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Management as a Key Driver of Energy Performance
Final Report

Zurich/Neuchâtel, 15 November 2017

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Catherine Cooremans, Alain Schönenberger, Moez Ouni: Université de Neuchâtel
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Summary

Introduction

Energy consumption and its related issues – safety of energy supply, various types of pollution, and greenhouse gas emissions – are subjects of growing importance and awareness.

The easiest, quickest, and cheapest way to reduce energy consumption is to improve energy efficiency: the invisible fuel. In the context of the Swiss Energy Strategy 2050, energy efficiency is a strategic path towards a sustainable energy system. The core hypothesis of the M_Key research project is that management is a key driver of energy performance; consequently, the project focuses on energy efficiency of large-scale energy consumers (LSEC) in the industry and service sectors. There is considerable untapped energy savings potential in many companies in this regard. However, investments in energy efficiency often remain undiscovered and projects undecided upon, even though they may be highly profitable. A large body of international research has discussed this under-investment in energy efficiency, known as the "energy efficiency gap", and has developed the concept of barriers to energy efficiency to explain it.

The M_Key project tries to better understand how large-scale energy consumers (LSEC) make energy efficiency investments decisions. M_Key specifically aims to investigate the influence of energy management as a way to reduce the energy efficiency gap in companies, and thus increase their energy performance.

Conceptual framework

The mainstream line of thought explains energy efficiency decisions mainly based on energy cost and profitability. To analyse the influence of energy management on energy efficiency investments, Cooremans' (2011, 2012a, 2012b) theoretical framework of investment decision-making was used, which includes alternative energy efficiency research findings and tries to explain companies' investment decisions better than the mainstream theories. According to this framework, investment decisions are the result of a complex process influenced by many different factors.

Among the factors influencing investment decision-making, investment characteristics play a paramount role. Investments can be categorized according to their functional object (research & development, production, etc.) or according to their strategic character. The strategic character of an investment – its "strategicity" – plays a paramount role in decision-making. Strategicity can be defined as an investment's contribution to a firm's competitive advantage. It is more important than profitability in the competition for resources, which exists in any organisation. In short, competitive advantage is a three-part concept formed of three interre-

lated constituents: value proposition, cost, and risks. However, the strategic character is not an objective fact: it is perceived, diagnosed and interpreted as such by decision-makers and companies. Therefore, the same investment project can be interpreted and infused with meaning differently by different companies. Individual and organisational filters influence this perception.

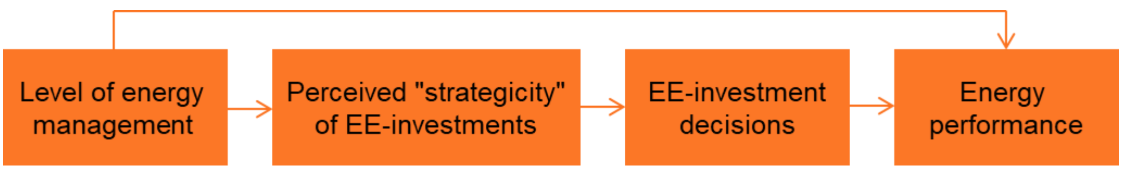
Research model

The objective of M_Key research is to better understand and describe the influence of energy management on a company's energy performance. The underlying core assumption is that energy management acts as an organisational filter which positively influences companies' perception of the strategic character of energy efficiency investments and, in turn, their choices regarding these investments.

M_Key also tries to confirm the relative importance of some other factors which, according to the literature review, appear to play a major fostering or hindering role. As a basis for the empirical work, M_Key took a detailed sounding of large-scale energy consumers in Switzerland and of the level and composition of energy management in Swiss companies. In Swiss cantonal energy regulations, large-scale energy consumers are usually defined as entities consuming more than 0.5 GWh per year of electrical energy and/ or 5 GWh per year of thermal energy.

Based on M_Key's theoretical framework, the influence of energy management on energy performance is hypothesised to happen through an impact chain which breaks down the influence of energy management on energy performance. Figure 1 illustrates the impact chain, which needs to be better understood.

Figure 1: M_Key's research model: The impact chain



Three relationships of influence to be analysed: 1) Influence of a company's energy management level on its perception of energy efficiency (EE) investment strategicity; 2) influence of energy efficiency investments' strategicity on energy efficiency investment decision-making; 3) influence of positive energy efficiency investment decisions on energy performance level.

Figure INFRAS, Université de Neuchâtel and Impact Energy.

Research questions and hypotheses

Based on the literature review and on M_Key's theoretical framework, the following research questions and hypotheses were formulated at the outset of the project (see Table 1):

Table 1: M_Key's research questions and hypotheses

Research Questions	Hypotheses
1. What is the level of energy management and its determinants in Swiss large-scale energy consumers?	1.1 The level of energy management in Swiss large-scale energy consumers is generally low.
	1.2 The main determinants of the energy management level are company size, company energy intensity and commitment or support of energy management by top management.
2. What is the influence of energy management on the perceived strategicity of energy efficiency investments?	2.1 The higher the companies' level of energy management, the more strategic they perceive energy efficiency investments to be.
3. What is the influence of the perceived strategicity on energy efficiency investment decision-making?	3.1 The more strategic an energy efficiency investment project is perceived by a company, the better the chances for positive decision.
	3.2 The less strategic the investments, the more restrictive the financial criteria in the selection of investment projects.
	3.3 The number of energy efficiency investments positively decided upon and realised depends mainly on the network relations/ knowledge exchange within the sector.
	3.4 Increasing requirements from cantonal energy policies for large consumers and/ or rising energy prices (in particular for electricity) positively influence energy efficiency investment decision-making by companies.
4. How does positive energy efficiency investment decision-making influence energy performance?	4.1 The higher the number of energy efficiency investments implemented, the higher the energy performance of a company (measured in energy intensity terms).

Table INFRAS, Université de Neuchâtel and Impact Energy.

Concept and methodology for empirical studies

M_Key combined quantitative and qualitative empirical research within the following three research methods that were applied sequentially: 1. survey, 2. interviews, 3. case studies.

The starting point was a large survey targeted to gather relevant data from Swiss large energy consumer companies. According to the 2011 Helbling survey (Brunner, *et al.*, 2012) on energy consumption in the industry and services sectors, there are about 10,000 (private) companies in Switzerland which qualify as LSEC. Those companies may have in total as many as 14,000 establishments (factory, plant, administrative or commercial building, *etc*.). In theory, the survey would have included all companies qualifying as LSEC. In practise—due to restrictions in time and resources—3,670 companies were contacted during the survey. The sample was composed as follows:

- Geographical distribution by language regions and cantons: in total about 13 cantons from the French-speaking part (the four cantons of Geneva, Friboug, Vaud, and Valais); the Italian-speaking part (Ticino), and the German- speaking part (Zurich, Bern, Basel-Stadt, Saint-Gallen, Luzern, Glarus, Graubünden, Solothurn and Aargau).
- Economic activities (two sectors, nine categories): industry with industrial food processing, chemistry, pharmaceutical, metal, instruments including watchmaking, machine and equipment, service with retail and wholesale, hotel, banks and insurance.
- Size of companies: large companies in terms of employment and/ or number of facilities plus a significant proportion of smaller companies.

About 900 companies responded to the online questionnaire, having at least started filling in the questionnaire. A careful process of evaluation resulted in the final selection of 305 valid responses, *i.e.* answers that were qualified as being comprehensive and strong enough for detailed analysis, and also of the correlation between determining factors and the interpretation of results.

Following the survey results, these 305 companies were asked to participate in interviews. The main objective was to gather further information to verify or falsify the hypotheses of the research project. Twenty-six companies were selected for face-to-face interviews, of which 18 companies were located in German-speaking Switzerland and eight were located in French-speaking Switzerland. Apart from the regional criteria, further selection criteria were the sector (two-thirds from the industry sector, one-third from the services sector), the range of energy consumption, and the level of energy management (as scored in the evaluation of the survey).

For the case studies, five out of the 26 interviewed companies were selected. The goal of the case studies was to verify the findings of both the survey and interviews, and to complement them with practical observations concerning the energy consumption, energy performance and energy efficiency measures implemented. Within the M_Key three-part research approach, the five case studies were the first and only time when the companies and their energy-using equipment had to undergo a “walk-through audit”, during which their energy efficiency data were evaluated and their past and future plans of energy efficiency measures were observed in more detail.

Main findings

Level and main determinants of energy management (EM)

The level of energy management of the companies was evaluated for the first time based on a 23-point scale. The energy management of the respondent companies is currently at a rather low level (10.3 points out of the maximum reachable score of 23 points).

The set of main determinants of EM is larger than expected. In most cases, one of the three factors mentioned in the hypotheses (company size, energy intensity, support from top management) is considered to be dominant. Other important factors are the public policy and the energy manager's support. A common result of all empirical studies is that the support from the top management seems to be the most relevant factor.

Influence of energy management on perceived strategicity

In general, no clear impact of the EM on the perceived strategicity of energy efficiency (EE) investments could be observed. The results of the interviews and the case studies indicate that in most companies the direction of the observed influence is the contrary: the more strategic EE investments are perceived, the more important strong EM is considered.

The main contribution of EM is that it informs decision-makers with reliable and solid data[1] regarding energy consumption and cost, energy efficiency projects and the energy savings they have the potential to generate. By providing facts and figures, it tries to make the impacts of EE measures quantifiable.

Strategic relevance of energy efficiency investments

Companies apparently have difficulty assessing energy efficiency investments. They often do not even know exactly how many projects were carried out over recent years, are not able to name the investment characteristics, or even identify which ones would qualify as strategic. In many companies, no specific budget category "investments to reduce energy consumption" exists at all.

Investments driven by efforts to strengthen the company's core business are generally considered to be more strategic than EE investments. High priorities normally dominating investment decisions are given to safety, continuity of production, and product quality. Many companies take energy efficiency aspects into account as a second step.

Large companies – or companies that are part of a corporate group – often have sustainability strategies and/or EE targets set by the top management or the corporate group. They put higher emphasis on EE and consequently EM. This is different in SMEs, for which the personal motivation and skills of the energy manager often are the main drivers of EM.

Financial evaluation of energy efficiency investments

Almost all companies apply at least one of the common methods to the financial evaluation of EE investment projects. More than 80% of them only use the simple payback method, without

[1] When they are available, which is often not the case, as demonstrated by another M_Key project finding.

using the two methods which enables to assess investment projects' profitability[2]: Net Present Value (NPV) and Internal Rate of Return (IRR). Most companies apply the following principle: the more strategic a project or investment is considered to be, the less restrictive the financial criteria applied are.

Influence of network relations/ knowledge exchange within the sector
Although many companies exchange relevant information and experience with other companies and participate in professional networks, most companies claim that decisions to implement EE projects are taken fully independently. The exchange of experience, however, is seen as a pool of ideas and innovation to stimulate the identification of EE potential and new projects.

Impacts of national or cantonal energy policies and/ or of rising energy prices
Public requirements (laws, regulations and incentive programs) appear to have a strong impact with regard to inciting companies to action. First, public policy influences EM positively. Second, public policy impacts EE investments, since it often triggers EE investments and/ or speeds them up. The most relevant public requirements appear to be the CO_2 target agreements, supported by CO_2 levy reimbursement agreements. Companies generally do not anticipate increasing future requirements from federal and cantonal energy policies.

Most companies take their investment decisions based on today's energy prices, which are taken for granted to remain constant in the future. Possible changes in energy prices are rarely considered, except in the case of large companies, whose energy intensities (the ratio of annual energy cost to gross added value) are significant (at greater than 5%).

Influence of energy efficiency investment decisions on energy performance
A majority of companies (60%) that have implemented EE projects over recent years claim to have experienced a reduction in energy consumption. However, these results have to be considered as merely qualitative evaluation, since many companies themselves expressed that they are not able to effectively assess any impact due to of a lack of monitoring tools and capacity. These companies cannot prove direct cause and effect relationships between EE measures implemented and energy consumption of the improved systems (as there are no specific measurements or analyses available).

[2] The payback method only indicates the time necessary to recover the initial investment, i.e. the time necessary to realise an operation without profitability (and without loss), while NPV and IRR evaluate investment profitability.

Main Conclusions

Based on the evaluation and discussion of the survey results, interviews and case studies, the following conclusions can be drawn:

Relevance of energy, in particular energy efficiency

Typically, energy issues are not a priority for companies. Since the share of annual energy costs, compared to the annual gross value added is mostly in the range of 1% to 3%,[3] the energy intensity is generally too small to be an issue of high relevance. The higher the energy intensity of a company, the more likely energy (and particularly EE) is considered to be relevant while deciding on investments. However, there is not a linear relationship between energy intensity and energy management but rather a threshold effect (*i.e.* above a certain level energy intensity becomes a significant decision-making driver and influences the level of energy management. There is virtually no difference between companies from the industry and service sectors.

In most of the five case study companies, the ceiling of possible, feasible and profitable energy efficiency improvement measures is not reached. When visited, in most of these five companies, untapped efficiency potential in thermal and electrical energy was observed: potential which the energy manager was not always aware of. For example, electrical machines like pumps, fans, and compressors for air and cooling were beyond a typical machine age, did not have load control, and seemed to be oversized. These untapped efficiency improvement potentials (Tieben, *et al*, 2015) and additional savings were not analysed in detail by the research team, compared to the planned list of measures.

