy Management.

Regarding this issue, another interesting contribution is provided by (Palm & Thollander, 2010), who identifies as major inhibitors for adapting cost-effective energy efficiency measures other priorities for capital investments, lack of sub-metering, lack of priority given to energy management and slim organisation.

These barriers have a managerial or organisational origin and the decision making process for energy efficiency investments takes place in the same origin. This leads to a self-reinforcing effect: for example a manager who has no interest in saving energy is likely to create an organisational environment that will suffocate energy efficiency improvements in the first place (e.g. by rationalising staff, emphasising slim organisation or by not respecting improvement suggestions).

Since including a management perspective is of utmost importance for future improvements of industrial energy efficiency (Palm & Thollander, 2010; Sandberg & Söderström, 2003), it is necessary to overcome all the organizational, behavioural, and informational barriers.

In the next chapter, concerning the description of the framework for energy management practices, this debate will be again treated.

2.1.6 Drivers to Energy Efficiency and Energy Management

In the literature some definitions are restrictive and focused on investments, like the one of (Reddy & Assenza, 2007) or still technology-related as the one of (Patrik Thollander & Ottosson, 2008): a driving force is the opposite of a barrier, in other words, different types of factors that stress investments in technologies, both energy-efficiency and cost-effective. (Worrell et al., 2003) describe driver as a factor that helps to accelerate the uptake of energy efficient technologies and practices; here the definition is wider but includes also the practices. The drivers can influence a portion of the company or a part of the decision making in order to provide a thrust towards energy efficiency. Often the best results can be achieved through the cooperation of multiple drivers simultaneously. In the theoretical and empirical literature there are many examples of drivers for overcoming the inefficiencies such us:

- Voluntary agreements: these drivers are linked to government's public policies or collaboration between different companies. Based on the opinion of (Worrell & Price, 2001) voluntary agreements are new approaches to energy efficiency.
- Efficiency due to legal restrictions: severe environmental regulations could persuade the industries to follow innovative measures. This driver is considered very useful in case of inertia barrier.
- Green image: (Hasanbeigi, Menke, & Pont, 2009) sustain that it is a matter of marketing within and outside the company. According to (Patrik Rohdin et al., 2007; Zailani, Jeyaraman, Vengadasan, & Premkumar, 2012) media and non-governmental organizations are putting an increasing pressure on the companies regard to the sustainability aspects.
- Willingness to compete: companies often invest a lot with the focus on core business and prefer the investment that improve the market share (Cooremans, 2011, 2012). If the company consider energy efficiency practices as competitive tools, these are no longer marginal and become of great importance to achieve business goals.
- Management with real ambition and commitment: often energy efficiency has not a right priority due to a lack of power by the responsible people (Sorrell & Scott,

2000). Hence it is mandatory to have a management with real ambition and commitment towards energy efficiency.

- Staff with real ambition: this driver affect the employees' culture through good communication, training, decentralization. The results totally depend on the motivation of personnel (Michaelis, Peszko, Worrell, & Jaffe, 2001).
- Increasing energy tariffs: the principal interest of the company is to decrease the energy costs and not necessarily save energy as said by (Hasanbeigi et al., 2009). This corresponds to an economic instrument to promote energy efficiency (Patrik Thollander & Ottosson, 2008).
- Cost reduction form lower energy use: the company is induced to consume less energy with a consequent perception of cost reduction. By (Patrik Thollander & Ottosson, 2008) an action could be the reduction by government of the taxes due to a lowered energy use or the pressure from clients to cut energy costs.
- Public investment subsidies: this is the most recognized and spread driver. These subsidies can be consider "financial instrument for energy savings" (European Commission, 2011).
- Private financing: this is an economic driver, in the form of loans that a company can obtain from financial institutions.
- Management support: often a company face difficulties to undertake energy efficiency initiatives because it is not capable of managing the project, its development and implementation (Aflaki, Kleindorfer, & de Miera Polvorinos, 2013)
- Knowledge of non-energy benefits: (Reddy & Assenza, 2007) affirm that this is an essential driver since non-energy benefits often encourage decisions. These benefits could be: improved indoor environment, comfort, health, quality, safety, productivity; reduced noise; labour and time savings: improved process control; increased reliability, amenity or convenience and direct/indirect economic benefits from downsizing or eliminating equipment. (Worrell et al., 2003) consider non energy benefits as key elements in the company decision-making process.
- Availability of information: the people should have information available in order to better decide and act.

- Clarity of information: the information should be sufficient to properly implement energy efficiency initiatives and to promote and control other measures.
- Trustworthiness of information: regarding the source of information often there is the problem of reliability underlined by (Sorrell et al., 2010). The influencing factor are: the nature of the source, past experience, the nature of interactions with the source, recommendations from colleagues, professional and social networks.

It is quite evident that a distinction between internal and external drivers can be made, in this way it is possible to understand if the correcting actions should be promoted internally or an external support could be more appropriate. Since Energy Management is mostly about the people within the company, the internal drivers are supposed to be more decisive than the external

Beyond this distinction, there is another one considered in the framework: the drivers can be grouped in four clusters, with sufficient detail for the purpose. The group can be:

- Regulatory: these actions involve all means and standards which aim to convince companies regarding the importance of energy efficiency.
- Economic: these actions refer to the monetary aspects
- Informative: these actions involve all aspects related to both information content and its flow within the company.
- Competence related: these actions permit the improvement of competences and skills of the people in charge of energy issue.

2.1.7 The scope of the research

The purpose of this chapter is to clarify the importance of the Energy Management and the implied better energy efficiency results once it is applied. Managing energy has traditionally been a hard issue to be accepted by executives and a difficult task for people in charge of it (Brown & Key, 2002). Nowadays growing attention and

awareness lead to recognize that effective management of energy requires an organizational structure that elevates the importance of energy and organizes people, resources and plans to achieve the desirable outcomes.

Energy Management is necessary to succeed in energy efficiency and in the recent years there is a perceived change in the way of considering it. Traditionally in the literature the Energy Management has been considered as a matter of technical issues: there has been a scarce consideration of the organizational and human dimension.

Actually in the recent studies the debate on Energy Management is still open, its definitions are really wide and general and hardly ever there is a sound position regarding this issue. In this chapter the fact that energy management concept is not described in a unique way is highlighted. It can be demonstrated that the implementation of Energy Management is essential to accomplish the overall energy strategy and the best results from energy efficiency.

Managing the energy has to be totally similar to manage the other resources in a company and the "soft" aspects related to organisational and human dimensions are as important as, or maybe even more, the mere operative, tactical and technical factors.

In the chapter the Energy Management has been nominated in practice since the "soft" activities that allow the effective implementation are the "practices.

As stated by many authors, for instance (Caffall, 1995), the combination of energy management practices and energy efficiency measures, more related to technological solutions, leads to the maximum results. But, while the aforementioned measures, like the BAT, are very available, popular and well-studied, the management practices in this field are still quite neglected.

The aim of the next chapter is to add knowledge about energy management practices and their value for the company.

Chapter 3

The characterization framework for energy management practices

3.1 The Energy Management Practices

As explained in the previous chapter, in the literature energy management is not described in a unique way: indeed, it can be seen from many different perspectives, and a cohesive definition does not seem to exist yet. Moreover, Energy Management has been widely observed from a technical point of view, with great attention to new energy-efficient technologies and related investments.

The organizational perspective is somehow quite novel, and tries to pay more attention to the people who create, manage and run the organization: "energy management is largely about people rather than technology", as stated by (Caffall, 1995).

If the analysis of energy management is on a higher level than the one of the operative interventions and measures, the technical perspective is not therefore sufficient: indeed, other aspects, beyond the technical ones, are essential.

Recently, authors highlighted that studying Energy Management at an intermediate level could be interesting, being the result of defined strategies and policies, from the corporate strategy, and as enabler to energy efficiency intervention, at a lowest levels (Patrik Thollander & Ottosson, 2010a). Therefore, placing energy management at this intermediate level shows that managerial and organizational aspects are essential, and thus cannot be considered as an exclusive matter of technical activities.

According to this perspective, the intermediate management becomes the link between the highest and lowest level of analysis: it is, thus, essential to make the technical improvements succeed and to make the energy policy become operative instead of abstract.

Said that, it is possible to introduce the concept of the Energy Management practices. In the next paragraph the aim is to understand the meaning of the practices within an organization.

3.1.1 The definition and background literature

As in the case of Energy Management, the related practices are poorly represented in the literature: although some studies exist, a consistent and comprehensive view is lacking. It is often much easier to indicate what an energy management practice is not, instead of trying to clarify its meaning. Furthermore, authors face the possible overlapping between energy management practices and energy efficiency measures, that are rather technology-related, and it is really very hard to differentiate the two concepts.

Some authors tend to simplify their approach, considering everything as an energy efficiency measure, i.e. an investment which decreases the use of energy and appears to be cost-effective according to the company's investment criteria (P Rohdin & Thollander, 2006). Here the term "investment" indicates either purchasing technological assets or simply adopting new practices or routines. Everything requires to devote appropriate resources in order to obtain future results in higher energy efficiency, but the focus of this work does not merely deal with the financial resources needed for technological investments. Therefore, in this case only a meaning of the term " investment" is considered, the one that concerns energy management practices.

(Caffall,1995) points out that almost every management practice leads to relevant savings without capital or with limited investment (short payback time compared to that of a technological measure), and such savings could be immediately re-used to finance subsequent investment in energy-efficient technologies.

In my analysis energy management practices belong to a higher level than the measures still related to the technological level. The difference is very hard to perceive but a different approach, with more focus on information, communication,

and employee involvement, has the power to increase energy savings above and beyond the savings realized by traditional tactical practices alone.

In the literature review it is very hard to find a definition of an energy management practice although being a term commonly used.
(Christoffersen et al., 2005; Gordi et al., 2010; V. Gorp, 2004) point out that energy management practices have so far mainly consisted in replacing inefficient equipment and then using different methods to estimate the obtained savings. Energy management has traditionally focused exclusively on technologies that increase the energy efficiency of energy-consuming processes and equipment, reducing the consumptions. Nonetheless, (J.C. Van Gorp, 2004) believes that traditional measures have not correspond to consistent and long -term energy.
Looking at other management practices in the company could provide an effective support to better understand and, thus, define an energy management practice. Energy should be treated as other resources (human, material etc.), hence the different management systems are characterized by some similarities. Therefore the concept of "practice" in a company is similar among the different disciplines.

The choice of positioning energy management practices at an intermediate level is a consequence of how the Energy Management is considered in this study. Moreover it is partially shared by some authors:

- (Backlund, Thollander, et al., 2012) highlight that energy management practices aim at improving energy efficiency of existing activities and the deployment level of energy policy programmes;
- (Backlund, Ottosson, et al., 2012) shows that energy management practices have large effects on energy utilization: they affect investment decisions and the outcome of investments in energy efficiency technologies.

After this brief debate an energy management practice could be defined as *a technique, a method, a procedure, a routine, a rule employed or followed by a company in the pursuit its objective regarding the management of the energy resource.*

Moreover energy management practices are low or even no-cost management techniques, which allow the fulfilment of the overall energy policy and the effective implementation of energy efficiency measures, often technical related, since they are necessary in the decision-making process.
They can be studied as enablers and facilitators to improvements in existing or new energy saving activities and often provide funding for subsequent investments in technology.

3.1.2 The need for a new characterization framework

An important study about the explained concept of Energy Management is the one of (Caffall, 1995). Based on the opinion of (Caffall, 1995) the approach to Energy Management and relate practices has changed to a people-based one but its dissertation s still not comprehensive. Then other authors tried to do study this approach but no sufficiently in depth (Backlund, Ottosson, et al., 2012; Diaconescu et al., 2011; Mashburn, 2001; Turner & Doty, 2007).
The main contribute of this research is the focus on the practices: in our knowledge there is no similar study. This subject is in general scarcely discussed but full of potential for future research.
The work aims at assessing a whole enterprise in the context of Energy Management: it is possible to study the maturity level of the practices' implementation within a company, through a characterization of the practices.
Moreover, the evaluation can support an enterprise to investigate which practices are more suitable and desirable, as well as to understand the actions necessary to improve them. The aim is supposed to be double: a general assessment of energy management in the company and a specific evaluation for each practice in use. After the AS-IS evaluation it could be able to provide some remedies regarding the implementation of energy management practices.
In order to achieve the aforementioned goals it is necessary to create a novel characterization framework, able to understand which are the most important characteristics of energy management practices, through an in-depth literature

review. In our best knowledge there is not an attempt to build such a framework. (Vikhorev et al., 2012) sustain that energy management requires a flexible approach but it would totally benefit form a framework able to easily structure the implemented practices: and this is the scope of this research.
In doing so, it is essential to identify measurable attributes of energy management practices.
The new characterization model of energy management practices will then be tested, in order to validate the framework and then it will be applied to some companies.

In order to create and apply this model some steps should be followed:

- to find, select and analyse the characteristics of energy management practices in the literature (axes nr.1) and the respective attributes (levels) for each characteristic;
- to find, select and review the practices discussed in the literature (axes nr.2);
- to join the two axes in order to create the characterization framework, applicable to companies;
- to fill the "practices/characteristics" framework with values proposed by the literature review, where it is possible. This allows making a feasible assessment of the company through the application of the framework.

3.1.3 The main characteristics of Energy Management practices

The first main step is to identify an exhaustive number of energy management practices' characteristics in order to set the first axes of the characterization matrix.
Even if the energy management practices are different from the energy efficiency measures, it is possible to be inspired by some studies, for instance (Andrea Trianni et al., 2014), concerning the characterization of the measures in order to figure out the suitable features for the energy management practices. Some characteristics can be right and adaptable also to energy management.
In the literature many authors deal with the characterization of energy efficiency measures through lists or clusters of attributes; for example the contribution of

(Cooremans, 2012; Pye & McKane, 2000; Worrell et al., 2003; Skumatz,2005) are very noteworthy in this field. The former work indicates the total benefits of energy efficiency projects; they list characteristics like increased productivity, reduced costs of environment observance, reduced production costs, reduced waste disposal costs, improved product quality, improved capacity utilization, improved reliability and improved worker safety. The latter contribution studies the non-energy impacts from energy efficiency activities.

(Mills & Rosenfeld, 1996) distinguish seven clusters of characteristics of energy efficiency measures: improved indoor environment, noise reduction, labour and time savings, improved process control, increased amenity or convenience, water savings and waste minimization, direct and indirect economic benefits.

There are other authors engaged with the identification of the characteristics of these activities. An exhaustive example is the work of (Fleiter, Hirzel, & Worrell, 2012): after an in-depth literature review, which allows the appreciation of the benefits and the characteristics of the adoption process of energy efficiency measures, they suggest a classification scheme. For each characteristic is defined a set of attributes Then the classification scheme is applied to six energy efficiency measures such as: energy efficiency electric motor, shoe press, inert anode, low temperature thermal cooling, closed furnace lid and compressed air leakage reduction. The conclusion of this research concerns the barriers to the adoption and policy suggestions; they can be obtained from the proposed framework.

This method helps to better understand the implementation process and the diffusion of energy efficiency measures. (Fleiter et al., 2012) sustain that the classification is "a trade-off between data availability and accuracy and the choice of having few broad ranges of attributes for each characteristic is right to build a framework".

One of the main efforts of the aforementioned work is to point out a set of attributes suitable for different kinds of measures, With respect to my wok the aim is to create a similar scheme for energy management practices instead of energy efficiency measures. It can be noticed, after the identification of the main characteristics, that many features are comparable to the ones applied for the energy efficiency measures. Other characteristics are different since the nature of the

practices is actually "softer" in comparison with the operative, technology related activities.

Since there does not exist in the literature a study that investigates the possible characteristics of energy management practices, it is harder to find them in an explicit way. From the descriptions of the different practices it is however possible to obtain some characteristics. Due to the fact that the framework has to be suitable for different energy management practices, the found attributes are more qualitative than quantitative, unlike the case of the energy efficiency measures.

The order of the characteristics follows a logic way of collecting information regarding the implementation of the practices. I believe that there could be a greater number of characteristics but those I used are adequate for my purpose, although the complexity would increase too much and it would be not justified.

1. Type of practice

The first important characteristic is the group to which the practices belong. If a practice is analysed the first factor that allows the differentiation is the related type. It is very important to understand which is the focus of the company when implementing some practices. This characteristic includes six categories in which the practices can be grouped: *general organisation*; *training*; *motivation*; *collection of information*; *spread of information*; *housekeeping.*

In order to choose the different groups I review the Energy Matrix, (Ashford, 1993).. This is an assessment tool to help the management develop a better approach to energy efficiency. Each column of the matrix deals with one of the six organizational issues, as shown in Table 4:

- policy: related to energy policy, action plan and commitment of top management;
- organizing: related to energy manager position and delegation of responsibilities;
- motivation: related to channels of communication;
- information systems: related to a comprehensive system that governs the energy information;
- marketing: related to marketing the value of energy management for awareness aims;

- investment: related to the pay back criteria of energy efficiency investment.

Here there is no difference between high and intermediate level of energy management. I intentionally treat the aspects of Energy Management, which are results of the corporate energy policy, as already explained in the previous chapter, hence the policy is not considered for the purpose

LEVEL	POLICY AND SYSTEMS	ORGANIZATION	MOTIVATION	INFORMATION SYSTEMS	TRAINING AND AWARENESS	INVESTMENT
4	Formal energy / environmental policy and management system, action plan and regular review with commitment of senior management or part of corporate strategy.	Energy / environmental management fully integrated into management structure. Clear delegation of responsibility for energy use.	Formal and informal channels of communication regularly exploited by energy /environmental manager and staff at all levels	Comprehensive system sets targets, monitors materials and energy consumption and wastes and emissions, identifies faults, quantifies costs and savings and provides budget tracking	Marketing the value of material and energy efficiency and the performance of energy / environmental management both within the organisation and outside it.	Positive discrimination in favour of energy / environmental saving schemes with detailed investment appraisal of all new build and plant improvement opportunities
3	Formal energy / environmental policy, but no formal management system, and with no active commitment from top management	Energy / environmental manager accountable to energy committee, chaired by a member of the management board	Energy / environmental committee used as main channel together with direct contact with major users	Monitoring and targeting reports for individual premises based on sub-metering / monitoring, but savings not reported effectively to users	Programme of staff training, awareness and regular publicity campaigns	Same pay back criteria as for all other investments. Cursory appraisal of new build and plant improvement opportunities.
2	Unadopted / informal energy / environmental policy set by energy / environmental manager or senior departmental manager	Energy / environmental manager in post, reporting to ad-hoc committee but line management and authority are unclear	Contact with major users through ad-hoc committee chaired by senior departmental manager	Monitoring and targeting reports based on supply meter /measurement data and invoices. Env. / energy staff have ad-hoc involvement in budget setting.	Some ad hoc staff awareness and training	Investment using short term pay back criteria mostly
1	An unwritten set of guidelines	Energy / environmental management the part-time responsibility of someone with only limited influence or authority	Informal contacts between engineer and a few users	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department	Informal contacts used to promote energy efficiency and resource conservation	Only low cost measures taken
0	No explicit policy	No energy / environmental manager or any formal delegation of responsibility for env. / energy use.	No contact with users	No information system. No accounting for materials and energy consumption and waste	No awareness raising of energy efficiency and resource conservation	No investment in increasing environmental performance / energy efficiency in premises

Table 4. The Energy matrix (Ashford, 1993)

It is possible a conjoint analysis with the consideration of (Caffall, 1995). This author examines the tasks of energy management concerning six areas:

strategic approach; monitoring energy use; motivating; good housekeeping; training and technology.

The first area concerns the energy policy and related general goals, necessary to raise the relevance of energy issues at corporate level, but this is not considered at this point of the work.

The information on the expected performance of energy-consumption equipment and on the actual energy inputs and flows is necessary to correctly manage energy. Furthermore, this information has to be analysed with respect to other measures, such as the production volumes, generating key performance indexes (KPI). This is crucial to allow energy use in being effectively managed similarly to other resources in a company. The monitoring leads to take care of savings from any existing efficiency investment, the identification of new opportunities for savings, a database to enable cost control and external comparison. Through the monitoring, the information can be spread within all the organization (Caffall, 1995).

The next area of interest is the motivation: the energy efficiency of a company is a matter of how the machinery are used and the material processed, furthermore there is a human dimension, both through the methods employed by the staff and the people themselves (Caffall, 1995).Figure 16 shows this aspects.

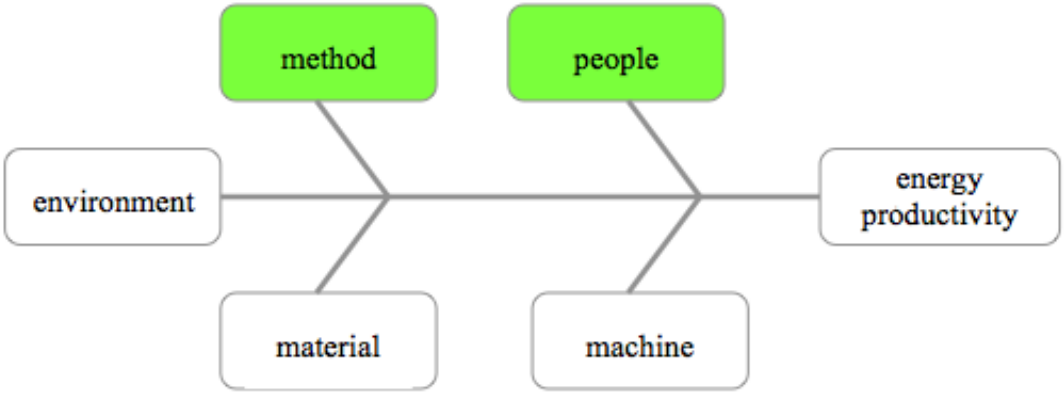


Figure 16. The five factors determining energy efficiency (Caffall, 1995)

The factor difficult to influence is the people, and method as well. Employees should have energy objectives, be motivated to achieve these goals and be aware of how they can do this. All the people within an organization have to be moved to the high awareness-high motivation quarter of the grid if significant savings are supposed to be achieved (Caffall, 1995).

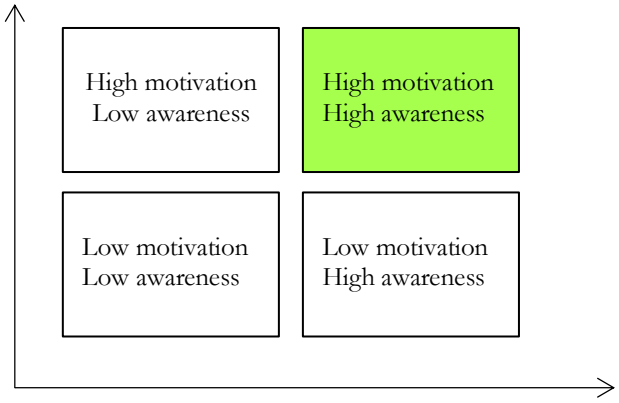


Figure 17. Awareness-motivation grid (Caffall, 1995)

However, for most companies the incentives to motivate employees lies in areas other than company cost-savings. While cost saving is still the management's main motivation, linking the savings with the employees' values and interest is worthwhile. The personal values are sound self-motivating factors (Caffall, 1995).

Another important mean to save energy is good housekeeping, often forgotten as a respectable source of energy savings, especially when compared to the installation of a new element of energy saving equipment.

Beyond the awareness and motivation effort, training sessions are more appropriate for groups of employees who have a greater influence on energy consumption than others. According to (Caffall, 1995), an energy training program encompasses six basic steps: analysing training requirements, developing learning objectives, outlining training content, selecting appropriate training methods, conducting the training, evaluating the learning.

From the Energy Matrix and the point of view of Caffall, it is possible to select the most interesting categories.

The strategic approach could be linked to the energy policy, corporate goals and organizing issues of the Energy Matrix, the monitoring energy use regards the information systems within the company, and technology is somehow related to the investment issue. The high level of the energy policy is not taken into consideration, as already mentioned.

Concerning the information system, decisively significant for energy management, I decide to split it in collection and diffusion of information in order to understand the flow of information, well debated in Caffall's work. Is not sufficient to gather information, the company should put effort into diffusing it and vice versa.

In this group a lot of practices can be positioned since the availability and accuracy of information is mandatory for the decision-making process.

In the Energy Matrix a light overlap between motivating and marketing can be appreciated: thus, I prefer to consider motivation and awareness linked to each other as made by Caffall.

The training issue is relevant and it is required to improve the skills of the employees concerning the energy management.

Housekeeping represents another type of practices that can be isolated from the others, and it is the one with greater "technical" aspects. Nonetheless, as necessarily depends from some behavioural aspects, I have decided to keep it in the framework.

The last point of discussion is the investment criteria which can be considered as a matter of organization of the company.

The knowledge of such a feature is important to appreciate which are the most implemented group of practices by the company.

2. Focus on

The second step, after the definition of the belonging group, concerns the understanding of where exactly the practice has influence. The attributes of this characteristic are two: *core processes; ancillary processes*.

Unit processes are considered "the smallest parts of an industrial production system and its related energy use" (Patrik Thollander et al., 2012). The unit processes are thus general across industrial companies, allowing comparison of specific processes between industrial companies as regards energy efficiency. Unit processes are defined

by the energy service they perform. Two major categories are found (Söderström, 1996):

- production processes: the processes needed to produce products (coating, moulding, heating, melting, drying, cooling etc);
- support processes: the processes needed to support the production processes, but not directly needed for production (ventilation, space heating, compressed air, lighting, pumping, cooling, administration etc.).

3. Type of enabler

An interesting feature is linked to the type of enabler. A practice can influence more directly the energy savings, the implementation of technical interventions, the energy efficiency technology investments or more indirectly. A practice can be closer to the technical, operative, part or not so closer, e.g. a motivating campaign acts indirectly on further measures. There are many tasks such as internal reporting, maintaining and upgrading information systems, training, marketing, and awareness raising, which are unlikely to create direct savings, but are essential to create a culture and support to improve energy efficiency. The suitable attributes are: *less direct; more direct.*

4. Energy source

Another characteristic of energy efficiency activities in general is the type or energy source. The choice is between: *thermal source and electrical source.*

It is interesting to know what is the main stream employed by an energy management practices. It could be worthwhile if a company uses both sources.

5. Strategy scope

In the literature the strategy scope indicates if the measure works for energy conservation or energy efficiency. In the first chapter the difference between them has already been explained. In the conservation strategy there is a reduction in energy use together with the reduction of the results of the system differently form energy efficiency. This difference exists in the literature but often the companies do not perceive it. Recently in some disciplines, like environmental and climate

management, this differentiation is becoming more worthwhile. the attributes are: *energy efficiency* and *energy conservation*.

6. Novelty grade for the company

A practice can be new or already in use in the company. This feature shows the company's predisposition to energy management, to improve the practice and to make some progresses.

The attributes are: *new; already in use.*

7. Scope of impact

After evaluating the focus of the practices, it is worth considering the extent of the impact within an organization. As energy management presents relevant behavioral and organizational issues, it interesting to know which is the level of involvement. This characteristic shows the diffusion of a practice in a company. The attributes related to this are: *one person; a group/a business unit/a division; more than an unit; the whole company.*

8. Involved organizational actors

This characteristic is of utmost importance concerning the organizational aspects. As already stated, the major contribution to energy management is up to the involved people in the daily tasks, activities and management of the company. The organization structure can be more or less hierarchical, but the roles and responsibilities within the company should be clearly identified.

Moreover, as already mentioned in Chapter 2 energy management practices deal also with the decision-making process. It should be respected the separation of decision management, initiation and implementation of decision, from decision control, the approval and monitoring of the decisions (Jensen, 1998). The hierarchical structure helps this separation and simplify the complexity: often the structures are described as simple top-down relationships, but, as sustained by (Schneeweirj, 1995), the interdependencies of the organizational levels are almost always more evident.

It is interesting to understand the corporate involvement and the degree of responsibility of each actor belonging to different levels. As for other types of

management disciplines (human resources, production, logistic, supply etc.), there is a level of the company that makes the decision and it is responsible for it, then some people are influenced by that decision and the actors that are in charge of the implementation of it. Often these two latter roles involve the same people or level, for example: the people affected by a practice are the some people who realize the practice.

There exists another kind of responsibility: the support to the implementation of the practice. This support can be internal, hence an employee, or an external person, e.g., a consultant. It is clear that in this case the important factor is having the right skills and knowledge, which allow a better support. This last attribute shows if the company requires all the resources from inside or instead if external parts are involved as well.

To resume the main levels/attributes of this characteristic are: *top/high management*; *middle management; staff/operator level; internal support*; *external support.*

9. Easiness of implementation

This characteristic opens the debate about the difficulties a company has to face and the feasibility of the energy management practice. It is evaluated whatever the accomplishment is more or less easy for involved people. It is a characteristic that highlights the perceived effort for the people. The values this feature takes upon are: *very easy; quite easy; quite hard; very hard.*

In the first case the implementation requires minimum effort and skills, and hence there is no need of further actions. If the practice is quite easy, still not much effort or knowledge is required, but the involved people have to be a bit more skilled. In the third case, the situation becomes harder and the people face some difficulties: more information, aids, assistance are necessary. If the attribute is very hard the people are reluctant to accomplish the practice.

10. Frequency of check/review

This is the second characteristic determining the effort required. Some practices may need continuing management attention, periodic check, updating, and flows of money and resources in order to be effective, for instance the targeting practice

should be reviewed every month in order to be effective.. Adoption of some practices can be considered a matter of one-time effort. Despite of this some procedures can be easily forgotten or can lose effectiveness. Also depending on this issue the organizational effort is evaluated. The values of the attributes could be simply identified: *one time; more than a year; yearly; monthly; weekly; daily*.

11. Frequency of implementation

It is not so immediate to distinguish this characteristic from the one previously explained: this is more related to the decision of the implementation of the practices. An example could help: the content of a practice and the manners of implementation can be reviewed every year but the practice actually runs more times in a year and hence the two frequencies are different. There are some cases in which the two frequencies can be the same if every time a practice is established its characteristics do change. Also depending on this the organizational effort is evaluated. The values of the attributes could be simply identified, as in the previous case: *one time; more than a year; yearly; monthly; weekly; daily*.