Investments to strengthen the competitiveness of a company are normally driven by core business. They are rarely driven only by their potential to improve EE and hence reduce energy consumption, even though energy efficiency provides numerous benefits to companies: improvements in worker comfort, product quality, overall flexibility and productivity, as well as reductions in maintenance cost, risk, production time and waste. These benefits are labelled as "non-energy benefits" of energy efficiency. By positively contributing to companies' value proposition, cost reduction and risk reduction, non-energy benefits increase companies' competitiveness. In other words, non-energy benefits have the potential to raise the strategic character of energy efficiency investments (their strategicity). Therefore, non-energy benefits can be more important than energy benefits in convincing the management to invest in energy efficiency.

[3] INFRAS calculations based on Nathani *et al.* (2013) and Iten *et al.* (2015): Average energy intensity = 1.5%, median = value 0.9%.

Role, significance and influence of energy management

The concept of EM (based on the standard ISO 50001[4]) is not yet widespread in Swiss companies and LSEC. Many companies remain at a low level of resources, capacity and competence, their priority being to collect and compare annual energy consumption data.

The role of the energy manager is certainly a crucial element in the decision-making process and in the subsequent implementation of energy efficiency investments. Being a member of the SME's top management gives an energy manager more authority and opportunity to positively influence decisions and implementation of EE improvements. However, energy managers often lack know-how, time, resources, and influence.

Whenever investments are – at least partly – classified as investments to reduce energy consumption, companies generally consider this investment category as weakly or moderately strategic. The perceived strategic relevance of EE investments is determined by many factors, of which the level of EM is typically not an important one.

The predicted positive influence of (the level of) EM on the perceived strategicity of EE, on investment decisions, and ultimately on energy performance could not be confirmed. Instead, the impact is often the contrary: if energy (efficiency) is perceived as strategic, then companies tend to have a high or higher level of EM.

EM is mostly understood as an instrument for the identification and implementation of energy efficiency investments and has an important role in the EE investment decision-making processes of companies: the better the EM, the better the procedures of collecting and analysing data, and defining project ideas which provide transparent ground for decisions and increase the chances of a project proposal of being accepted and eventually implemented. However, in many cases, energy management can not fulfil this role because of a lack of monitoring and control tools (for instance meters and sub-meters).

Relevance of laws and regulations

Requirements from national or cantonal energy policies have a significant role (in the case of SMEs a key role) in inciting companies to action. While public policy strongly influences EM and indirectly EE investments, it also tends to have a direct positive impact on EE investment decisions, since it often triggers EE investments. However, most companies do not anticipate increasing stringency of these requirements in the near future.

Laws and regulations seem to be particularly effective for companies where the top management is not interested in energy efficiency. The management usually wants to comply with all regulations to avoid compliance issues. The chances of EM of realising EE projects can be

[4] ISO 50001:2011 – Energy Management System

increased by the importance given to the project *via* a competent external driver; this increases the chances of creating a commitment towards EE measures from the top management.

Influence of EE investments on energy performance

Although it seems to be logical that the higher the number of EE investments, the higher the company's energy performance, the M_Key project could not provide sufficient data and evidence to prove it.

Sixty percent of the survey responses and almost all interview partners expressed a positive influence of EE investments on energy performance. However, they had to admit that in fact, they could not prove direct cause and effect relations between EE measures implemented and energy consumption of the improved systems, since no specific measurements are available. The case studies confirmed this inability to prove the impact of specific measures since companies generally cannot provide sufficient data for a quantitative *ex-post* analysis.

Policy recommendations

Based on the results and experiences from the three sub-studies, the M_Key project team outlines an approach that is thought to be suitable for promoting EM and EE improvement measures in LSEC. This approach structures the individual recommendation *as per* the headings given below.

Reinforcement of information, education and training; additional technical support

1) The support to LSEC and energy-intensive companies regarding the understanding of the federal and cantonal regulation and incentive mechanisms should be improved (better structured and more specified information).
2) Efforts should be taken to better define the position of an energy manager, including common tasks and duties. Once done, syllabuses of instructions/ reference manuals for EM should be produced and training programmes set up for energy managers.
3) Additional support should be provided to LSEC, through qualified external know-how for initial analysis and identification of potentials as well as the implementation of energy efficiency improvements and follow-up. Particular support should be provided in:
   - intensified specific expertise in the electrical field;
   - illustrative and and easily-understandable information and practical tools regarding the identification, evaluation, and communication of the non-energy benefits of energy efficiency projects;
   - methods or tools regarding systematic and improved monitoring of energy savings.

Expansion and intensification of national and cantonal strategies and regulations

4) The extent of the goals of the target agreements related to the CO_2 levy and the cantonal requirements for large-scale energy consumers should be critically assessed. If there is room for improvement, options should be explored to set targets at a higher level. Furthermore, potential for strengthening the supervision, monitoring and control of the target agreements should be assessed.

Additional instruments

5) A common obligation for energy audits, as is the case already in the European Union (see Energy Efficiency Directive 2012/27/EU), should be checked. If, despite the fact that the EU system is different from the Swiss system, such a common obligation turned out to be reasonable and realisable, it should be established. It should be further examined if the obligation for energy audits should be combined with a financial incentive system.
6) The empirical results of this study confirm the relevance of energy cost as one of the relevant drivers for the strategic relevance of EE investments. Accordingly, a stepwise and foreseeable increase of prices for conventional energy sources by levies would be an effective measure to promote the implementation of energy efficiency measures in LSEC.

Abbreviations

ACT	Cleantech Agency Switzerland (Cleantech Agentur Schweiz)
EE	Energy efficiency
ETS	Emission Trading Scheme
EEM	Energy efficiency measure
EM	Energy management
EnAW	Energy Agency of the Swiss private sector (Energie-Agentur der Wirtschaft)
EnDK	Conference of Cantonal Energy Directors (Konferenz Kantonaler Energiedirektoren)
EPFL	École polytechnique fédérale de Lausanne
GDP	Gross domestic product
GHG	Greenhouse gas
HSLU	Lucerne University of Applied Sciences and Arts (Hochschule Luzern)
IEA	International Energy Agency
IOT	Input-Output Table
IRR	Internal rate of return
ISO	International Organization for Standardization
KEV	Compensatory feed-in remuneration (Kostendeckende Einspeisevergütung)
KOF	Swiss Economic Institute
KPI	Key Performance Indicator
LSEC	Large-scale energy consumers (Grossverbraucher)
M_Key	Management as a Key Driver of Energy Performance
MB	"Multiple Benefits" of energy efficiency
MEPS	Minimum Energy Performance Standards
MuKEn	Harmonised energy regulations within each canton (Mustervorschriften der Kantone im Energiebereich)
NEB	Non-energy benefit
NPV	Net present value
PFE	Swedish programme for improving energy efficiency in energy-intensive industries
SFOE	Swiss Federal Office of Energy (Bundesamt für Energie, BFE)
SME	Small- and medium-sized enterprise
SNF	Swiss National Science Foundation

PART I – INTRODUCTION AND FRAMEWORK

1. Introduction

In Switzerland, as in other countries, energy consumption and its related issues – safety of energy supply, various types of pollution and greenhouse gas emissions – are issues of tremendous and growing importance. The easiest, quickest and cheapest way to reduce energy consumption is to improve energy efficiency: the invisible fuel. The 2014 IEA energy efficiency market report (IEA, 2014c:16) confirms energy efficiency's place as the "first fuel".

The importance of energy efficiency in energy policy was highlighted for the first time by Amory Lovins in a now famous paper, "Energy Strategy: The Road not Taken" (Lovins, 1976). In this paper, Amory Lovins diagnoses inefficient use of energy resources, resulting in an efficiency deficit: the "energy efficiency gap". Although energy efficiency in Swiss companies has been an important issue for more than two decades, there are only a few studies and analyses on the issue of the energy efficiency gap and of energy efficiency decisions by Swiss companies.

Switzerland's public policy efforts to curb energy consumption and greenhouse gas emissions, as well as their results, reflect those of many other countries: these policies have often obtained encouraging results, but there is still significant potential in many companies to reduce energy consumption. The Swiss Federal Office of Energy (SFOE) states on its website that "improving energy efficiency of companies contributes significantly to reducing energy consumption and CO_2 emissions in Switzerland". The potential is considerable, since not all energy-saving measures, which could lead to savings, have yet been introduced in companies. If all such measures were introduced in trade and industry, energy consumption in these sectors would be around 15% lower.[5] An energy efficiency gap has been demonstrated by Jakob and Häberli (2012), more specifically with regard to electrical efficiency potential in Swiss companies.

According to the International Energy Agency, if current trends continue in the years to come, two thirds of the economic potential to improve energy efficiency will remain untapped until 2035, including 55% of the energy efficiency opportunities in the industrial sector (Benoit, 2014).

Research has often found evidence of an energy efficiency gap, including in high energy-intensive industries. Various examples describe its existence: in the European cement industry (Moya et al., 2010, 2011), the US economy (DeCanio, 1998; Granade, et al., 2009), in several industrial sectors in Brazil (Sola and Xavier, 2007), in the German commercial and services sec-

[5] http://www.bfe.admin.ch/themen/00519/00522/index.html?lang=en.

tors (Schleich, 2009), in the German iron and steel industry (Brunke and Blesl, 2014), in the Swedish pulp and paper industry (Thollander and Ottosson, 2008) and steel industry (Johansson and Söderström, 2011), in the Belgian cement, ceramic and lime industries (Venmans, 2014).

For more than four decades now, scholars and practitioners have discussed the reality of an energy efficiency gap or have tried to explain it, generating abundant scientific literature.

In this research, we investigate the influence of energy management as a way to reduce the energy efficiency gap in private (for-profit) large-scale energy consumers, and thus increase their energy performance. The overarching objective of this study is to gain a better understanding of energy efficiency investments drivers. This, in turn, will contribute to the conception and implementation of adequate policy measures and regulations which aim to reduce the energy efficiency gap and to improve energy performance in private companies.

This final report documents the three-year research of the consortium INFRAS / University of Neuchatel and Impact Energy. The report is divided into three parts:

- The first part (I) summarises the state-of-the-art of national and international research on the subject and sets the conceptual framework for the study;
- The second part (II) presents the results of the three complementary empirical components applied successively in order to answer our research questions: 1) a standardised enterprise survey of large-scale enterprises, 2) qualitative interviews of a subset of company representatives, and 3) a case study with five selected companies;
- The third part (III) is devoted to the synthesis of the analyses carried out and develops policy recommendations derived from the research results.

2. Framework and fundamentals

2.1. Basic concepts and definitions

2.1.1. Energy efficiency, energy intensity, energy "intensivity"

In general, energy efficiency refers to using less energy to produce the same amount of services or useful output. This relationship can be represented by a simple ratio:

$$\frac{\text{Useful output of a process}}{\text{Energy input into a process}}$$

However, energy efficiency is a generic term and, as pointed out by several authors (Filippini and Hunt, 2015; Li and Tao, 2017; Patterson, 1996; Proskuryakova and Kovalev, 2015), and behind the apparently simple ratio above, there is no consensus on how energy efficiency is actually defined and measured. "Instead, one must rely on a series of indicators to quantify changes in energy efficiency" (Patterson, 1996:377).

Indicators can be categorized into four main groups: thermodynamic, which relies on the science of thermodynamics; physical-thermodynamic, which are hybrid indicators where energy input is measured in thermodynamic units, but output is measured in physical units (such as tonnes of product or square meters); economic-thermodynamic, which are also hybrid indicators where the service delivery (output) of the process is measured in terms of monetary units (such as market prices) while the energy input is measured in thermodynamic units; and finally, economic indicators, for which both the energy input and service delivery (output) are measured in monetary units (Patterson, 1996:378).

Each of these four indicators presents difficulties in measurement and evaluation. Even "thermodynamic measures of energy efficiency are not as satisfactory measures of energy efficiency as they might at first appear" (idem), because they only prove unique measures for a given process in the context of a particular environment (prescribed by temperature, pressure, concentration, *etc*.). Therefore, any change in the environment makes the measure obsolete. The difficulties associated with each type of indicator are discussed in detail by Patterson (1996).

The engineering approach measures thermodynamic indicators at the process level and focuses on the thermodynamic or physical-thermodynamic aspects. The scope of the economic or financial approach is broader since it can be applied to evaluate energy input and service delivery, not only at a process level (for instance, evaluating the number of litres of milk or beer produced) but also at the level of a company, a sector or a country (or a group of countries). The greater the distance between the physical reality and the level at which the economic-thermodynamic—or economic—evaluation is made, the higher the level of aggregation, and the greater the risk of approximation and confusion. Reconciling the so-called bottom-up approach (which aggregates engineering measures of process consumption) and the top-down approach (which hypothesizes and generalizes energy consumption of various entities) has always proven difficult, since the two approaches give quite different results (with bottom-up evaluations generally being more optimistic than top-down ones).

Economic-thermodynamic indicators are typically used in energy policy analysis. In this case, the result of the ratio (for instance physical units of energy input: GDP[6]) is generally not described as energy efficiency but as energy intensity, defined as "the amount of energy used per unit of activity" (IEA, 2009:19) or as the "energy consumed divided by an economic indicator (*e.g.* gross domestic product [GDP] or value-added by sector)" (IEA, 2014a). As emphasized by Filippini and Hunt (2015), energy intensity and energy efficiency are often used interchangeably, with energy intensity being taken as a proxy for energy efficiency. This is, however, not entirely accurate and can lead to misleading results since energy intensity is determined by many factors "which include the structure of the economy, the type of industry base, the exchange rate, the affordability of energy services, the size of a country, climate and behaviour. Efficiency impacts can be masked by variation in these non-energy-related factors" (IEA, 2014a:17).

To unmask the impact of non-energy-related factors and to assess the extent to which energy efficiency contributes to changes in final energy use, the IEA (2014a, 2017) uses decomposition analysis. This means that changes in energy use are decomposed, by sector, into three main effects: growth, structure, and efficiency.

Growth effect includes the level of economic activity (gross value added), population, and distances travelled by passengers and by freight.

The structure effect includes changes in the share of different sub-sectors, appliance ownership rates, floor area and number of dwellings per person, and the share of different modes of transport.

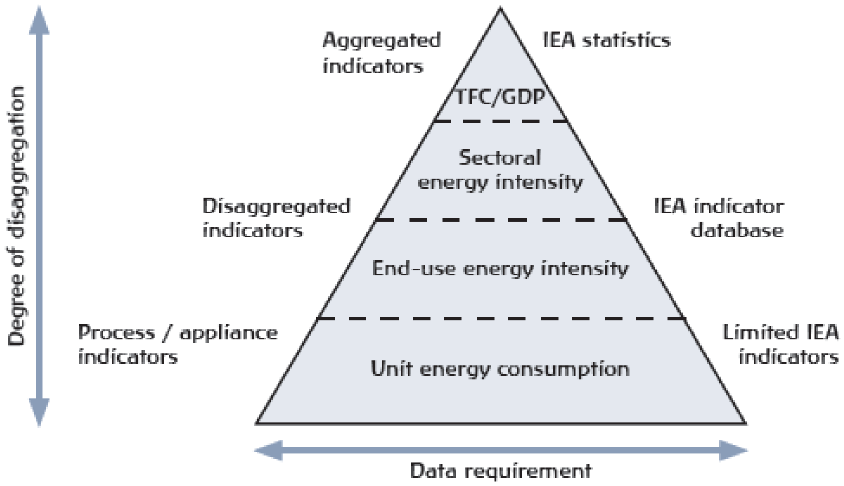
The efficiency effect includes changes in the amount of energy used per unit of gross value added in the industry and services sectors, per vehicle-kilometre in passenger transport and per tonne-kilometre in freight transport. In the residential sector, the efficiency effect varies depending on end use. For heating, cooling and lighting, it is the energy use per unit of floor area; for cooking and water heating, it is energy use per number of dwellings; for appliances it is energy use per unit of stock (IEA, 2017:20).

Of course, decomposition analysis does not erase all difficulties in tracking energy efficiency. Indicators are "powerful statistic tools" and "basic industrial processes and products are

[6] Gross Domestic Product

more or less the same across the world. This enables the use of universal indicators. However, as usual, the devil is in the detail. Comparing the relative energy performance of industries around the world needs to consider that individual technologies, qualities of feed stocks and products are often different in various countries even for the same industry (IEA 2007:21). In fact, comparing the relative energy performance of industries is also difficult for a country or for a sub-sector in a country, since effective aggregation depends on an often all-too-rare[7] resource: reliable data. The figure below illustrates the four levels of aggregation or disaggregation of IEA energy intensity statistics.

Figure 2: The IEA energy indicators pyramid



TFC = total final consumption. In the same report, IEA usefully provides energy indicators pyramids – and alternative pyramids, depending on data availability – for the residential, services, and industry sectors.

Figure IEA. Source: IEA (2014a:20).

M_Key research exclusively focuses on for-profit companies legally considered by the Swiss energy Law as "large-scale energy consumers", which means that they consume more than 0.5 GWh of electrical energy and/ or 5 GWh of thermal energy annually. This means a highly diverse population of companies. This diversity relates to the economic activities (industry and services) and sub-sectors concerned, as well as to companies' size (SMEs and large companies) and to energy consumption: some of the large-scale energy consumers are close to the lower limit of 0.5 electrical GWh per year while others consume massive amounts of energy[8] and can be considered as energy-intensive.

[7] As also highlighted by M_Key results.

[8] For instance, one company consumes 500 GWh electricity per year (0.8% of the total Swiss annual consumption) and 500 GWh natural gas per year (1.5% of the total Swiss annual consumption).

It is difficult to find precise definitions of "energy-intensive industries" in scientific literature. Wesseling, *et al.* (2017:1303) define energy-intensive processing industries as "industries that convert natural resources into basic materials through processes that require high energy inputs", but this definition remains vague with regards to what "high energy inputs" means. Similarly, in their in-depth review of methodologies and policies for evaluation of energy efficiency in high energy-consuming industries (2017), Li and Tao do not define what "high energy-consuming" means. The International Energy Agency (IEA, 2007) does not give any ratio of energy use in percentage of physical production, but indicates that energy-intensive industries' energy costs represent an important part of production costs (for instance, 60-90% of production costs in the chemical industry, 20–40% of production costs in the cement industry). IEA, rather, defines energy-intensive industries as industries belonging to some manufacturing sectors: chemical, petrochemicals, iron and steel, cement, paper and pulp, aluminium and other non-ferrous metals and minerals (IEA, 2007:21-22). Most authors follow the IEA sectoral categorization (Lechtenböhmer, *et al.,* 2016; Napp, *et al*., 2014; Prashar, 2017; Saygin, *et al*., 2011; Van Hasselt and Biermann, 2007). A precise definition can be found in the Swedish programme for improving energy efficiency in energy-intensive industries (PFE), which identifies energy-intensive companies by the following criteria: 1) purchases of energy products and electricity amount to at least 3% of the production value and/ or 2) the energy, carbon dioxide, and sulphur taxes on energy products and electricity used by the company amount to at least 0.5% of the added value (Stenqvist and Nilsson, 2012:228). Companies participating in PFE mainly come from the pulp and paper sectors, mining, iron and steel, non-metal minerals and industrial chemicals and, less often, from food processing industries, saw mills and engineering industries.

Concerning Switzerland, there are no official data on energy intensity (energy cost as a percentage of sales, or in relation of value added). A KOF study (Arvanitis, *et al.*, 2016) indicates, based on a representative survey of Swiss firms, an average intensity of 1.4% of sales (manufacturing 2.1%, construction 2.0% and services 1.2%). Here the indicator uses total sales; as is common in surveys it is easier to obtain this figure instead of value added. Based on the Swiss energy related input-output table (IOT) 2008[9] the average value of the share of energy cost of gross value added for Swiss private companies can be estimated at approximately 1.5%.[10] In this context it is not possible to identify the reasons for the differences between the two estimates of average energy intensity of the Swisscompanies. Nevertheless, the estimates give an indication of the order of magnitude of the average energy intensity.

[9] Nathani, *et al.,* 2013
[10] INFRAS calculations based on Nathani, *et al.* (2013) and Iten, *et al.* (2015): Average energy intensity = 1.5%, median value = 0.9%.

Swiss energy law applies a pragmatic concept of energy intensity: the provisions of the Energy Ordinance, which came into effect on 1 April 2014, have, among other consequences, revised the implementation modalities for the reimbursement of the network surcharge for electricity-intensive companies. Companies with electricity costs of at least 10% of their gross value added can apply for a full refund of the paid network surcharge. In the case of electricity costs of at least 5% and less than 10% of the gross value added, the paid network surcharge is partially refunded. Swiss CO_2 law applies an approach based on a list of greenhouse gas-intensive industries. It stipulates that greenhouse gas-intensive companies from industries which have a high tax burden in relation to their value added, and which would be severely impaired in their international competitiveness, can be exempt from the CO_2 tax. The relevant industries are listed in Annex 7 of the CO_2 Regulation.

The 2017 IEA report on energy efficiency shows that Switzerland has one of the lowest energy intensities, as defined by the value of primary energy supply (TPES) as a percentage of gross value added, adjusted to price level differences (at purchasing power parity), among the IEA member countries (Figure 3). Note that the share of high energy intensive manufacturing activities (chemical, iron and steel, pulp and paper, food processing and machine/ equipment) in the Swiss industrial sector (manufacturing) represents around 30% of gross value added, and the level of energy prices, which co-determines energy value and costs, lies in the second highest quartile in international comparison.

Figure 3: Industry energy intensity and contribution to industry gross value added from energy-intensive sub-sectors by IEA member country, grouped by energy price, 2015

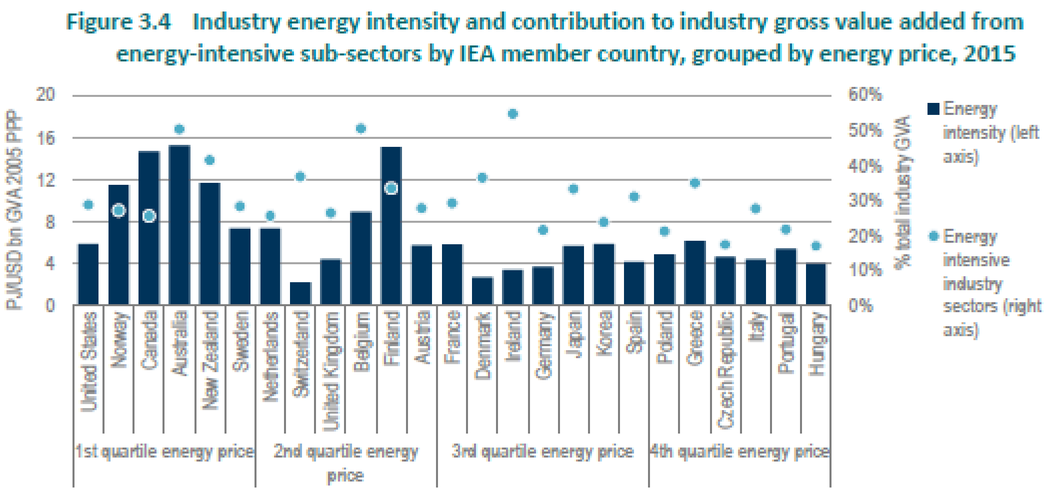


Figure IEA. Source: IEA (2017:71).

2.1.2. Energy management

Until recently, few definitions of energy management were available in the literature. A large majority of empirical research studied energy management without defining what energy management—or management in general—is. In fact, most researchers analysed, more or less comprehensively, the procedures which make up energy management, without giving a definition of the concept itself. As of today, there is no commonly accepted definition of energy management, and different definitions have been proposed. They are very diverse, as shown by Schulze, *et al.* (2016:3694), who list eight definitions in their literature review. Some definitions insist on the scope of energy management (for instance, according to O'Callaghan and Probert, 1977, energy management applies to "supply, conversion and utilisation of energy"), some focus on the means to be applied (for instance, Bunse, *et al.,* 2011:668, who indicate "control, monitoring, and improvement activities for energy efficiency"), and others focus on the general goal of energy management ("maximizing profits and enhancing competitive positions", as *per* Kannan and Boie, 2003).

A comprehensive definition of industrial energy management, provided by Schulze, *et al.* (2016:3704), considers industrial energy management as follows: "Energy management comprises the systematic activities, procedures and routines within an industrial company including the elements strategy/planning, implementation/operation, controlling, organisation and culture and involving both production and support processes, which aim to continuously reduce the company's energy consumption and its related energy costs".

More generally, the international standard ISO 50001 Energy management systems, issued in 2011, states that an Energy management system (EnMS) is a "set of interrelated or interacting elements to establish an energy policy and energy objectives, and processes and procedures to achieve these objectives" (ISO 50001, June 2011, Art. 3.9). This definition views energy management as a system, aiming at continuous improvement. Energy performance is quantified by measurable results related to energy consumption, energy use and energy efficiency.

ISO 5001 builds on several existing national standards (Denmark, Ireland, The Netherlands, Sweden, USA) in applying a five-step methodology: definition of an energy policy, energy planning (evaluation of energy performance and conception of an action plan containing energy efficiency measures), implementation of the action plan, analysis of results and correction for the next improvement cycle. This set of interrelated elements is important since experience has shown that energy performance gains from various one-off energy efficiency projects do not deliver sustained energy performance improvements if they are not monitored and adjusted in a continuous manner (Therkelsen, *et al.,* 2013; Jelic, *et al*., 2010; Ates and Durakbasa, 2012).

In this research project, we also consider the following definition relevant because it is the only one which emphasises the tri-dimensional nature of energy management: "energy management is the process of organisational, technical or human actions enabling organisations to use energy in a more efficient way and to reduce energy consumption in a profitable way" (Cooremans, 2015, Certificate of Advanced Studies in Energy Management, University of Geneva). As *per* this definition, organisational measures include financial, managerial, strategic or change management aspects, while human actions refer to individual behaviour, power or cultural aspects.

2.1.3. Energy efficiency investments

Although there is a huge stream of research on energy efficiency investments, it is again extremely rare to find definitions of the concepts of "investment" and "energy efficiency investment". To improve energy performance in an organisation, two general courses of action are available: the first one is optimisation of existing equipment use (*i.e.* without any replacement), and the second one is investment in new equipment (*i.e.* "capital investment")[11] according to finance theory terminology.

Capital investment can be defined, in essence, as cash outflow made in the present in the hope of future cash inflows. Beyond this generic definition—very important as it summarises the entire concept of what investing intrinsically means—different approaches define investment: in legal or accounting terms, an investment is the purchase of a fixed asset, *i.e.* the allocation of an expenditure to the balance sheet fixed assets, based on certain legal or accounting criteria (such as the amount of the expenditure). According to the dominant financial-economic perspective, the purpose of an investment is to increase a company's economic capacity and financial value. The strategic approach to investment, as discussed in Cooremans (2011), proposes a more complex view: investing, in the language of strategy, is related to a company's choices of development and "without strategy, without a direction, the emergence of good projects is unlikely to happen. The main part of the process lies in the identification of true problems" (De Bodt and Bourquin, 2001:127).[12] Investment decisions are not only financial decisions, but also strategic decisions because most strategic decisions translate into resource allocations or imply investment decisions. Strategic and financial approaches influence each other. Therefore, investment projects or decisions must be analysed by companies—and often are—not only from a financial angle, but also from a strategic angle.