12. Organizational cost

The economic analysis is very important for the energy efficiency measure, in past works, since the new energy efficiency technologies have a considerable cost for the company. In case of practices, establish the single costs is harder and, thus, it is better to sum up different kinds of cost items: initial expenditure, change cost, implementation cost, life cost etc. One of the most important is the organizational cost concerning the change required by a practice. This deals with the effort of changing set of mind, culture, improve motivation, awareness, of making understandable the benefits of the practice.

This characteristic could be divided in two parts*: hidden costs* (transaction-organizational costs) *and real costs* (invoice costs). The hidden costs could worsen energy-efficiency investments profitability (Cooremans, 2012). (Sorrell et al., 2010; Andrea Trianni, Cagno, Thollander, & Backlund, 2012) propose some example of hidden cost such as: overhead costs for management, disruptions to production, staff

replacement and training, and the costs associated with gathering, analysing and applying information.

One of the main components of hidden cost is the organizational transaction costs, such as monitoring and control costs, decision-making costs, cost for establishing, maintaining and running energy information systems etc. Furthermore, there is a cost related to the time of the people involved in the implementation and in some cases production disruption.

The real costs are less important for energy management practice since the focus is always on organizational aspects, hence the hidden costs become significant.

The values of the attributes are: *very low; low/moderate; significant/high; very high.*

13.Barriers

The debate regarding the barriers to energy efficiency and energy manger has already been treated in Chapter 2 (paragraph 2.1.5). The scientific and empirical literature is very wide and in this work is used the novel taxonomy for empirical investigation obtained by (E. Cagno et al., 2013). It takes into account principally the internal barriers, very important from the energy management point of view. Technology-related barrier will not take into consideration, as the work does not deal with technological issues.

The nature of barrier is considered as maximum detail and it depends on the company's characteristics. With respect to the barriers, the analysis of the diffusion of the practices within the company is feasible, then it is noteworthy to figure out the types of difficulties characterizing the practices. The possible levels for each type of barrier come from the Likert scale. It is a "psychometric scale" commonly involved in research for measuring attitudes, invented by (Likert, 1932). I choose a four point scale: *1 not important; 2 scarcely important; 3 important; 4 very important*.

14.Drivers

The debate concerning the drivers has been already treated in the Chapter 2 (see paragraph 2.1.6). The division in four groups is used in the framework:

- Regulatory: these actions involve all norms and standards aimed to push companies towards an efficient use of energy.

- Economic: these actions look at the monetary aspects. Reasonably financing subsides are less necessary for energy management practices rather than technical investments.
- Information: these actions involve all aspects related to both information content and its flow within the company.
- Competence related: these actions allow improving the competences and skills of the people in charge of energy issue.

Moreover, it is clear that a distinction between internal and external drivers can be made, therefore being able to understand which actions might be promoted internally or which kind of external support should be required. Since Energy Management is about the people within the company, the internal drivers are supposed to be more decisive than the external: as in the case of the barriers, the possible levels for each kind of barrier come from the Liker scale: *1 not important; 2 scarcely important; 3 important; 4 very important.*

Hereafter Table 5 and Table 6 resume the characteristics and respective attributes and then the main literature references. This set corresponds to the first axis of the characterization framework.

	CHARACTERISTIC		*LITERATURE*
1	**TYPE OF PRACTICE**		(Christoffersen et al., 2005) (Gordić et al., 2010) (Patrik Thollander & Ottosson, 2010a) (Kannan & Boie, 2003b) (Wai et al., 2011) (Backlund, Ottosson, et al., 2012) (Abdelaziz et al., 2011) (V. Gorp, 2004) (Bloom, Genakos, Martin, & Sadun, 2010) **(**Caffall, 1995)
2	**FOCUS ON**		(Caffal, 1995) (Fleiter et al., 2012) (Patrik Thollander & Ottosson, 2010a)
3	**TYPE OF ENABLER TO INTERVENTIONS**		(Caffal, 1995) (United Nations Industrial Development Organization, 2011)
4	**ENERGY'S SOURCE**		(Hagelstein, n.d.) (Braun, n.d.)
5	**STRATEGY SCOPE**		(Piglia, 2012)
6	**NOVELTY GRADE FOR COMPANY**		**(**Caffall, 1995)
7	**SCOPE OF IMPACT**		(Fleiter et al., 2012) (Fleiter et al., 2012) (Tornatzky & Klein) (Caffall, 1995)
8	**INVOLVED ORGANIZATIONAL ACTORS**	**INFLUENCED LEVEL**	(Caffal,1995) (Schneeweirj, 1995) (Anthony,1965) (Sandberg & Söderström, 2003) (Astley & Ven, 2013) (Schwarz, 2002) (Zou, Dai, & Ran, 2007) (Brown & Key, 2002; Mckane, 2009; Scheihing, 2009) (Raes, Bruch, & De Jong, 2012)
		DECISION-MAKER	
		IMPLEMENTING LEVEL	
		SUPPORT	
9	**EASINESS OF IMPLEMENTATION**		(Wulfinghoff, 1999)
10	**FREQUENCY OF CHECK/REVIEW**		(Caffal, 1995)
11	**FREQUENCY OF IMPLEMENTATION**		**(**Caffall, 1995)
12	**ORGANIZATIONAL COSTS**	**REAL COSTS**	(Caffal, 1995) (Woodruff et al.) (Harris et al., 2000)
		HIDDEN-TRNASACTION COSTS	
13	**BARRIERS**	**INFORMATION BARRIER**	(Sorrell et al., 2010) (Sorrell & Scott, 2000) (Jaffe & Stavins, 1994) (E. Cagno et al., 2012) (Patrik Thollander, 2008) (Patrik Rohdin et al., 2007) (Andrea Trianni et al., 2012) (E. Cagno et al., 2013) (A. Trianni & Cagno, 2012)
		ECONOMIC BARRIER	
		BEHAVIORAL BARRIER	
		ORGANIZATIONAL BARRIER	
		COMPETENCES RELATED	
		AWARENESS	
14	**DRIVERS**	**REGULATORY**	(Enrico Cagno & Trianni, 2012b) (Alam Hossain Mondal, Kamp, & Pachova, 2010) (Björheden, 2006) (Patrik Rohdin et al., 2007) (Reddy & Assenza, 2007) (Liu, Niu, Bao, Suk, & Shishime, 2012) (Aflaki et al., 2013)
		ECONOMIC	
		INFORMATION	
		COMPETENCES RELATED	

Table 5. The collection of practices' characteristics and literature references

CHARACTERISTIC		*ATTRIBUTE*	
TYPE OF PRACTICE		general organization	housekeeping
		collection of information	motivation
		spread of information	training
FOCUS ON		core processes	ancillary/support processes
TYPE OF ENABLER TO INTERVENTIONS		direct	indirect
ENERGY'S SOURCE		electrical	thermal
STRATEGY SCOPE		energy efficiency	energy conservation
NOVELTY GRADE FOR COMPANY		new	already in use
SCOPE OF IMPACT		one person	a group of people/ a business unit
		more than one group	the whole company
ORGANIZATIONAL ACTORS	**INFLUENCED LEVEL**	middle management	top management
		staff/operator level/shop floor	
	DECISION-MAKER	middle management	top management
		staff/operator level/shop floor	
		middle management	top management
		staff/operator level/shop floor	
	SUPPORT	internal	external
EASINESS OF IMPLEMENTATION		very easy	quite easy
		quite hard	very hard
FREQUENCY OF CHECK/REVIEW		one time	daily
		weekly	monthly
		yearly	more than a year
FREQUENCY OF IMPLEMENTATION		one time	daily
		weekly	monthly
		yearly	more than a year
ORGANIZATIONAL COSTS	**REAL COSTS**	very high	significant/high
		moderate/low	very low
	HIDDEN-TRNASACTION COSTS	very high	significant/high
		moderate/low	very low
BARRIERS	**INFORMATION BARRIER**	1-2-3-4*	
	ECONOMIC BARRIER		
	BEHAVIORAL BARRIER		
	ORGANIZATIONAL BARRIER		
	COMPETENCES RELATED		
	AWARENESS		
DRIVERS	**REGULATORY**	1-2-3-4* internal/external	
	ECONOMIC		
	INFORMATION		
	COMPETENCES RELATED		

** 1 not important; 2 scarcely important; 3 important; 4 very important.*

Table 6. The collection of practices' characteristics and attributes

3.1.4 The collection of Energy Management practices

The second step of the creation of the model is the collection of the practices through the scientific literature review. Among all the available information regarding energy management, possibly characterized by a people-based approach as considered, it is not easy to find a comprehensive treatise about the practices' concept.

First of all another source has been taken into consideration: the IAC centre database "Industrial Assessment Centers Database" (iac.rutgers.edu/database). This American database embraces all the activities for energy efficiency and there is a section for the energy management: investigating this part it is evident that energy management is pondered only from a technical point of view. Almost everything corresponds to a technical intervention, like replacing old equipment or components with energy efficiency machines or best available technologies (BAT) and also the "softer" intervention are still focused on the technical level. There is not anything concerning the human and organizational dimension, the importance of the information and communication within the company. Here the practices are not enablers to technical interventions and to improvements in the decision-making process. As conclusion such a database is not useful to this framework, instead it is worthwhile to assess the lack of knowledge and the need of studying the practices from another point of view.

An important reflexion is that the practices in the literature are often company-specific and since the framework is supposed to be valid for different kind of companies, the suitable practices have to be quite general. So the selection of the practices requires attention.

In this section are mentioned the authors, which deal with energy management practices. Then the main practices, clustered by author, are summarized in the Table 7.

- (Christoffersen et al., 2005): in this article some minimum requirements are set in order to establish whether a firm actually practices Energy Management. One of them is "put forward an energy policy" because it is necessary to effectively implement the other practices, and this demonstrates the assumption of the previous chapter. Then the three authors indicate some practices necessary to reach a higher level of Energy Management.

- (Gordić et al., 2010): within the practices pinpointed by the authors there is the energy policy as part of the corporate strategy: this belongs to a higher level then the one of my analysis, hence I prefer to differentiate it from the others practices.
- (Patrik Thollander & Ottosson, 2010a) studied the large potential for energy efficiency in industry through the adoption of energy management practices, in two different Swedish energy-intensive industries. The main practices debated by the authors are only four and among them there is the long-term strategy. Since it is an enabler to the other practices and it does not belong to the intermediate level, this requirement will not be included within the final practices, which are:
- (Ates & Durakbasa, 2012): point out as a minimum requirement for Energy management having a written energy policy. As for the previous cases, I will not consider it an energy practice at the intermediate level together with the others.
- (Kannan & Boie, 2003b): they recognize the need to target the companies with information on energy management concepts and practices. The journal article's purpose is to provide a guideline for entrepreneurs in implementing energy management and these four practices are proposed.
- (Backlund, Ottosson, et al., 2012): the study is of utmost importance since it investigates to what extent energy management practices influence firms' valuation of energy efficiency potentials. Previous studies of energy efficiency potentials have focused on diffusion of technology, but the potential from energy management practices is not negligible and can be reached without large intervention costs. Also in this research the long-term energy policy is supposed to be extreme significant for successful energy management practices.
- (Abdelaziz et al., 2011): the preliminary components of comprehensive energy management program are the organizational structure and the policy then energy savings can be obtained by few types of energy management activities.
- (V. Gorp, 2004): this author confirms the overall assumption of the transition from tactical practices to more comprehensive strategic energy management practices. A sound strategy and a structured way of managing energy are considered of utmost importance.
- (Wai et al., 2011): this article embraces a quite large list of energy management key practices for Malaysian Universities. The practices are grouped into three phases:

planning, monitoring and implementation phase. Then every practice is evaluated through the Likert scale in order to assess the perceived importance. Again there is the establishment of the energy policy as a practice unlike my hypothesis. Differently form the other study the scope of this under consideration is not industrial sector, but it concerns the service/residential one. Anyway the practices used in this field can completely be assimilated to the industrial sector and they bring the same benefits.

Author and year	N°	List of practices
Christoffersen et al., 2005)	12	Mapping of energy use; continuous energy accounting; quantitative efficiency goals; action goals; action plan; concrete efficiency projects; energy efficiency purchase; systematic energy efficiency design; organising energy efficiency questions; inform employees; motivate employees; educating key employees.
(Gordić et al., 2010)	10	Energy policy and action plan as parts of a corporate strategy; energy manager integrated into organisation structure; clear delegation of responsibility for energy consumption; formal and informal channels of communication; targeting, monitoring consumption reports; allocation of energy cost (sub metering); programs of staff training, awareness and motivation; regular publicity campaigns; specific pay back criteria in energy savings investments.
(Patrik Thollander & Ottosson, 2010)	4	Pay off criteria; long-term energy strategy; allocation of energy costs; energy manager.
(Ates & Durakbasa, 2012)	10	Giving information to staff about how energy can be reduced / staff awareness program; recognition of energy reduction initiatives; monitoring energy use and cost; signs/stickers to encourage staff to turn off light or equipment; metering energy consumption of main production processes; written energy policy; official energy manager; setting an energy saving target; procuring energy through competitive bids; procurement guidelines indicating energy efficiency as one of the selection criteria for the procurement of goods and services.
(Kannan & Boie, 2003)	4	Energy auditing; energy manager; energy budgeting; housekeeping.
(Backlund, Ottosson, et al., 2012)	9	Energy auditing and gathering of information regarding to energy flows; quantify energy efficiency targets and communicate targets; housekeeping; long-term energy policy; energy plan; energy manager position; set aside funding for sub metering installations; payoff criteria: energy services.
(Abdelaziz et al., 2011)	3	Energy audit (preliminary, general, detailed); energy efficiency courses and training program; housekeeping (maintenance, waste removal)
(Gorp, 2004)	7	Set performance goals; action plan; educate and motivate participants; evaluate on going performance; communication strategy; benchmarking; recognition strategy
(Wai et al., 2011)	47	Gain top management; establish energy goals and objectives; budget allocation; establish procedures: develop a master plan; establish data base; establish energy policy; provides sufficient tools; develop strategy plan; provide guidelines; determinate capital investment and priorities; visibility start-up; formulate energy management committee appoint energy management manager; develop contingency plan; develop educational plan (Planning Phase); conduct energy use and performance analysis; measurement and verification; periodic review and evaluation of overall program; ensure regulations always met; conduct economic analysis; demand control; keeping abreast of latest development; attention the detail of use and costs; perform follow-up tasks; conduct energy management forecasting; tracking and targeting; review of drawing data sheet, and equipment specification; maintain good relations with other department; advice on energy matters (Monitoring and Evaluation Phase); conduct energy audit; communicate to employee; promote awareness; efficiency improvements in electrical appliance system; conduct energy walk-through survey; all level employee involvement; educate and train all staff; establish uniform record keeping system; identify energy conservation opportunities; perform maintenance; motivation; periodic meetings between energy management committee and coordinator; establish uniform reporting system ; inform the reason-need; automatic control; conduct program to stimulate and sustain interest; use sophisticated technical innovation (Implementing Phase).

Table 7. The whole collection of energy management practices and literature references

After this general collection it is clear that a review and a rationalization of the practices are mandatory, since they are almost a hundred and often too company-specific. Furthermore many practices refer to the same action, or subject, so the overlaps have to be recognized.

The result of the selection is supposed to be a list of the main practices found in the literature. I use as a criterion of choice the number of appearances in the examined scientific and empirical literature. Moreover I do not take into consideration the ones, which are too company-specific and thus not appliable on a general base.

1. Monitoring of energy use and costs

This practice facilitates keeping track of the energy consumption of the enterprise. A famous quote *"you cannot manage what you cannot measure"*, said by Bill Hewlett, highlights the importance of this practice. The goal is to provide of the necessary data on energy consumption in order to have all the possible information to decide, invest, and act. Periodic monitoring requires some measuring equipment and maintaining an energy record.

2. Consumption reports to inform

To be fully effective, energy monitoring requires all parties of the company to be provided with relevant energy information at the right time.

3. Allocation of energy cost (metering)

A monitoring system using sub-metering at all levels is one of the major prerequisites for proper energy cost allocation, and successful energy management adoption.

4. Energy audit (preliminary, general, detailed) - Map of energy use and flows

Energy audit is an inspection, survey and analysis of energy flows. The energy audit is the key for decision-making in the area of energy management. It is a reliable and systematic approach in the industrial sector, helping any organization to analyse its energy use and discover areas where energy use and waste can be reduced. There are

three types of energy audits: preliminary, general, and detailed audit. An energy audit can be seen similar to the monthly closing statement of an accounting system.
The data needed for energy auditing are: amounts of energy consumed, their end uses, types of fuel and volume of production. The outcome of the audit is to provide options to reduce energy consumption and improve the energy efficiency.

5. Performance analysis through key performance indicators (KPI)

After monitoring, an evaluation over a period of time gives an indication of the success or failure of the energy saving activities. It helps to understand whether the predicted energy savings are in line or not with the targets. It will also support to identify alternate corrections and new possibilities.

6. Establishment of uniform record keeping system

It is important to develop a uniform record keeping system to document the energy consumption, energy saving, improved actions etc. This allows a structured and common way of recording data.

7. Establishment of uniform reporting system

In order to share energy management progresses within the whole company it is reasonable to have standard reporting procedures. The report should be regularly submitted to top management and other party concerning what actual energy savings have resulted. Moreover the reports have to contain the right and sufficient information for each involved employee and in a right, common format. The people within a company speak different languages and they need different type of information, more or less detailed or aggregate. Hence the reports have to respect this assumption.

8. Automatic control

The practice of optimizing efficient operations through automatic energy management control system is a common decision and can lead to direct savings. This is the most efficient and advanced way of controlling energy usage.

9. Program/course of training

This is considered a key practice and concerns the education of employees on a specific energy issue and energy saving opportunity through training, seminar or workshop. The participants are taken through a rich combination of focussed lectures and practical exercises.

10. Energy manager

In order to be successful, initially, an energy management program has to require the commitment by the top management. Right from the beginning, it should be made clear that energy management is a permanent activity as other management disciplines. A company should introduce an organisational structure in which at least one person is appointed as energy manager to plan, lead and manage energy. He or she should be made responsible for the overall energy related activities. In small companies, to minimize the personnel cost on a dedicated energy manager, the production manager or plant supervisor could be the responsible actor for energy related activities. The new organizational structure and the decentralization of responsibilities could generate an increasing interest and commitment to the energy saving issue.

11. Energy management team

Beyond an energy manager, selected people, authorized by an appropriate level of management, are required to work in support of energy management activities.

12. Energy action plan

It is a short-term plan, necessary to summarize conditions and set right operational parameters, including potential savings, maintenance functions and needs of resources. In order to achieve the pre-determined energy conservation objectives, included in the mission, the company has to set short-term strategies. The action plan is a mean of driving everyone in the organization to focus and prioritize the energy efficiency efforts.). It clarifies how the organisation plans to use energy. The second planning stage includes creating an energy plan. The energy plan is based on an energy review and energy performance indicators.

13. Energy savings targeting

After setting the general policy, the task is an effective planning of energy management requiring the organizations to set targets, which provide the means to transform policy into action. Setting saving targets determinate criteria of success: in this way progresses can be made toward an improved energy management system and energy savings. For the goals, the principle of Specific, Measurable, Accurate, Reality and in the Time Frame must be taken into consideration. Energy performance goals provide direction for decision-making and they are a baseline for tracking and measuring progresses.

14. Targets communication

Once the targets are set, the necessary action is to communicate them throughout the company. Without this information the employees cannot be aware of the required effort to improve energy efficiency and save energy costs.

15. Establishment of data base

After gathering a great amount of data, it is useful to keep it in a suitable database, which is sufficiently inclusive to show the present and historical energy-usage trends. It the first step to develop a uniform energy record, report and account system.

16. Awareness and motivation program (specific/general)

Energy efficiency courses and programs are very important to increase the awareness of people who are involved in energy management and energy efficiency. Building the right education and capacity is the heart of a sustainable improvement of the energy efficiency capacity and the implementation of energy management. In this regard, the main stakeholders have to fulfil their duties in order to increase the education level and skills of other employees in terms of energy management.

For instance in the past an energy manager course deals predominantly with the technical tasks of energy managers. Therefore, an additional section with regard to the management and organizational aspect of energy should be included in the courses. Organizing programs and courses regularly creates and sustains interest among people to save energy within a company.

17. Publicity campaign

Another way to increase motivation and awareness among employees is to do several campaigns as a matter of internal marketing.

18. Recognition of energy reduction initiatives

This practice is becoming very popular and the benefits are totally recognized. The practice of rewarding outstanding an employee or a group for their contribution in saving energy is of utmost importance. The ideas coming from the employees are almost always very innovative and adequate to the firm's characteristics. Moreover there is also an effect on the increase of the people involvement and commitment.

19. Meetings

This practice refers to the planning of periodic and regular meeting to make all the stakeholders aware of the energy management tasks and progresses. It is necessary to share information about proposed approaches regarding energy and costs savings.

20. Care and maintenance

Care and maintenance involve every phase of industrial operations. It is more than mere cleanliness. It requires good conditions and attention to details such as an orderly layout of the workplace, suitable storage arrangements, and appropriate provision for cleaning and maintenance.

Unlike the other practices, this may be the trickiest one because it involves several activities and it can overlap with other technical measures. Often the maintenance and care of the equipment and plants are evaluated together with other energy efficiency measures. Nonetheless the consideration in this work is quite different: housekeeping is mostly a matter of behaviour and hence of people.

21. Networking

The collaboration with the industrial sector in which a company operates generates the exchange of free information and the on-going confrontation. The relevance of the network practice is pointed out by (Patrik Thollander & Ottosson, 2008). It is a collaborative practice and it allows an opportunity of transferring knowledge, skills,

information, business and real case etc within companies belonging to the same step of the supply chain (among competitors for example) or different ones (suppliers and clients for example). Moreover the companies can learn also from firms of other industrial sector, for example some innovative practices, initiatives.

22. Sustainable leadership course

When any resources in a company have to be managed and the involved organizational levels are different, there always exists the problem of leadership and communication. In a company the people, belonging to diverse levels of the hierarchy, speak and understand different languages. Moreover they need different kinds of information for their aims. The person together with the team in charge of energy management have to learn how to lead the other people, who may be stay on a higher or lower level. The leadership is one of the most important concepts in the business theory.

1. Monitoring of energy use and costs	(Caffall, 1995) (Christoffersen et al., 2005) (Ashford, 1993; Gordić et al., 2010) (Ates & Durakbasa, 2012) (Wai et al., 2011) (V. Gorp, 2004)
2. Consumption reports to inform	(Caffall, 1995) (Christoffersen et al., 2005) (Ashford, 1993; Gordić et al., 2010) (Ates & Durakbasa, 2012) (Wai et al., 2011) (V. Gorp, 2004)
3. Allocation of energy cost (metering)	(Caffall, 1995) (Backlund, Ottosson, et al., 2012) (Ates & Durakbasa, 2012) (Backlund, Thollander, et al., 2012)
4. Energy audit (preliminary, general, detailed)	(Caffall, 1995) (Patrik Thollander et al., 2012) (E. Cagno, Trucco, Trianni, & Sala, 2010) (Diaconescu et al., 2011) (Christoffersen et al., 2005) (Kannan & Boie, 2003b) (Wai et al., 2011) (Backlund, Thollander, et al., 2012) (Abdelaziz et al., 2011) (V. Gorp, 2004)
5. Performance analysis through key performance indicators (KPI)	(Hrustic, Sommarin, Thollander, & Söderström, 2011; Patrik Thollander & Ottosson, 2010a; Wai et al., 2011)
6. Establishment of uniform reporting system	(Kannan & Boie, 2003a; J. C. Van Gorp, 2004; Wai et al., 2011; Caffall, 1995)
7. Establishment of uniform reporting system	(Kannan & Boie, 2003a; J. C. Van Gorp, 2004; Wai et al., 2011; Caffall,1995)
8. Automatic control	(Kannan & Boie, 2003a; J. C. Van Gorp, 2004; Wai et al., 2011)
9. Program and course of training	(Christoffersen et al., 2005) (Ashford, 1993; Gordić et al., 2010) (Wai et al., 2011) (Abdelaziz et al., 2011) (V. Gorp, 2004)
10. Energy manager	(Caffall, 1995) (Ashford, 1993; Gordić et al., 2010) (Ates & Durakbasa, 2012) (Wai et al., 2011) (Patrik Thollander & Ottosson, 2010a)
11. Energy management team	(Caffall, 1995) (Ashford, 1993; Gordić et al., 2010) (Ates & Durakbasa, 2012) (Wai et al., 2011) (Patrik Thollander & Ottosson, 2010a)
12. Energy action plan	(Christoffersen et al., 2005) (Ashford, 1993; Gordić et al., 2010) (Wai et al., 2011) (Backlund, Thollander, et al., 2012) (V. Gorp, 2004)
13. Energy savings targeting	(Ashford, 1993; Gordić et al., 2010) (Ates & Durakbasa, 2012) (Wai et al., 2011) (V. Gorp, 2004) (Bloom et al., 2010)
14. Targets communication	(Ashford, 1993; Gordić et al., 2010) (Ates & Durakbasa, 2012) (Wai et al., 2011) (V. Gorp, 2004) (Bloom et al., 2010)
15. Establishment of data base	(Kannan & Boie, 2003a; J. C. Van Gorp, 2004; Wai et al., 2011)
16. Awareness and motivation program - specific and general	(Caffall, 1995) (Christoffersen et al., 2005) (Ates & Durakbasa, 2012) (Kannan & Boie, 2003b) (Wai et al., 2011)
17. Regular publicity campaigns	(Caffall, 1995) (Ashford, 1993; Gordić et al., 2010) (V. Gorp, 2004)
18. Recognition of energy reduction initiatives	(Caffall, 1995) (Ates & Durakbasa, 2012) (Bloom et al., 2010)
19. Meetings	(Caffall, 1995) (Wai et al., 2011)
20. Care and maintenance	(Caffall, 1995) (Kannan & Boie, 2003b) (Wai et al., 2011) (Backlund, Thollander, et al., 2012) (Abdelaziz et al., 2011)
21. Networking	(Patrik Thollander & Ottosson, 2008)
22. Sustainable leadership course/program	(V. Gorp, 2004) (Elenkov, 2005)

Table 8. The final collection of energy management practices and literature references

After these two steps the framework is almost completed since the two main axes are ready. The axis of the practices is used in order to assess which practices are implemented and where the company has to improve.

Joining together the 13 characteristics and the 22 practices we have the whole characterization framework that is presented as a matrix. Each practice can be described by choosing for each characteristic the suitable values: in the validation part of the work some examples will be presented. In some specific cases the company can choose more than an attribute if it suitable

The last part of this chapter concerns the identification of the proposed values, which are suitable for the combination practices-characteristic. The literature background is necessary for the assessment and orientation purpose. The outcome of the application of the model is a picture of the company's situation. By filling the form, it is likely to get the information necessary to analyse the business situation regarding energy management. Once the characterization framework is complete some general considerations can be made with respect to the way of working on energy management. A second analysis, regarding each practice, can bring out some important evidences thanks to the comparison with the values proposed in the literature. These are theoretical and hence can be different from the reality, but it is useful to investigate the possible deviations and to understand the reason.

It has to be clear that not all the attributes, suitable for a certain combination of practice-characteristic, can be evaluated through the literature review: it is quite scarce regarding this issue. However from the literature concerning the practices and characteristics some value can be identified and then used in order to evaluate the company's energy management status.

In regard to the characteristics "barriers and drivers", it is possible to indicate the most important factors in general, since it is hard to find in literature the level of each barrier and driver for each practice. In the literature background the obstacles, which frequently inhibit the organizational ability to manage energy, are taken into consideration together with the drivers that can lower these barriers.

These are identified by (Brown & Key, 2002) as: lack of organizational commitment, insufficient resources, lack of energy data, shifting priorities, result not sustained and

narrow focus. These examples belong to the *organizational, behavioural categories*. Moreover the barriers that supposed to be higher are *awareness* and *competence related.*

The most important barriers to energy management practices have a managerial or organisational origin (Palm & Thollander, 2010; Sandberg & Söderström, 2003). The economic barrier is not very important since the practices are almost always low-cost actions; maybe the hidden cost can be in general higher than real costs and this can be a point of attention during the assessment.

With respect to the drivers it is necessary to try to overcome the barriers, which have organizational, behavioural and cultural nature. The suitable drivers for energy management practices are considered *competences and informational related* ones.

Table 9 presents some values with the corresponding literature references.