[11] Often referred to as "Capex" in English business management terminology.
[12] We have freely translated from the original: "Sans stratégie, sans projet connu, l'émergence de bons projets est rendue peu probable. C'est dans l'identification des vrais problèmes que réside l'essentiel du processus" (De Bodt and Bourquin 2001).

Financial evaluation methods of investment projects enable judgement of the financial attractiveness of an investment in two ways: *profitability* measures the relationship between the capital invested and the ensuing income. Profitability is expressed in monetary terms (as in the case of net present value, NPV) or as a percentage (internal rate of return, IRR; return on investment, ROI). *Payback time* consists of calculating the time necessary to recover the initial spending (Capex). In other words, the payback evaluates the time necessary to realise an operation with no gain (and therefore with no profitability). Thus, the payback method does not evaluate the profitability of an investment, but the risk associated with it.

The expected reward of energy efficiency investment is the cost saving involved in a reduction of energy consumption. High energy prices favour energy efficiency investment but, in periods of low energy prices, engaging in energy efficiency investment might be less attractive compared to other investment opportunities, especially those related to companies' core business.

However, many benefits other than energy savings accrue in energy efficiency projects. Commonly referred to as the "Non-energy Benefits" (NEBs) or the "Multiple Benefits" of energy efficiency (MBs), they include important core business benefits, such as improved product quality, greater flexibility, reduced production time and losses, or reduced risks. Often-observed examples of MBs also include reductions of maintenance cost, increases in workplace comfort or safety (for instance when an old industrial oven is replaced by a new, better insulated one) and increases in productivity (due to lower production time or a reduction of the rejection rate). A reduction in GHG emissions is another frequently-observed MB of energy efficiency projects. Similar to energy benefits, multiple benefits of energy efficiency translate into financial benefits for the investor. Of course, NEBs vary from one investment project to another and between business activities. Not all proposed NEBs concern all firms.

According to the IEA report, *Capturing the multiple benefits of energy efficiency* (2014b), the monetary value of NEBs could be in the range of 40% to 50% of the value of energy savings per measure and they may lower energy efficiency project paybacks by more than half. MBs raise the strategic character and financial attractiveness of energy efficiency investments.

Therefore, considering NEBs can increase the attractiveness of an energy efficiency investment project, and thus the chances for a positive investment decision. Most NEBs involve lower cost and risk, as well as an increase of sales due to an improved value proposition to clients. However, there is no standard methodology to include these non-energy benefits in project analyses, and therefore engineers in charge of the projects often lack the skills enabling identification, analysis and evaluation of their monetary value.

In addition to the difficulty of evaluating non-energy benefits in the absence of a standard methodology, three main problems make the financial and strategic evaluation of energy efficiency investments difficult. First, the physical savings of an energy efficiency project are often difficult to assess precisely. Second, the translation of physical energy savings into monetary terms is problematic due to the difficulty of predicting future energy prices. This difficulty increases with duration. Third, managers in charge of energy efficiency projects—mostly engineers with a technical background—lack financial and strategic skills, which makes it difficult for them to properly evaluate an investment project in financial terms. The following quote illustrates the confusion often made in the field of energy between evaluation of profitability and evaluation of the time necessary to recover the initial spending: "one needs to determine the profitability of each energy efficiency measure by calculating the duration of the return on investment (CRDE, 2015:13).[13]

Almost all companies classify investment projects "Investments to maintain or renew existing production capacities" and "investments to increase productivity of existing means of production" are the categories recognized by the largest number of companies (Cooremans, 2012a). "Investment to reduce energy consumption" does not exist as an investment category for all companies (idem).

Energy efficiency projects can also be categorised in different ways. According to the Energy Efficiency Financial Institutions Group (EEFIG, 2017:17), EEFIG Underwriting Toolkit Value and risk appraisal for energy efficiency financing): "Energy efficiency projects can either be: 1) retrofits stand-alone projects where the primary purpose is improving energy efficiency such as changing lighting to LEDs. 2) Embedded – part of wider renovation projects such as building refurbishments or an upgrade of a production line that is being undertaken for other purposes such as increasing rent or change of product. An example would be replacing heating plant or adding insulation as part of a building refurbishment. 3) New build – new buildings and production lines tend to be more efficient than old ones due to improved technology and tighter regulations. Building just to regulation or norms should be considered 'business as usual' because in most situations there are cost-effective opportunities to improve energy performance beyond those levels which are neglected". Another categorisation is usefully provided by G20 Energy efficiency Finance Task Group (EEFTG, 2017:1). In the G20 Energy efficiency Investment Toolkit, which defines and separates "core" energy efficiency investments (those stand-alone projects where the delivery of energy savings is the lead driver) and "integral" energy efficiency investments (where overall asset performance is the lead driver, yet multiple benefits—including improved energy performance—are delivered by an incremental "embedded" investment).

[13] We have freely translated from the original : " Il faut déterminer la rentabilité de chaque mesure d'amélioration en calculant la durée de son retour sur investissement" (CRDE, 2015 :13).

In this research, we define investment in energy efficiency as an investment in which the reduction of energy consumption (obtained by using more efficient equipment) is a priority decision factor. Therefore, we focus on the first category identified by EEFIG and EEFTG: the “stand-up projects” or “core” energy efficiency investments. However, as will be discussed in analysis of the survey results, it is often difficult to precisely categorise projects, since companies themselves do not always make this categorisation or keep tracks of their investments in energy efficiency.

Within the framework of the Swiss Energy and CO_2 laws, financial evaluations of energy efficiency measures also have to make the difference between the total cost of an investment project and the portion of the total cost related to the energy improvements (which can be related to energy efficiency or to renewable energy sources).[14] Based on this principle, “the duration of the return on investment will be calculated by applying the following formula” (CRDE, 2015:13):[15]

$$\text{Durée du retour sur investissement} = \frac{\text{Coûts de l'investissement} \bullet \text{part des coûts liés à l'énergie}}{\text{Coûts annuels économisés}}$$

2.2. Swiss energy and climate policy review

2.2.1. Cornerstones

Improving energy efficiency is the primary pillar of the Energy Strategy 2050 (Bundesrat, 2013). Switzerland also has ambitious goals regarding CO_2 emissions reduction: according to the revised CO_2 Act, by 2020 the country intends to reduce its domestic greenhouse gases (GHG) by at least 20% in comparison to 1990. Based on this commitment, the CO_2 Act sets sector-specific emissions targets.

There is a wide range of instruments to reach these ambitious energy efficiency and GHG emissions targets in the industry and service sectors. In this regard, major policy instruments can be summarised as follows:

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[14] *“La part des coûts liée à l’énergie (%E) sert à évaluer quelle part des coûts de l'investissement effectué pour la mesure d’amélioration a été dépensée pour économiser de l'énergie. Comme il s’agit d’une estimation, il faut l’indiquer par paliers de 25 %. Si cette part est inférieure à 25 %, il est toutefois utile d'être plus précis.*
‘0%’ = Investissement réalisé uniquement à des fins de remplacement.
‘100%’ = La totalité des coûts sont destinés à l’amélioration de l’efficacité énergétique” (idem).

[15] We have freely translated from the original: *“La durée du retour sur investissement est calculée comme suit”* (CRDE, Guide pour l’analyse de la consummation énergétique [des gros consommateurs], 2015:13). In fact, the result of the calculation will be a percentage, as is normal for the result of a ROI calculation, and not a duration (months or years), which again illustrates the general confusion prevailing in the field of energy efficiency regarding financial evaluation of investment projects.

- CO_2 tax and Emission Trading Scheme (ETS): Since 2008, a CO_2 tax has been levied on thermal fossil fuels. The tax was set at of 60 Swiss francs per tonne of CO_2 for the period 2013 to 2020. It could increase to 120 Swiss francs per tonne of CO_2 post-2020 if pre-defined targets are not reached. The Swiss Emission Trading Scheme (ETS), similar to the Kyoto Protocol and European ETS, applies the "cap-and-trade" principle.[16] It is mandatory for companies with a total installed power of 20 MW or more (or that are engaged in an activity referred to in Annex 6 of the CO_2 Ordinance).
- The building programme is another key pillar of the energy and climate policy. It was begun in 2010 as a joint initiative of the federal and cantonal governments, and is financed by one-third of the CO_2 levy (currently around 300 million Swiss francs per year) as well as by cantonal contributions.
- Large-scale energy consuming companies (LSEC)—defined by the Federal Energy Act as agents whose annual energy consumption is equal or superior to 0.5 electric GWh or 5 thermal GWh per year—are a central concept and a principal target in the federal energy policy because they represent an important percentage of the total Swiss energy consumption. According to official figures, they consume between 30 and 50% of total cantonal electricity and may consume about one-fifth of total thermal consumption.[17]

Buildings are the physical vectors of LSEC's energy consumption. Almost no residential buildings consume more than 0.5 GWh electricity or 5 GWh thermal energy annually. Thus, large consumers make up almost exclusively tertiary buildings (administrative or commercial buildings) or industrial facilities.

2.2.2. Large-scale energy consumers

According to the Swiss Federal Energy Act, legal provisions for energy use in buildings fall under cantonal legislation. In 2008, the conference of the energy directors of the cantons (EnDK)

[16] The quantity of emission allowances available is limited. The total quantity of emission allowances is determined in advance, representing the maximum quantity available (cap). This cap was 5.63 million tonnes of CO_2 for 2013 and has been reduced each year by 1.74% of the initial 2010 quantity. The emission allowances needed for greenhouse gas-efficient operation are allocated annually, free of charge, to ETS companies and are tradable (trade). ETS companies are exempt from the CO_2 tax. Some 50 companies that together emit over five million tonnes of CO_2 are included in the ETS (Source: https://www.bafu.admin.ch/bafu/de/home/themen/klima/fachinformationen/klimapolitik/emissionshandel/schweizer-emissionshandelssystem--ehs-.html). Medium-sized companies in energy and trade-intensive economic sectors may voluntarily participate.

[17] Information regarding energy consumption by large-scale energy consumers in relation to total cantonal energy consumption are given in the following documents for the cantons of Geneva, Neuchatel and Vaud:
http://ge.ch/energie/media/energie/files/fichiers/documents/loi_plaquette-grands-consommateurs-pages.pdf
http://www.ne.ch/autorites/DDTE/SENE/energie/Documents/Conf%C3%A9rences/2016_12_13_GCE.pdf
https://www.vd.ch/fileadmin/user_upload/themes/environnement/energie/fichiers_pdf/GC_Pr%C3%A9sentatio_CVCI__20141006.pdf.

adopted the "model regulations of the cantons in the energy sector" ("MuKEn 2008"), aimed at reducing energy consumption in the building sector (EnDK, 2008). In 2015, the EnDK passed the revised MuKEn 2014 (EnDK, 2015). The articles concerning large-scale energy consumers (Articles 1.44 to 1.46) remained unchanged. According to the MuKEn, cantons can oblige large-scale energy consumers to analyse their energy consumption and to implement measures to improve energy efficiency (so-called the "large-scale consumers' article").

In principle, Swiss regulations, whether federal or cantonal, favour voluntary commitment to foster energy efficiency improvement and CO_2 emissions reduction. According to this approach, voluntary commitment frees a company from being legally obliged to improve energy efficiency or from paying the CO_2 tax. This principle is applied in MuKEn's Article 1.44. Article 1.45 specifies that measures to be implemented based on analysis of LSEC's energy consumption are considered as "reasonably required if they correspond to the state of the art, if they prove profitable over the life of the investment and if they do not entail major drawbacks at operations level". The principle is also applied in the Swiss Federal law concerning the reduction of CO_2 emissions. Companies in certain sectors can be exempted from the CO_2 levy if they make a commitment to the Swiss federal government to reduce their greenhouse gas emissions (reduction commitment).

To fulfil the cantonal (and the federal) requirements, LSEC have to choose between three options (EnDK, 2016):

- Conclude a universal target agreement, either with an energy efficiency target or a measurement target. The universal target agreement can be supervised by EnAW or act. It can also serve as a base for exemption from the CO_2 levy.
- Conclude a Cantonal target agreement, which is supervised by the Cantonal energy authorities.
- Elaborate an energy audit and implement the required measures to improve energy efficiency (supervised by the Cantonal energy authorities).

Whatever the option they choose, LSEC have to analyse their energy consumption and implement energy efficiency measures, matching pre-defined payback time criteria within a required time frame. In the universal target agreement with an energy efficiency target, an in-depth energy and operations analysis is carried out, while in the universal target agreement with a measurement target (aimed especially at small or medium-sized companies), a consultant performs an energy check-up (*i.e.* not an in-depth energy audit) to identify appropriate energy efficiency measures. In both models, targets for reducing CO_2 emissions and increasing energy efficiency are translated into a target agreement, which can be voluntary or binding.

At the end of 2016, 3,800 companies were engaged in a target agreement with EnAW: about 70% in the "Energy Model" for large companies and almost 30% in the model for small and medium-sized companies (EnAW, 2017). Energy management is one of the tools promoted by EnAW to help companies achieve the defined targets, no matter which model was applied. It is interesting to take note of the fact that the EnAW Energy management system was certified ISO 50001 in June 2013 (EnAW, 2014). As emphasized by EnAW, this means that "several ISO requirements are automatically met by utilising the EnAW tools".[18]

EnDK recommends that all cantons implement the model regulations completely and without changes. However, how regulations are introduced into cantonal legislation is ultimately decided by the cantonal parliaments. Therefore, precise legal provisions terms regarding LSEC vary from one canton to another, as well as the criteria defining which measures have to be implemented and the time allowed for their implementation.

In March 2017, 23 cantons (totalling at least 85% of the Swiss population) had defined requirements concerning large consumers in their legislation, most of them in accordance with the "MuKEn 2014" (BFE, 2017). Table 2 shows the current status of enforcement of the large-scale consumers' article in cantonal legislation.