	TYPE OF PRACTICE 1	FOCUS ON 2	STRATEGY SCOPE 3	TYPE OF ENABLER TO SAVINGS 4	ENERGY'S SOURCE 5	NOVELTY GRADE FOR COMPANY 6	SCOPE OF IMPACT 7	ORGANIZATIONAL ACTORS 8				EASINESS OF IMPLEMENTATION 10	FREQUENCY OF CHECK/REVIEW 10	FREQUENCY OF IMPLEMENTATION 11	ORGANIZATIONAL COSTS 12		LITERATURE REFERENCES
								INFLUENCED LEVEL	DECISION-MAKER	IMPLEMENTING LEVEL	SUPPORT 9				HIDDEN COSTS	REAL COSTS	
Monitoring energy use and costs	CI	C/S	EE	MD	T/E	na	C	L	M	L/M	na	na	na	D	na	na	(Ates & Durakbasa, 2012; Christoffersen et al., 2006; J. C. Van Gorp, 2004; Caffall, 1995)
Consumption reports to inform	SI	C/S	EE	LD	T/E	na	C	L/M/T	M	M	na	na	na	M	na	na	(Ates & Durakbasa, 2012; Christoffersen et al., 2006; J. C. Van Gorp, 2004; Caffall, 1995)
Allocation of energy cost (metering)	O	C/S	EE	MD	T/E	na	C	na	M	M	na	na	na	na	na	L	(Backlund, Thollander, et al., 2012; Caffall, 1995)
Energy audit (preliminary, general, detailed)	CI	C/S	EE	MD	T/E	na	C	L	M	M/L	na	na	na	na	H	H	(Christoffersen et al., 2006; Patrik Thollander & Ottosson, 2010a)
Performance analysis through key performance indicators (KPI)	CI	C/S	EE	LD	T/E	na	C	L/M/T	M/T	M	na	na	na	M	na	L	(Christoffersen et al., 2006; Patrik Thollander & Ottosson, 2010a; Wai et al., 2011)
Establishment of uniform record keeping system	O	C/S	EE	LD	T/E	na	C	L/M/T	M	M	na	na	na	na	na	na	(Wai et al., 2011)
Establishment of uniform reporting system	O	C/S	EE	LD	T/E	na	C	L/M/T	M	M	na	na	na	na	na	na	(Wai et al., 2011)
Automatic control	O	C/S	EE	MD	T/E	na	C	na	M	L	na	na	na	na	na	na	(Wai et al., 2011; Caffall, 1995)
Program and course of training	T	C/S	EE	MD	T/E	na	MG	L	M	M	na	na	na	na	na	na	(Abdelaziz et al., 2011; Patrik Thollander & Ottosson, 2010b)
Energy manager	O	C/S	EE	LD	T/E	na	O	M	T	M	na	na	Y	YY	na	na	(Ates & Durakbasa, 2012; Gordić et al., 2010; Wai et al., 2011; Caffall, 1995)
Energy management team	O	C/S	EE	LD	T/E	na	G	M	T	M	na	na	Y	YY	na	na	Ates & Durakbasa, 2012; Gordić et al., 2010; Wai et al., 2011; Caffall, 1995)

Energy action plan	O	C/S	EE	LD	T/E	na	C	L/M	M	M	na	na	M	Y	na	L	(Christoffersen et al., 2006; Wai et al., 2011)
Energy savings targeting	O	C/S	EE	LD	T/E	na	C	L/M	T	M	na	na	M	Y	na	L	(Gordić et al., 2010; Wai et al., 2011)
Targets communication	SI	C/S	EE	LD	T/E	na	C	L/M	T	M	na	na	M	Y	na	na	(Gordić et al., 2010; Wai et al., 2011)
Establishment of data base	CI	C/S	EE	LD	T/E	na	C	Na	M	na	na	na	na	na	na	na	(Wai et al., 2011)
Awareness and motivation program (specific and general)	M	C/S	EE	LD	T/E	na	C	L/M	M	na	na	na	na	na	na	L	(Christoffersen et al., 2006; Kannan & Boie, 2003a; Caffall, 1995)
Publicity campaigns	M	C/S	EE	LD	T/E	na	C	L/M	M	M	na	na	na	na	na	na	(Caffall, 1995)
Recognition of energy reduction initiatives	M	C/S	EE	LD	T/E	na	C	L	M	M	na	na	na	na	na	na	(Caffall, 1995)
Meetings	SI	C/S	EE	LD	T/E	na	MG	L/M/T	M	M	na	na	na	D	na	na	(Wai et al., 2011; Caffall, 1995)
Care and maintenance	H	C/S	EE	MD	T/E	na	C	L	M	L	na	na	na	D	L	L	(Christoffersen et al., 2006; Kannan & Boie, 2003a; Caffall, 1995)
Networking	SI	C/S	EE	LD	T/E	na	G	M	M	M	na	na	na	na	H	L	(Backlund, Ottosson, et al., 2012)
Sustainable leadership course/program	M	C/S	EE	LD	T/E	na	G	M/T	T/M	M/T	na	na	na	na	na	na	(J. C. Van Gorp, 2004)

Table 9. The characterization framework and the proposed values

1	M: motivation	T: training	O: general organisation	CI: collection of information	SI: spread of information	H: housekeeping
2	C: core processes	S: support processes				
3	LD: less direct	MD: more direct				
4	T: thermal	E: electrical				
5	EE: energy efficiency	EC: energy conservation				
6	N: new	U: already in use				
7	O: one person	G: a group/a business unit/a division	MG: more than an unit/group	C: whole company		
8	T: Top/high management	M: middle management	S: staff/operator level/shop floor			
9	I: internal	E: external				
10	VE: very easy	QE: quite easy	QH: quite hard	VH: very hard		
11	O: one time	D: daily	W: weekly	M: monthly	Y: yearly	YY: more than a year
12	VL: very low	L: low/moderate	H: significant/high	VH: very high		

At this stage the framework is built through the literature review and what is necessary is the validation of it, using empirical tests. After the testing phase it is of utmost importance the application of the framework to some selected companies in order to have conclusions about the usefulness of the work and the evaluation of the companies.

In the next chapter I explain the used methodology, the criteria of choice of the companies and how is the structure for the investigation.

The validation of the framework is functional to the real application of it in order to assess if everything is consistent and reliable.

To summarize, the research methodology is split in two different parts:

- First research methodology and testing phase
- Second research methodology and application phase

The difference is due to the fact that the scopes are different but the methodologies present some dissimilarity, which will be explained in the following chapters.

It has to be remembered that existing literature fails to adequately describe the Energy Management practices employed by firms. Few empirical studies adopt a global approach and analyse the practices from a point of view similar to the one of this work. The research has different aims and tries to study the practices within a company with a major degree of detail.

Chapter 4

Validation of the novel framework

"If you don't ask the right questions, you don't get the right answers ... Asking questions is the ABC of diagnosis. Only the inquiring mind solves problems."

Edward Hodnett

After the development of the characterization framework for energy management practices, this chapter presents the rationale behind the undertaken research methodology. This methodology is valid for the *validation phase* of the framework. Some issues will be in common with the methodology used in the application phase, described in the next chapter. In this chapter the two aims of the testing phase are discussed.
With respect to the structures suggested by some authors, the following debate aims to formulate the research questions, then to describe the case-study methodology and finally to detail the research design.

4.1 The case study methodology

One of the main experts in the field of research and social science is Robert K. Yin, who deeply studied case study design and qualitative research methods. In his book (Yin, 2009), the author asserts that case study is one of the various ways of doing research and each mentioned method has advantages depending on the type of research questions, on the control the investigator has over the effective behaviour and events and the focus on contemporaneity as opposed to historical phenomena.

Table 10 displays these three conditions and the link between them and the five most relevant used research methods.

METHOD	Form of Research Question	Requires Control of Behavioral Events?	Focuses on Contemporary Events?
Experiment	how, why?	yes	yes
Survey	who, what, where, how many, how much?	no	yes
Archival Analysis	who, what, where, how many, how much?	no	yes/no
History	how, why?	no	no
Case Study	how, why?	no	yes

Table 10. Relevant Situations for Different Research Methods (Yin, 2009)

The case study methodology is desirable when "how" and "why" questions are asked, the interviewer has little control over events and the focus is on contemporary phenomena. Here these three conditions wholly correspond to the situation under consideration. The empirical research takes on the case study methodology as it respects the conditions proposed by (R. Johansson, 2003; Yin, Quarterly, & Mar, 2008; Yin, 2009). First of all, the investigation assumes explanatory purpose depending on the kind of questions, presented in the next paragraph. Then low control over behavioural events obviously distinguishes case studies from experiments: the investigator of attitudes displayed by an industrial sector cannot claim to have control over the behaviour of the involved subjects, since the phenomenon and the context are not always distinguishable (Yin, 1994). In the end, the focus is on contemporaneity: what is interesting to study is the current state-of-the art of the energy management practices. Moreover the case study methodology bear on the use of contemporary sources of evidence that is direct observation through interviews.

The more the questions try to explain the present circumstances, the more the case study method is suitable. The main scope of this work is to get a deeper understanding of the managerial practices supporting energy management. As stated

by (Zorzini, Hendry, Stevenson, & Pozzetti, 2008), the case method is the most suitable mean of building a new elaborate theory. Moreover due to the relevance of contingency factors, a case study research strategy has been implemented. This allows for an in-depth investigation of the effects of several business and environment factors on company choices and performance.

The goals of this first part of the research are:

- collecting general information about the company, its use of energy, its consideration about energy management practices and the ongoing changes;
- testing the two axis of the framework: it has to be validated before applying it to the selected company. This prior phase is necessary in order to identify possible gaps with respect to the literature background. The characteristics and the information about energy practices have to follow respect some requirements such as clearness, completeness, and comprehensibility. What I found in the literature review has to be in accordance with the real cases, although the starting base of the classification framework would not be totally valid and right.

This research is preliminary and it does not correspond to the real application of the novel framework, furthermore the studied cases will be not analysed with a comparative perspective but only treated as *single case studies*. At this stage, it is not interesting to compare one case with another: the obtained information is not useful for validating the model.
To conclude (Yin, 2009) pinpoints some necessary stages in doing a case study research, as shown in the following figure.

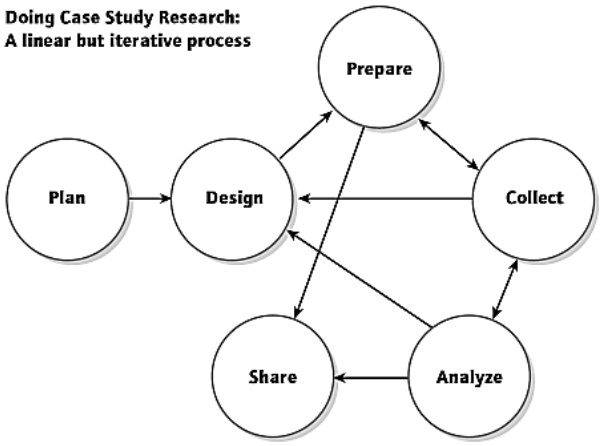


Figure 18. The stages of the Case Study Research (Yin, 2009)

The first step is to identify research questions or other rationale for doing a case study, then decide to use the case study method compared to other methods and in the end understand its strengths and limitations.

4.2. Research design

A research design is defined by (Yin et al., 2008) as: "a logical plan for getting from here to there, where here may be defined as the initial set of questions to be answered and there is some set of conclusions about these questions." The aim is to guide researchers in assembling, analysing and interpreting data and information.

There are two main research approaches: the cross-sectional design and the longitudinal design. The cross-sectional approach gathers data at one point in time from a sample of interest at that time. The second approach assembles data for at least at two points in time, e.g. before and after an intervening phenomenon such as the implementation of new technology (Pinsonneault & Kraemer, 1993). This study implements the first approach, since there is no temporal priority and the time dimension is excluded.

A semi-structured interview, based on the theoretical background of scientific publications, has been developed. In order to meet the stated goal of validating the framework, the research is based on a qualitative approach. The evaluation of energy management does not require specific quantitative data, since the analysis focuses on "soft" and qualitative aspects.

In this phase the data collected from the interviews and the theoretical background are combined and analysed.

Many authors have studied the qualitative research methods, interview structures and case-study methodology. This session sums up the main principles regarding these issues, which will find application in this work.

4.2.1 Qualitative research for the testing phase

Based on (Dicicco-Bloom & Crabtree, 2006), qualitative interviews have been categorised in a variety of ways. In this work I decide to use semi-structured interviews, since they are often considered the only data source for a qualitative research. Generally speaking, (Tom Wengraf,….) outlines that:

- it is a research interview designed for the purpose of improving knowledge;
- it is a special type of conversational interaction;
- it has to be planned and prepared and what is planned is a deliberate half or quarter-scripted: the questions are only partially prepared in advance (semi-structured) and therefore interviewer can improvise;
- it is supposed to go into matters "in depth", unlike the questionnaire method;
- it is generally organised on a set of predetermined open questions, with other questions emerging from the discourse between interviewer and interviewee. Semi-structured in-depth interviews are the most widely used interviewing format for qualitative research. Most commonly they are only conducted once for an individual or group and take between 30 minutes to several hours to complete.

The interview is intended to maximise the rate of response and cover accurate and relevant information: the design is the result of a trade-off between length, complexity and comprehensibility (Foddy, William. 2003. Constructing Questions for Interviews and Questionnaires - Theory and Practice in social Research. s.l. : Cambridge University Press, 2003.)

The semi-structured interviews require preparation, discipline, creativity and long time for analysis (T. Wengraf).

Semi-structured interview, according to (Bernard, 1988), is appropriate when there will not be a second chance to interview someone and when several interviews will be conducted into the field to collect data. Semi-structured interviews also allow informants the freedom to express their views in their own term and this is an important factor.

4.2.2 Methodology of the interview for the validation phase

As already anticipated, the interview is designed according to a semi-structured approach. The interview focuses on several questions regarding energy management, related practices, barriers, drivers and then the test of the novel framework. In detail the three parts of the interview are:

- brief collection of the main data of the company;
- introduction with open questions about energy policy, goals, energy management, barriers, drivers, energy efficiency potential from the company's point of view;
- test of the characteristics and practices found in literature background.

Hence the aims of the interviews are:

- collecting general information about the company, its use of energy, its consideration about energy management and the ongoing changes;
- testing the two axis of the framework: it has to be validated before applying it to the selected companies. This prior phase is necessary in order to identify possible gaps with respect to the literature background. The characteristics

and the information about energy practices should respect some requirements such as clearness, completeness and comprehensibility.

1. Based on your experience energy management in practice is more: technology-related, people-related, both?
2. Is there an energy policy?
3. Is there an Energy Manager?
4. Do you consider EM practices important as enablers to the implementation of energy efficiency technologies?
5. Is your company a member of some voluntary agreement as the PFE
6. Has your company got a certification? ISO 50001-Energy Management System (2011) ISO 9001-Quality Management System or ISO-14001 Environmental Management System? If not, why?
7. What is your idea about EM in your company (people or technology-based)? And about energy management practices? What is the role and the position with the organization of EM practices
8. Does your company take a strategic approach to manage energy use?
9. Is there a clear and sound Energy strategy for the medium-long term
10. Do your company focus only on energy efficiency technology and technical measures in general or also on energy management practices?
11. Technical and management measures: which kind of measures is more important from an energy efficiency point of view in your company?
12. In my work, EM practices are positioned on a higher level than technical measures but on a lower level the energy corporate strategy (intermediate level). What is your opinion about this assumption?
13. Based on your experience and your current information about energy efficiency technologies. What could be the overall reduction of energy use assuming all available cost-effective energy efficiency technologies were installed in your company [%]?
14. Besides technology, what could be the overall reduction of energy use through energy management measures [%]?
15. Can you estimate the reduction of energy each year? Are the reductions more related to the interventions?
16. How much do you spend in energy efficiency investments each year? Where do you find the fund?
17. How do you evaluate overall EM in your company? Look at energy matrix
18. Barriers to energy efficiency have a great impact. There is a large untapped potential of cost effective energy efficiency measures that is not realised. Which barriers are the most important in this context?
19. Which barriers have impact on EM and EM practices?
20. Which drivers for energy efficiency are the most important for promoting these measures?

Table 11. Introductory questions of the interview

After the introduction session, the interview goes on assessing the characterization framework. First of all a brief summary of the work concerning energy management practices is presented as explanation. Then, in this order, the collection of the characteristics and the practices is submitted: the aim is to compare the literature background with the actual knowledge and the status of the companies. I asked some questions in order to understand if the gathered information is suitable for the further application of the classification framework:

- After carefully reading the characteristics, that help to describe the practices in a structured manner, in your opinion are they clear and easily understandable? Are the characteristics enough for the explained purpose? Do you have any suggestions or something to add in order to improve the list?
- After carefully reading the most discussed energy management practices in the scientific and empirical literature, in your opinion is the list comprehensive? Are there in your company any other practices that are implemented (not already included in the list)? Do you have any other suggestions, which can improve the collection?

Based on the collected opinions, the adequacy of the framework is evaluated and it is verified that there is nothing neglected in the theory of energy management.
In order to have appropriate data and information, the interviews are conducted with energy managers or people in charge of energy management and they are vocally recorded to create a further transcript.
Moreover, all the interview documents, submitted to the interviewees, have been translated in Swedish in order to facilitate the understanding, although the conversation has taken place in English.

4.2.3 Case selection procedure

In the introduction chapter, Sweden is presented as the focus of this study. From an energy point of view this country is peculiar and since the energy question has

become critical, the companies have been changing their operating way. Nowadays many firms deal with energy efficiency and implemented a lot of BAT (best available technologies), but the main problem keeps being the mind-set change.
It is interesting to investigate which is the level of energy management in such a country, considering the notable availability of resources. Sweden indeed has rich deposits of iron ore, abundant waterpower resources, and extensive forest reserves. Through technological innovation and efficient work processes, Sweden has been using these resources to become one of the world's leading manufacturing and exporting country.

As stated in the official report of the United Nations (Nations, 2008), the manufacturing sector includes the physical or chemical transformation of materials, substances or components into new products, although this cannot be used as the universal and unique criterion for defining manufacturing. The output of a manufacturing process is finished in the sense that is ready for utilization or consumption or it can be semi-finished because it becomes an input for further manufacturing.
Metallurgical and engineering industries, followed by the lumber, pulp, and paper industries, have dominated Sweden's export-oriented manufacturing sector for long time. Sweden mostly produces goods such as iron and high-grade steel, ball bearings, automobiles, agricultural machinery, airplanes, machine tools and precision gauges, appliances, and telecommunications equipment. In Sweden the manufacturing sector is very wide and of utmost importance in the national economy.
In manufacturing sector companies belong either to energy intensive industries (chemicals, pulp and paper, iron and steel, refining and non-metallic minerals etc.) or to non-energy intensive ones (plastics, computers, transportation equipment etc.).
For this research I choose to select 8 case studies, which effectively represent the manufacturing sector. It should be noted that the adequate number of case with the purpose of "analytic generalization" is requested to be around 10 cases (Yin, 2009): actually at the end of this work the total sample will be composed by 11 companies. This first sample of 8 industries encompasses small, medium and large companies: the diversity of the sample is mainly due to the fact that I prefer to explore the

industrial landscape in a complete manner to understand how each type of company deals with the energy management.

Regarding the contact procedure, I used a list of the most important foundries in Sweden and then I added other contacts of manufacturing industries with some processes in common with foundries. In this way my sample would be quite homogeneous.

In order to get these contacts I was helped by my Swedish supervisor, Patrik Thollander, who has a great experience concerning energy questions and conducted a lot of studies in foundry industry.

At the first stage I contacted 30 industries of the aforementioned sector (iron foundry and industries with similar processes) via e-mail, asking for a personal interview of at least 2 hours. Soon after, I contacted these companies by telephone to verify their suitability and to check their availability. Once a firm accepted the interview, I also asked them if they could indicate other companies: in this way I managed to get a significant set of industries (40 companies) to get in touch with.

The rate of success was 11 out of 40, that is 27,5%, but in this preliminary part of the research I analyse only 8 companies out of 11 (the other cases will be considered in the Chapter 5, that is the application of the framework).

These preliminary 8 interviews have been conducted with selected energy mangers or other mangers in charge of energy issue. Luckily the most appropriate people suitable for this research were available to conduct the proposed interview. Due to the considerable number of information, acquired during the interview, the length of each meeting was significant: in order to obtain general information regarding energy management practices and to confirm the novel framework, the discussions lasted in average 2 hours each.

As already highlighted, accordingly to the manager, each conversation was recorded as proof and as help for my later transcript.

Following the Table 12 briefly summarizes the selected companies and some general characteristics.

COMPANY	*TYPE*	*SIZE*	*DATE*	*HOURS*	*INTERVIEWEE*
SMF- SKYLT	engineering	S/M	17/10	1,5	Lars Runbom - CEO
BRUZAHOLMS BRUK	foundry	S/M	22/10	2	Lars Alfredsson - Managing Director
SWEREA SWECAST	research centre (foundry-engineering sector)	-	24/10	2,5	Per Sommarin & Anders Svensson - Energy researchers
VADSTENA	engineering	S/M	29/10	3	Mikael Gunnarsson - CEO
FERGAS	engineering-foundry	M	7/11	1,5	Hans Karlsson -
AKERS SWEDEN AB	engineering-foundry	L	13/11	2	Mattias Abrahamsson - Specialist electricity
GARO AB	engineering	M/L	11/11	2	Magnus Arvidsson - Environmental and Quality Manager
ELECTROLUX	engineering	L	19/11	2	Tomas Dahlman - Director Global Energy Strategies

Table 12. The companies sample for the validation phase

4.2.4 Data collection and analysis

After collecting primary information through semi-structured interviews and secondary information through other reports or companies websites, the data have to be analysed. Since the research is qualitative any statistical analysis is possible and worthwhile.

The information related to the first part of the interview is used to make a presentation of the company, and understand the principles of energy management. Moreover it is of great value to compare the company's perception regarding energy management practices with the theory in scientific literature. The case studies could help to improve the empirical literature in this field. It is worthwhile to understand the kind of approach to Energy Management and verify if it is in accordance with the studied literature background.

Then, the information regarding the last part of the interview leads the testing of the characterization framework. In order to achieve a sound validation of the framework the axes are evaluate based on some performance variables.

The set of the characteristics is valuated based on these attributes:

- Completeness of the contents: the characteristics have to be sufficient and suitable to describe the practices. The characteristics indicate all the possible interesting perspectives of the energy management practices. The interview should not indicate other characteristics that can be referred to the energy management practices.
- Comprehensibility of the contents: the characteristics have to be comprehensible, understandable; the meanings have to be clear.
- Degree of detail: it is a qualitative research, the suggestion is to keep a quite low grade of detail since the more accurate is the required detail, the less the answers are confident. Moreover the characteristics are many and it is desirable to limit the number of attributes for each characteristic in order to contain the complexity.
- Degree of overlapping: the interviewee should perceive the differences among the characteristics. They represent all the points of view regarding energy management practices and the overlapping of two characteristics is not suitable or at least it could be perceived as minimum as possible.

The set of the practices is valuated based on these variables:

- Completeness of the contents: the number of the collected practices has to be sufficient and the company should not be able to add other practices, implemented in the company and absent in the set
- Comprehensibility of the contents: the practices have to be comprehensible, understandable; the meanings have to be clear.

The evaluation scale for the aforementioned variables is a balanced scale, balanced with an equal number of positive and negative categories: *poor, fair, good, very good* (Powell, 2009).

Then the third kind of test is the application of the characteristics to a practice implemented in the company, as for example: if the practice can be easily described, the result will be in accordance with the expected one.
Each case study is analysed as single case, without cross-evaluation, and at the end some conclusive comments are made taking into consideration every contribution.

4.3 Case studies results

In this paragraph the 8 case studies are presented in a structured way: brief presentation of the company, summary of the first part of the interview and of the opinions regarding the framework.

4.3.1 SMF – SKYLT Company

Name	Svenska Maskinskyltfabriken SMF-Skylt
Location	Linköping
Interviewee	Lars Runbom - CEO
N° employees	56
Annual turnover	28 million SEK (about 3,2 million euro)
Website	www.smf-skylt.se/en/

Table 13. SMF-SKYLT main data

AB Svenska Maskinskyltfabriken SMF-Skylt is a small/medium company, founded in 1916 and it is a leading supplier of modern product labelling. It is an engineering company, leader in the business of information display. In the Quality and Environmental policy the vision is. "SMF Skylt's employees are trained and committed to quality and environmental management"

4.3.1.1 Energy Management approach

From the first part of the interview, made up by open questions, I managed to collect a lot of information regarding energy management. First of all it is still technology-related instead of people-related: the company is working in this direction but there

is a lot of work to do to reach a good level of energy management. The focus on the best available technologies is still predominant.

As discussed in the second chapter, energy policy is an important factor enabling energy management and its practices at a lower level; in this case is not written energy policy. Strategies are not officialised. The person in charge of energy matter, that is the CEO, plans a reduction of energy consumption over three year. i.e. with quite a long-term perspective. On the other hand, lowering energy consumption assumes importance when related to production volume: if the firm estimates a higher production in a given year in the future, it will put more effort to lower the energy consumptions. This way of thinking is not in accordance with the theoretical principle of energy efficiency and management:, according to which, a firm should aim at saving energy constantly during its life-time.

One of the most important requirements for energy management is to have a skilled energy manager: in this case there is not a person only in charge of energy issue, but the CEO is responsible. Hence, it is reasonable to believe that he will have other tasks to consider beyond the matter of energy management.

The perception of the CEO is that energy management is still not so people-related due to the limited size of the company; energy management practices are important (Likert scale 3) as enablers to the implementation of energy efficiency technologies, but this is more valid in the case of larger companies. In this case the practices are in average scarcely important, the focus is more on the practices related to information system (collecting information) because they are easier and more immediate, but there is a lot of work to do regarding the human dimension. Some efforts are made to figure out which improvements could be possible but the ongoing changes are small and technical solutions.

About the involvement with voluntary agreement and certification, this company has only the ISO 9001 (Quality Management System) and the ISO 14001 (Environmental Management System) but it does not intend to get the newest certification, ISO 5001, as too much effort is required.

Then the interview covers the approach to Energy Management; the main goal of this company is to reach a higher level of shared information so the CEO puts a lot

of effort in the practices concerning the information system. The firm needs information in order to improve the investment decision-making process.
The company recognizes the importance of both energy management practices and technical measures from the energy efficiency point of view but it is not able to implement all the proposed practices. Moreover the interviewee agrees with me regarding the position of energy policy and energy management: the former belongs to a higher level and is a prerequisite of the latter one. The replay about the hypothetical three steps, high level-energy policy and strategy, intermediate level-energy management in practice, low level- operative and technical interventions, is positive, even if this division is still far from the actual conditions. The level most considered by the company is the lowest: this is the focus of many new energy efficiency investments.
The answers to the energy efficiency potentials demonstrate the aforementioned considerations: this company evaluates the energy efficiency potential from cost-effective energy efficiency technologies equal to 50%, and from energy management measures 5%. These percentages confirm the current low level of energy management.

The last point of discussion is about barriers and drivers of energy efficiency and energy management. The main recognized barriers are economic and information; with more money and information the other barriers are overcoming difficulties. The same consideration is valid for the barriers related to energy management. Furthermore the CEO admits also the relevance of behavioural barriers: in his opinion the awareness and interest of the employees are quite high and so the problem is the following step: changing the behaviour and the mind-set.
In a specular manner the economic and informational drivers are at the highest level. In regard to the first driver it is better to have available internal funds, but some external funds are desirable, for example the EU financial support for employees' competences. Then regarding the informational driver the interviewee affirm that it has to be internal since the interest is deeper if it comes directly from people.

4.3.1.2 Test of the framework

Now there is the "testing phase" of the model; previously I made sure to share the meaning of energy management practice, as considered in this work, in order to be aligned. The first axis of the model that has to be evaluated is the one related to the characteristics. After reading each term, the interviewee gives his opinion regarding completeness, comprehensibility, degree of detail and overlapping. The proposed set is exhaustive and easily to understand. As expected the only characteristic that is not immediately understandable is the type of enabler to interventions: the differentiation among direct and indirect type has to be explained. The degree of the detail is correct and the manger is able to identify each characteristic as different from each other

Then the list of practices is discussed: this analysis is easier than the previous one. The CEO is able to recognize every practice and he is not able to add something that is not already included. Hence the judgement about the completeness, comprehension is positive.
In the end the company indicates the practices recently implemented: meetings to motivate employees and to spread the information, setting of energy savings targets, monitoring energy use, energy audit and housekeeping (the motto of the company is "do what you do at home").

The last part of the interview concerns the application of the characteristics to one practice as example. In this way the validation of the framework can be considered satisfactory and complete. The practice is *care and maintenance:*

- It belongs to the housekeeping group
- it is focused only on core processes
- it is an direct enabler to energy savings because it is close to technical measures
- it is focused on both thermal and electrical source
- the strategy's scope is the energy efficiency
- it is a program already in use
- it is related to more than a group of people but to the whole company

- the influenced level is groups of the shop floor and it corresponds also to the level that implements the practice; the decision comes from the energy manager of the middle management. The company does not require an external support
- it is hard to be implemented
- the review of this activity is it every year and the practice is daily implemented
- the direct cost is very low and also the hidden ones
- the behavioural is the higher barrier (4 of the Likert scale)
- the drivers recognized very important are the informative and regulatory ones, always internal drivers.

4.3.2 Bruzaholms Bruk Company

Name	Bruzaholms Bruk
Location	Bruzaholms
Interviewee	Lars Alfredsson - Managing Director
N° employees	55
Annual turnover	104 million SEK (about 11,6 million euro)
Website	www.bruzabruk.se

Table 14. Bruzaholms Bruk main data

AB Bruzaholms Bruk is one of the leading manufactures of wear parts for asphalt and concrete mixers in Europe. This foundry was founded in the year 1660 and it has been manufacturing castings since the mid 19th century. In order to maintain a sound reputation as European suppliers of casting, the company has invested heavily in its production facilities during the last 15 years.

4.3.2.1Energy Management approach

This is the case of a medium company, mostly for the production volume, and the conversation starts with the assertion that energy management in practice regards both technology and people. Three levels of management and control can be

identified and the person in charge of energy issue is belonging to the middle and it is the interviewed Managing Director. For the future there is the goal of writing the energy policy in an official way and currently only a part of the program is written. The good thing is that the vision is long-term, more than 3 years.

The aim is to save cost of energy for core and no-core processes . The company is expanding and it is more efficient every year, the amount of energy use per ton is decreasing. In the past technology was the most important factor but nowadays people-based management is important as well and this is coherent with the literature suggesting that energy management practices are relevant as enablers (Likert scale 3).

The company is not a member of some voluntary agreement but there is a plan of being part of a smaller system than PFE, and this demonstrates the good intention for the future. Moreover the firm is working in order to be ready in two/three years for the ISO 50001 certification thanks to the help of SWEREA SWECAST, a research centre that has implemented a system named Energy System Light (Ekander, 2013). This is an online tool that leads the certification of small and medium enterprises, which have difficulties because of scarce competences.

These initiatives show the undertaken direction to establish a right system to manage energy and to improve the knowledge owned by people.

The Managing Director confirms that the firm is following a strategic approach to manage energy, looking at the newest energy efficiency technology to support processes like the lightening system. Furthermore a new huge building is designed with great attention to environmental matter and energy saving (right windows for the daylight etc.) and the excess heat form the core processes is used to heat up the workspaces.

In this company the managerial and organizational aspects are now required to take under control all the energy usages: for this reason quantitative goals are set for each years about MWh to be saved.

When I explained the three steps regarding energy issue, energy policy - energy management - technical interventions, the comments about this way of distinguishing tasks are positive. The interviewee appreciates the degree of novelty. the implementation is easier if you have a sound organization regarding energy

management. His opinion is that energy management practices are necessary but not sufficient.

In regard to the comparison among the two different energy efficiency potentials, the one from the technology is very low, i.e. 10% while the one from energy management is higher, i.e. 20%. The difference is positive: from a technological point of view the company is very updated, when it invests there is a great attention to the energy efficiency. Instead it is less efficient from the management point of view, here there is room for action.

Moreover there is a higher discrepancy between the expected level and the current level of Energy Management, compared to the results of other known foundries; this is an incentive to improve.

According to the company, the most relevant obstacles to an efficient energy management process are the economic and behavioural ones; the manager claims that some economic incentives could determine changes in the employees' attitude. Moreover other priorities and the lack of time are mentioned as relevant and they are included in the organizational barriers. Regarding the drivers, beyond the financial incentives, a desire is expressed of an external regulation: in spite of the volatility of energy cost in Sweden, there is not a long term vision future projects in companies.

4.3.2.2 Test of the framework

Concluding the introduction about Energy management approach of the firm there is the validation phase, starting with a brief presentation of the model. With respect to the characteristics the manager expresses some doubts about the length of the list: maybe some characteristics as the frequency of review and implementation are too similar and could create some misunderstanding. His advice is to join the two frequencies, since it is the only case of possible overlap. He appreciates the organizational attributes and the cost, highlighting that the inclusion of hidden cost is necessary. Another observation is related to the energy source: perhaps the differentiation is not so decisive, at least in his company.

Regarding the detail, the manger agrees that the degree is sufficient for the purpose.
Regarding the second axis of the model the considerations are positive as well: the set of practices is certainly complete and comprehensive. The interviewee is able to identify a lot of practices not implemented in his company and some of them are new for him and hence really interesting. About the complete framework, the idea is that it very original, innovative but also complex mostly if presented in S/M enterprises where there can be lacks of right competences in this field. So the applicability would require more attention and support in those cases, or at least the model should be easier. A clear introduction and explanation of the model and a support in the filling phase is needed if the people are not properly skilled or used to this kind of approach to energy management practices.
The discussion continues concerning the practices implemented in the company: there are regular meetings during the week with one person of each division, and these people can build in some way an energy management team. At the same time the firm is trying to realize some publicity campaigns. Regarding general awareness, there are not still the right competences: maybe an external support could be desirable. The company is sure that if the ideas derive from the shop floor the rate of success will be great unlike the case of obligations coming from the top organization level. Moreover a growing attention is on the monitoring system and once a year a meeting takes place with other foundries, belonging to the foundry association.
The interviewee give importance to sustainable leadership course because in his opinion there is a lack in this soft skill: the managers have to learn how to better communicate in the right and appropriate way the knowledge about energy management.

The last part of the interview concerns the application of the characteristics to one practice as example. In this way the validation of the framework can be considered satisfactory and complete. The practice *is energy saving targeting:*

- the practice belongs to the general organizing group
- it is focused both on support and core processes

- it is an indirect enabler to the technical intervention and energy savings; it is something that facilitates the implementation of other practices, which still precede the technical measures
- it is focused on both thermal and electrical source
- the strategy's scope is the energy efficiency
- it is new for the company, the company has just implemented it
- it is related to the whole company
- the influenced levels are low, middle, top management ; the decision comes from the top management but the people, which effectively implement the practice, belongs to the energy team of the middle level. The company does not require an external support, an expert that helps the energy manager to set the targets.
- this practice is quite hard to be implemented
- the review of this program is yearly as the frequency of decision/implementation
- the real cost is very low but the hidden cost is high
- the organizational and competence related barriers are the higher (4 and 3 of the Likert scale)
- with respect to the aforementioned barriers, the drivers recognized very important are the informative and competences ones.

4.3.3 Vadstena Varmförzinkning Company

Name	Vadstena Varmförzinkning
Location	Vadstena
Interviewee	Mikael Gunnarsson - CEO
N° employees	30
Annual turnover	24 million SEK (about 2,7 million euro)
Website	prozink.se

Table 15. Vadstena Varmförzinkning main data

Vadstena Varmförzinkning is a small company, specialized in the process of galvanizing, covering metal with plating. The process is automated and usually takes

place in a "closed" system while the plant in Vadstena may seem more "artisanal" with their open bath and its "open" stews. The company is considerably engaged with using new technology; moreover all the production processes are quality and environmentally safe.

4.3.3.1 Energy Management approach

Vadstena can be considered as an energy intensive company: the core processes for coating steel use almost all the available energy (99,9%) and a little percentage is used for support processes (non-core processes). One of the main improvements is the reduction of waste during production: for example discarded energy can be used for heating the working environment. Thanks to this kind of improvement many enterprises in Sweden save a lot of money, mostly during the winter. The interviewee admits that is the first planned change for the immediate future.

Based on his experience, energy management is related both people and technology. The people-based approach is a novelty for the company and something is changing in the mind-set of the employee, mostly in the top management, but it is not a fast process: the prevalent attitude is still technology-related. The focus is still on the consumption of production.

In this factory processes are very old, but at the same time modern: currently they are adopting the best solution and for the future any other improvement is expected. For this reason, the only opportunity for the company to save energy and money is the focus on non-core processes, where there is the room for actions. In this processes, energy management can be crucial.

The goals related to the consumption are included in a long term vision and policy (more than 3 years), but for organizational and human goals the road has been undertaken and the education program is starting from 2015.

The company has 3 managers in the company's board (the so called white collar), than there is a production leader and the rest of the employee belong to the shop floor (blue collar). The three managers at the highest level hold the task of energy manager, so the responsibility and the interests are split. The energy management

practices are considered very important as enablers to the implementation of energy efficiency (Likert scale 4): in the future the company is planning to expand and financial savings are required.

The involvement in a voluntary agreement has never been considered but now an interest is growing since the company is more interest in energy efficiency question.

In regard to certifications, the company has the ISO 14001 and ISO 9001 because of past requirements of the customers. There is not a plan about the newest ISO 50001 and currently they are still far from it; maybe in some years they could be more ready but now there a lot of necessary steps to be considered. In the future the firm will pay attention to the people-based management together with technology even if there are many perspectives of improvements in this area. The company has not the full knowledge so it has to seek the competences and the information from other actors, though the sectorial or cross-sectorial networking. Employees have to learn where improvement could be done in the non-core processes since in the core processes all the BAT are already in place. Indeed the energy efficiency potential from technology is very low (3%) since the technological solutions are very old but at the same time updated. The potential improvements could be in the lightening, ventilation, heating system and in people education

In a year an educational plan is starting and one of the its purposes is to debunk the idea that energy reductions occur only in the case of increasing production volume: the energy efficiency is a way of working, independent of other factors.

Concerning the general evaluation of Energy management the CEO confirms that there are a lot of steps to take in order to improve it. Until some years ago, the board was composed by old people not interested in the modern idea of Energy Management and only with technical competences.

The last part of the interview is about barriers and drivers; the main obstacles correspond to economic and organizational barrier. The information is quite good and available and also the interest in the energy contest: the board, with young people, is well involved and feels confident of diffusing the information within the company.

4.3.3.2 Test of the framework

The energy management practices world is not well known by the company and the managers are recently approaching it. After submitting the first list of characteristics, the interviewee confirm that the characteristics are more than what is necessary, and maybe it could be easier if the number of them is limited. For instance joining together the two frequencies. It is worth noticing that the strategy's scope of energy management is always identified as energy efficiency instead of energy conservation.
For this company the attributes of the characteristics are too detailed.

Regarding the practices, the CEO is able to easily understand every term; some practices are indicated as the most important actions, planned for the next future.
At the current state of the company, the framework is not applicable since it is complex and very few practices are implemented. the focus on energy management is still not sufficient.

The last part of the interview concerns the application of the characteristics to one practice as example. In this way the validation of the framework can be considered satisfactory and complete. The selected practice is*: meetings*.

- the type of practice is spreading information
- it is focused only core processes
- it is an indirect enabler to energy savings and technical interventions, it is something that facilitate the implementation of other practices
- it is a focused on both thermal and electrical source
- the strategy's scope is the energy efficiency
- it is a practice already in use (3 years)
- its impact is on more than a group of people but not on the whole company
- the influenced and implementing levels are low and middle management and the latter level is also responsible for the decision. The company does not require an external support
- this practice is quite easy to be implemented

- the review of the ways ok doing the meetings is every year, while the implementation is every week
- the real cost is very low but the hidden cost is high because the employees loose part of their work day every week
- the awareness and organizational barriers are the higher (4 and 3 of the Likert scale)
- With respect to the aforementioned barriers the drivers recognized very important are the informative and regulatory (4 and 3 of the Likert scale) and always internal drivers.

4.3.4 Fergas Company

Name	Fergas
Location	Linkoping
Interviewee	Hans Karlsson – Head of Engineering
N° employees	100
Annual turnover	150 million SEK (about 17 million euro)
Website	www.fergas.se

Table 16. Fergas main data

Established in Linköping, Sweden in 1949, it is one of the leading global producers of blower wheels, cross flow blowers and air blaster units (air moving solution).
Fergas has total market presence with manufacturing facilities and universal quality standards in Europe, North America and China. There are also commercial and technical representations throughout the world.

4.3.4.1 Energy Management approach

This medium company is characterized by an energy/non energy intensive production. As in the previous the company is undertaking the road of energy management more related to people and organization. The aim is to connect the

people to technology, very important in the production processes. In line with this the energy management is considered people and technology related. There is not a real energy policy, but within the wider environmental policy, which has a long-term vision (more than 3 years), there is a part dedicated to the energy issue. Almost the same happens to the energy manager: this role is included in the environmental management, at the middle organizational level. The energy efficiency practices are very important as enabler to the implementation of technologies since the investments usually cost a lot of money and affect the environmental. Hence everything that is necessary in order to effectively implement the technical improvements is important.

Regarding the certification the company has the ISO 14001 and the ISO/TS 16946, aiming to the development of a quality management system based on the ISO 9001. The manger knows the Energy Management Light tool in order to get ready for the ISO 50001 and he is thinking about it. The company has always preferred technical solutions, since it is easy their implementation. In this case theoretically the main obstacles are the economic and technological barriers, but the company can handle these problems since it has enough internal funds and is well technologically skilled. The problems are related to the change of mind-set and behaviours. For this reason, until recent times the strategic approach concerned only technological investments. The awareness of the importance of people-based energy management is growing but more effort is required. Regarding the distinction between energy policy, energy management in practice and technical, operative implementation, the interviewee declares that it sounds good but his concern is for the real applicability. In his opinion it is a right way of thinking but maybe too much theoretically: in the practice the energy management can overlap the lower level of interventions.

The energy efficiency of the company is at a good level so the potential from technology is quite low: 10% of improvement. Concerning the potential from energy management actions the interviewee is not sure of the answer because he has not enough information, the percentage could equal the one of the technological point of view. Moreover it is becoming difficult to reduce every year the consumptions: 10 years ago the company started to work on energy efficiency with challenging goals, but now it is hard to save energy with the technology since they have already the

right equipment. In regard to the overall evaluation of Energy Management, the impression is that a lot of improvements have been done in the recent years but this is not sufficient to state that the level is high. The firm keep working in this direction, consulting external experts, university and research centres.
About the barriers to energy efficiency and management, as usual the economic barrier is seen important: with more money it is easier to address the energy management road, according to the company. Furthermore there is the awareness problem of the employees: even if the top management and some line mangers are well committed, other people still underestimate the potential. Correspondingly the economic drivers become important, mostly if the funding is internal; then more information can mitigate the motivational problem. Moreover if the environmental manager had more competences related to the energy issues, he could deal with the problem in this field in a better way.

4.3.4.2 Test of the framework

After collecting this information, it is the turn of the testing phase: according to the manager, the characteristics seem coherent and the list looks complete. The only features that are questioned: the type of enabler, the barriers and drivers; their meaning are not immediately understandable. Regarding the former, the response is that it makes sense but it is less easy to understand this characteristic than in the other cases. The manager is not used to measure the level of barriers and drivers, but he expresses interest in such an issue. Moreover expressing opinions for each barriers/drivers and practices is too demanding; maybe it could be easier to decrease the degree of detail and analyse the barriers and drivers for group of practices. The manger states that understanding each single term of the barriers and drivers requires knowhow.

The judgement about the list of practices is positive: it is complete; there is nothing to add or any improvements. Generally speaking the framework is considered more suitable for large or medium/large companies, instead of the small or medium/small

ones. In the latter cases the interviewee suggests a simplified version, with less characteristics and practices.
The manger highlights the need of the practices referred to the collection and spreading of information: even if the information about the consumption is available every day, now it is supposed that the employees pick up the reports but thanks to a higher motivation the spontaneous access to the information could be better.

The last part of the interview concerns the application of the characteristics to one practice as example. In this way the validation of the framework can be considered satisfactory and complete. The selected practice is *consumption reports:*

- it belongs to the spreading information group
- it is focused on core and non-core processes
- it is an indirect enabler to the energy savings and other interventions; the information is necessary for a better decision making process
- it is focused on both thermal and electrical source
- the strategy's scope is the energy efficiency
- it is a practice new for the company, the company has recently implemented it
- the extent of the impact is more than one group but not the whole company
- the influenced level is the low and middle management and the latter organizational level has also the responsibility for the decision and implementation. The company does not require an external support, an expert that helps the energy manager regarding this task
- this practice is quite easy to be implemented
- the review of this program is every year while the effective implementation is monthly
- the real cost is very low and the hidden cost is low
- the organizational barriers is the highest (4 of the Likert scale) and then important are also the information and awareness
- with respect to the aforementioned obstacles the driver very important is the informative one.

4.3.5 Garo Company

Name	Garo
Location	Gnosjö
Interviewee	Magnus Arvidsson - Environmental and Quality Manager
N° employees	150 (Sweden); (230 in the Group)
Annual turnover	404 million SEK (about 45,7 million euro)
Website	www.garo.se

Table 17. Garo main data

Garo is a manufacturing company established in 1939 and it has three partners. The parent company and the Group Head Office are based in Gnosjö, while subsidiaries are placed in Sweden, Ireland, Finland, Norway and Poland. The company develops, manufactures and sales a wide range of products for the electrical installations in a big market. Due to the dimension, the three organizational levels are well identifiable.

4.3.5.1 Energy Management approach

The decision of the management board to reduce energy consumption by 15% began about 5 years ago with the intention to reduce environmental impact, save money immediately and in the long term, and the reliability. The company is selling energy efficiency products to the market and it is also important to have an internal program to work with energy efficiency.
The company stands for security and has ISO 14001 and 9001 certifications; moreover it is an AAA company since 2003.

The manger shows me the completed energy efficiency actions:

- Lighting: new light fixtures (T5) and change the layout; control of lighting (strategic locations); energy saving lamps ex. led (ex. from 40 W to 4 W). The results: longer life and less consumption (10 times)
- Ventilation: timing (Monday – Friday: 06.00 – 18.00); reduction with 64% (operation time)
- Air: new compressor; reduction of energy consumption (30%)

- Computers: shutting down the computer after work
- New gas boiler: improved efficiency of 10%
- KNK control: heat, water, lighting and cooling
- Industrial ceiling fan: smoothing of the temperature in rooms with high ceilings; warm air is lighter than cold air and therefore rises to the ceiling. The effects: heating costs can be reduced by 30% with this little investment.

The company is really involved in energy efficiency programs since it understands the potential from energy management. The board management and the manager in charge of energy question believe that cheap investments can be profitable and lead to savings of energy and money: these low cost actions can be energy management practices. Everything in the support process is under control of automatic sensors: the decision of this investment was made once all the energy efficiency technologies were implemented in the core process, on which in the past was focused the attention. The growing interest in energy issues and the awareness that also the non-core process can be managed in an efficiently way, conduct to the decision of doing something in this area.

Based on the experience of the interviewee energy management involves both people and technology, but if in the past the technology dominated now a change is happening. The attitude of the people is very important and young people in the company can be decisive in order to change the culture, a slow but necessary process.

There is a written policy since 2007 and the term is very long, about 5 years: it includes the vision and the general goals, also with respect to environmental question. Regarding the fundamental requirement of energy manager, this company has a quality and environmental manager, the interviewee, with energy management tasks too. This person is supported by a team at the middle level, as shown in the figure below, and he reports directly to the board.

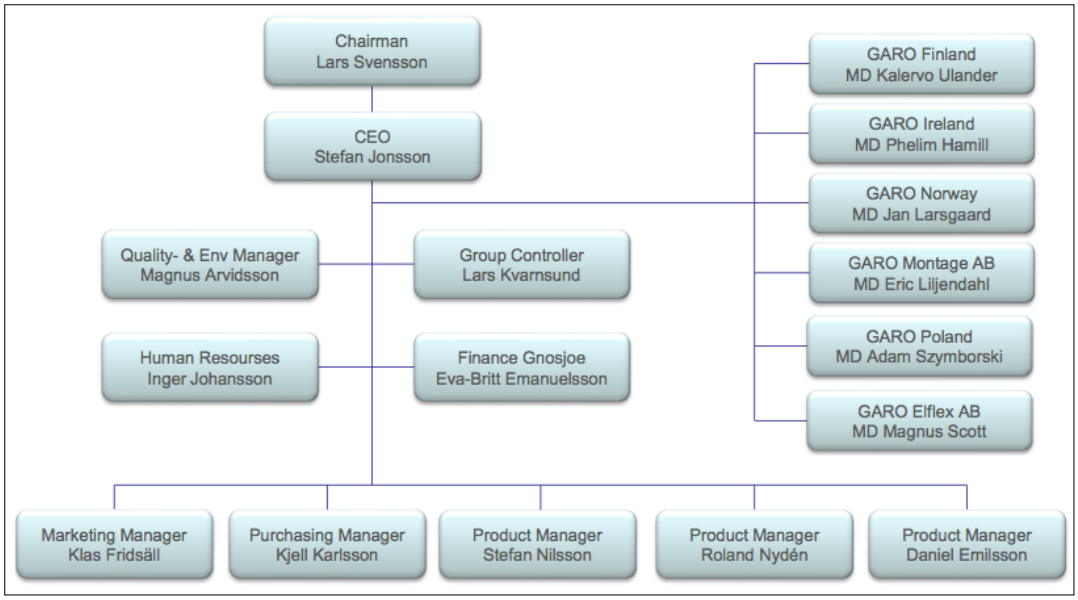


Figure 19. The tree structure of Garo (www.garo.se)

The company is not a member of some governmental voluntary agreements, like the PFE. it prefers to participate to some meetings with other companies, mostly competitors. The trust in the networking system is very high, because the possibility to learn from the others is of utmost importance. The owned certification are ISO 9001 and 14001, while the ISO 50001 is planned for the future and, even if the company could be ready, currently it is not within the priorities.

The approach to energy question is very strategic since it became part of the agenda of the top management; four time a year the energy team and the board have meetings in order to share the goals and the progresses. The energy strategy or policy is a novelty for the company and this thanks to the new generation in the firm, with more interest in it. The focus on technical measures is still critical with a share of 60-65%, hence the percentage dedicated to the energy management practices is lower but anyway higher than the average in other cases.

When the interviewee is asked to comment the idea of the division of energy policy-energy management in practice and operative, technical interventions, the manger agrees with it. The suggestion is that maybe the actions of the second and third level could be implemented together, in a sort of simultaneous work. The division is right, with less overlaps than the aforementioned case, for the first and second level: the

policy is on a higher level, is quite abstract and it is necessary and preliminary to the implementation of the energy management practices.
Concerning the energy efficiency potential from technology, the possible reduction is low, about 10-15%, because the firm has already improved upon many production processes though the new energy efficiency technologies and BAT. The percentage of potential reduction from energy management practices is almost the same, 15%.
The evaluation of energy management of his company is very good: a lot of actions have been undertaken. A part of them (25%) comes from employees at the lowest organizational levels: the decentralization is high and there is an excellent reward system to recognize the engagement of the people. The majority of the management actions are decided by the middle management and energy management team and the rest of the ideas are given by the suppliers or networking members.
The last question are about the barriers and drivers: for the manger the main obstacles are generated from lack of competences, inadequate behaviour and organizational aspects as lack of time and other priorities. Regarding the drivers the main supports can be the availability of more competence and information, both external and internal. Anyway the economical driver is always important: the management can benefit from more funding. After the general presentation of the company and its works related to the energy and environmental area, it is the turn of the testing phase.

4.3.5.2 Test of the framework

The characteristics of the practices seem understandable and sufficient to describe them, the manager agrees also with the degree of detail of the attributes: too much detail would not be desirable for the work. The only tricky characteristic is the type of enabler: it makes sense but it requires further explanations rather than the others. Any overlaps are recognizable but maybe the differences between the two frequencies is too subtle.

Then collection of the practices is considered complete and based on the interviewee observations, every area related to the energy and environmental issue is covered. In

his company a lot of mentioned practices are in use and the manager is pleased of this. Hence the information coming from the theoretical or empirical literature seems valid and consistent with the real industrial system. The area more affected by actions and improvements is the one concerning the collection and spreading information: the company is working on obtaining information from internal resources, measuring the consumptions, and from external resources, meeting the suppliers and taking advantage of networking. Moreover the practices within the motivation and training are considered so important if the energy management has to be more focused on human dimension. Therefore the reward strategy is considered worthwhile. The discussion ends with the doubt regarding the length and complexity of the novel framework: it could be suitable for large company where at least one manger is able to handle the topic. In the case of medium and small company, an expert would be necessary in support of applying this model.

The last part of the interview concerns the application of the characteristics to one practice as example. In this way the validation of the framework can be considered satisfactory and complete. The practice is *motivation and awareness program (specific):*

- the type of practice is the motivation
- it is focused only on support processes
- it is an indirect enabler to the technical intervention because it is not so close to the technical measures, it is something that facilitate the implementation of other practices, which still precede the technical measures
- it is a program focused on both thermal and electrical source
- the strategy's scope is the energy efficiency
- it is a program new for the company, the company has just implemented it
- it is related to only a group of people
- the influenced level is a group of the staff; the decision come from the energy manager of the middle management and it corresponds also to the level that implements the program. The company does not require an external support, an expert that helps the energy manager in the organization of the program
- this program is quite easy to be implemented

- the review of this program is it one time because it is planned to implement it only one time
- the direct cost is very low but the hidden cost was high because the employees loose almost a day of work and there could be some inconvenient for this
- the behavioural and organizational barriers are the higher (4 and 3 of the Likert scale)
- the drivers recognized very important are the informative and competences ones.

4.3.6 Akers Company

Name	Åkers
Location	Åkers Styckebruk
Interviewee	Mattias Abrahamsson - Specialist electricity
N° employees	200 (in Sweden) (more than 1500 in the Group)
Annual turnover	300 million SEK (about 33,9 million euro)
Website	www.akersrolls.com

Table 18. Akers main data

Åkers Group has the strongest presence in the roll industry and it has facilities in six countries spread on three continents. It is an ancient company, founded in 1580 by royal decree. Is a large company with a total annual turnover exceeding 2400 MSEK. The Head Office is placed in Sweden. The main output is cast rolls, the main core processes are melting, casting, mechanical workshop and the most use of energy in the non-core processes is due to the ventilation.

4.3.6.1 Energy Management approach

The enterprise is taking a long term view and is creating sustainable value for customers, co-workers and shareholders. Regarding the overall vision of quality and environmental the company state that all the production plants fulfil the requirements of, and are certificate to, ISP 9001. Moreover they are additionally

certified to ISO 14001. In this context the firm tends to minimize the impact the operations have on the environment, with the objective of maintaining good working conditions for the employees and good relations to customers and the local community.

Examining the website and the last available annual reports, it is evident that the company has not a dedicated structure for managing energy: the effort is put mostly into environmental problems. The perception is that there is not an energy manager or a team and this can be noticed looking at the organizational and hierarchical tree (see Figure 21).

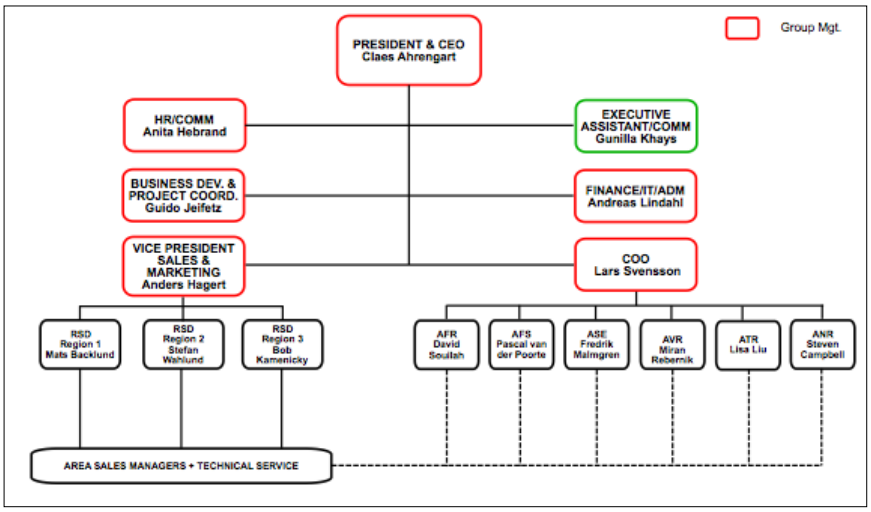


Figure 20. The tree structure of Akers (www.akersrolls.com)

The interview analyses the point of view of the Head Office in Sweden: it was not possible to meet a manager of the top level, instead the meeting was with a middle manager really interested in energy issue and with many plans for the future. Based on the experience and though the interviewee the energy management in practice is increasingly people-related: the people have to work in the proper way. There is a lot of new and old equipment and the employees have to work with it in the most energy efficient way. The company has a new energy policy: it is quite qualitative and aims to persuade the people to consider the energy savings as a great value for the company and for themselves.

The commitment of a middle manager in the energy question is necessary and planned for the next year: the interviewee admits that he is ready to present to the board his proposal regarding the establishment of a management team. The idea is also to join environmental and energy issues together, in order to facilitate the approval by the top management.

The energy management practices are considered important as enablers to the implementations of other intervention: a well-organized structure is necessary in order to be effective on the consequent actions and investments. In the company the attitude of the people can affect the process and the efficiency: the melting processes count for 40% of the total energy use, the heating treatments for the 25%, the casting for the 20% and the residual 15% can be managed and affected by the people.

There is the project about the certification ISO 50001: in 5 years the company could be ready for this, using also the support of the Energy System Light (the tool provided by SWEREA). The company recognized the importance of the strategic and people-based approach when the management had to figure out why the new technologies had not delivered the expected results: the old and new machines were run in the same way, not in an efficiently way. The people have to learn how to work efficiently. The plan for the next years includes many sessions of training and education: the approach will be increasingly strategic. The company will focus both on energy efficiency technologies and energy management practices: new interventions and installations in the production processes are necessary and the company can handle investments with higher payback times if the energy efficiency level will consequently increase. In the past there was not attention to the energy efficiency actions since the energy price was very low.

The interviewee agrees with the partition of energy issue in 3 steps: energy policy with main goals and vision, energy managements with actions, indicators, figures that contribute to develop the strategy, and at the end the technical and mere implementations.

Regarding the potential from technical interventions the percentage is low, in average 10%: the company has the right equipment and it is going to make other investments

but now the challenge is to work efficiently with them. The potential from energy management practices is hence a bit higher: 15-20%.
The overall evaluation of energy management is good (level 3 on the Likert scale): in the last two years a lot of steps and many decisions have been taken, concerning the focus on energy management activities, leaving the technology based approach.
In regard to the obstacles to energy efficiency the manger states that economic barrier is right for investments but not if the subject is the organizational and human side of energy management; in this case the behavioural and awareness aspects are more important since changing the mind-set is hard and require a lot of efforts. The competences and the information, concerning energy, are accessible in the company if there is the interest in this topic. What could be very useful is the availability of competences and information in order to increase awareness and interest in the people: these could be real drivers. The economical driver is always desirable, but the interviewee doubts that it could correspond to the solution to energy management problems.

4.3.6.2 Test of the framework

In the second part of the interview the list of characteristic is submitted after explaining the aims of the framework. In the manager's opinion, the characteristics allow to get all the necessary information to describe a practice, in an effective way. Understanding the way a company implement the practices could be very useful for a better evaluation. The opinion regarding the other two performance variables, overlapping and detail issues, are quite positive: a greater level of detail would not be useful. Maybe the differentiation among internal and external drivers is not necessary and redundant.

Also concerning the collection of practices the observation is positive: the interviewee could not find other actions, which have not been yet included. If a company was able to implement everything, the result would be excellent. Discussing the energy management practices, the interviewee individuates the activities that are

going to be implemented in the next period: education plan for the whole company, meeting every week with middle and top management, action plan, specific goals, stronger and more accurate measuring system, regular and effective care and maintenance of the equipment and plants in general.

The last part of the interview concerns the application of the characteristics to one practice as example. In this way the validation of the framework can be considered satisfactory and complete. The practice is *monitoring energy use and costs:*

- the practice belongs to the collecting information group
- it is focused only on core processes
- it is a direct enabler to energy savings since the activity directly suggests the possible improvements
- it is focused on both thermal and electrical source
- the strategy's scope is the energy efficiency
- it is several years that this practice is in use in the company
- it concerns the whole company
- the influenced and implementing organizational level corresponds to the shop floor while the decision is up to the energy manager. The company has never required an external expert such as a consultant
- the implementation is quite easy
- the review of this activity is every year while the implementation is every day
- the real cost is high since the monitoring system is expensive and mostly its maintenance, the hidden cost is instead low
- the organizational, information and awareness barriers are significantly high (4, 3, 3 of the Likert scale)
- the driver supposed to be important in order to overcome the barriers is the informative one.