Table 2: Status of enforcement of large-scale consumers's article in cantonal legistlation

Status of enforcement of the large-scale consumer's article	Year	Cantons
Implemented/being implemented	Before 2013	GE, ZH, NE
	Since 2013	AG, GL, GR, SG
	Since 2014	FR, TG
	Since 2015	BE, VD
	Since 2016	ZG
Enshrined in cantonal legislation		AR, BS, BL, JU, NW, OW, SH, SO, SZ, UR, TI

Table INFRAS. Source: BFE (2017) and EnAW (2017).

In most cantons, the legal basis for the implementation of the provision of the large-scale consumers is the cantonal energy law. The cantonal laws all explicitly offer the choice between an agreement or an audit of energy consumption, but only a minority introduce explicit targets as specified in MuKEn 2014, as well (*i.e.* an expected 2% annual average increase of energy effi-

[18] https://enaw.ch/en/enaw-tools-retain-certificate-of-conformity-with-iso-50001/ "Specifically, the support relates to clauses/requirements 4.4.3 Energy review, 4.4.4 Energy baseline, 4.4.5 Energy performance indicators, 4.4.6 Energy objectives, energy targets and energy management action plans, and 4.7.2 c), e), h) Input to management review".

ciency over a period of ten years). As a standard formulation, a majority of cantonal laws allow large consumers to be exempt from energy consumption analyses, provided that they are prepared to enter an agreement. At least four cantons (Aargau, Fribourg, Graubünden and Thurgau) specify minimum figures for the increase of energy efficiency in case large consumers choose the option of the energy consumption analysis. In all four cantons, the minimum expected efficiency increase is 15% within the first three years following the energy audit, a target that is much more ambitious than the target figures of an agreement at short term.

Limited information is available on the number of large-scale energy consumers at the cantonal level, both with regard to the number of large consumers in the canton as well as to the number of large consumers having signed agreements already, or being in the process of entering one. In addition, it is often unclear whether figures apply to the number of companies or to the number of buildings (tertiary or industrial). While some cantonal legislation clearly considers buildings as the unit to be taken into account for large consumers (for instance the pioneer cantons of Geneva and Neuchatel), other cantons, publicly available statistics, and presentations often refer to the number of companies (each company managing or owning at least one large energy-consuming building).

The variation of the number of large-scale energy consumers per canton is extremely wide (see BFE (2017)). Seven cantons (Appenzell Ausserrhoden, Appenzell Innerrhoden, Glarus, Jura, Schaffhausen, Solothurn, Schwyz) show figures in the range up to 100 large consumer units. Another seven cantons (Basel-Landschaft, Basel-Stadt, Fribourg, Graubünden, Neuchâtel, Thurgau, Zug) are home to between 100 and 400 large-scale consumers. Five cantons (Aargau, Bern, Geneva, Saint-Gallen, Vaud) show figures in the range of 400 to 700 large-scale companies. In the canton of Zurich, there are around 1,200 large-scale energy consumer sites.

Evaluations of the target agreements (and the CO_2 levy)

Several studies have been conducted during the past few years analysing the effectiveness of regulatory instruments (including the target agreements):

- Kuster, *et al.* (2009) evaluate the importance and the effects of the target agreements on companies, and draw three main conclusions. First, the net effect of the target agreement concluded before 2007 on the reduction of energy respectively CO_2 emissions was maximally 40%. This implies that 60% of the declared effect would have been reached even without a target agreement. Energy-saving investments, when made, depend primarily on their profitability and on the age-related need to replace the facility. Second, in more than half of the companies, the target egreement and/ or the EnAW-consultant collaboration resulted in a greater awareness of the importance of energy efficiency within senior management. This fostered the implementation of energy-saving measures. Third, given the procedures involved (consultancy, events, exchange of experiences with other companies), more than half of the companies learned about new technical opportunities to save energy during the implementation of the target agreement.

- Jakob and Häberli (2012) evaluated the performance of 620 EnAW partners and their 3'500 electric efficiency measures based on company reports. The average annual efficiency gain between 2003 and 2010 was 1% per year. Scenarios are presented to increase this effect by factors 2 to 3.
- Jakob, *et al.* (2016) did an online survey in 2015 with 4,300 enterprises (20% complete responses) in Switzerland to assess the effect of the CO_2 levy. A key element of the study was to determine the criteria of the companies in deciding whether or not to avoid paying the levy. Also, the research attempted to clarify the reaction of the enterprises if the levy were to be increased.
- Müller and Steinmann (2016) evaluated the target agreements in Switzerland, based on available literature, data of the 2'000 companies with target agreements and qualitative interviews with the actors involved in the implementation of the target agreements. While companies with target agreements reduced their energy consumption by 6% and their CO_2 emissions by 10% between 2013 and 2016, only 20% to 47% of these savings can be attributed to the target agreements. The companies would have implemented several measures included in the target agreements anyway. Especially in the large companies, in which energy costs constitute a significant factor for business success, the planned measures within the target agreements are those the companies had planned to implement anyway. In the smaller companies, the target agreements help to raise the value of energy and show efficiency potentials. On average, the set targets are not too ambitious (since for individual companies it can be a challenge). This has to do with risk aversion: companies prefer to set targets they are confident of achieving, and which allow them to avoid potential sanctions. As a result, the targets are significantly over-achieved on the whole. Overall, the system of the target agreements is assessed as cost-effective. The study recommends simplifying and harmonising the system of the target agreements with the LSEC obligations and providing one central point of contact of the federal government, as a "one-stop-shop". In addition, opening the market of external support to enable more competition alongside the two agencies active today is recommended, as well.

2.3. Key findings from literature review[19]

Energy efficiency investments — even when highly profitable — often remain undecided by for-profit companies. A rich literature has discussed this under-investment in energy efficiency, known as the "energy efficiency gap" and has developed the concept of barriers to energy efficiency to explain it. A significant amount of research has described the low level of energy management as a result of these barriers or has identified energy management as a way to overcome them.

What are the main factors which explain an under-investment in energy efficiency: the energy efficiency gap? In order to answer these questions and to assess the relevance and originality of our core research assumptions (see chapter 3), our literature review is organised around three main themes:

- Energy management: What is the level of energy management in companies? What are the main factors driving energy management? What is energy management contribution to companies' (energy) performance?
- Barriers and drivers: Many barriers and drivers to energy efficiency investments have been identified during the last three decades. We review the relevant literature in order to identify the most influential ones, to identify possible explanatory gaps and to further develop our research questions and hypotheses.
- Capital budgeting, methods of investment appraisal and financial criteria: How do companies in the field of energy efficiency investment assess financial attractiveness? What are the financial selection criteria applied? Are they the same selection criteria as for other investment categories?

2.3.1. Energy management

As emphasised by May*, et al.* (2016) and Schulze, *et al.* (2016), who both tried to summarise and evaluate the current state of the field of Energy Management in Manufacturing, the literature on energy management is growing. Schulze, *et al.* (2016:3697) highlight the "evolutionary development of the field": out of the 44 articles they selected, only four studies appeared between 1979 and 1999 and most of the articles were published in 2013.

Based on our literature review, the main findings regarding energy management are the following:

- Most surveys focus on industrial energy-intensive companies and/or on manufacturing (a significant exception is Schlomann, *et al.*, 2009, 2013). Indicators used to evaluate energy

[19] These key findings are based on the extensive literature review which is described in detail in M_Key Inception report. Please refer to this document for details and sources.

management vary greatly between surveys, making comparisons of results difficult, as also shown by the extensive literature reviews of May, *et al.* (2016) and of Schulze, *et al.* (2016) on energy management in manufacturing.

- Schlomann, *et al.* (2009, 2013), Bründl, *et al.* (2012), and Cooremans (2012b) provide the only research where a level of energy management is measured on a scale (although with different terminology and basis for measurement).
- Whatever the terminology used ("level of success," energy management "intensity," or energy management "level"), energy management is found to be low in most surveys, even in energy intensive companies. Energy management is found to be even lower in non-energy intensive companies.
- Although the general level of energy management is found to be low, energy management activities vary widely between companies.
- Many factors are put forward to explain the introduction and implementation of energy management by companies: improvement in the security of supply, reduction of energy-price risk, optimisation of energy procurement, reduction of energy costs, positive results involved in energy efficiency measures which could otherwise not be maintained in the long term due to the lack of a systematic approach (Kahlenborn, *et al.,* 2010). Few companies implement energy management systems on their own, *i.e.* in the absence of supporting governmental programmes.
- Companies' size and energy intensity seem to be the most important factors driving the adoption of an energy management system, together with top management support and commitment.
- On the whole, research concludes with a positive contribution of energy management to energy performance, whether at the level of a company or at the level of a country. However, the diverse approaches used in the studies make it difficult to compare their results.
- With the exception of some papers from the United States, the effect of energy management systems on companies' energy and carbon performance has hardly been addressed by academia (Böttcher and Müller, 2014) and few published studies can be found for benchmarking at company or plant level (Bunse, *et al.*, 2011).

2.3.2. Barriers and drivers of energy efficiency investment

The following main conclusions can be drawn from our literature review on the barriers and drivers of energy efficiency investments and of energy management:

- Barriers to energy efficiency are classified in multiple and various ways in the literature, which makes the comparison between different studies extremely problematic.

- Energy efficiency investment (or energy efficiency measure, EEM) decision-making is overdetermined, since many overlapping factors play a role.
- Size and energy intensity positively influence the adoption of EEM and/or energy efficiency investments (but there are also some contradictory research results).
- Sector (industry) seems to play a significant role in energy efficiency investment decision-making. One main reason would be that companies in the same sector have contact with each other or belong to the same network(s); as a result, they exchange information and/or imitate each other. However, a sector's influence and its modalities need to be better understood and deserve more research.
- Organisational context. A significant amount of research mentions the influence of elements of the organisational context (structure, strategy, corporate culture, resource availability, top management support, *etc*.) on energy management or on energy efficiency investment. Corporate culture is mentioned by several works of research as playing a major role in energy efficiency investment decisions. However, these works lack a theoretical framework to integrate their findings.
- Low priority of energy efficiency is often mentioned as a barrier. However, companies' highest priorities are rarely discussed.
- The link—or absence of such—of energy efficiency investments with core business is often mentioned as playing an important role in choices. Some researchers find the lack of link with core business as entailing increased stringency regarding the financial criteria applied to energy efficiency investments.

2.3.3. Investment characteristics, financial evaluation methods and selection criteria

The main findings regarding the financial criteria applied by companies to assess and select investments are the following:

- Although they often refer to the Sorrell, *et al.* (2004) taxonomy based on neo-classical, transaction costs and behavioural economics (to which they have added several various items), research in the field of energy efficiency generally reflects mainstream view that financial factors (access to capital, cost effectiveness) determine investment decision-making.
- A few works of research show, on the contrary, that profitability is not the main driver of investment decision-making and that financial evaluation tools often play a secondary role in corporate investment choices.
- To the exception of Cooremans (2012a), which analyses the influence of investment category on investment decision-making, no research systematically compares the financial methods and criteria applied by companies to energy efficiency investments and those applied to other types of investments.

- The payback time method seems to be by far the financial method most commonly used by firms to estimate the financial attractiveness of energy efficiency investments. In contradiction with financial theory, only a small minority of companies seems to use the net present value (NPV) and internal rate of return (IRR) methods to complement their payback analysis.
- Payback length criteria. The payback used by companies is generally equal to or less than three years, in line with finance investment choices theory.

2.3.4. Discussion of the literature review

After reviewing the most important contributions in the field (extensively until 2015 and partially for 2016), some striking elements emerge regarding energy efficiency decision-making by for-profit companies and regarding research on this theme.

Financial requirements are not the foremost criteria

- The mainstream perspective remains that financial considerations explain energy efficiency investment decision-making, and most energy efficiency investment research generally reflects, even implicitly, this dominant view. For mainstream energy economists, negative investment decisions are due to a high level of risk and a low real return (due to hidden and transaction costs and, sometimes, to the fact that energy savings may have been overestimated). Thus, for these economists, energy-saving investments are technically energy-efficient but economically inefficient. Yet energy economics, even enlarged to behavioural and principal-agent theories, does not properly explain why many profitable energy efficiency investment projects remain undecided by for-profit companies. As described by Cooremans (2011), the primary importance of financial considerations in investment choices given by mainstream energy economists is not satisfactory, for several reasons: "first, the rate of return for certain projects is such that none of the explanations provided can explain why potential investors reject them; second, the first step to reducing the energy efficiency gap is a simple adjustment of existing equipment, which is achievable at a negligible monetary cost; third, it does not explain the differences in behaviour between similar firms operating in the same industry; fourth, energy economists often mention the hidden cost as an explanation for not considering profitability, but never the hidden benefits of energy efficiency investments, although many such benefits, contrary to the hidden costs, have been estimated rather precisely. More profoundly, the financial approach analysis is flawed in two important aspects:
- First, one cannot pretend that profitability is only apparent, when the costs (hidden and transaction costs) responsible for non-profitability cannot be proved. Besides, it seems that these costs are not even taken into account by firms in their investment calculations.

- Second, payback time seems to be a well-accepted and commonly used criterion by firms in deciding on energy efficiency investments. This means that the debate in the literature on the high rate of return required for energy efficiency investments is artificial insofar as this rate is only implicit in the payback time method. When using this method, an investor's requirements rely on the time frame necessary to recover the initial spending and not on the investment return” (Cooremans, 2011:475).