4.3.7 Swerea SWECAST

Name	Swerea SWECAST
Location	Jonkoping
Interviewee	Per Sommarin; Anders Svensson – Research Engineers
N° employees	51 (in Sweden) (527 in the Group)
Website	www.swerea.se

Table 19: Swerea SWECAST main data

The Swerea Group encompasses five research institutes, it is owned by owners' associations form industry (57%) and by the State (43%). The working areas are: electronics, energy and the environment, materials technology, modelling and simulation, process development, product development, production technology, testing and analysis, work environment. In the energy area Swerea assists Swedish companies in their efforts to work towards sustainable development. It provides practical information and solutions.

4.3.7.1 Energy Management approach

Within the Group there is the Swedish foundry industry's research centre: I chose it since it is worth having the opinion of an external expert. This centre deals with industry problem related to energy question every day; the knowledge about the subject is deep and it very interesting for my work to have an overall view. Swerea SWECAST conducts researches and consultancy in the foundry area, including materials, casting simulation, process technology, energy and environmental issues.
The interview is structured in a different way: here it is not possible to ask the same questions of the other cases; similar information is collected during the debate and the presentation made by the two researchers.

Regarding Energy management the centre organizes some courses and these are a novelty in this context and of utmost importance. The objective is to provide insights on how a company can apply the new international standard for energy management, ISO 50001. These supporting initiatives help the companies that want

to move to an energy efficient way of working. To apply a management system does not necessarily mean that the firm certifies itself: a light version of management is also part of the course content. The elements treated are: the purpose of an energy management, the development of ISO 50001, comparisons with environmental management, energy policy and energy, how to lower energy costs, practical tips to start working on energy management and related system.
Moreover it is highlighted a coexistence of environmental and energy management: these two disciplines look at each other and the energy reduction positively affects the environment, both requiring the control of the industrial processes. Managing together these to matters might help the companies and facilitate the conjunct actions.

Based on the experience of the interviewees, the current approach to energy management in practices is changing: from technology to people-related. People have to learn to work systematically in order to get the best results from technical interventions. The long term energy policy in this case is very important as first official engagement, then it is necessary to set specific goals with a shorter term. The approach is top-down: first the main qualitative and long-term goals and second the specific goals for each department or area. The energy strategy or policy addresses everything implemented after it and this preliminary decision is up to the leader, the top management.
The energy management is essential to effectively plan the investments, address the way of working, decide and improve the knowledge about the processes. Moreover it needs to encompass what is the right mind set to successfully work with the technologies: knowing the best way of using the new energy efficiency technologies can lead to important results. The passing of time has brought a gap of knowledge related to the use of advanced technologies. There is the need to apply the best available method (BAM) to the best available technologies (BAT), and this implies the need for a strategic approach.
The discussion continues with respect to the barriers and drivers:. the main barrier of energy efficiency is the economic one. Mostly the foundry sector has a low capital availability and the consequence is the choice of investments with lower payback

time. In the case of energy management, further funding could certainly be desirable, but it is not the real solution: energy management practices usually require low investments. Based on their experience, the key problems are behavioural and organizational. Changing the mind-set and increasing the awareness of the employees is now a challenge and the change management discipline deals with such problems. Then other obstacles, mostly in larger companies, are lack of time and other priorities. There are no problems regarding the information or the interest: both are on a sufficiently high level.
The most common driver in energy efficiency is the economic; as previously mentioned it is still valid in the management case mostly if energy audit or other practices require initial investments higher than other. The desirable driver could be specific competences that can support the management in the energy approach: first of all the energy manager and team have to be educated and helped to manage and involve the other employees.

4.3.7.2 Test of the framework

The testing phase gives the expected results: the researchers appreciate the list of characteristics, stating that it is complete and the detail sufficient for the purpose. With respect to the ability to understand each term, the interviewees can identify the meanings in an easily way. The type of activity, the organizational actors and the cost are seen as the most useful characteristics. There do not exist any overlaps, also regarding the trickiest characteristics such as the two frequencies and the type of enabler to energy savings.

Regarding the collection of the practices, based on their knowledge and information of the industry sector, all the practices presented in the literature correspond to those really implemented. They do not know any companies able to implement all the listed practices: this would be the optimal condition. The practices seen as novelty in the industrial sector are: create networking and training in sustainable leadership. The meetings between energy managers of different companies could be of utmost

importance since the firms have similar energy problems and they can support and help each other in figuring out solutions. The networking system is necessary to share information and knowledge. The middle management, in charge of energy issue, needs support to communicate in the most efficient way the information to the employees: data, figures could not only be sent, they have to be communicated. It has to be clear that different levels in the organization "speak" different languages: hence the communication must be appropriate to each involved level. The top level need and want specific information, while the requests of the staff are different: the energy manager has to respect this evidence. Again another interesting practice related to the just mentioned difference of languages and requests among the organizational actors is the performance evaluation through KPI: this way of reporting data and figures facilitate the communication and the understanding. This practice is easy to implement and can constitute a benefit for the all company.

4.3.8 Electrolux Company

Name	Electrolux
Location	Stokholm
Interviewee	Tomas Dahlman – Director, Global Energy Policy Affairs
N° employees	61000 (all over the world)
Annual turnover	110 billion SEK (12,4 billion Euro, all over the world)
Website	group.electrolux.com

Table 20. Electrolux main data

Electrolux was founded in 1919; today the company is one of the main global leader in home appliances and appliances for professional use, selling more than 50 million products to customers in 150 markets every year. In the Annual Report 2013 the vision of the company indicates: "Electrolux is committed to growth that is sustainable. This means continually reducing environmental impacts across products, services and operations".

4.3.8.1 Energy Management approach

The Group's objective includes efficient use of resources with the benefits of cost savings and sustainability advantages. Through the Green Spirit program, an integral part of the Electrolux manufacturing System, goals are regularly set to reduce resource consumption, waste and emissions. The results of the energy efficiency program are: saving more than SEK 300.000 a year in energy cost and emitting 200.000 tonnes less carbon dioxide compared to 2005. Energy use and CO_2 emissions are the priorities of resource efficiency: the targets are formulated for absolute reductions as well as relative objectives. The average energy consumption per unit produced has decreased by 21% during the last five years. In Figure 21 the trends of consumption, waste and emission are shown: the start-up of new factories and increases in electricity emission factors have had a negative impact on the energy consumption and emission in 2013.

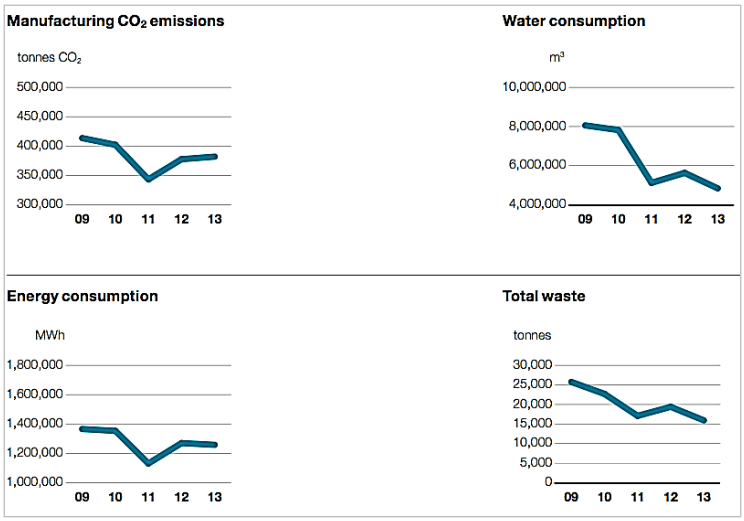


Figure 21. The consumption trends in Electrolux (group.electrolux.com)

The company is characterized by a long heritage of sustainability leadership: ISO 140001 Group standard since 1996, environmentally leading products, sustainability reports since 1995, advocating sound environmental principles, promoting ecoefficient products (launched Ecosavings in 1997), endorsing Global Compact since 2002 (a critical platform for the United Nations to engage effectively with

enlightened global business) and founder of the Nordic network. Moreover the firm has won a lot of sustainability leadership awards:

- Dow Jones Sustainability indexes: sustainability sector leader in the world (2006-2013)
- ClimateCounts.org: sector leader (2012-2013)
- Oekom research: it is a component of this world's leading rating agency that provides the crucial start in the segment of sustainable investments.
- Vigeo: component of this Index
- FTSE4Good: component of the FTSE4Good Index Series
- ROBECOSAM: global sustainability leader and Gold Class (2013)
- CDP: Carbon Disclosure Leadership Index; Electrolux is great in reporting climate and energy data and being transparent.

The tricky issue is to maintain the leadership during the years: the commitment and effort have to remain at the highest level. The key strategic areas are: products, services &markets; people & operations; stakeholders & society. Regarding the second area the aim is to engage and inspire employees and improve Group operations for people and environment through: sustainability compliance; targets for energy, water, waste and emission; emission targets for transports; ethic and conduct program; targets for occupational safety (zero accidents); engaging employees.

Moreover the company aims to raise awareness and build partnership for sustainable solutions, improving the stakeholder's engagement, the public awareness campaigns, the sustainability reports, and the awards system.
The program about energy efficiency is named "Green Spirit", and it concerns the aforementioned areas. The tool required to achieve the targets and to track each single factory is the energy management system, it is a toolbox: without energy target and management committee it would not be possible to achieve any savings. Moreover the focus on energy management has to be constant, not limited to a short period of time. The first energy target was set in 2007: the expected 15% of consumption reduction was achieved in only one year so in 2008 the new goal was

28% of reduction by 2012 (base 2008) and after this, the current target is 15% by 2015 (base 2011). These goals are related to the group, so they are an average of the individual targets of the 60 factories: some factories have more resources, more capabilities and a processes' structure that allow saving more energy and money than in other plants. For this reason the goals are split in a right way paying attention to the companies' conditions. Despite this flexibility regarding how to implement the activities, the factories have to follow the principles of the group; each plant has the same setup and has to work according to the global policy and strategy. This is the key to succeed in achieving the planned results.

Figure 22 shows the achievements, considering constant the production volume between 2005 and2011, and confirms how effectively the company works.
The company lowered the consumption more than the planned target: the energy reduction target curve (in red) is higher than the one of absolute energy use. For example in 2011 the target was 28% of reduction and the real achievement was 36%, considering the same amount of production volume. With such a reduction the saving was SEK 300 million, that compared to the company profit of SEK 3,5 billion at that time, corresponds to 6-8% of it: this is a big result. The energy costs for the company are 2-3% of the total, so not an energy intensive enterprise, but thanks to this program the reduction results in a significant benefit compared to the profit.

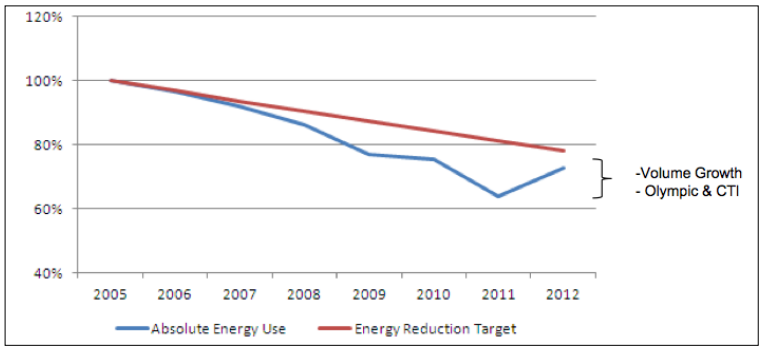


Figure 22. Energy consumption and energy targets trend (group.electrolux.com)

The surprising fact is that until now the company has almost never invested in technologies: only energy management practices (for example: switch off management, training, measuring, awareness, employee engagement).

The *Green Spirit Program* requires a well-organized structure and setup; in the middle management there are three levels in charge of energy management:

- The director of Global Energy Policy Affair – Global Energy Manager
- Sector/region Energy Leaders
- Plant Mangers

The global energy manger is the interviewee and he has under his control all the 60 factories and directly reports to the Group top management, then in each sector/region there is an energy leader who follows the progress, support the single plants and reports to the global energy manager. Finally in each factory there is a manager, belonging to the respective middle level, in charge of developing and implementing the planned actions related to energy program. The sector/region leader and the person in charge of energy question within a plant usually have other tasks, for example they can be production managers, facility managers etc., while in the global energy guide case the manger is fully dedicated to this task. The energy efficiency on the plant level is usually related to the maintenance team.

The global energy manger has the responsibility to present the energy strategy to the top management in order to be approved and endorsed, and then he has the task to assign the target. The targets are set on a yearly base for the factories, while at the high level of the Group management they are long-term goals (about 3 years); this allows a better control and comparison among plants. In order to track everything many meetings have to be planned: every second week there is a call between sector leaders and global energy manger about progresses, achievements, best practices to share etc., then, with the same frequency, meetings or calls between the leaders are requested. Instead more frequent are the meeting between each single sector/region with the factories' energy supervisors. The final report of all the progresses to the top management is on a monthly base: it shows the energy consumed per month, the number of produced units and the tracked progresses.

The data about consumption are collected on daily base in each factory.

The *Green Spirit Program* strategy includes further principles, which have to be strictly followed. Regarding the energy management system the company prefers to do regular energy surveys rather than to do energy audit: the employees have an excel shell in support of doing the energy surveys, since they have not the adequate competences for the audit. The energy survey allows engaging the people, raising the awareness and it is an effective method. In the manger's opinion the solutions or suggestions, outcomes of energy audits made by consultants or external experts, seldom are followed. The rate of success is 5-10%. More the employees are involved, more they are willing to understand the energy processes, sources and to figure out which could be the suitable suggestions and ideas of improvement. Furthermore the energy management team sets the energy saving plan in order to reach the specific target and follow up on energy efficiency effort. The action list is signed off by plants' mangers and the sector/region leaders. Following Figure 23 shows an example of energy action plan.

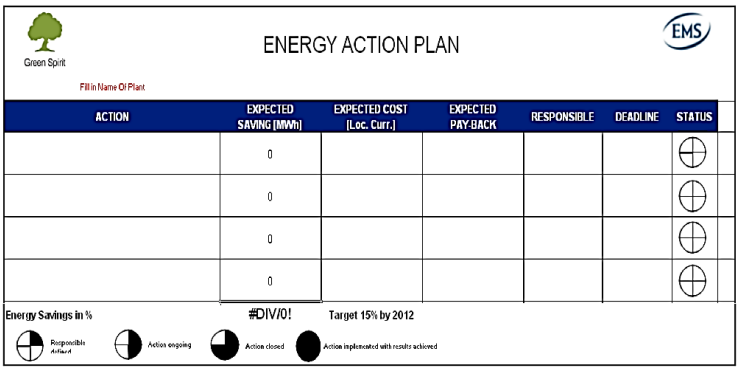


Figure 23. An example of energy action plan (group.electrolux.com)

The novelty is the integration of the program within the lean program and principles. The Lean Certification program encompasses three levels, bronze, silver and gold, to represent the growing achievement by Lean practitioners. A similar solution to recognize the results was implemented three years ago: four steps identify the reached levels of energy efficiency and management (bronze, silver, gold and

platinum). It is a sort of internal certification as in the lean program and the minimum required level is silver or gold; the current situation is: 40 factories in gold, 1 in platinum and 19 in silver level.

The company considers the use of KPI, key performance index, towards targets of utmost importance. Some indicators, for example the simple energy/unit, are useful to compare the different factories with a benchmark. Figure 24 shows an example: the aim is to understand why there is a difference in kWh/unit between the factories.

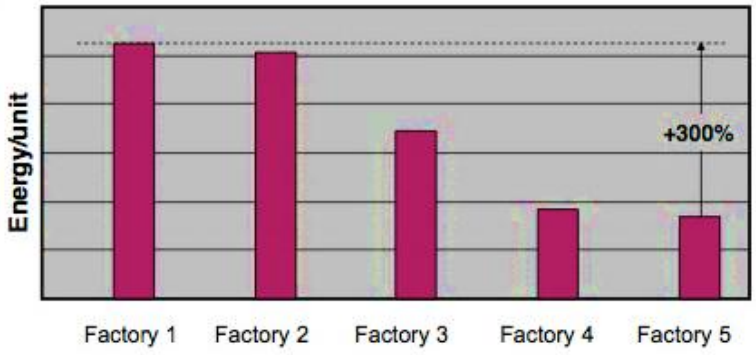


Figure 24. Key Performance Indicators among factories (group.electrolux.com)

Another fundamental element is the employee engagement through: sharing best practices, Green Spirit information points, and suggestion & win campaigns. The employees can see monthly the reports, the responsible actors, the implemented and ongoing actions. Moreover the policy of rewarding the initiatives and ideas related to save energy is strategic to raise the awareness, motivation, commitment of the people and to improve the company saving. The culture within the group about energy efficiency is very sound.

To conclude it is interesting resume the key element to succeed in energy management:

- Management decision and clearly defined targets: the management committee is critical and the language to communicate the policy, goals, results, as well.
- Targets should be short and/or medium term: the policy concerns the long-term vision with its goals, but the factories need more specific and limited goals.

- Regular meetings of core team: a loss of focus on energy management can frustrate the effort and make inefficient the planned actions.
- Follow up KPI in standardized format
- Report progress to local and central management on regular basis
- Specific program on energy saving, as the Green Spirit Program: the principles of the programs have to be shared and followed by the employees.
- Engineering approach vs Employee engagement: the best results are achievable with a mix of both approaches.
- Communication and encouragement of good projects through recognitions (awards, employee magazines, etc.).

4.3.8.2 Test of the framework

After this exhaustive presentation of the Group, the manger examines the framework that I have created. The opinion about the characteristics is positive: the manager is an expert in this subject and easily he understands each feature. The suggestion is to not excessively detail the attributes of the characteristics, since the investigation is very qualitative and the people would not be able to answer in detail to every question. The numerous characteristics permit to obtain a lot of interesting information concerning the application's manners of the energy management practices. Maybe there could be other features, but in this case they are sufficient and enough for the assessment of an enterprise.

The list of the practices is easy to analyse because almost everything corresponds to what he already explained to me. In his opinion the collection is complete and it encompass the necessary actions, which could lead to a high level of energy management and significant savings.

The interviewee seems interested in the framework and his application, even if state that the comparison has to be not only with the literature but also with an excellent company as empirical benchmark. Moreover the operative application of the characterization framework needs a support to the interviewees, if they are not so skilled or if the selected companies are of small and medium size.

The last part of the interview concerns the application of the characteristics to one practice as example. In this way the validation of the framework can be considered satisfactory and complete. The practice is *recognition of energy reduction initiatives:*

- the practice belongs to the motivating group
- it is focused on support and core processes
- it is direct enabler to the energy savings, because it refers to operative and effective actions on the systems
- this activity focuses on both thermal and electrical source
- the strategy's scope is the energy efficiency
- it is totally new, the company has just implemented it
- the impact is on more than a group
- the influenced level is the staff/shop floor; the decision and the effective implementation is up to the energy manager of the middle management. The company does not require an external support as expert
- the implementation if this practice is very easy
- the frequency of review and upgrading of the practice is in line with the frequency of implementation, that is yearly
- the awareness and organizational barriers are very important (4 and 3 of the Likert scale).
- the drivers recognized very important in order to overcome the barriers are the informative and regulatory, always internal drivers.

4.4 Conclusions

In the previous paragraph the case studies are analysed as single and explorative cases and a lot of information regarding Energy Management have been collected. The aim is not to compare the enterprises since the energy management is company-specific but it is interesting to sum up the opinions, contributions and perceptions with respect to Energy Management and the characterization framework. Actually the real

purpose of the preliminary " testing phase" is to examine the feasibility of my own model. Moreover in the chapters related to the literature background, I reviewed the concept of Energy Management and I chose to consider it as the management of human and organizational dimensions concerning energy; it has to be clear that in my work the identification of Energy Management with the technology is not right.

Energy Management

In the first case study the company SMF is small, with quite low profit and the energy management is still more technological rather than people-related.

Regarding energy management the firm recognizes that with a more efficient and upstream structure the results would be even better in terms of technology: this will be the direction of the future. An observation is that small size and other priorities limit the possibilities. The energy management, as conceived in Chapter 3, is considered more applicable in a medium/large company with already a good organization and structure, and where the available resources are abundant. Even in the small enterprise Vadstena the attitude is still focused on technology. In the last period, however, the interest in changing mentality has grown: the specific type of production process does not allow improvements through technology so the only way to save energy and money is through "soft" practices.

In the case of larger enterprises energy management is a road already taken. For example, the company Bruzaholm, more profitable than the previous two cases, is more active in the field of energy management. It is expanding and energy management projects are underway. There seems that working on the human and organization dimensions leads to better results. Energy management practices are considered necessary but not sufficient. Also in other medium -sized enterprises energy management focus on people, even if the technology remains crucial.

In the case of an even larger firm as Garo many low cost energy management actions have already been implemented and have led to good results, thanks also to the efforts of the new young generation in the middle and top management. The people are very involved and participate actively.

The research centre SWERA, which has visibility on the Swedish manufacturing sector, especially on the foundry industry, expresses a very important opinion. The

change in approach is nowadays mandatory, the idea of giving value to the human and organizational structure is innovative and abreast with the times. Since the BATs (best available technologies) are widely accessible, it is time to make room for BAMs (best available methods): involving people actively can lead to a better and more efficient use of existing or not technologies.
The case strengthening the hypothesis that Energy Management is of utmost importance is represented by the company Electrolux. Among the surveyed companies the aforementioned one is the biggest and here the level of energy management is certainly the highest. This reinforces the opinion of smaller companies that implementing energy management is easier and the rate of success is higher in large organizations. In this multinational company everything is structured and under control, roles and responsibilities are well defined, the energy and environmental culture is strong and sound. This is an example of how the practices of energy management, which do not require large investments, can lead to significant savings: the company saves 6-7% of its profit per year and without investing in new technologies.

Additionally from the interviews, it is evident that in small/medium industries the energy manager or person in charge of the energy issue belongs to middle management and he has further tasks related to production, maintenance or other business functions. Instead in the medium/large cases business functions like quality, environment and energy are grouped: actually the three disciplines are interrelated and affect one another, especially the management of energy and environment. Moreover, even if the company is large, a full time manger and a supporting team are able to handle the tasks together, this solution avoid wasting resources. Also in Electrolux, leading example, has conveyed the responsibilities of environment and energy into a single global manger and his team of collaborators.

With regard to the barriers and drivers session, the most important barrier to energy efficiency is considered the economic one, in line with what is claimed in the literature, while in the case of energy management at the top there are the organizational and behavioural barriers. The difficulty lays in changing the

organization, mostly regarding other priorities and lack of time, and changing the attitude and behaviour of people. The awareness of the benefits of energy management is growing, but there is a lot of work to do in order to motivate people. The information is adequately accessible and available. The economic barrier is always cited, especially in smaller firms, in line with the certainty that economic incentives can help encourage people to work more actively on energy management. In reality, companies, such as Electrolux, deny this: there is no need of further economic resources to change the mind set and attitudes.
Regarding the drivers, apart from the economic driver often named but not so appropriate for energy management, information and competences can be helpful in raising awareness, motivation and overcoming organizational and behavioural obstacles. Also if the initiatives come from inside, the results are certainly better and this assumption is claimed by all the companies.

Thanks to this first analysis, the empirical study highlights many aspects in common with the theoretical study of literature, presented in Chapter 3. As expected, only few companies, advanced, really engaged in the energy efficiency context and of considerable size and turnover, consider energy management people- related. In the other cases, the firms agree this is the direction of the future and are moving to change in line with it, but the required effort is significant. Changing the organizational structure, defining new roles and activities, improving the culture and changing the attitude of the people are difficult tasks. On the other hand, the surveyed companies, quite advanced in terms of new energy efficiency technologies, recognize that there is still room to reduce the energy costs through good and efficient energy management practices. Hence the analysis has led to the desired results; the theory describes an ideal situation that obviously does not yet correspond to the reality. But recently the approach has changed from technological to people centre in all companies involved in the study: this is the route undertaken for the future. This is happening as the increasing importance of the soft aspects of energy management has been proved.

Test of the framework

Thanks to the opinions of the eight case studies, it is now possible discuss the results of the testing phase. Concerning the first axis, the performance variables used to evaluate the set of characteristics are: completeness, comprehensibility of the contents, degree of detail and degree of overlapping and judgments poor, fair, good, very good. The Table 21 presents the aggregate results.

The interviewees point out the value and the importance of the information obtained looking at the characteristics. The attributes are useful to understand how a company implements some practices. Above all, the features related to the organizational actors, the extent of the phenomenon, the costs, particularly those that are hidden, and the type of activity are judged the easiest to be understood. Two companies doubt about the subtle difference between the two types of frequencies (implementation and review), suggesting that it might be a good idea to simplify and merge them. It is clear that the difference is subtle but the two frequencies are interesting if the aim is to evaluate how often a company reviews and upgrades a practice in comparison with the implementation frequency. The information concerning the effort is different, hence it makes sense to keep this characteristic.

After an explanation and further examples regarding the implication of direct and indirect enabler (indirect if it is prior to other practices and interventions and therefore does not give direct benefits in terms of savings, such as the difference between housekeeping and motivation course), the meaning of the characteristic "type of enabler to interventions" is clearer, hence the difference is still perceptible. According to these opinions, this is a delicate issue but still worthwhile to understand which is the predisposition of the firm. Attention is paid to the degree of detail of the attributes: since it is a qualitative research, the suggestion is to keep a quite low grade of detail The more accurate is the required details, the less the answers are confident.

In conclusion the completeness is very good for every enterprise; on the average the comprehensibility is considered very good, only 2 cases good; the degree of detail is good except for a company that indicates that the attributes for the characteristics are too many; the degree of overlapping is quite good unless two cases (Table 21) The validation of characteristics set could be considered successful

	Completeness	Comprehensibility	Degree of detail	Degree of overlapping
SMF- SKYLT	VG	G	G	G
BRUZAHOLMS BRUK	VG	VG	VG	F
SWEREA SWECAST	VG	G	F	F
VADSTENA	VG	G	VG	VG
FERGAS	VG	VG	VG	G
AKERS SWEDEN AB	VG	VG	G	G
GARO AB	VG	VG	G	VG
ELECTROLUX	VG	VG	G	G

Table 21. The grid of judgements for the characteristics' set

The evaluation of the practices' axis does not spot any specific problems. The Table 22 shows the result of this second testing phase. The list is judged complete and each term easily understandable by all the companies. The number of practices, included within the model, is appropriate and the level of detail too. The practices are not too detailed otherwise it could fall back into the problem related to the "company specificity": the more specific the practices are, the less they can be used to analyse different companies.

Firms recognized within the list the practices currently in use and they were not able to add new activities, not already included.

The most common practices in the case studies are: to measure the energy consumption and regularly communicate through reports in the company, to have an energy manager, to participate in networking system with comparable companies and to do housekeeping. Moreover the best companies adopt practices such as recognition of energy reduction initiatives with a specific reward policy, training and specific motivation course on energy management. In general it is considered very interesting the practice related to sustainability leadership, since even skilled energy managers need to learn how to be a leader in this field and be able to communicate and involve all levels of the organization in the best way.

As expected, the practices more adopted are those related to information system, information is a direct way to increase the knowledge, improve the decision-making process and investment planning.

In conclusion the completeness is very good for every enterprise; on the average the comprehensibility is considered very good except form a case where it is evaluated as good (Table 22). Hence the validation of practices' set could be considered successful .

	Completeness	Comprehensibility
SMF- SKYLT	VG	VG
BRUZAHOLMS BRUK	VG	G
SWEREA SWECAST	VG	VG
VADSTENA	VG	VG
FERGAS	VG	VG
AKERS SWEDEN AB	VG	VG
GARO AB	VG	VG
ELECTROLUX	VG	VG

Table 22. The grid of judgements for the practices' set

Once submitted the axes, it is also sought an opinion on the overall characterization framework. For each case study a practice is analysed using the framework and the result is positive, since the way the practice is implemented is well described.

The perception is that the proposal is innovative and challenging, no one has ever used such a model to understand how the practices and activities are managed in the company. Small and medium-sized enterprises believe the framework is more applicable to medium/large firms: it is quite long and complex, requiring a certain degree of knowledge and time. In order to apply the model to smaller companies, it is necessary to simplify it, for example by reducing the number of features or attributes.

Chapter 5

Application of the novel framework and results

After testing the model with the eight case studies, the next step is to apply the model to the remaining selected companies and analyse the results. Once obtained results, the goal is to make an assessment of the status of the implementation of energy management in each company and then to suggest the outline of some useful improvements. Regarding the assessment and orientation purposes, relevant literature is always taken into consideration as a baseline for comparison.

5.1 The case study methodology

About the used methodology, the reasons for the choice of a qualitative research and semi-structured interviews can be found in the corresponding sections of the previous chapter (4.1, 4.2, 4.2.1, 4.2.2).

What was said for the methodology of testing phase remains valid here, the only change is that now, instead of testing the model, the characterization framework is applied to companies.

Actually the framework has not been used during the previous test: the comprehensibility of the elements, which build the framework, has been investigated. The interview questions have been previously designed to understand the degree of clarity, completeness, detail and overlapping of the model, in order to define whether the further application of the model would have been feasible.

5.1.1 Methodology of the interview

As for the previous eight cases, the interview is designed using a semi-structured approach. The interview focuses on general questions about energy management, barriers and drivers, and then the application of the model: this is the new part in place of test questions.
Hence, the sections of the interview that will be analysed are:
• a brief collection of general information regarding energy management approach;
• open and semi-open questions about energy policy, goals, energy management, barriers, drivers, energy efficiency potential from the company's point of view;
• application of the model to characterize the energy management practices.