Organisation is important but a conceptual framework is lacking

Over the last decade, an organisational perspective on energy efficiency investment decision-making has gained strength. This alternative perspective on the barriers and drivers to energy efficiency investments includes the work of academics and practitioners, mostly engineers, working in the field of energy efficiency. However, there is no unified approach on organisational barriers to energy efficiency, but rather a compilation of disparate observations. The literature identified has sought to identify the drivers of energy efficiency decisions taken by companies (whether related to energy efficiency “measures” or investment projects) or has analysed the reasons for differences in companies’ behaviour. However, authors of these streams of research have generally not tried to integrate their findings into a theoretical framework.

Energy efficiency investment decisions appear as being overdetermined by a high number of confusing and overlapping factors

Alternative research on firms' energy efficiency investments depicts investment decisions as a complex process which results from the interaction of numerous factors. The high number of factors identified as influencing energy efficiency investment decision-making *ipso facto* reduces the relative weight of financial factors on these decisions. Still, energy efficiency investment (or measures) decisions appear as being overdetermined by a high number of confusing and overlapping factors. This research offers often contradictory conclusions regarding companies’ behaviour: 1) a wide diversity, without any patterning, is observed between companies regarding energy management level and investments in energy efficiency, regardless of any sector influence, 2) the evidence for a possible patterning in firms’ behaviour is found by the Centre for Sustainable Energy and the Environmental Change Institute (CSE/ECI), University of Oxford, but this patterning is fragmented and partial, and more research across a broad range of sectors and size categories is needed (CSE/ECI, 2012).

Lack of transdisciplinary research

Researchers in the field of the barriers and drivers to energy efficiency investment have generally not tried to compare their findings with those of other research fields. This illustrates the ivory-tower approach, which unfortunately prevails in academic research. It is unfortunate because a transdisciplinary approach enables us to benefit from the findings of other streams of research. Energy efficiency investment decision-making can be related to several fields of research, which offer many fruitful concepts and findings: organisational behaviour, organisational finance, decision-making and strategic decision-making in organisations, and adoption of innovations. It is a striking fact that, to the exception of Cooremans (2011, 2012a, 2012b), no recent research has tried to compare its findings with those of other streams of research. The great number of findings accumulated by the Organisation Behaviour research field over several decades has remained almost totally unexplored by energy efficiency research.

In the case of energy efficiency investments, a transdisciplinary approach is extremely important, since it enables comparison between general investment decision-making and energy efficiency investment decision-making. In general investment decision-making, three evaluation methods (*i.e.* NPV, IRR and payback time) are commonly applied together to investment projects. On the contrary, the payback time method seems most often to be the only financial method used by firms to estimate the attractiveness of energy efficiency investments. This shows that different selection criteria apply to different investment categories and that a different—and apparently unfavourable—treatment (in terms of financial methods and selection criteria) is applied to energy efficiency investments compared to other investment categories. This important issue remains almost untouched by energy efficiency research (to the exceptions of Cooremans, 2012a, Kulakowski, 1999; Parker, *et al.*, 2000; Quirion, 2004).

Low priority and consideration of energy issues

Beyond confusion and complexity, energy and energy efficiency appear as being secondary and peripheral issues in many organisations and not taken into account in most organisational decisions (investment on new equipment for instance) which have an impact on energy consumption. Often, energy use and consumption are not even managed. When an energy manager is present in an organisation, he frequently lacks power because of the secondary nature of his mission. In addition, this manager sometimes lacks the skills necessary to promote energy efficiency within the organisation. One factor is often put forward as explaining the lack of consideration of energy in firms: the lack of contribution of energy issues to a company's core business. The importance of the link between an investment project and a company’s core business is also confirmed by organisational finance research. Another negative factor identified by the literature, as already mentioned, is a low organisational energy culture (though often without providing any definition of culture or of energy culture).

To conclude, there is still significant energy efficiency improvement potential in many companies, known as the energy efficiency gap. As this literature review has shown, for more than three decades different streams of research have tried to identify the reasons for this situation, building up a very rich literature on the "barriers"—market barriers, organisational barriers and human or behavioural barriers—or drivers to energy efficiency. However, the dominant view in this literature—that profitability explains investment choices—does not satisfactorily explain economic agents' energy efficiency investment behaviour and alternative research to mainstream lacks a conceptual framework to integrate its findings. No research has tried to systematically assess the influence of energy management on energy efficiency investments or on the energy efficiency gap.

This literature review, which includes contributions until 2016, shows that the factors explaining energy efficiency investment decision-making deserve further research. In particular, two factors which seem to play an important role need to be better explained: on one hand, the role and modalities of influence of energy management on these decisions; on the other hand, the relationship between investment characteristics (especially its link with core business and competitiveness) and the financial selection criteria applied.

2.4. Conceptual framework for M_Key research project

To analyse the influence of these two factors on energy efficiency investment, we use Cooremans' (2011, 2012a, 2012b) theoretical model of investment decision-making. This model is based on an extensive literature review of different fields of decision-making research, on a theoretical exploration of the academic field of decision-making and on Cooremans' own empirical research. Most parts of the model have been studied and supported by theoretical and empirical research.

2.4.1. A new model of investment decision-making

According to our theoretical model, investment decisions are the product of a complex process influenced by many different factors. Our investment decision-making framework, represented in Figure 4 below, is described in the following paragraphs.

Figure 4: A new model of investment decision-making

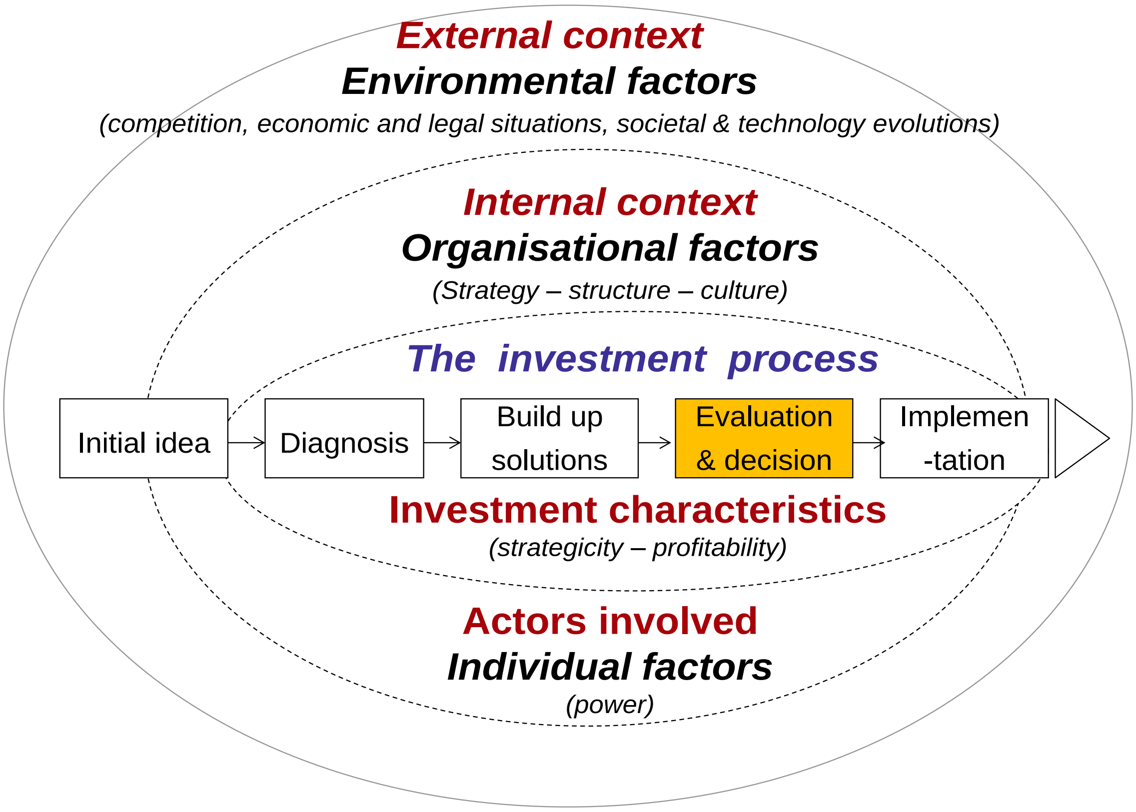


Figure Université de Neuchâtel. Source: Cooremans (2012a).

Decision-making: not a point in time but a process

A decision is a step in a decision-making process, defined as a dynamic chain of actions and events with three possible results: negative, positive, or no decision. The decision-making process comprises three phases: identification (diagnosis), development (build-up of solutions), and selection (evaluation of the different solutions and choices). In the real world, contrary to what is described in the figure above, the decision-making process is generally cyclical and uneven, with feedback loops, pauses, and dead ends. It is only linear and sequential in the case of highly structured decisions, based on ready-made solutions.

At the very beginning of the decision-making process, the diagnostic phase is crucial in two ways: firstly, it translates an initial idea (Desreumaux and Romelaer, 2001) into a decision event (or fails to do so); secondly, it influences the subsequent phases of development and selection.

Decision-making: a process influenced by organisational and external contexts
Organisational context and external context influence all of the decision-making process phases. Organisational context comprises structure, strategy, culture, control systems; the external context refers to the organisation's environment. Main external context components are competition moves, demand, social evolutions, regulation, the general economy, and technological progress. However, an organisation's environment is not given; rather, it is interpreted and "built" by actors' vision and by organisational filters (strategy, corporate culture, and control systems).

Decision-making: a process influenced by actors' power
The actors involved influence the course of the decision-making process and its result. Decision-making is political because organisations are political systems, *i.e.* they are collectives of people with competing interests. In any organisation, a dominant coalition (Prahalad and Bettis 1986), or a "key collection of individuals" composing top management, has a significant influence on the way a firm is managed.

According to Miller, *et al.* (1996), the dominant coalition is a "core triad of heavy-weight functions": production (or its equivalent in services companies), marketing and sales, and finance. Heavyweight functions are closely associated with core business. Together with general management, the dominant coalition imposes its choices upon the organisation because, "simply put, decisions follow the desires and subsequent choices of the most powerful people" (Eisenhardt and Zbaracki, 1992:23).

Decision-making: a process influenced by investment characteristics:
Investment characteristics strongly influence decision-making. Investment characteristics are numerous and diverse. They include investment importance to the organisation; the project complexity and the level of organisational change it would entail; the number of actors involved and the stimuli provoking them to action (threat or opportunity, level of urgency); the available solutions (*ad hoc* or ready-made, internal or external). Investments can also be categorised according to their functional object (production increase, new production, new product, human resources, *etc*.) or according to their strategic character (Cooremans, 2012:500). An investment's strategic character – its "strategicity" – plays a paramount role in decision-making. In our model, an investment is strategic "if it contributes to create, maintain or develop a sustainable competitive advantage". **"Strategicity" can be defined as an investment's contribution to a firm's competitive advantage. Competitive advantage is a three-dimensional concept, since it is formed of three interrelated constituents: costs, value, and risks**" (Cooremans, 2011:19). This definition implies that an investment, or an investment deci-

sion, is not simply strategic or non-strategic. Strategic decision-making is a continuum, where decisions can be non-strategic, weakly strategic, strongly strategic or totally strategic (Cooremans, 2011). Figure 5, below, represents the concept of strategicity in a simplified manner. Investment characteristics strongly influence decision-making. Investment characteristics are numerous and diverse. They include investment importance to the organisation; the project complexity and the level of organisational change it would entail; the number of actors involved and the stimuli evoking them (threat or opportunity, level of urgency); the available solutions (ad hoc or ready-made, internal or external). Investments can also be categorised according to their functional object (production increase, new production, new product, human resources, etc.) or according to their strategic character (Cooremans, 2012:500).

Figure 5: The three dimensions of competitive advantage

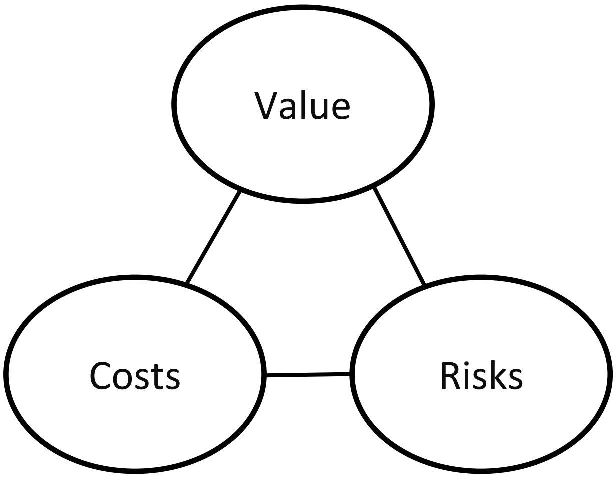


Figure Université de Neuchâtel. Source: Cooremans (2011:486).

It appears from this conceptual framework and from empirical research that strategicity is more influential than profitability in corporate investment choices. Strategic investments are thus in a better position to win the competition which exists between projects within organisations (a competition theorized by Langley, *et al.,* 1995). Investment profitability appears as a generally necessary but not sufficient condition. If a project is diagnosed as non-strategic, upper management will not be interested and sufficient resources will not be allocated.

Companies perceive energy efficiency investments, when they do exist as an investment category, as weakly strategic. When they do not exist as a category, they are placed in the category "Other", which most probably is not subject to the same procedures, consideration and resources. This would explain why many energy efficiency projects, although highly profitable, remain unchosen. This theoretical framework leads to propose an explanation of the energy efficiency gap different from the mainstream one, by redesigning the market barrier concept.

The strategic character of an investment is not given, it is interpreted

Companies perceive investments as strategic, and certain filters influence this perception: cognitive filters within individuals' minds, as well as interpretative filters in organisational systems.