The preliminary analysis of the framework highlighted some important elements to consider: the combination of practices and characteristics was considered interesting, unusual and challenging, but at the same time its implementation complex and time consuming.
Regarding the structure of the model, it is composed of 22 practices and 14 characteristics, with their respective attributes. It is recognized that length and complexity can become some limitations. To facilitate the filling of the framework a support is needed. The application of the model is arranged as a discussion about the practices currently implemented. It is preferable to set a brief discussion following the logical sequence of the features in order to understand how the practice is implemented and subsequently obtain the suitable attributes.

The purpose of this interview is divided as follows:
• to collect information on the company, its energy use and opinions on energy management and on-going initiatives;
• to assess the status of the implementation of the practices of energy management: which practices are implemented and how, and then address some improvements.
The outcome of the application of the model is a picture of the company's situation. By filling the framework, it is likely to get the information necessary to analyse the business situation regarding energy management. Once the characterization

framework has been completed, some general considerations can be formulated with respect to the company's way of working on energy management. Its predisposition to effectively implement energy management practices can be evaluated.
Then, thanks to the comparison with the proposed values in literature an analysis of each practice could bring out some important evidences. These are theoretical values but, even if reality could differ from theory, it is useful to investigate the possible deviations and to understand the reasons. The theory discussed in Chapter 3 is capital for this analysis. The as-is evaluation allows the orientation/directing phase: some improving actions can be suggested if there is no accordance with the literature background.

5.1.2 Case selection procedures

The general dissertation about the selection of case studies expressed in Chapter 4 is still valid. The selection procedure and contact of three companies surveyed here correspond to the criteria previously discussed in the previous methodology.
The choice of the three companies was partly influenced by the information obtained from the previously analysed cases. The case studies show that almost all the companies have undertaken the path of energy management as a mean to improve energy efficiency. The model appeared to be more appropriate for companies of a medium/large size, already engaged with energy management, which have abundant resources and expertise.
The selected companies are three multinationals: two of the automotive and one of engineering industry, all of the manufacturing sector. The first two belong to the same sub-sector while the third to a different one, but they have something in common: the global dimension, the commitment to energy efficiency, the organizational complexity and some production processes, which are typical of foundries and placed at the beginning of the production chain.
The decision to choose these large manufacturing companies is related to the absence of resource limitations, which can influence the strategic approach to Energy Management and the effective implementation of the practices.

COMPANY	TYPE	SIZE	DATE	HOURS	INTERVIEWEE
Xylem	Engineering - foundry	L	12-11 23/10	4	Leif Rydell Rydell - Energy Head Engineer
SCANIA	Automotive-engineering (foundry)	L	31/10	3	Dahlström Roland – Energy Manager
VOLVO	Automotive-engineering (foundry)	L	15/11	2,5	Cecilia Bengtsson - Environmental Director Real Estate Services

Table 23. The companies sample for the application phase

5.2 Case studies results

The analyses of the three case studies are reported: the setting of investigation is similar to the one adopted for the eight case studies of the previous chapter, with the addition of a section related to the compilation of the framework and its analysis.
In the analysis of each individual case, two purposes of the model's application are discussed: assessment and orientation purposes.

5.2.1 Xylem Company

Name	Xylem
Location	Emmaboda
Interviewee	Leif Rydell – Head Energy Engineer
N° employees	1100 (12700 all over the world)
Annual turnover	3,8 billion $ (all over the world) 11???
Website	www.xyleminc.com

Table 24. Xylem main data

Xylem is a leading global water technology company with factories in more than 150 countries.
Its overall business encompasses four growth centres: treatment, dewatering, analytics and applied water systems. These businesses are interconnected, anticipating and reflecting needs and sharing their applications expertise to cover every stage of the water cycle.

Energy Management approach

The global company has a sound culture towards the sustainability and its vision is: "sustainability is a way of thinking about your business and about the world and considering what's best for both with the same level of commitment". The commitment to sustainability reflects the engagement with energy efficiency and energy management.

I visited the Emmaboda factory, one of the largest in Europe and of utmost importance in Sweden. The site includes: a foundry, an electric motorshop, a workshops (machine shop, assembling, testing area) an IT department, a financial department and a facility department.

The trend of electricity consumption is decreasing: now it is around 40 kWh and in 10 years the district heating has decreased from 11GWh to 5GWh. The company knows how the total 45 kWh are used: heating (5 GWh), residential electricity (8 GWh), production (12 GWh), foundry (18 GWh) and losses (2 GWh). The most consuming business processes are related to the foundry site: it corresponds to the 40% of the total consumption.

Priorities from the management are resources and competences: one important resource is energy and it can be optimized by several management practices:

- Survey of consumption data based on energy invoices and energy statistics
- Understanding of production processes and activities with energy demands
- Inventory of equipment/facilities that use electricity and thermal energy (heating and cooling)
- Measurements on energy consumption (requires installation of monitoring equipment)
- Create and apply an Energy Plan (Energy Management System)
- Inform and motivate colleagues for energy efficiency

The interview shows me many flowcharts concerning the use of energy and the consumption: this is a first indication of the control on the processes and energy that the company has adopted in the recent years.

In order to specify the detailed actions implemented during the period 1999-2010 I was able to collect the main interventions:

- Biomass heating
- Green electricity contract
- Monitoring of Electricity, district heating and water consumption
- Energy statistic on Electricity, district heating, water and waste heat
- WEB- based controlling system using intranet
- Demand controlled heating and ventilation
- Load controlled electricity consumption
- Recovery of waste heat from foundry and other processes
- Usage of solar collectors
- Free cooling from ground water (two wells)
- Comfort cooling based on waste heat
- Optimization of vacuum suction system
- Recovery of heat from the computer rooms (by heat pump)
- Heat recovery from ventilation air by heat pumps
- Monitoring and recovery of heat from compressed air
- Seasonal storage of waste heat using a Borehole Storage

Some of these actions correspond to energy efficiency improvements and technical solutions, other are energy management practices. The difference is that the former activities, presented in the first list of this paragraph, are necessary to decide about the energy efficiency improvements and technical solutions. The will to effectively and tactically work on energy efficiency derives from the management practices which influence the way of thinking and the decision making process.

Based on the opinion of the energy manger, belonging to the middle level the energy management is technology and people related. For this group each site has an energy manager, supported by a team, who decides and manages energy resource. The several energy managers, with the global group, are independent.

Each site has a written energy policy with a 3 years long term. The discussed energy management practices are considered very important to implement energy efficiency interventions, technological or not. The factory owns all the certifications: ISO 140001, ISO 90001 and recently ISO 50001. The Swedish Foundry Association and further networking systems have helped a lot in this direction. This factory is at a

high level of energy efficiency compared to the factories in the other countries, owing to the strategic approach that this company have undertaken for several years. The attention to energy efficiency and consumption reduction stated 30 years ago and the focus was mostly about energy efficiency technologies. Then, few years ago, the attention moved to energy management: changing the organization structure, the behaviour is the biggest potential to lower the energy use and save money. The commitment to energy management and its soft aspects is due to a recent growing awareness, thanks to the new generation within the company, but the level of awareness and motivation is not still very high. Furthermore more competences, more motivation and a different mind-set are the necessary resources to change the way of managing energy.

Having the right people with new competences is the key to succeed in energy management. At this time the company implements both technical solutions and management practices but in the future there will be more space for the latter ones.

The manger agrees with the assumption that energy policy, energy management in practice and technical interventions are interrelated but can be manage following this order: energy policy is necessary as enabler to everything, energy management with its practices helps to improve knowledge, save directly energy and improve the effective implementation of interventions.

A good number of recent investments are consequences of a better management regarding energy use: the information level has increased and the results on the decision-making process and proactivity are evident.

5.2.1.1 Discussion: assessment and orientation of the company

After the presentation and the introduction of the company, obtained with the first part of the interview, the new part of the interview is about the application of the proposed framework and the related evaluations. Table 25 shows the results of the application of the characterization framework..

It should be noted that after linking the implemented practices with their features, filing the corresponding box with a value, the aim is the assessment and orientation

of the company with reference to what has been studied from the theory. The good result of the application is the ability, using this method, to have a picture of how the company implements energy management practices, hence of the "state of the art" of energy management. The assessment can be double: one general, mostly looking at the characteristic and their attributes, and one more specific, analysing each single practice. The manager, who has been asked to identify the practices implemented in the company and to specify the attributes for each characteristic, filled it out.

	TYPE OF PRACTICE 1	FOCUS ON 2	STRATEGY SCOPE 3	TYPE OF ENABLER TO INTERVENTIONS 4	ENERGY'S SOURCE 5	NOVELTY GRADE FOR COMPANY 6	SCOPE OF IMPACT 7	ORGANIZATIONAL ACTORS 8				EASINESS OF IMPLEMENTATION 9	FREQUENCY OF CHECK/REVIEW 10	FREQUENCY OF IMPLEMENTATION 11	ORGANIZATIONAL COSTS 12		BARRIERS 13							DRIVERS			
								Influenced Level	Decision-Maker	Impl. Level	Support				Hidden Costs	Real Costs	Information	Economical	Behavioural	Organizational	Awareness	Comp. Related	Regulatory	Economic	Information	Comp. Related
Monitoring energy use and costs	CI	C/S	EE	MD	T/E	A	MG	L	M	L	-	QE	Y	D	L	H	3	2	4	3	3	1	1	3	3	1
Consumption reports to inform	SI	C/S	EE	LD	T/E	A	MG	L/M	M	M	-	QE	Y	M	L	L	2	1	3	4	3	2	3	1	3	2
Allocation of energy cost (metering)																										
Energy audit (preliminary, general, detailed) - Map of energy use and flows	CI	C	EE	MD	T/E	A	G	L	M	M	I	QH	O	O	H	H	1	3	3	4	4	4	2	3	3	3
Performance analysis trough key performance indicators (KPI)	CI	C/S	EE	LD	T/E	N	MG	L	M	M	-	QE	Y	Y	L	L	2	2	2	3	3	2	2	1	3	2
Establishment of uniform record keeping system																										
Establishment of uniform reporting system																										
Automatic control	O	C/S	EE	MD	T/E	A	C	L/M	M	L	-	QE	M	D	L	H	3	3	1	3	3	1	2	3	3	1
Program and course of training																										
Energy manager	O	C/S	EE	LD	T/E	N	O	M	T	M	-	QE	O	O	VL	H	1	3	1	1	1	2	1	3	1	3
Energy management team	O	C/S	EE	LD	T/E	N	G	M	T	M	-	QE	O	O	VL	H	1	3	1	1	1	2	1	3	1	3
Energy action plan	O	C/S	EE	LD	T/E	N	C	L	M	M	-	QH	Y	Y	L	L	3	1	2	4	3	3	2	2	4	3
Energy savings targeting	O	C/S	EE	LD	T/E	N	C	L/M	M	M	-	QH	M	Y	L	L	1	1	2	4	3	3	3	1	3	3
Establishment of data base																										
Targets communication	SI	C/S	EE	LD	T/E	A	C	L/M	M	M	-	QE	Y	Y	L	L	3	1	3	4	2	2	3	1	4	2
Awareness and motivation program - specific and general	M	C/S	EE	LD	T/E	N	MG	M	M	M	-	QE	Y	Y	H	L	1	1	3	4	3	3	1	1	2	4
Regular publicity campaigns																										
Recognition of energy reduction initiatives																										
Meetings																										
Care and maintenance																										
Networking																										
Sustainable leadership course/program																										

Table 25. The application results of the characterization framework

1	M: motivation	T: training	O: general organisation	CI: collection of information	SI: spread of information	H: housekeeping
2	C: core processes	S: support processes				
3	LD: less direct	MD: more direct				
4	T: thermal	E: electrical				
5	EE: energy efficiency	EC: energy conservation				
6	N: new	U: already in use				
7	O: one person	G: a group/a business unit/a division	MG: more than one unit/group	C: whole company		
8	T: Top/high management	M: middle management	S: staff			
9	I: internal	E: external				
10	VE: very easy	QE: quite easy	QH: quite hard	VH: very hard		
11	O: one time	D: daily	W: weekly	M: monthly	Y: yearly	YY: more than one year
12	VL: very low	L: low/moderate	H:high	VH: very high		
13/14	1:not important	2: scarcely important	3important	4: very important		

Among the 24 most cited and important practices cited in the literature review, the company is implementing ten of them: this suggests that the level of energy management is still not satisfactory. The company is working in the right direction, as anticipated in the introduction, but many practices, which can improve the management, are not yet implemented. Some are planned for the future, as pointed out during the interview.

An important observation looking at the filled framework is the type of practices implemented and on which area the company should begin to focus. Regarding training and housekeeping there is no activity: this may be a problem since these kinds of practices are perceived as more direct enablers to interventions.

With respect to the motivation area, the company should focus on other practices in addition to the general course of awareness, if the intention of the company is to involve employees. An example is the recognition of energy reduction practices initiatives: rewards are not necessarily pecuniary and other encouragement forms are winning as well. In the collection of information field the implemented practices are sufficient and the attention on information of processes is considerable. As stated in the introduction the level of information within the company is high: the first

implemented practices concerned this field. Regarding the spread of information two practices, very important are missing: the meetings and the creation of networks with other companies in order to share knowledge and thereby increase the ability to determine new activities of energy management. In the cases, previously analysed, the aforementioned practices have been recognized as easy to implement and very important: this company should be aware of this.

In the last area, general organization, important practices are implemented as the energy manger, the team, setting goals and it is relevant to point out the establishment of an action plan. This is necessary to identify actions that have be taken in order to meet the energy strategy, in line with the objectives.

A positive factor is that almost all the practices under examination affect both core and non-core processes: this underlines the commitment to manage all business processes without ignoring the support processes. The same is valid for the source of energy: thermal and electrical are both well included in energy management. Regarding the strategy scope the company works on energy efficiency, this also because the concept of energy conservation is not considered.

The majority of the practices affect more than a group of employees or the whole company: this is really positive since it represents the predisposition of the company to extend the energy management impact to more and more people.

Most practices are new to the company and this is a confirmation of the fact that energy management has been recently introduced within the company. In the past the kind of practices implemented were the monitoring and informative reports; also the energy audit is quite dated.

With respect to the organizational actors, it can be stated that the top management is not involved in any practices: its responsibility concerns only the energy policy. A better commitment and involvement of the high level are supposed to influence the employees and to prioritize the energy management issue. The middle management is the most involved and in charge of the implementation of many practices: this shows the active role of the energy manager and team but it not sufficient. A positive consideration is that the company does not implement only easy or quite easy practices: the effort to implement different kinds of practices, concerning the easiness of implementation, is noticeable. The same is valid for the organizational

costs: some practices are characterized by high real and/or hidden costs but they are implemented as well. Examples can be the measuring, energy audit and energy manger.

Generally the most important obstacles are considered organizational, awareness and competence related barriers. This is in accordance with the literature review about this issue and what is the reflection of the interviewee, reported in the previous paragraph. The economical barrier is quite important in few cases, energy manager and energy audit, where the costs are significant rather than in other cases but is better to try to overcome the other barriers, which are higher. Consequently, the company should focus on informative and competence related drivers while financial support is rarely identified critical. All the drivers are internal and this fact shows that the company is willing to find the necessary resources from inside since energy management is essentially a matter of internal management, organization and employees. The only external driver that is mentioned is the economic support, for instance from the government or other associations.

An analysis for each practice can bring out some important evidences thanks to the comparison with the values proposed in the literature. These are theoretical and hence can be different from the reality, but it is useful to investigate the possible deviations and to understand the reason.

- *Awareness and motivation program (general).* A first difference with the theoretical values concerns the scope of impact: this practice is addressed to multiple groups but still not to the entire company. It would be better if all the people were aware of the importance of energy efficiency and energy management. In addition, the influenced organizational level should not be only the middle management as in this case: even the low and high need to be motivated. The literature often mentions the usefulness of external support with adequate skills, and this is missing in this case study. The difference between real and hidden costs is also justified in the literature. In general the energy management practices are low-cost but the organizational impact can be considerable, for instance considering the necessary time and resources, which have to be dedicated. In fact, the main barriers are related to organizational issues and, as rightly recognized, informative

driver such as management support and expertise are important. A consideration can be made about the low frequency of implementation and check: only one time per year on average. It would be preferable that both the implementation and the updating review were more frequent.

- *Energy managers and energy management team*. These two practices are characterized in the same way, the difference is that the energy manager is one person and the team instead includes more people belonging to the middle level. Up to the present only once the energy manger and team have been appointed, but the frequency of review of the roles and responsibilities should be increased even if this means higher costs. The main barrier are the economic one linked to the salary of managers and a need of skills, in this case, in accordance with the company, further financial support and competences would be desirable. As stated in the literature, it is very helpful to assign to energy manager and its team other tasks related to Environmental Management.
- *Energy action plan*. This practice is directed to more than one organizational unit and the affected organizational level is the shoop floor. In fact, the energy action plan should influence the whole enterprise and the other organizational levels, hence the involvement must be greater. Another point of attention is related to the two different frequencies: the implementation frequency is a year and that is appropriate, while, according to the values proposed in the literature, the check and review one should be higher, such as a month.
- *Energy savings targeting*. The proper involvement of the entire company should also correspond to the total influence of all organizational levels. In addition, this practice is sufficiently of high level and it would be preferable that the responsible actor belonged to the top management instead of being part of middle management. Then the person who implements this practice is the energy manger belonging to the middle level, but the collaboration with top management could be winning as mentioned in the literature. This company has faced some difficulties and indeed organizational, awareness and competence barriers are considered quite significant. In accordance with this, the company should need further managerial support, included in the information driver, and more skills.

- *Monitoring of energy use and costs*. This practice is important if related both to the core and non-core processes. The first consideration is about what could be improved that is the frequency of review and check. In accordance with other practices, such as the action plan that decides the actions, this practice might need to be updated (for example, what monitor and how). So an improvement would be to increase this frequency. In terms of costs, the initial cost for the monitoring system is high for the company, so obviously the greatest obstacle is the economic one. Financial support would also benefit for the maintenance of the system.
- *Consumption reports to inform*. This practice is already implemented and as the previous one involves multiple organizational units. The first positive contribution, in line with the literature, concerns the scope of impact: the whole company must be involved in order to have all the available information. In addition, the company informs through reports once a month, but the revision of this practice is every year: in fact it would be preferable that the information system were reviewed more regularly. Organizational and awareness barriers are considered very important: it is necessary to convince the entire company on the importance of information sharing.
- *Energy audit (detailed)*: this practice has been referred to core processes until now, but since also support processes are imported, they are supposed to be investigated too. The audit was detailed and expensive, both real and hidden were high, and for these reasons it was conducted only within an organizational unit: an intervention might be to extend the scope of impact of the audit in order to map more units/groups. Moreover if it is general it is less expensive. One issue is highlighted and that corresponds to the lack of appropriate skills for a specific audit: this problem could be diminished by using an external rather than internal support.
- *Performance analysis through KPI* . This is a very important practice in order to aggregate information, facilitate communication and understanding the performance. Such analysis affects the entire company and all hierarchical levels, differently from the current situation. Furthermore, the frequency of

implementation must be in line with the iteration of the practice *consumption reports to inform*, that is monthly.

- *Automatic control*. The proper involvement of the entire company should also correspond to the total influence of all organizational levels, while the top management is not included, neither as decision market. The positive aspect is that it affects both core and no-core processes. Moreover the frequencies result adequate. It is not a new practice and the company decided to implement it even if the real cost was high, due to the automatic system. Thus this company has faced some difficulties regarding economic and informational aspects.
- *Targets communication*. This practice should follow the energy saving targeting, with respect to the scope of impact, the frequency of implementation and check/review. The company implements it in a sufficiently accurate way. In this case, informative drivers, such as managerial support, precision of information and awareness can help to overcome the barriers.

5.2.1.2. Conclusions

In this case study the energy management is both technology and people related. The discussed energy management practices are considered very important to implement energy efficiency interventions and to save energy costs. The attention to energy efficiency and consumption reduction started 30 years ago with a lot of technical interventions while the focus on energy management practices started few years ago. This is confirmed by many new practices indicated in the framework. The attention concerning the change of the organization structure and the behaviour is growing since these aspects correspond to the biggest potential to lower energy use and save money.

The company believes that more competences, more motivation and a different mind-set are necessary resources to change the way of managing energy but the level of awareness and motivation is still not very high. These considerations are in accordance with what can be read from the framework. Reading the matrix, some

evidence and directions of improvements become clear. they have been are well explained in the previous paragraph.

Here it is useful to resume only some possible improvements and intervention priorities.

- With respect to the motivation area, the company should focus on other practices in addition to the general course of awareness, if the intention of the company is to involve employees and improve the awareness.
- There are two areas, which are totally not interested by any practices: housekeeping and training. These practices are of utmost importance as they are also direct enablers to energy savings.
- The company requires only commitment of the middle management, especially energy manager and its team, but the top management is not involved as responsible actor and decision-maker. This kind of commitment is a prerequisite for the success (Brown & Key, 2002; Mckane, 2009; Scheihing, 2009).
- Analysing some practices, a critical situation concerns the frequency of check and review: the company should improve it, in order to review and upgrade the ways of implementing practices. Examples are the monitoring of energy use and costs, the energy action plan, consumption reports to inform.

5.2.2 Scania Group

Name	Scania – Dynamate
Location	Södertälje
Interviewee	Dahlström Roland – Energy Manager
N° employees	1500 (35000 all over the world)
Website	www.scania.com ; www.dynamate.se

Table 26. Scania main data

The group Scania operates in about 100 countries and its employees are more than 35000. The production sites are placed in Europe and Latin America. In the following figure some data, presented in the annual report of the company, about the sites in Sweden and all over the world are shown (www.scania.se 2013 annual report).

	Sweden	Total
Number of employees	15,294	23,641
Direct and Indirect energy consumption, MWh	461,482	615,706
Direct energy consumption, MWh	72,372	129,159
Fossil fuel, MWh	27,969	83,007
Diesel, engine testing, MWh	43,845	45,570
Other fuel, engine testing, MWh	557	582
Total Indirect energy consumption, MWh	389,110	486,546
Electricity; MWh	305, 252	397,471
Municipal heating, MWh	83,858	89,075
Emission of carbon dioxide, tonnes	41,817	75,344
Total Direct CO_2, tonnes	19,296	30,795
Fossil fuel, tonnes	6,894	17,908
Diesel, engine testing, tonnes	12,402	12,887
Indirect CO_2, tonnes	22,521	44,548
Electricity, tonnes	18,010	38,472
Municipal heating, tonnes	4,511	6,076

Table 27. Main consumption data of Scania (www.scania.com)

In Sweden, Scania is of utmost importance for the national economy and the headquarters, production, sales and service points are in this country. Manufacturing components correspond to the most energy-intensive operations, consuming considerably more energy than vehicle assembly. These activities occur mostly in Sweden and then in Brazil and Argentina. Particular attention is being paid to energy-savings potential within operations such as foundries: this is one of the main production processes and for that reason it make sense to assimilate this enterprise to the others of the sample. The energy savings potential is quite significant: an approximation of 5,500 MWh can be saved, corresponding to SEK 2.4 million (290,000 euro) in energy cost. Hence this is a first focus of the company.

Energy Management approach

The visited site, Södertälje, consumes about half of all energy consumed in Group operations. Thus many of the activities aiming to improve performances take place in Södertälje, this has to be an example for the rest of the factories.

There is a sound culture concerning the sustainability, integrated in the business strategy and in the company's website it is stated "Sustainability starts with doing the right things at home. Scania strives to maintain high ethical, social and environmental standards in which we operate and in all our business contacts."
At Scania, the procedure is to report energy use related to the number of vehicles produced. An important observation is that while the production increased and decreased again over the past five years, the energy use has continued to decline: this is desirable when a company intend to work on energy efficiency. In the previous Chapter there are several cases in which a company improves the energy efficiency only if the estimated production volume grows, and this is not the optimal situation.

Important information about the current approach of Scania is the novel program about the exploration of measures, which optimise energy usage. In the last years the achieved reductions correspond to an annual energy saving of 800 MWh, about SEK 450,000 without investing in new equipment. This is an evidence of the potential of energy savings coming from the energy management practices. Moreover checking the website of the company (www.scania.se) the challenge in the next period is:

- complete and follow the energy strategy up in 2014;
- improve the energy efficiency levels in 2013;
- spread the energy management practices from the Swedish operations to the rest of the facilities in the world.

Actually I interviewed the energy manager belonging to Dynamite, this legal entity started its business as a maintenance department of Scania Group until becoming a separate company in 2001. Dynamite is a wholly owned subsidiary of Scania and it is responsible for the energy management of the sites in Sweden, it is a support company with 880 employees and a turnover of approximately SEK 1.5 billion. It is located in the same site of Scania Södertälje.
Based on the experience of the manager the concept of energy management in practice is more people related: 75% of the effort is to improve the soft aspects of energy management and the rest is still dedicated to energy efficiency technologies; in the past the situation was totally different and likely the opposite. There are two

different kinds of policies: one for energy efficiency objectives (3 yeas) and one for environmental objectives (5/6 years). The energy policy is considered very important since it addresses the way of working on energy efficiency, and it stresses the commitment of the board that is necessary to reinforce the culture. The practices are important (level 3 of the Likert scale) to the better implementation of other interventions, mostly is such a big group where the policy is at very high level and there is a significant need of having in the middle some practices, which help to achieve the goals.

The company has the ISO 9001 and 14001 certifications, working in line with the PDCA (plan do check act) of the Energy Management System is a standard, the method used to manage the energy question. The company has always taken a strategic approach in the energy field, in the past with the energy efficiency technologies and currently with the people based energy management. The focus on using in the most efficient way the existing systems is predominant, but several technical improvements are planned and long payback are accepted against a better energy efficiency level. The energy management practices are in support of deciding, doing and following up: the aim of changing the mind set and managing this alteration is attainable only with energy management practices. Of course changing the mind-set of the employees concerning the importance of energy consumption is a great challenge, since the group is worldwide and the organizational complexity is significant. It is big deal of effort and the leadership has to be really effective. Anyway the first step is to motive and increase the motivation within a limited site, than region, than country and so on.

The energy manger and its team put a lot of effort in spreading "good practices" in facility installations and production processes as: establishment of guidelines, review of energy mapping and related activities and collection of key performance indicators.

According to the manger the differentiation among energy policy, practices, and interventions is valid in his company; the board sets the main goals and ascertains how to achieve them. Then the objectives have to be translated in action.

Regarding the energy efficiency potential, the one related to energy management practices is predominant (70%): there is a lot of work to do, but actually there is a

considerable room for energy managements actions in order to save energy and money. The company is used to opt for KPIs related to production volume, since they are the easiest to understand and use: in the last few years the energy consumption per truck is decreased even if the production outcomes have reduced.

The last discussed issues are the barriers and drivers. The barriers recognized very critical are: competences, organizational and behavioural. The economic and information barriers con be considered the less important since the funding availability is crucial for technological investments and the information is easily accessible. Instead there is a lack of competences because in such a big company several people should understand the sustainability question and decide from an energy management point of view: this requires new skills or a continuous updating. The organizational barrier concerns the corresponding complexity and often there are other priorities and lack of time. Young people within the organization are of great value, since they transfer new knowledge and they have "green" way of thinking.

Concerning the forces helping to overcome the barriers, the most important is the information one, particularly related to green image: if the stakeholders and customers of the company pay more and more attention to green products, the effort in this direction should increase. Moreover such a brand has to be a sign of sustainability and green culture since the products are cars and truck, which noticeably influence the environmental. Another driver considered significant is the one related to the competence: this, together with a higher level of information, could improve the knowledge and the awareness regarding energy management. Based on the opinion of the energy manager the drivers with less influence are regulatory and economical.

5.2.2.1 Discussion: assessment and orientation of the company

Filling out the framework, general and specific evidence can be obtained in order to assess the state of implementation of energy management practices and to address improvements if necessary. Table 28 shows the results of the application of the characterization framework..

By analysing the matrix it is possible to get the indication of how the company implements the practices.

	TYPE OF PRACTICE 1	FOCUS ON 2	STRATEGY SCOPE 3	TYPE OF ENABLER TO INTERVENTIONS 4	ENERGY'S SOURCE 5	NOVELTY GRADE FOR COMPANY 6	SCOPE OF IMPACT 7	ORGANIZATIONAL ACTORS 8				EASINESS OF IMPLEMENTATION 9	FREQUENCY OF CHECK/REVIEW 10	FREQUENCY OF IMPLEMENTATION 11	ORGANIZATIONAL COSTS 12		BARRIERS 13							DRIVERS			
								Influenced Level	Decision-Maker	Impl. Level	Support				Hidden Costs	Real Costs	Information	Economical	Behavioral	Organizational	Awareness	Comp. Related	Regulatory	Economic	Information	Comp. Related
Monitoring energy use and costs	CI	C/S	EE	MD	T/E	A	MG	L/M	M	L	-	QH	M	D	L	H	1	3	2	2	2	2	2	3	1	1
Consumption reports to inform	SI	C/S	EE	LD	T/E	N	MG	L/M/T	M	M	-	QE	M	W	L	L	2	1	2	3	2	2	1	2	3	2
Allocation of energy cost (metering)																										
Energy audit (preliminary, general, detailed) - Map of energy use and flows	CI	C	EE	MD	T/E	A	C	L	T	M	I	QH	YY	YY	H	L	4	3	1	2	4	4	1	3	4	4
Performance analysis trough key performance indicators (KPI)	CI	C/S	EE	LD	T/E	A	C	L/M/T	M	M	-	QE	M	W	L	L	2	1	2	3	2	2	1	2	3	2
Establishment of uniform record keeping system																										
Establishment of uniform reporting system	O	C/S	EE	LD	T/E	N	C	L/M/T	T	M	-	QH	Y	O	H	L	4	1	2	4	2	4	4	1	4	3
Automatic control																										
Program and course of training	T	C	EE	MD	T/E	N	G	L	M	M	I	QE	Y	Y	H	L	2	2	4	4	4	3	2	2	4	4
Energy manager	O	C/S	EE	LD	T/E	A	O	M	T	M	-	QE	YY	YY	L	H	1	3	2	3	2	4	1	3	3	4
Energy management team	O	C/S	EE	LD	T/E	A	G	M	T	M	-	QE	YY	YY	L	H	1	3	2	3	2	4	1	3	3	4
Energy action plan																										
Energy savings targeting	O	C/S	EE	MD	T/E	A	C	L/M/T	T	M	-	QH	Y	Y	L	L	4	1	2	4	2	4	3	1	4	4
Establishment of data base																										
Targets communication	SI	C/S	EE	MD	T/E	A	C	L/M/T	M	M	-	QH	Y	Y	L	L	2	1	1	4	1	4	1	1	4	4
Awareness and motivation program - specific and general	M	C	EE	LD	T/E	A	G	L	M	M	-	QE	O	Y	H	L	2	1	3	3	3	4	1	2	3	4
Regular publicity campaigns																										
Recognition of energy reduction initiatives																										
Meetings																										
Care and maintenance	H	C	EE	MD	T/E	A	C	L	M	L	-	QE	Y	D	H	L	1	1	4	4	3	1	4	1	3	1
Networking	SI	C/S	EE	LD	T/E	N	O	L/M/T	T	M	-	QE	Y	M	H	L	2	3	2	4	3	1	3	3	3	1
Sustainable leadership course/program																										

Table 28. The application results of the characterization framework

1	M: motivation	T: training	O: general organisation	CI: collection of information	SI: spread of information	H: housekeeping
2	C: core processes	S: support processes				
3	LD: less direct	MD: more direct				
4	T: thermal	E: electrical				
5	EE: energy efficiency	EC: energy conservation				
6	N: new	U: already in use				
7	O: one person	G: a group/a business unit/a division	MG: more than an unit/group	C: whole company		
8	T: Top/high management	M: middle management	S: staff/operator level/shop floor			
9	I: internal	E: external				
10	VE: very easy	QE: quite easy	QH: quite hard	VH: very hard		
11	O: one time	D: daily	W: weekly	M: monthly	Y: yearly	YY: more than a year
12	VL: very low	L: low/moderate	H: significant/high	VH: very high		
13/14	1:not important	2: scarcely important	3important	4: very important		

First of all it is reported the general evaluation of the status of the company at an aggregate level.

The area of motivating is scarcely populated: only a specific awareness and motivation program/course is scheduled; other practices are not yet implemented. Since this Swedish factory has a considerable size, implementing one practice related to motivation is not enough. Activities such as publicity campaigns, recognition of energy reduction initiatives are desirable. Moreover, in such a large company, it is necessary to engage, interest, lead and communicate with all organizational levels: a real challenge is to be a true leader and a course of sustainability leadership can support this. It is positive that the company recognizes the importance of the training and it implements its practice, as well as for the housekeeping. In the area of information system, spreading and collecting information, the implemented practices are satisfactory. Nonetheless a practice very important, that is not in use, is the meeting for spreading information: brief meetings with some key employees can bring a lot of benefits regarding the awareness and the active engagement.

The area that has to be improved is the general organizing: there is a very important practice, i.e. the fundamental action plan is missing. This fact may suggest that there

is not a clear guideline to achieve the goals set in the energy policy: it is desirable a better structure.

The company implements both practice less direct o more direct to energy savings or interventions: for instance care and maintenance, audit and monitoring are more direct enablers but there are also many other practices recognized as "softer" enabler and necessary as well. Moreover both the thermal and electrical sources are affected and this is great. As regard to the focus of the implemented practices four practices out of thirteen concern the core processes: the focus of the majority is both core and ancillary processes but this situation could be improved. The ideal condition is that everything concerns both kinds of processes. The scope of impact is rather extended: many practise involve the whole company or more than a group, only the establishment of the energy manager and the networking system affect correctly one person.

In general it can be observed that more than half of the practices has not been recently implemented: the company has been working on energy management for years. Anyway since few practices are new, the company should aim to update and adopt new practices in order to achieve a higher level of energy management. This great company has no problems of availability of resources, such as economical one, so it is interesting to understand the presence of other barriers.

A positive factor is the involvement of top management as a decision maker in different practices: for such a big company it is important that the top management always maintains a certain level of control, moreover the top management commitment is considered a prerequisite for the success of energy management in the literature background. Anyway the most important level is the middle one of the energy manager: he has many responsibilities and a good control on the energy management in practice. Concerning the few practice requiring a support, the company prefers an internal support but if the competences are not adequate it should try to work with an external expert.

The good predisposition of the company towards energy management practices is shown also considering the easiness of implementation and the costs. Even if the company has to face some difficulties with the implementation and with the high hidden and real costs, the effort to succeed in achieving the results is noticeable.

Generally speaking the most important obstacles are organizational, awareness and competence related barriers. This is in accordance with the values proposed by the literature review. The economical barrier is quite important in few cases, for instance in the cases of energy manager and energy audit, where the costs are more significant rather than in other cases. Anyway the priority should be to try to overcome the other barriers, which are higher. Consequently, the company should focus on informative and competence related drivers while financial support is rarely identified critical. All the drivers are internal and this fact show that the company is willing to find the necessary resources form inside since energy management is essentially a matter of internal management, organization and employees. The only external driver that is mentioned is the economic support, for instance from the government or other associations.

After some general considerations it is possible to investigate each practice and to understand, thanks to the structure of the framework, how it is implemented. Also is it a further aim to figure out some improvement actions, with reference to the analysed literature background.

- *Monitoring of energy use and costs*. Rightly, this practice is considered a more direct enabler as directly gives information to understand what it takes to save energy and costs. The scope of impact of this practice is more than a group while it would be better that each type of consumption within the enterprise was monitored. In addition, this practice is not so easy to implement, probably due to the amount of processes to be monitored. The real cost is considered high and this also is in line with the difficulty of implementation. In fact, the barrier most imported is considered the economic and this is a point of attention: this obstacle must be overcome.
- *Consumption reports to inform*. The first observation is related to the scope of impact: even here the influence must extend to the whole company. It is good that all organizational levels are affected. As regards the frequency of implementation, the action of reporting is weekly and it is higher than the one considered in the literature. A trade-off could be to enlarge the scope of impact and decrease the frequency to one month, in line with the frequency of checking

and reviewing. The latter one proves a regular commitment in order to update and adapt the communication way.

- *Energy audits (general)*. The first point of attention is the focus: until now the company has performed an audit only on the core-process. It has also been implemented throughout the company. A trade-off could be to map the consumption of multiple organizational units/groups but also the non-core processes. Moreover, this practice is not easy to implement even for high costs, both the real costs and those related to the time of the people or stopped production. Decrease the extension of the scope could bring a benefit. The competence barrier is considered important: the expertise and support is internal during the implementation. Relying on an expert form outside, such as a consultant, may improve this situation.
- *Performance analysis (KPI)*. This practice aims at core and non-core processes and the whole the enterprise is involved. These are positive factors but in disagreement with the scope of impact of monitoring and reporting. KPIs are used in reporting and thus the frequency of implementation and review are consistent with those of consumption reports. A frequency of one month is enough.
- *Establish uniform reporting system*. This is a practice linked to the action of reporting, the communication, affecting all levels of the organization, has to be well structured. It is also a practice deemed easy to be implemented and is supported directly by top management. This practice has been implemented only once but then a review each year can be considered adequate. The difficulties faced by the factory are related to information and competence barriers: bringing more knowledge and skills through external support can improve the situation.
- *Specific program / course of staff training*. It is a practice, which is more directly related to technology and energy savings, because you work for an efficient use of the facilities. In this company, it is only applied to the core process but the best thing would be to make training even on non-core processes, in order to operate effectively on everything. There is not a support and in fact the drivers show that more competences would be desirable, for instance by hiring an outside expert. Once a year, this practice is implemented and the positive factor is that at

the same time is monitored and reviewed. The high hidden cost is a point of attention: if the enterprise could lower the cost, it could be possible to make training not only for a limited group of employees.

- *Energy Manager and energy management team*. These two practices are characterized almost in the same way, the difference is that the energy manager is one person and the team instead includes more people belonging to the middle level. Until now only once the energy manger and team have been appointed, but the frequency of review of the roles and responsibilities should be increased even if this means higher costs. Barriers are the economic and competence ones, in this case in accordance with the company, financial support and expertise, for instance specific training, would be desirable. As stated in the literature, it is very helpful to assign to energy manager and its team other tasks related to Environmental Management.
- *Targets communication*. The communication is widespread, all organizational levels are affected but it lacks the involvement of the highest level as decision-maker . This communication is closely linked to the practice of energy saving targeting, where the top management is very important. It is not easy to implement this practice probably for the extension of the scope of impact, in fact, a high barrier is the organizational one.
- *Energy savings target*. The proper involvement of the whole company is also noticeable in the affected organizational levels. Then the person who implements this practice is the energy manager belonging to the middle level: the collaboration with top management could be winning as mentioned in the literature. While implementing this practice the company has encountered difficulties related to firm size: organizational barriers awareness and skills are considered high. In line with this, the company would need more managerial support, included in the informative driver, and more skills.
- *Awareness and motivation program course (general)*. The first point is the focus: only the core process is affected but the practice is supposed to affect both types of processes. In addition the extent of the influence of this activity is only a group of employees in the production maintenance: if it is not possible to extend to the entire company, the ideal case, the company should try to broaden the scope of

impact at least involving more units. In addition, only low management is influenced while all organizational levels should be involved. Every year, this practice is implemented but only once until now has been reviewed: the way of learning are not very up to date and this fact must be changed. In addition, the hidden costs are high, especially related to time of people. One further suggestion considering the competence barrier is consider external support if it is not possible with an internal skills.

- *Care and maintenance*. As in the previous case, the focus is only on the core business but it should be improved. It is rightly regarded an enabler to more direct interventions and energy savings. It is a practice that encompasses the entire company and that you implement every day. The times the housekeeping is reviewed, are however few, the frequency is expected to be greater than one year. For this practice, the main barriers are organizational and behavioural: they people do not need great skills to make good housekeeping, what is necessary is the will. Hence the focus has to be on changing the behaviour: management support and information could be very suitable.
- *Networking*. This is the practice most recently implemented by the company. It is decided by the top management, which implies a direct involvement. The scope of impact is on the whole company and the people who implement this practice are the energy manager and some representatives of the facility maintenance personnel. Each month a meeting is scheduled with industry associations in order to share information. The implementation costs are low while the hidden ones are more significant since the participants are engaged for a fairly long time . Lack of time and other priorities are at the greatest obstacles. The company suggests that a domestic regulation, economic support could mitigate the problems for instance the one of hidden costs.
- *Establish data base*. This is an important practice to keep the historical data and collect data from the whole enterprise: all processes are affected and the level of organization that implements and lead the practice is the energy manger. The influenced organizational levels are both middle and low. Until now, only once this practice was implemented, and the frequency of revision is more than one year. Greater control over this practice, for instance every year, could improve

the efficiency of the practice. As for costs, there are virtually no hidden costs while the real ones are high, related to the initial costs and maintenance of the system. The barrier the most important concern the awareness that such a practice is important but is not yet good enough.

5.2.2.2 Conclusions

This company is characterized by a sound culture concerning sustainability. It can be proud of significant annual energy savings, without investing in new equipment. This is an evidence of the potential of energy savings coming from the energy management practices. Indeed the practices are important to the better implementation of other interventions and enabler to energy savings.

The company has always taken a strategic approach in the energy field, in the past with energy efficiency technologies and currently with people based energy management. Of course changing the mind-set of the employees is a great challenge, due to the company's size and complexity. It is a big deal of effort and the leadership has to be really effective. Very critical barriers are: competences, organizational and behavioural ones. People should understand the sustainability question and think from an energy management point of view: this requires new skills and a continuous updating. The organizational barrier concerns the corresponding complexity and often the existence of other priorities and lack of time. These considerations are in accordance with what can be read from the framework.

Reading the matrix some evidence and directions of improvements are clear and they have been well explained in the previous paragraph. Here it is useful to resume only some possible improvements and intervention priorities.

- More than half of the practices are already in use, hence there are few practices recently implemented. The company has been working on energy management for years and it should aim to update and adopt new practices in order to achieve a higher level of energy management. The possible barriers are related to organizational issues.

- The company expresses some difficulties regarding the leadership: people and processes to be managed are numerous and a sustainable leadership course could be the solution. This is a lack of the company and the aforementioned practice can transfer useful knowhow and skills.
- Concerning the practices of energy audit and training, which usually require a support, the company has never provided a support: at least for energy audit it is desirable. If internal competences are not adequate, as it results from the barriers, an external support can partly solve this problem.
- An area that needs some improvements is the general organization: there is a very important practice missing: the action plan. This fact suggests that there is not a clear guideline to achieve the goals set in the energy policy, hence it is desirable a better structure.

5.2.3. Volvo Group

Name	Volvo
Location	Gothenburg
Interviewee	Cecilia Bengtsson - Environmental Director Real Estate Services
N° employees	(95533 all over the world)
Annual turnover	272,622 billion SEK (30,8 billion euro)

Table 29. Volvo main data

Volvo was founded in 1927 and currently is considered on of the main " world-leading provider of transport solutions", as stated in the group report presentation on its website.

Energy management approach

The vision of the group stresses the importance of the environmental care and of working with the energy, and the following brief comment confirm such a vision: "Climate change is one of the most important and challenging issues of our time. Fossil fuels such as oil and coal are the largest source of greenhouse-gas emissions, which, in turn, are deemed responsible for climate change." Volvo is one of the main

manufactures of vehicles and the majority of the goals refer to lower the emissions form its products; the focus on energy savings related to the processes has to be improved, since more effort is on the efficiency of the outcomes and company's reputation.

The energy and environmental policy points out some requirements: minimize the consumption of natural resources, minimize and responsibly manage waste and residual products. This can be possible by formulating, communicating, monitoring clearly defined goals and engaging the employees.

I visited the Volvo Truck Company located in Gothenburg; it is one of the main divisions within the Group since its share of net sales is 65% of the total.

The functional division in charge of energy management is really broad and it encompasses the real estate and environmental management; it is a support function under the top management control. The mangers belonging to this area are middle managers and the environmental team.

Based on the opinion of the manger the Energy Management is both technology and people related. In the past the focus was only on technological interventions but now management practices of other industrial disciplines are succeeding in the energy field. Actually the energy management level, related to the "soft" aspects, is not excellent: the company has just begun working on organization and human dimensions, but it is putting a lot of effort into the energy management practices.

The energy management practices are considered very important as enablers: there is a considerable need of spreading practices and the energy management culture. Within the Group Trucks Operations all the best practices, also energy related, are listed: it is necessary to learn, have experience regarding energy management. The group and especially the factories in Sweden have not an excellent culture in energy management and mostly a good organizational structure, with defined roles and responsibilities, is absent.

Some factories of the group, in particular some foundries are members of the PFE; moreover some plants but not in Sweden have the ISO 50001 certification, while the majority has the ISO 14001 an ISO 9001: the energy management system is a excellent tool and it allows to involve the management. It is only recently that energy management has become more people related: this is an important transition, but it is

not a global decision. What is missing is an overall decision of the top management that can address the move to the energy management practices. The interviewee agrees with the division in three steps, stressing that the real improvement in the future has to concern the second level of the energy management practices. The policy and the technical interventions and investments are suitable and well defined.

Concerning the kinds of energy efficiency potentials, there is always potential from energy efficiency technologies but a percentage between 10-20% of reduction of energy cost can be obtain through the energy management practices.

The strategic approach to the energy question is quite good but there is not yet a fully strategy: a great deal of effort is put into the production of efficient vehicles, but less into the most efficient way to produce them. Many investments regarding the new energy efficiency technologies have been made following a strategic approach, choosing investments with longer payback time against a higher energy efficiency level.

The recent strategic approach regarding energy management practices is due to the new CEO: he has a different way of running a company and a special idea of organization, more centralized and structured.

The last issues are barriers and drivers; the main barriers are organizational and behavioural, and this demonstrates the aforementioned problem of the group and single factory. Then the awareness obstacle is also important. The less important barriers are the economic ones, since a lot of work can be done with few money with energy management practices. The force that can help to overcome the barriers, could be any support to the people, in the transition processes from a technical to a management point of view. Further information and competence can be useful to improve the awareness and motivation of the people. Moreover the green image has always been a very important marketing factor, but almost always related to energy efficiency products instead of processes: the image of a company able to reduce consumption internally could be of great value. The benefit would be savings of money and improving the reputation of the company towards external stakeholders, including consumers more interested in the effects on the environment that in the internal cost-cutting.

5.2.3.1 Discussion: assessment and orientation of the company

Regarding the application of the framework, Table 30 shows the results. Reading the matrix it is possible to get a lot of indications of how the company implements the practices.

	TYPE OF PRACTICE 1	FOCUS ON 2	STRATEGY SCOPE 3	TYPE OF ENABLER TO INTERVENTIONS 4	ENERGY'S SOURCE 5	NOVELTY GRADE FOR COMPANY 6	SCOPE OF IMPACT 7	ORGANIZATIONAL ACTORS 8				EASINESS OF IMPLEMENTATION 9	FREQUENCY OF CHECK/REVIEW 10	FREQUENCY OF IMPLEMENTATION 11	ORGANIZATIONAL COSTS 12		BARRIERS 13							DRIVERS			
								Influenced Level	Decision-Maker	Impl. Level	Support				Hidden Costs	Real Costs	Information	Economical	Behavioral	Organizational	Awareness	Comp. Related	Regulatory	Economic	Information	Comp. Related
Monitoring energy use and costs	CI	C/S	EE	MD	T/E	A	MG	L/M	M	L	-	QE	M	D	L	H	1	2	2	3	2	2	2	3	1	1
Consumption reports to inform	SI	C	EE	LD	T/E	A	MG	L/M/T	M	M	-	QH	M	W	L	L	3	3	2	3	2	2	1	2	3	2
Allocation of energy cost (metering)	O	C/S	EE	MD	T/E	N	C	L	M	M	-	QE	Y	YY	L	L	3	1	2	4	3	1	4	1	4	1
Energy audit (preliminary, general, detailed) - Map of energy use and flows	CI	C	EE	MD	T/E	A	C	L	M	M	E	QH	YY	YY	H	L	4	2	1	4	4	2	1	3	4	2
Performance analysis trough key performance indicators (KPI)	CI	C/S	EE	LD	T/E	A	C	L/M/T	M	M	-	QE	M	W	L	L	2	1	1	4	2	2	3	2	2	2
Establishment of uniform record keeping system																										
Establishment of uniform reporting system																										
Automatic control																										
Program and course of training	T	C	EE	MD	T/E	N	MG	L	M	M	-	QH	Y	Y	H	L	2	2	4	4	4	3	2	2	4	4
Energy manager	O	C/S	EE	LD	T/E	N	O	M	T	M	-	QE	YY	YY	L	H	1	3	2	3	2	4	1	3	3	4
Energy management team	O	C/S	EE	LD	T/E	N	G	M	T	M	-	QE	YY	YY	L	H	1	3	2	3	2	3	1	3	3	3
Energy action plan	O	C/S	EE	LD	T/E	N	C	L/M	M	M	-	QH	M	Y	L	L	3	1	3	4	3	2	2	1	4	3
Energy savings targeting	O	C	EE	LD	T/E	N	C	L/M	M	M	-	QH	M	Y	H	L	3	1	2	3	3	3	3	1	3	4
Establishment of data base																										
Targets communication	SI	C/S	EE	LD	T/E	N	C	L/M/T	M	M	-	QH	Y	Y	L	L	2	1	1	3	1	3	1	1	4	4
Awareness and motivation program - specific and general	M	C	EE	LD	T/E	A	G	L	M	M	-	QE	O	Y	H	L	2	1	3	3	3	3	1	2	3	4
Regular publicity campaigns																										
Recognition of energy reduction initiatives	M	C	EE	MD	T/E	N	G	L	M	M	-	QE	Y	M	L	L	3	1	4	4	4	2	1	1	4	2
Meetings	SI	C/S	EE	LD	T/E	N	MG	L/M	M	M	-	QE	M	D	L	L	2	1	4	4	4	1	1	1	4	2
Care and maintenance	H	C	EE	MD	T/E	A	C	L	M	L	-	QE	Y	D	H	L	1	1	4	3	3	1	3	1	3	1
Networking																										
Sustainable leadership course/program																										

Table 30. The application results of the characterization framework

1	M: motivation	T: training	O: general organisation	CI: collection of information	SI: spread of information	H: housekeeping
2	C: core processes	S: support processes				
3	LD: less direct	MD: more direct				
4	T: thermal	E: electrical				
5	EE: energy efficiency	EC: energy conservation				
6	N: new	U: already in use				
7	O: one person	G: a group/a business unit/a division	MG: more than an unit/group	C: whole company		
8	T: Top/high management	M: middle management	S: staff/operator level/shop floor			
9	I: internal	E: external				
10	VE: very easy	QE: quite easy	QH: quite hard	VH: very hard		
11	O: one time	D: daily	W: weekly	M: monthly	Y: yearly	YY: more than a year
12	VL: very low	L: low/moderate	H: significant/high	VH: very high		
13/14	1:not important	2: scarcely important	3important	4: very important		

First of all it is reported the general evaluation of the status of the company at an aggregate level.

The energy management level is becoming good and the company implements many practices. The areas of training and housekeeping are populated in the right way. Regarding the increase of the motivation the company has chosen to implement a practice very important: recognition of energy reduction initiatives. If the contributions come from the people, the awareness and the motivation grow in a great way.

Since the factory under consideration is of large dimension, it is necessary to engage, interest, lead and communicate with all organizational levels: a real challenge is to be a true leader and a course of sustainability leadership can support this

Regarding the general organization, many practices are implemented, but it the company would like to reach a better level of energy management, it should structure itself in the best possible way. For instance having uniform record keeping and reporting systems it is very important in order to set unique and organized systems in the whole company: this permits alignment and accordance.

In the spread of information area the missing practices is the networking with other companies. As shown in the previous cases, this practices is really well evaluated and lots of companies actively participate.

Regarding the overall focus, many practices regard only the core process and this could be improved. The company implements both practice less direct o more direct to energy savings or interventions: for instance care and maintenance, audit and monitoring are more direct enablers but there are also many other practices recognized as "softer" enabler and necessary as well. Moreover both the thermal and electrical sources are affected and this is great. The scope of impact is well extended: many practise involve the whole company or more than a group.

As regard to the organizational actors, it can be affirmed that the top management is not involved in almost any practices: its responsibility concerns only the energy policy. A better commitment and involvement of the high level are supposed to influence the employees and to prioritize the energy management issue, mostly in such a big company The middle management is the most involved and in charge of the implementation of many practices: this shows the active role of the energy manager and team but it not sufficient.

The majority of the practices is new to the company and this is a confirmation of the fact that energy management has been recently introduced within the company. In the past the kind of practices implemented were the monitoring and informative reports; also the energy audit is quite dated. The good predisposition of the company towards Energy Management is verified considering that many practices are quite hard to be implemented, but the company put effort into these activities as well.

Generally the most important obstacles are considered organizational, awareness and informational barriers. This is in accordance with the literature review about this issue and what is the thinking of the interviewee. The economic barrier is presented mostly in the cases of high hidden costs but maybe the problems can be reported to the organization structured and can be overcome without further economic incentives; changing the organization and behaviour can benefits also in this case.

After the previous discussion, an analysis for each practice can point out some important evidence thanks to the comparison with the values proposed in the literature.

- *Monitoring of energy use and costs*. This practice is considered a more direct enabler as directly provides information to understand what it takes to save energy and costs. The scope of impact of this practice is more than a group while it would be better that each type of consumption within the enterprise was monitored.. Even if the real cost is considered high, it is affordable for this company and indeed the practice is quite easy to be implemented. The frequency are correct and in line with the values of the literature. The barrier considered important is the organizational one, while the others are quite low.
- *Consumption reports to inform*. The first consideration is related to the scope of impact: even here the influence must extend to the whole company. It is good that all organizational levels are affected. A critical situation refers to the focus: only the core process is interested. As regards the frequency of implementation, it is is weekly and it is higher than the one considered in the literature. A trade-off could be to enlarge the scope of impact and decrease the frequency to one month, in line with the frequency of checking and reviewing. The latter one proves a regular commitment in order to update and adapt the communication way. The hidden cost of this practice is high, probably because it is implemented very often and there is a standard way to report. Also a lack of information is recognized; in this case the best driver is the informational one.
- *Allocation of energy cost (submetering):* this practice is well implemented since it involves both the core and non-core processes and mostly the whole company. The company has not faced difficulties also because the hidden and real costs are low. A point of attention could be the barriers: organizational and informational obstacles are evaluated relevant. In this case an internal regulation could help to establish the right allocation in an efficient way within the whole company.
- *Energy audits (general)*. The first point of attention is the focus: until now the company has performed an audit only on the core-process. It has also been implemented throughout the company. A trade-off could be to map the consumption of multiple organizational units/groups but also the non-core

processes. Moreover, this practice is not easy to implement probably this is due to the high hidden costs, related to the time of the people or stopped production. For this practice is required an external support since the internal competences are not adequate. Here the organizational barrier is the most important, for instance lack of time, internal control and complexity.

- *Performance analysis (KPI)*. This practice aims at core and non-core processes and the whole the enterprise is involved. These are positive factors but in disagreement with the scope of impact of monitoring and reporting. KPIs are used in reporting and thus the frequency of implementation and review are consistent with those of consumption reports. A frequency of one month is sufficient both for KPIs analysis and consumption report.
- *Specific program / course of staff training*. It is a practice, which is more directly related to technology and energy savings, because you work for an efficient use of the facilities. In this company, it is only applied to the core process but the best thing would be to make training even on non-core processes, in order to operate effectively on everything.

  It is addressed to more than a group and it could be correct. There is not a support and in fact the drivers show that more competences would be desirable, for instance by hiring an outside expert. This practice is implemented with a frequency lower than a year and the same for the frequency of review and check: this is an aspect that could be improved, increasing the two frequencies.
- *Energy Manager and energy management team*. These two practices are characterized almost in the same way, the difference is that the energy manager is one person and the team instead includes more people belonging to the middle level. There are practices already in use and the two frequency are low: at least the review of the roles and responsibilities should occur more frequently. The cost for these practices are low and indeed the economic barrier are not important. Instead the competence barriers are important.
- *Energy action plan*. This practice is directed to the whole company unit and the affected organizational levels are the shop floor and middle management. In fact, the energy action plan should influence the whole enterprise and the other organizational levels, hence the involvement must be greater. Another point of

attention is related to the two different frequencies: the implementation frequency is a year and the frequency of check and review is monthly: this correspond to the right interpretation of the practice.

- *Energy savings targeting*. The proper involvement of the entire company should also correspond to the total influence of all organizational levels, while the top management is not included, neither as decision market. Then the person who implements this practice is the energy manger belonging to the middle level, but the collaboration with top management could be winning as mentioned in the literature. The main critic point is the focus only on the core process. This company has faced some difficulties and indeed organizational, awareness and competence barriers are considered quite significant. In accordance with this, the company should need further managerial support, included in the information driver, and more skills.
- *Targets communication*. The communication is widespread, all organizational levels are affected but it lacks the involvement of the highest level as decision-maker . This communication is closely linked to the practice of energy saving targeting, where the top management is very important. It is not easy to implement this practice probably for the extension of the scope of impact, in fact, a high barrier is the organizational one. Moreover the competences required in order to effectively communicate with all kinds of organizational levels is a critical situation.
- *Awareness and motivation program course (general)*. The first point is the focus: only the core process is affected but the practice is supposed to affect both types of processes. In addition the extent of the influence of this activity is many groups of employees in the production maintenance: the maximum improvement could be to extend to the entire company. Then only low management is influenced while all organizational levels should be involved. Every year, this practice is implemented but only once until now has been reviewed: the way of learning are not very up to date and this fact must be enhanced. In addition, the hidden costs are high, especially related to time of people.
- *Recognition of energy reduction initiatives*. It one of the most effective motivating practice and the first aspect that the company should try to enhance is the focus

only on core process. It is correct that the influenced group of people is the low level. A further improvements could be align the two kinds of frequencies, both monthly.

- *Care and maintenance*. Again the focus is only on the core business but it should be improved. It is rightly regarded an enabler to more direct interventions and energy savings. It is a practice that encompasses the entire company and that you implement every day. The times the housekeeping is reviewed, are however few, the frequency is expected to be greater than one year. For this practice, the main barriers are organizational and behavioural: they people do not need great skills to make good housekeeping, what is necessary is the will. Hence the focus has to be on changing the behaviour: management support and information could be very suitable.
- *Meetings*. This is an important practice in order to spread information and it is new for the company. A positive factor is the focus on both core and non-core processes, unlike other practices. The influenced organizational levels are low and middle, but the involvement of the top management is not required: this can be enhanced. Very good are the frequencies of implementation and review: daily and monthly, as stated in the literature. The critical barriers are related to organization, behavioural and awareness aspects, here the commitment and support of the management is hence really advantageous.

5.2.3.2 Conclusions

Based on the opinion of the interviewed manager, Energy Management is both technology and people related. In the past the focus was only on technological interventions. Actually the energy management level, related to the "soft" aspects, is not excellent: the company has just begun working on organization and human dimensions. The commitment of the company is evident: a lot of practices are implemented among the proposed practices.

The group and especially the factories in Sweden have not an excellent culture in energy management; moreover a good organizational structure, with defined roles and responsibilities, is absent.

What is missing is an overall decisional and controlling competence of the top management to address the change to energy management practices.

Finally, the recent strategic approach regarding energy management practices is due to the new CEO's vision: he has a different way of running a company and a special idea of organization, more centralized and structured.

The last issues are barriers and drivers; the main barriers are organizational and behavioural. Furthermore the awareness obstacle is also significant. The less important barriers are the economic ones, since a lot of work can be done with few money with energy management practices.

These reflections are in line with the information that can be obtained reading the characterization framework.

Analysing the matrix some evidence and directions of improvements are clear and they have been well explained in the previous paragraph. Here it is useful to sum up some possible improvements and intervention priorities.