At the individual level, information is distorted by the use of heuristics—rules of thumb, shortcuts, routines, which decision-makers use to simplify complex problems—and by cognitive biases. In addition to cognitive biases, which are common to all individuals, managers' personal pre-existing knowledge systems (also labelled as mental schemes or cognitive schemes) also act as filters of organisational events or issues.

Filters are especially powerful at the very beginning of the decision-making process in the issue diagnosis phase. Issue diagnosis – as well as strategic issue diagnosis – "infuses with meaning" new issues, data and stimuli, through the interpretation and judgement of decision-makers. In our model (see Figure 4) issue diagnosis is a sub-process of the decision-making process.

Dutton, *et al*. (1983) have theorised how decision makers in organisational settings diagnose strategic issues (on this concept, see also the next section on organisational filters). "Strategic decision makers in organisations are continuously bombarded by an array of ambiguous data and vaguely-felt stimuli which they must somehow order, explicate and imbue with meaning. Strategic Issue Diagnosis (SID) refers to those activities and processes by which data and stimuli are translated into focussed issues (*i.e.* attention organising acts) and the issues explored (*i.e.* acts of interpretation)" (Dutton, *et al*., 1983:308). Thus, during the issue diagnosis process, information is distorted or interpreted by filters, whether individual (cognitive biases and cognitive schemes) or organisational (interpretative schemes and pre-defined procedures and routines of the control systems).

Organisational context influences the emergence of decision-making process in the diagnostic phase, acting as a set of forces that constrains the way managers interpret their environment and the events that occur there (Alkaraan and Northcott, 2007; Daft and Weick, 1984; Kuvaas and Kaufmann, 2004; Thomas, *et al*., 1994). Therefore, the organisational context plays a major role in the process of attribution of meaning (Dutton and Jackson, 1987). Organisational context influences how managers interpret their environment by filtering information (Kuvaas and Kaufmann, 2004) and by creating incentives to interpret information in a certain way (Dennison, *et al*.; 1996; Thomas and McDaniel, 1990; Thomas, *et al*., 1994). As described by Lyles (1987:266), with reference to Weick (1979), "**organisations will invent the environment to which they will respond by deciding which aspects of the environment are important**

or unimportant". Therefore, the meaning given to a particular event will be different from one organisation to another and, since subsequent actions depend on the meaning attributed to an event or issue, organisations will respond differently to similar events (Dutton and Jackson, 1987; Dutton and Duncan, 1987; Meyer, 1982).

Most researchers of the cognitive approach admit the existence of these "interpretive mechanisms" (according to Johnson's, 1989, formula), under different names: organisational scheme or organisational level scheme (Cossette, 2004), organisational knowledge structure (Lyles and Schwenk, 1992), common cognitive system (Laroche and Nioche 1994), dominant logic (Prahalad and Bettis, 1986), ideologies (Johnson, 1989), interpretive schemes (Bartunek, 1984), cognitive maps (Bougon, *et al.,* 1977; Weick, 1979). The term "interpretive" overcomes the problem of using the term "cognitive" to describe mechanisms of production of meaning at the organisational level.

The organisational scheme plays the same role for organisations that the individual scheme for individuals: it structures the way a group, organisation, or even an industry apprehends reality, serving as a reference system in the observation or perception of current events, in the interpretation of past events and in the prediction of future events (Cossette, 2004), it directs research information (Bougon, *et al.,* 1977; Weick, 1979) and, finally, it influences decision-making or action. As main elements of the internal context, strategy, structure, culture and control systems of a firm are the main organisational filters.

There are interactions and mutual influences between individual and organisational levels: organisational context controls managers (through control systems), but managers influence organisational context.

The next section is dedicated to describing two important organisational filters in more detail: control systems and corporate culture(s).

2.4.2. Control systems and culture: two powerful organisational filters

Control systems are both elements of a firm's structure and an emanation of its culture (an artefact as per Schein's, 2004, terminology). As such, they are very powerful organisational filters: they influence the meaning and importance attributed to incoming events and information, as well as to new investment proposals, and they define the procedures to treat them.

Definitions of control systems put the emphasis alternately on their incentive or coercive aspects. Therefore, they are defined as "systems to influence individual efforts within the company" (Marginson, 2002), as "behaviour remote control" by Burlaud and Simon (1997:139), and as "control of managers' behaviour to ensure compliance with organisational strategies" (Alkaraan and Northcott, 2007). De Bodt and Bouquin (2001) give a more complete definition: "control is primarily a set of rules, formal or even informal, that normalize behaviour. It is less than we usually believe an analytical and sorting activity based on measurement. It is a mix of formal and informal, of trust and verification of individual behaviours, of choice of individuals and of incentive systems”.[20]

Control concerns external aspects (interventions performed by actors not involved in the current operations of the organisation, such as auditors) as well as internal aspects (rules implemented by the organisation itself). In determining, for example, at what level of the organisation investment projects can be initiated, based on what categorisations and budgetary autonomy, control rules influence the start, and therefore the course of investment projects (De Bodt and Bouquin, 2001). The various management systems existing in companies, such as the energy management system, are different types of control systems.

Some studies have attempted to assess the influence of control procedures on investment decisions and on strategy formulation. Alkaraan and Northcott’s research (2007), conducted with managers of major British industrial companies, building on organisational finance research by Slagmulder, *et al*. (1995), Butler, *et al*. (1993) and Van Cauwenbergh, *et al*. (1996), showed that control systems influence investment decisions in two directions: first, control procedures determine the pre-conditions under which an investment project will be identified as requiring a formal financial analysis; second, control procedures define the criteria upon which this analysis will be performed.

Results of the Alkaraan and Northcott (2007) research show that investment choices are influenced by financial criteria but that “how investment decisions take shape also depends on the decision objectives, strategies and procedures employed to guide choices and to harmonize different views...” (Alkaraan and Northkott, 2007:147). Their findings also reveal that “pre-decision controls, in a variety of forms, have a significant impact on how organisational actors view and evaluate strategic capital investment projects. The capital budget and capital expenditure limits at different hierarchical levels emerge as among the traditional accounting-based control systems most frequently used to guide the investment decision process. Formal project appraisal procedures, standard formats for investment proposals, hurdle rates, and pre-set authorization levels are also major pre-decision control mechanisms that influence managerial behaviour at an early stage in the investment process” (idem).

Control systems' influence on investment choices was mainly studied by the “Strategic Issue Diagnosis” (SID) research field. According to SID categorization theory, control systems codify the interpretation of strategic issues and perpetuate their initial categorization (Dutton

[20] Freely translated by us from: *“le contrôle, c'est avant tout un ensemble de règles, formelles ou même informelles, qui normalisent les comportements, et, au fond, moins qu'on ne le croit sans doute, une activité d'analyse et de tri à l'aune d'un instrument de mesure. C'est un assortiment de formalisation et d'informel, de confiance et de vérification, de choix des personnes et de systèmes d'incitation"* (De Bodt et Bouquin, 2001 :116).

and Jackson, 1987). They influence perceptions of actors within the organisation by making more or less important and visible certain aspects of business management.

Similarly, to the decision-making process (of which it is the first step), SID is a dynamic, complex, and non-linear process, unspecified and marked by successive revisions. Various actors are involved in SID. They have access or are sensitive to different data, which they analyse with different cognitive schemes, being run by different interests. The issue diagnosis finally emerges after successive judgment revisions resulting from the emergence of new data and the constant interaction between different actors and between the individual and collective levels.

Managers are influenced by the organisational context but in turn, they influence organisational context through their decisions on strategy, routines and control systems, and through their influence on organisational culture. There is a constant joint influence of individuals and organisational filters on (strategic) issue diagnosis. The relative weight of these influences varies from one organisation to another but also from one diagnosis to another. This is why, ultimately, "any attempt to explain why an organisation has made a particular diagnosis or why certain diagnosis outputs exist is incomplete unless it addresses these individual level forces in addition to issue-specific factors".

Energy management (EM) is a management system, focusing on managing energy usages in a company. **According to the conceptual framework described above, an energy management system, an element of organisational context, is an organisational filter which influences the investment decision-making process and the (perception of the) more or less strategic character of a new energy efficiency investment project.**

Organisational culture is another extremely powerful filter—or interpretative scheme—influencing organisations' behaviour. One useful definition of culture, according to the interpretative perspective on organisations, is proposed by Cossette (2004:121): "Culture is an organisational scheme, mainly composed of values which are more or less shared, more or less consciously, by organisation members. It is a normative system of ideas, ultimately shaped by the actors involved themselves; thus, culture is created, maintained and transformed by individuals who, themselves, have schemes, some of those being of a normative nature, *i.e.* composed of these individuals' personal values. This organisational scheme of culture is in close relationship with other organisational schemes, even if the influence of one scheme on another goes through individuals… The concept of culture almost always refers to values, defined as what is desirable in a given spatio-temporal context".

But corporate culture, in the field of energy as in other areas, is not the only culture that influences the values, beliefs and behaviours of actors (individuals and groups) because it interferes with other "spheres of culture" that influence interpretations and behaviour of individuals and organisations (Schneider and Barsoux, 2003). Corporate culture refers to the main values, *i.e.* those that are considered as priorities by the organisation members, it integrates basic assumptions and fundamental common beliefs that compose the "paradigm" (Johnson, 1992), the "dominant logic" (Prahalad and Bettis, 1986). Corporate culture more or less unifies (depending on its strength) sub-cultures in the organisation, but it does not erase them. Other cultures—or sub-cultures—are still alive. They include national, regional, professional, functional, and the sector of activity cultures. The more the content of these "cultural spheres" (Schneider and Barsoux, 2003) between organisation members is similar, the more cultural spheres they share, the more their cognitive schemes will be similar. Conversely, individuals' peculiarities create informal borders within the organisation between groups of different cultures, with different cognitive schemes and therefore a different way of perceiving their environment and of reacting to it.

Edgar Schein, one of the most important theoreticians of organisational culture, provides a useful framework to better understand how culture influences organisations' behaviour and decision-making. In his theory of organisational culture, he distinguishes between three major levels of culture—or levels of cultural analysis—defined as the "degree to which the cultural phenomenon is visible to the observer" (Schein, 2004:25; first published in 1985). These levels range from the least to the most visible or tangible. At the deepest, least visible level, there are the basic assumptions, deeply embedded and subconscious, which Schein defines as "the essence of culture". Basic assumptions comprise beliefs, perceptions, thoughts, and feelings. They are "taken for granted by group members and are treated as non-negotiable". At the most visible and tangible level, are the artefacts, the "overt manifestations that one can see and feel". Artefacts include structural elements, such as charters, as well as organisation processes, procedures and routines, reward and control systems. In between basic assumptions and artefacts are the "espoused beliefs, values, norms, and rules of behaviour" (idem). These in turn influence attitude (people's ideas, convictions or tastes) and behaviour (what people are doing)" (Schneider and Barsoux 2003:22).

Based on Schein (2004), as well as on Johnson (1989), we can consider control systems of an organisation as artefacts of its culture. **Being a special type of management system, energy management can therefore be regarded as an artefact of organisational culture, a manifestation of a company's energy efficiency culture. According to this logic, energy management can be considered as an indicator of the importance of energy in a firm's corporate culture**. Therefore, energy management should positively influence the perception of energy efficiency investment strategicity, through creating a more favourable organisational context to these investments.

According to our theoretical framework, energy management is both a type of control system and an emanation of corporate culture. Therefore, energy management influences energy performance not only through a set of operational tools (described in ISO 50001), but mainly as a filter positively influencing the perception of energy efficiency investment strategicity by firms, at the very beginning of the decision-making process (*i.e.* at the diagnosis stage). This is because on one hand, energy management as a control system makes energy issues visible in the organisation with rules and criteria to deal with them. On the other hand, as a manifestation of corporate energy culture, it acts as a positive filter in individuals and organisational perceptions of energy issues.

2.4.3. Conclusions on the theoretical model

More specifically, regarding energy efficiency investments, contributions of the research field of decision-making in organisations are valuable for three reasons: first, they allow escape from the debate about their financial profitability (real or apparent); second, they validate the criticism made by some energy economists (DeCanio, 1993) on the inadequacy of the dominant neo-classical economic theoretical framework to describe and explain energy efficiency investment decision-making; third, contributions of decision-making research allow the build up of the heretofore absent theoretical framework to better explain energy efficiency investment no-decisions.

On the whole, the theoretical framework described in this chapter better describes and explains energy efficiency investment decision-making than the mainstream, and enables us to integrate results of alternative energy efficiency research.

Research (see our literature review in Chapter 2.3) has shown that energy management positively influences a firm’s energy performance. Yet the importance of this influence and its modalities have to be better understood in order to better explain organisations’ behaviour and to be able to purposefully strengthen energy efficiency in companies.

Our conceptual framework explains—at least partially—why energy management positively influences companies’ energy performance: by acting as a filter which increases companies' perception of energy efficiency investment strategicity, it induces more positive decisions regarding these investments and, in turn, a higher energy performance. Therefore, the higher the energy management level, the higher the perceived strategicity of energy efficiency investments, the higher the number of energy efficiency investments, the higher the energy performance. The next section describes how this chain of events is translated into our research model.

2.5. Research model, relationship of influence

2.5.1. Development of the Research Model

Based on the theoretical framework described in the previous chapter, the first aim of M-Key's research is to better understand and describe the influence of energy management on firms' energy performance. As discussed in the previous section, the general assumption underlying the research is that energy management acts as an organisational filter which positively influences companies' choices regarding energy efficiency investments and in turn, companies' energy performance. Thus, in this overdetermined decisional situation which characterises energy efficiency investment decision-making, we focus our analysis on one relationship: the influence of energy management—an element of the organisational context which is, at the same time, a control/management system and an artefact of corporate culture—on the perceived strategic character of the investment. In doing so, we will also try to confirm the relative importance of some other factors which seem, according to our literature review, to play either a major fostering or hindering role: firms' size and energy intensity (other aspects of the organisational contexts); sector and networks (aspects of the external context), Swiss federal and cantonal policies (aspects of the external context). In order to verify this general assumption, we will take a detailed picture of large-scale energy consumers in Switzerland and of the level and composition of energy management in Swiss companies.