- The majority of the practices focuses only on core process: this is the first aspect that the company should enhance, involving the support processes as well. Some examples of practices, which focus only on core processes are: consumption reports to inform, energy audit, energy savings targets, awareness and motivation course, recognition of energy reduction initiatives, training, care and maintenance.
- The company faced some problems regarding the leadership: the large company has to manage a lot of people and processes and a sustainable leadership course could be the solution. This is a lack of the company and the aforementioned practice can transfer useful knowhow and skills.
- A further suggestion interests the involvement of the top management. Culture about energy efficiency issue. There is not already a sound culture and the commitment of the high organizational level could influence it. In only one practices out of fifteen the top management is involved as decision maker.

- An improvement for two practices, consumption reports to inform and monitoring of energy use and costs, could concern the scope of impact. It would be desirable if the whole company should be affected by these activities, not only some groups of people or organizational units.

Chapter 6

Conclusions

The attention paid to the control of energy consumption and energy use has been significant for many years, leading to a renovated interest towards energy efficiency issues. Improving energy efficiency has been identified as one of the main contributions to energy consumption reduction and, consequently, GHGs emissions mitigation. It is very interesting to focus on industry since this sector uses more energy than any other end user, consuming about one-half of the world's whole delivered energy.

So far, improving energy efficiency has been synonym of large investments in new and more efficient technologies. Nonetheless, research has recently started to evaluate the importance of adopting simpler energy efficiency measures, but the potential of Energy Management has been neglected for many years. Nonetheless, studies have started to point out the relevance of an energy efficiency awareness, and Energy Management has started to be recognized as one of the most relevant means to reach a higher level of energy efficiency within the industry.

The main challenge concerning Energy Management issue is that in the scientific and industrial literature it is not described in a unique way: firstly, it is looked from different perspectives, and secondly, a cohesive and comprehensive definition cannot be found. The debate on such topics is still significantly open, and much more still needs to be done. After a thorough evaluation of the main contributions, the thesis has focused on studying Energy Management at an intermediate level, as result of defined strategies and policies of corporate strategies, and as enabler to energy efficiency improvements. Starting from the core issue, namely that energy

management is largely aligned with other resources' management within enterprises, the "soft" aspects related to organisational, informational and human dimensions are as important as the operative, tactical and technical factors. Indeed, the relevance of soft aspects has been clearly expressed , in the literature, pointing out that "Energy Management is largely about people rather than technology" (Caffall, 1995).

The effective application within industry of Energy Management introduces the concept of the related practices, i.e., the aforementioned "soft" components. As for the definition of Energy Management, the debate on the definition of the related practices is quite open. Literature has provided several interesting cues: after a thorough and comprehensive review of the existing literature, both scientific and empirical, the thesis has provided a novel definition of energy management practice, defined as: "a technique, a method, a procedure, a routine, a rule employed or followed by a company that allows to effectively support the corporate energy strategy, and facilitate the implementation of other energy efficiency practices and investments".

The relevance of the present study in terms of novelty of the approach is clear: this research has conducted a comprehensive assessment of Energy Management with a company, starting from an evaluation of how Energy Management is structured and characterized, as well as characterizing the broad set of energy management practices. To do so, a novel characterization framework has been developed, allowing to collect and process the large set of information necessary to characterize and evaluate Energy Management and its practices. In detail, the objective of the framework is twofold:

- Assessment scope: an overall evaluation of the approach of the company to Energy Management and an assessment of the maturity level of the practices' implementation;
- Direction/Orientation scope: a support for an enterprise to investigate which practices are more suitable and advisable according to its specific characteristics, as well as to understand the actions needed to improve them, thus improving Energy Management.

To create the classification framework, the work has conducted an in depth literature review to identify a set of the most important energy management practices (reclassified into 22 practices) and a set of the corresponding characteristics (14 characteristics) and related attributes.

The characteristics, considered necessary in order to wholly describe the way of implementing a practice, provide information regarding: the type of practice; the extend of impact on people and processes; the commitment of the different organizational levels, the hidden and real costs, the frequency of implementation and updating, and, in the end, several barriers and drivers. These features are considered relevant, differently from others, since they allow to characterize the energy management practices from different points of view. The organizational, managerial and human aspects become the focus of the characterization process, and this is a novelty.

The second set concerns the most important practices, the criterion of choice has been the number of appearances in the examined scientific and empirical literature. Significantly, too company-specific practices are not taken into consideration, as not applicable on a general base. The set encompasses practices related to the important areas of monitoring, mapping of energy use and costs, performance analysis, training, information systems, motivating and company overall organization. In line with what is valid for the characteristics' set, the selected practices refer only to organizational and managerial aspects, as the scope of Energy Management in this research. Thus practices related to technical issues are excluded from the set.

The framework has then been improved by applying some proposed values according to the relevant literature on the topic. This action is necessary for the comparison between the company's values of the framework with the theoretical values, in order to achieve the assessment and orientation aims.

To provide an effective tool for empirical investigation, the theoretical framework has been first validated and then applied to a selected sample of companies, through semi-structured interviews. The companies are analysed as single case studies.

The validation of the model has involved the investigation of 8 Swedish small, medium and large manufacturing companies in order to exhaustively represent the interested sector, as well as evaluating its capability to describe very different industrial contexts. The variables used to validate the model are: completeness, comprehensibility, degree of the detail and overlapping. In order to well describe the practices the characteristics have to be sufficient, comprehensible; the grade of detail should be quite low since the more accurate is the required detail, the less the answers are confident; moreover the interviewee should perceive the differences among the features. The collected practices have to be understandable and the company should not be able to add other practices, implemented in the company and absent in the set. The test phase was successful, as proved able to describe the way energy management is structured, and how energy management practices are characterized and implemented.

After the validation test, the framework has been applied to 3 multinational companies based in Sweden: Xylem, Scania and Volvo, belonging to the manufacturing sector. Again, these three enterprises are analysed as single case studies, since the comparison would be pointless. The application aimed first at evaluating the selected sample with respect to their approach to the energy management practices. Once the characterization framework was complete, general and specific pieces of evidence could be obtained in order to assess the state of implementation of energy management practices and to address improvements, if necessary. The assessment and orientation goals need the support of the proposed values of the literature review as a baseline for the comparison.

The application of the framework proved successful, since the practices resulted well described by the characteristics included in the framework, providing a detailed picture of the status of the enterprise with respect to Energy Management.

Beside a thorough evaluation of energy management and practices, the framework could be effectively used as tool to support enterprises in a better understanding of the needed actions to improve energy efficiency through an enhanced Energy Management.

Considering Xylem, the application of the framework revealed some points of attention. This company moved its attention to Energy Management only few years ago: earlier it focused mostly on energy efficiency technologies. The push to consider organizational and managerial aspects is due to the commitment of the energy manager, belonging to the middle management, but much more work still needs to be done. In line with this, applying the framework, one of the priorities regards the motivation area: the company implements only one practice in this area and, if the intention is to involve more people and create a sound culture, other practices should be taken into consideration. The framework presents other practices related to the motivation and not implemented such as: recognition of energy reduction initiatives, publicity campaigns and sustainable leadership course. Another suggestion, for instance, concerns the commitment of the middle management only: hardly ever the top management is involved as decision-maker. This corresponds to the recent attention to Energy Management, mostly paid by middle management. Literature nonetheless highlights the relevance of top commitment as key for the success. In this case the framework wholly describes the situation of the company concerning its approach to Energy Management and highlights the right critical situation.

By looking at Scania, this company manages the energy resource in a strategic way and it has been working on Energy Management for years, mostly on the information systems. In fact the framework has allowed to point out that the majority of the practices has been already in use for year. Nonetheless, Scania should aim to update and adopt new practices in order to improve its energy efficiency. The framework confirms that a lot of practices are implemented in the area of collection and spread of information such as: monitoring consumptions, energy audit, performance analysis through KPI, establishment of data base, communication of energy savings targets and consumption reports to inform. Despite such wide application of energy efficiency practices, the application of the novel framework has allowed to highlight a relevant area in which several improvements could be done. In fact, concerning the general organization, the action plan is missing and this is an important practice as a mean of driving everyone in the organization to focus and prioritize the energy efficiency efforts. This fact suggests that there is not a clear

guideline to achieve the general goals, set in the energy policy, and the specific energy targets.

In Volvo company, Energy Management, related to the "soft" aspects, is not excellent: the company has just begun working on organization and human dimensions, but it is putting an increasing effort into the energy management practices. The framework highlights some problems regarding the motivation and awareness of the employees and it can be explained with a lack of competence to lead, guide and inspire. The large company has to manage a lot of people and processes and a sustainable leadership course could be the solution since this is a practice still not implemented. The Energy Management should involve all the different organizational levels and the manager in charge of energy issue is supposed to be able to communicate and engage people in energy efficiency initiatives. This is a lack of the company and the aforementioned practice can transfer useful knowhow and skills. Another priority concerns the focus of the practices. Lots of practices are merely focused on core processes: this is the first aspect the company should enhance, involving the support processes as well, in order to have a complete control of the company's processes. For instance practices like consumption reports to inform, energy audit, energy savings targets, awareness and motivation program and recognition of energy reduction initiatives should affect the support processes as well, thus resulting more effective.

In the end, the application of the framework has allowed to point out several perspectives on how Energy Management is characterized, as well as its practices, proving to be a valid and innovative tool for studying the energy management practices within the industrial sector

The research had some limitations: the complexity and length of the framework could require a support during the application, particularly critical if does not exist in a company a structure to manage energy and related issues. The interviewed mangers hardly can be independent during the application of the framework. An improvement could be a simplification, for instance considering less characteristics or lowering the degree of detail of the attributes.

Moreover another point of attention is the quite limited sample: the analysed companies have been very useful to verify the good application of the framework, but it could be interesting to widen the investigation scope in order to collect more information regarding the energy management status within the involved sector.

To conclude, this study sets out to highlight a few ideas for future research. First of all, the assessment and orientation could be conducted within a wider scope: this analysis could be performed from a policy-maker's perspective, in order to understand the interventions to improve the implementation and the diffusion of energy management practices in the investigated context. Moreover the framework could be applied to other companies within the manufacturing sector or within other kinds of sectors, in order to have a wider assessment of the maturity level of energy management practices. For instance a suggestion could be to investigate enterprises of other size, not only large companies as in this case. By applying the framework to a greater number of companies, the comparisons would be more significant and, as has already been pointed out, be a useful tool for policy makers.

Additionally this work has analysed the Energy Management at an intermediate level and a further interesting study could investigate how this level can be linked to the higher level, i.e. the corporate energy policy, and lower level, i.e. the operative and technical interventions, through an integration model.

To conclude, the framework encompasses a lot of characteristics and practices: if it could be feasible a further rationalization of the number of elements, the framework would definitively result simplified. A company could decide to consider only some characteristics, for instance the ones related to barriers and drivers or the ones related to organizational aspects, such as the involved organizational actors and the scope of impact, based on its aims. A simplified framework would make possible the design of a self-assessment model, which would allow managers to be independent.

Bibliography

Abdelaziz, E. a., Saidur, R., & Mekhilef, S. (2011). A review on energy saving strategies in industrial sector. *Renewable and Sustainable Energy Reviews*, *15*(1), 150–168.

Aflaki, S., Kleindorfer, P. R., & de Miera Polvorinos, V. S. (2013). Finding and Implementing Energy Efficiency Projects in Industrial Facilities. *Production and Operations Management*, *22*(3), 503–517.

Alam Hossain Mondal, M., Kamp, L. M., & Pachova, N. I. (2010). Drivers, barriers, and strategies for implementation of renewable energy technologies in rural areas in Bangladesh—An innovation system analysis. *Energy Policy*, *38*(8), 4626–4634.

Anthony, R.N. (1965), Planning and Control System: a framework fo analysis. *Division of Research, Graduate School of Business Administration, Harvard University*, (pp.180)

Ashford, C. J. (1993). Energy Efficiency : A Managed Resource, 24–27.

Astley, W. G., & Ven, A. H. Van De. (2013). Central Perspectives and Debates in Organization Theory, *28*(2), 245–273.

Ates, S. A., & Durakbasa, N. M. (2012). Evaluation of corporate energy management practices of energy intensive industries in Turkey. *Energy*, *45*(1), 81–91.

Backlund, S., Ottosson, M., & Broberg, S. (2012). Energy efficiency potentials and energy management practices in Swedish firms (pp. 669–677).

Backlund, S., Thollander, P., Palm, J., & Ottosson, M. (2012). Extending the energy efficiency gap. *Energy Policy*, *51*, 5.

Björheden, R. (2006). Drivers behind the development of forest energy in Sweden. *Biomass and Bioenergy*, *30*(4), 289–295.

Bloom, N., Genakos, C., Martin, R., & Sadun, R. (2010). Modern Management : Good For The Environment Or Just Hot Air ?, *120*(1997), 551–572.

Boyd, G. A., & Pang, J. X. (2000). Estimating the linkage between energy efficiency and productivity. *Energy Policy*, *28*.

Braun, J. E. (n.d.). Reducing Energy Costs and Peak Electrical Demand through Optimal Control of Building Thermal Storage (p. 35).

Brown, M., & Key, V. (2002). Overcoming Barriers to Effective Energy Management in Industrial Settings Barriers to Effective Energy Management (p. 8).

Bunse, K., Vodicka, M., Schönsleben, P., Brülhart, M., & Ernst, F. O. (2011). Integrating energy efficiency performance in production management – gap analysis between industrial needs and scientific literature. *Journal of Cleaner Production*, *19*(6-7), 667–679.

Cagno, E., & Trianni, A. (2012a). Analysis of the Most Effective Energy Efficiency Opportunities in Manufacturing Primary Metals, Plastics, and Textiles Small- and Medium-Sized Enterprises. *Journal of Energy Resources Technology*, *134*(2), 9.

Cagno, E., & Trianni, A. (2012b). Exploring drivers for energy efficiency within small- and medium-sized enterprises : First evidences from Italian manufacturing enterprises. *Applied Energy*, 11.

Cagno, E., Trucco, P., Trianni, A., & Sala, G. (2010). Quick-E-scan: A methodology for the energy scan of SMEs. *Energy*, *35*(5), 1916–1926.

Cagno, E., Worrell, E., Trianni, A., & Pugliese, G. (2012). A novel approach for barriers to industrial energy efficiency. *Renewable and Sustainable Energy Reviews*, *19*, 290–308.

Cagno, E., Worrell, E., Trianni, A., & Pugliese, G. (2013). A novel approach for barriers to industrial energy efficiency. *Renewable and Sustainable Energy Reviews*, *19*, 19.

Christoffersen, L. B., Larsen, A., & Togeby, M. (2005). Empirical analysis of energy management in Danish industry. *Journal of Cleaner Production*, *14*(5), 516–526.

Cooremans, C. (2011). Make it strategic! Financial investment logic is not enough. *Energy Efficiency*, *4*(4), 473–492.

Cooremans, C. (2012). Investment in energy efficiency: do the characteristics of investments matter? *Energy Efficiency*, *5*(4), 497–518.

De Groot, H. L. F., Verhoef, E. T., & Nijkamp, P. (2001). Energy saving by firms: decision-making, barriers and policies. *Energy Economics*, *23*(6), 717–740.

Department of Alternative Energy Development and Efficiency Energy Conservation Center Thailand. (2005). Total Energy Management Handbook, (November), 92.

Diaconescu, I., Patrascu, R., Grogorescu, L., & Simionescu, C. (2011). *New Strategy for Energy Management Program* (pp. 101–105).

Dicicco-Bloom, B., & Crabtree, B. F. (2006). The qualitative research interview. *Medical Education*, *40*, 314–321.

Drumm, C., Busch, J., Dietrich, W., Eickmans, J., & Jupke, A. (2012). STRUCTese® – Energy efficiency management for the process industry. *Chemical Engineering and Processing: Process Intensification*, *67*, 99–110.

Ekander, F. (2013). *ENIG Network for Energy Efficiency* (p. 7).

Elenkov, D. S. (2005). Top Management Leadership and Influence on Innovation: The Role of Sociocultural Context. *Journal of Management*.

European Commission. (2008). 20 20 by 2020 Europe's climate change opportunity (pp. 1–12).

European Commission. (2011). Energy Efficiency Plan 2011 (p. 16).

European Commission. (2013). *I*nternational Energy Outlook 2013.

Fleiter, T., Hirzel, S., & Worrell, E. (2012). The characteristics of energy-efficiency measures – a neglected dimension. *Energy Policy*, *51*, 502–513. doi:10.1016/j.enpol.2012.08.054

Fleiter, T., Worrell, E., & Eichhammer, W. (2011). Barriers to energy efficiency in industrial bottom-up energy demand models - A review. *Renewable and Sustainable Energy Reviews*. doi:10.1016/j.rser.2011.03.025

Gielen, D., & Taylor, M. (2007). Modelling industrial energy use: The IEAs Energy Technology Perspectives. *Energy Economics*, *29*(4), 889–912.

Gordić, D., Babić, M., Jovičić, N., Šušteršič, V., Končalović, D., & Jelić, D. (2010). Development of energy management system – Case study of Serbian car manufacturer. *Energy Conversion and Management*, *51*(12), 2783–2790.

Gorp, V. (2004). Enterprising Energy Management , (february), 59–63.

Hagelstein, P. L. (n.d.). Thermal to electric energy conversion (pp. 305–314).

Harris, J., Anderson, J., & Shafron, W. (2000). Investment in energy efficiency: A survey of Australian firms. *Energy Policy*, *28*, 867–876.

Hasanbeigi, A., Menke, C., & Pont, P. (2009). Barriers to energy efficiency improvement and decision-making behavior in Thai industry. *Energy Efficiency*, *3*(1), 33–52.

Hrustic, A., Sommarin, P., Thollander, P., & Söderström, M. (2011). A Simplified Energy Management System Towards Increased Energy Efficiency in SMEs. In World Renewable Energy Congress 2011 (pp. 1513–1520).

Internationa Energy Agency. (2013b). Key World Energy Statistics. *Energy Policies of IEA countries Sweden 2013*.

International Organization for Standardization. (2011). *I*nternational Standard Iso 50001.

Jaffe, A. B., & Stavins, R. N. (1994). The energy-efficiency gap. *Energy Policy*, *199422*(10), 804–810.

Jensen, M. C. (1998). Organization theory and methodology, (2), 319–339.

Johansson, B., Modig, G., & Nilsson, L. (2007). Policy instruments and industrial responses – experiences from Sweden, 1413–1421.

Johansson, R. (2003). Case Study Methodology (Vol. 1, pp. 22–24).

Kannan, R., & Boie, W. (2003). Energy management practices in SME—case study of a bakery in Germany. *Energy Conversion and Management*, *44*(6), 945–959.

Kostka, G., Moslener, U., & Andreas, J. (2013). Barriers to increasing energy efficiency: evidence from small-and medium-sized enterprises in China. *Journal of Cleaner Production*, *57*, 59–68.

Likert, R. (1932). A Technique for the Measurement of Attitudes. Archives of Psychology 140: 1–55

Liu, X., Niu, D., Bao, C., Suk, S., & Shishime, T. (2012). A survey study of energy saving activities of industrial companies in Taicang, China. *Journal of Cleaner Production*, *26*, 79–89.

Martin, R., Muûls, M., de Preux, L. B., & Wagner, U. J. (2011). Anatomy of a paradox: Management practices, organizational structure and energy efficiency. *Journal of Environmental Economics and Management*, *63*(2), 208–223.

Mashburn, W. (2001, January). Effective Energy Management.

Mckane, A. (2009). Achieving Sustainable Energy Efficiency in Industry through a Management System for Energy (p. 23).

Michaelis, L., Peszko, G., Worrell, E., & Jaffe, A. (2001). Barriers, Opportunities, and Market Potential of Technologies and Practices, (August).

Mills, E., & Rosenfelds, A. R. T. (1996). Consumer non-energy benefits as a motivation for making energy-efficiency improvements. Energy, 21(718), 5-9.

Ministry of the Environment. (2013). The Swedish Environmental Code (p. 40).

Möllersten, K., Westermark, M., (2001). Outsourcing of energy facilities in the pulp and paper industry e motives for outsourcing partnerships between energy companies and pulp and paper manufactures. *In: Paper presented at World Energy Council, 18th Congress, Buenos Aires*

Nagesha, N., & Balachandra, P. (2006). Barriers to energy efficiency in small industry clusters: Multi-criteria-based prioritization using the analytic hierarchy process. *Energy*, *31*, 1633–1647.

Nations, U. (2008). International Standard Indutrial Classification of All Economic Activities (ISIC) (p. 306).

O'Callaghan, P.W., Probert, S.D., 1977. Energy management. *Applied Energy* 3, 127-138

Palm, J., & Thollander, P. (2010). An interdisciplinary perspective on industrial energy efficiency. *Applied Energy*, *87*(10), 3255–3261.

Patterson, M. G. (1996). What is energy efficiency ? Concepts , indicators and methodological issues. *Energy Policy*, *24*(5), 377–390.

Pelenur, M. J., & Cruickshank, H. J. (2012). Closing the Energy Efficiency Gap: A study linking demographics with barriers to adopting energy efficiency measures in the home. *Energy*, *47*(1), 348–357.

Piglia, A. (2012) L'efficienza energetica come contributo alla sostenibilità ambientale ed economica, SAFE, (pp.235)

Pinsonneault, A., & Kraemer, K. (1993). Survey research in management information systems:an assessement. *Journal of Management Information System*, *10*, 75–105.

Powell, E. T. (2009). *Wording for rating scales* (p. 2).

Prindle, B., Zarnikau, J., & Allis, E. (2010). Barriers and Policy Solutions to Energy Efficiency as a Carbon Emissions Reduction Strategy. In *Generating Electricity in a Carbon-Constrained World* (1st ed., p. 33). Elsevier Inc.

Pye, M., & McKane, A. (2000). Making a stronger case for industrial energy efficiency by quantifying non-energy benefits. *Resources, Conservation and Recycling*, *28*(3-4), 171–183.

Raes, a. M., Bruch, H., & De Jong, S. B. (2012). How top management team behavioural integration can impact employee work outcomes: Theory development and first empirical tests. *Human Relations*, *66*, 167–192.

Reddy, B. S., & Assenza, G. (2007). Barriers and Drivers to Energy Efficiency – A new Taxonomical Approach Barriers and Drivers to Energy Efficiency. *Energy - The International Journal*, (March), 43.

Rezessy, S., & Bertoldi, P. (2011). Voluntary agreements in the field of energy efficiency and emission reduction: Review and analysis of experiences in the European Union. *Energy Policy*, *39*(11), 7121–7129.

Rohdin, P., & Thollander, P. (2006). Barriers to and driving forces for energy efficiency in the non-energy intensive manufacturing industry in Sweden. *Energy*, *31*(12), 1836–1844.

Rohdin, P., Thollander, P., Moshfegh, B., Karlsson, M., Söderström, M., & Trygg, L. (2013). Energy in Swedish industry 2020 – current status, policy instruments, and policy implications. *Journal of Cleaner Production*, *51*, 109–117.

Rohdin, P., Thollander, P., & Solding, P. (2007). Barriers to and drivers for energy efficiency in the Swedish foundry industry. *Energy Policy*, *35*(1), 672–677.

Rudberg, M., Waldemarsson, M., & Lidestam, H. (2013). Strategic perspectives on energy management: A case study in the process industry. *Applied Energy*, *104*, 487–496.

Sandberg, P., & Söderström, M. (2003). Industrial energy efficiency: the need for investment decision support from a manager perspective. *Energy Policy*, *31*(15), 1623–1634.

Sardianou, E. (2007). Barriers to industrial energy efficiency investments in Greece. *Journal of Cleaner Production*, *16*(13), 1416–1423.

Scheihing, P. (2009). *Energy Management Standards* (p. 28).

Schleich, J. (2009). Barriers to energy efficiency: A comparison across the German commercial and services sector. *Ecological Economics*, *68*, 2150–2159.

Schneeweirj, C. (1995). Hierarchical structures in organisations : A conceptual framework, *2217*(95).

Schwarz, G. M. (2002). Organizational hierarchy adaptation and information technology. *Information and Organization*, *12*(3), 153–182.

Skumatz, L. A., & Gardner, J. (2005). Methods and results for measuring non-energy benefits in the commercial and industrial sectors pp. 163-176.

Söderström, M., (1996). Industrial Electricity Use Characterized by Unit Processes – A Tool for Analysis and Forecasting. I*n Proc. of the 13th International Congress on electricity applications*. June 16-20, Birmingham UK.

Sorrell, S., Mallett, A., & Nye, S. (2010). *Barriers to industrial energy efficiency : a literature review* (p. 87).

Sorrell, S., & Scott, S. (2000). Reducing Barriers To Energy Efficiency In Public And Private Organisations, (February 1998).

Stenqvist, C., & Nilsson, L. J. (2011). Energy efficiency in energy-intensive industries—an evaluation of the Swedish voluntary agreement PFE. *Energy Efficiency*, *5*(2), 225–241.

Swedish Energy Agency. (2011). Programme for Improving Energy Efficiency Experiences and results after five years with PFE (p. 8).

Swedish Energy Agency. (2012b). The electricity certificate system 2012. *Energy in Sweden 2012*.

Swedish Energy Agency. (2012c). The EU Emissions Trading Scheme after 2012.

Tanaka, K. (2011). Review of policies and measures for energy efficiency in industry sector. *Energy Policy*, *39*(10), 6532–6550.

Thollander, P. (2008). Towards Increased Energy Efficiency In - Barriers , Driving Forces & Policies (p. 73).

Thollander, P., & Ottosson, M. (2008). An energy efficient Swedish pulp and paper industry – exploring barriers to and driving forces for cost-effective energy efficiency investments. *Energy Efficiency*, *1*(1), 21–34.

Thollander, P., & Ottosson, M. (2010). Energy management practices in Swedish energy-intensive industries. *Journal of Cleaner Production*, *18*(12), 1125–1133.

Thollander, P., & Palm, J. (2012). *Improving Energy Efficiency in Industrial Energy Systems* (p. 161).

Thollander, P., Rohdin, P., Karlsson, M., Rosenqvist, J., & Söderström, M. (2012). A standardized energy audit tool for improved energy efficiency in industrial SMEs (p. 11).

Thollander, P., Svensson, I. L., & Trygg, L. (2010). Analyzing variables for district heating collaborations between energy utilities and industries. *Energy*, *35*(9), 3649–3656.

Thumann, A., & Mehta, D. P. (1997). Handbook of Energy Engineering. Lilburn, GA: Fairmont Press.

Tonn, B., & Martin, M. (2000). Industrial energy efficiency decision making, *28*(December 1999).

Tornatzky L.G, Klein K.J. (1982). Innovation characteristics and innovation adoption-implementation: a meta-analysis of findings. IEEE Trans. Eng. Manage., 29(1): 28-45.

Trianni, A., & Cagno, E. (2012). Dealing with barriers to energy efficiency and SMEs: Some empirical evidences. *Energy*, *37*(1), 12.

Trianni, A., Cagno, E., & De Donatis, A. (2014). A framework to characterize energy efficiency measures. *Applied Energy*, *118*, 207–220.

Trianni, A., Cagno, E., Thollander, P., & Backlund, S. (2012). Barriers to industrial energy efficiency in foundries : a European comparison. *Journal of Cleaner Production*, 17.

Trianni, A., Cagno, E., & Worrell, E. (2013). Innovation and adoption of energy efficient technologies: An exploratory analysis of Italian primary metal manufacturing SMEs. *Energy Policy*, *61*, 430–440.

Turner, W. C., & Doty, S. (2007). Energy Management Handbook (p. 924).

U.S Energy Information Administrad. (2013). *Annula Energy Outlook 2013* (p. 244).

United Nations Industrial Development Organization. (2011). *Barriers to industrial energy efficiency: a literature review* (p. 98).

US. Energy Information Admnistration. (2009). *World energy outlook*.

Van Gorp, J. C. (2004). Enterprising Energy Management. *IEEE Power and Energy Magazine*.

Verein Deutscher Ingenieure (VDI) (Association of German Engineers) (2007) - Guideline 4602, (p. 3), Beuth Verlag, Berlin

Vikhorev, K., Greenough, R., & Brown, N. (2012). An advanced energy management framework to promote energy awareness. *Journal of Cleaner Production*, *43*, 103–112.

Wai, C. W., Mohammed, A. H., & Ting, L. S. (2011). Energy management key practices : A proposed list for Malaysian universities. *Energy and Environment*, *2*(4), 749–760.

Walsh, C., & Thornley, P. (2012). Barriers to improving energy efficiency within the process industries with a focus on low grade heat utilisation. *Journal of Cleaner Production*, *23*, 138–146.

Weber, L. (1997). Some reflections on barriers to the efficient use of energy. *Energy Policy*, *25*(10), 833–835.

Worrell, E., Laitner, J., Ruth, M., & Finman, H. (2003). Productivity benefits of industrial energy efficiency measures. *Energy*, *28*(11), 1081–1098.

Worrell, E., & Price, L. (2001). Policy scenarios for energy efficiency improvement in industry. *Energy Policy*, *29*(April 2001), 1223–1241.

Wulfinghoff, D. R. (1999). Energy efficiency manual. *Energy Institute Press*.

Yin, R. K. (2009). Case Study Research: Design and Methods. Essential guide to qualitative methods in organizational research (Vol. 5, p. 219).

Yin, R. K., Quarterly, A. S., & Mar, N. (2008). The Case Study Crisis : Some Answers The Case Study Crisis : Some Answers *, *26*(1), 58–65.

Zailani, S., Jeyaraman, K., Vengadasan, G., & Premkumar, R. (2012). Sustainable supply chain management (SSCM) in Malaysia: A survey. *International Journal of Production Economics*, *140*(1), 330–340.

Zorzini, M., Hendry, L., Stevenson, M., & Pozzetti, A. (2008). Customer enquiry management and product customization: An empirical multi-case study analysis in the Italian capital goods sector. *International Journal of Operations & Production Management*, *28*(12), 1186–1218.

Zou, X., Dai, Y.-S., & Ran, X. (2007). Dual-Level Key Management for secure grid communication in dynamic and hierarchical groups. *Future Generation Computer Systems*, *23*(6), 776–786.