The next section describes the research model developed to verify this general assumption regarding the positive influence of energy management on energy efficiency investments and in turn, on energy performance.

An overarching aim of our research is to categorise companies along the drivers and practices of their energy efficiency investment behaviour, in order to help public programme developers and policy-makers build public programmes better adapted to support the implementation of the Energy Strategy 2050.

2.5.2. Three relationships of influence

Based on our theoretical framework, the influence of energy management on energy performance (this relationship is represented on the low part of the graph) is hypothesized to happen through an impact chain which breaks down the influence of energy management on energy performance. Along the impact chain, relationships of influence need to be better understood or confirmed, as described in the following paragraphs.

Three relationships of influence need to be analysed:

1. Influence of a company's energy management level on its perception of energy efficiency investment strategicity;

2. Influence of energy efficiency investments' strategicity on energy efficiency investment decision-making;
3. Influence of positive energy efficiency investment decisions on energy performance level. This impact chain is represented in Figure 6.

Figure 6: Impact chain

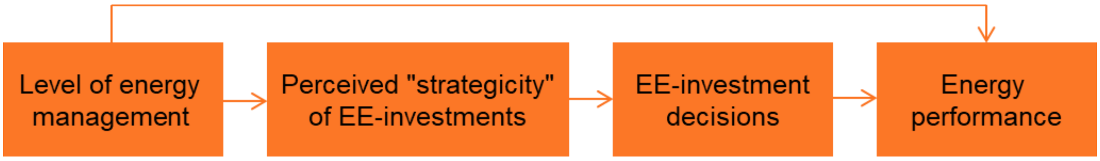


Figure INFRAS, Université de Nauchâtel and Impact Energy.

(1) Energy management level.

Energy management is defined[21] here as "the process of organisational, technical or human actions enabling organisations to use energy in a more efficient way and to reduce energy consumption in a profitable way".[22] We need to assess energy management level to be able to analyse its influence on the perceived strategicity of energy efficiency investments. An energy management system is composed of basic elements,[23] such as a commitment to continuous improvement of energy use and the existence of energy performance indicators, or of an energy manager. By assessing these elements, we can evaluate the level of energy management in a company (on a measurement scale). This level has often been shown as being low, even in energy-intensive companies (see Section 2.3). However, knowledge regarding the level and composition of energy management in Swiss companies is still insufficient. Energy management composition also makes reference to various organisational factors, such as the existence of an energy manager and of an energy team, their organisational power, top management support, and monitoring and control of energy use.

(2) Perceived "strategicity" of energy efficiency investments.

According to our theoretical framework (see Conceptual Framework, Section 2.4), financial criteria and financial evaluation tools play a secondary role in investment decision-making, in

[21] Please refer to Section 2.1.2, p.21, on energy management for a more detailed description of the concept and of other definitions.
[22] Adapted from Senter Novem (now the NL Agency) definition (http://www.senternovem.nl/mmfiles/3MJAF04.15%20-%20Energy%20Management%20Checklist%20-%20June%202004_tcm24-122945.pdf .
[23] based on the Bess project, NL Agency "Energy Management Checklist" (http://www.senternovem.nl/mmfiles/3MJAF04.15%20-%20Energy%20Management%20Checklist%20-%20June%202004_tcm24-122945.pdf), on the McKane, *et al*. (2007), framework and on ISO 50001.

spite of their extensive use. The strategic character of an investment is the most important decision-making factor, more important than investment profitability. “Strategic investments are thus in a better position to win the competition which exists between projects within organisations” (Cooremans, 2011:481). The role of other investment characteristics, such as the potential impact of an investment project on a company, or the controllability of an investment result, could also be sought in the recent literature[24].

The positive influence of strategicity on investment decision-making (the higher the strategic character of an investment the more likely it is to be chosen) has been demonstrated by research, whether on general investment decisions (Alkaraan and Northcott, 2007, 2006; Burcher and Lee, 2000; Butler, *et al*., 1991; Carr and Tomkins, 1996; De Bodt and Bouquin, 2001; Maritan, 2001; Van Cauwenbergh, *et al*., 1996) or on energy efficiency investment decisions (de Groot, *et al*., 2001; Sandberg and Söderström, 2003; Sardianou, 2008). Still, this influence has to be better analysed, as well as the relationship between investment strategicity and investment profitability in particular. Some research (Cooremans, 2012a, Kulakowski, 1999; Parker, *et al.,* 2000; Quirion, 2004) has shown that when strategicity is high, profitability requirements may be reduced by firms (for instance, a longer investment duration[25] is considered to calculate the investment profitability). However, this subject of crucial importance is practically unaddressed by research.

(3) Level of [perceived] strategicity of an investment

By assessing the level of strategicity, on one hand we can analyse how it is related to the level of energy management and on the other hand, how it influences investment choices:
An assessment of strategicity—through the analysis of an investment contribution to value proposal increase, risk decrease and cost decrease—also enables study of the non-energy benefits of energy efficiency investments for companies: an important and so far rather unknown issue at the investment project level. “Using the tri-dimensional concept of competitive advantage to analyse firms’ investment decisions highlights how different their needs and behaviours are, because sources of competitive advantage are varied and depend on the structure of the industry, as well as on firms’ individual activities and resources” (Cooremans, 2011:14).

Strategic logic encompasses financial logic. This leads to understanding why energy cost is an important decision-driver in energy-intensive industries only if cost leadership is a compulsory competitive strategy. If not, firms—even energy-intensive ones—may neglect energy cost reduction opportunities because corresponding investments are not strategic enough or

[24] The decisional weight of these investment characteristics has been studied by decision-making research but not by energy efficiency literature.
[25] Defined as the number of years taken into account to calculate investment profitability.

because they are less strategic than other investments. Therefore, energy efficiency investments projects, even if highly profitable, will lose out in the competition for financial resources and for the time and energy of powerful managers" (idem).

Energy performance

Positive influence of energy management on energy performance (normally in the form of reduced energy intensity) has been shown but it has to be more thoroughly and effectively assessed, especially in Swiss companies.

Other factors

Apart from the issues described above, the influence of several factors which have been identified by research on the barriers or drivers to energy efficiency as influencing energy behaviour (see Section 2.3) need to be included in analyses. These factors are: companies' size and energy intensity, sector, companies' networks, financial evaluation (including a possible difference in treatment of different investment categories), and federal and cantonal policies aimed at large consumers.

3. Research questions and hypotheses

Based on the literature review, our theoretical framework and our research model, we formulated our research questions and hypotheses. The general objective in this regard was to remain clear and straightforward in order not to fall into the same over-determination and overlapping traps as a lot of other research. This implied the following guidelines in the definition of the hypotheses:

- the number of hypotheses was limited and any redundancy was eliminated;
- the hypotheses had to describe the different parts and relationships of the impact chain between energy management and energy performance on which we focused (see Figure 6)
- whenever possible, hypotheses were grouped together.

The main research hypothesis is that energy management significantly raises companies' "perceived strategicity" of energy efficiency investments. Thus, energy management induces positive decisions regarding these investments and ultimately increases the energy performance of a company.

The research questions, which allow testing and/or verification of this general hypothesis by breaking down the impact of energy management on energy performance along the impact chain (see Figure 6) are the following:

1. What is the level of energy management and its determinants in Swiss large-scale energy consumers?
2. What is the influence of energy management on the perceived strategicity of energy efficiency investments?
3. What is the influence of the perceived strategicity on energy efficiency investment decision-making?
4. How does positive energy efficiency investment decision-making influence energy performance?

The following hypotheses test the validity of the above questions:

Research question 1: Level of energy management and its determinants in Swiss large-scale energy consumers

- Hypothesis 1.1: The level of energy management in Swiss large-scale energy consumers is generally low.

- Hypothesis 1.2: The main determinants of the energy management level are company size, company energy intensity and commitment or support of energy management by top management.

Research question 2: Influence of energy management on perceived strategicity of energy efficiency investments

- Hypothesis 2.1: The higher the companies' level of energy management, the more strategic they perceive energy efficiency investments to be.

Research question 3: Influence of perceived strategicity on energy efficiency investment decision-making

- Hypothesis 3.1: The more strategic an energy efficiency investment project is perceived by a company, the better the chances for positive decision.
- Hypothesis 3.2: The less strategic the investments, the more restrictive the financial criteria in the selection of investment projects.
- Hypothesis 3.3: The number of energy efficiency investments positively decided upon and realised depends mainly on the network relations/knowledge exchange within the sector.
- Hypothesis 3.4: Increasing requirements from cantonal energy policies for large consumers and/or rising energy prices (in particular for electricity) positively influence energy efficiency investment decision-making by companies.

Research question 4: Influence of positive energy efficiency investment decision-making on energy performance

- Hypothesis 4.1: The higher the number of energy efficiency investments implemented, the higher the energy performance of a company (measured in energy intensity terms).

PART II – EMPIRICAL RESEARCH

4. Overall concept and methodology

The project combined quantitative and qualitative empirical research within the following three research methods (applied chronologically): 1) survey, 2) interviews, 3) case studies. In order to validate or invalidate the research hypotheses (see section 3), quantitative and qualitative data were gathered from large energy consumer companies. The starting point was a survey of 305 companies. Based on the survey results, 26 companies were selected for face-to-face interviews and five companies for case studies. The three methodological approaches are complementary as the results of the standardised survey were supplemented (better understood) by the insights of the qualitative analysis (in the interviews and case studies). Contradictory outcomes were discussed and open questions defined if necessary. The following figure shows the research model and main methods used to verify and test the research hypotheses.

Figure 7: Research model and main methods

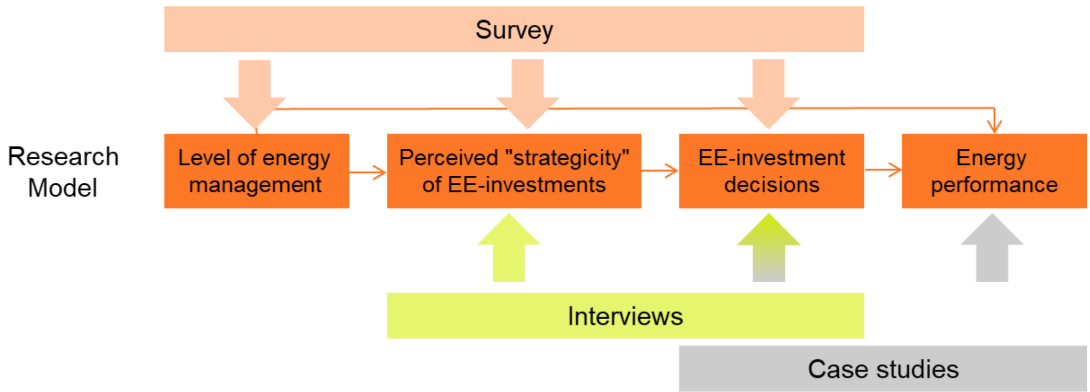


Figure INFRAS, Université de Neuchâtel and Impact Energy.

The data collection took the following elements into account:

- For the survey, only people in charge of energy (*i.e.* contact people on the list of electricity distributors or the list of large energy consumers of cantonal authorities) within the companies were contacted. This presented two advantages: 1) it provided important insights on what type of people (education, training, professional background, hierarchical position, functions) are in charge of energy in the organisation, and 2) these people, being energy protagonists, were probably more competent and willing to answer the questionnaire.
- The people in charge of energy issues in a company were not able to answer all survey questions (because they were related to very different subjects and approaches: technical, finan-

cial, managerial, strategic, *etc*.). The person in charge of energy issues would therefore look for answers from other people or managers in the company.

- Companies already engaged in energy efficiency projects and having some sort of energy management in place might have been more willing to answer the questions (selection bias).

Apart from the three main research elements described above (survey, interviews and case studies), documentary research was the initial step. It identified relevant literature and commonly available data to be used.

Allocation of issues to be addressed by the research methods

Table 3 summarises the principle organisation of data collection. The matrix indicates what type of information was collected and by which research method.

Table 3: Overview of the proposed empirical methods

Issues	**Research Methods**		
	Survey (305 companies)	**Interviews** (26 companies)	**Case Studies** (5 companies)
Research question 1: Level of energy management and its determinants in Swiss large-scale energy consumers			
Hypothesis 1.1: Level of energy management in Swiss large-scale energy consumer companies	X	–	–
Hypothesis 1.2: Main determinants of the energy management level, especially company size, company energy intensity and commitment or support of energy management by top management	X	X	X
Research question 2: Influence of energy management on perceived strategicity of energy efficiency investments			
Hypothesis 2.1:			
▪ Level of perceived strategicity of energy efficiency investments	X	X	X
▪ Relationship between the companies' level of energy management and the level of perceived strategicity of energy efficiency investments	X	X	X
Research question 3: Influence of perceived strategicity on energy efficiency investment decision-making			
Hypothesis 3.1:			
▪ Drivers and barriers for energy efficiency investments	X	X	X
▪ Relationship between the level of perceived strategicity of an energy efficiency investment project and the chances for positive decision	X	X	X
Hypothesis 3.2:			
▪ Type of criteria in the selection of investment projects	X	X	X
▪ Relationship between the perceived strategicity of an investment and the definition of the financial criteria in the selection of investment projects	X	X	X

Issues	Research Methods		
	Survey (305 companies)	**Interviews** (26 companies)	**Case Studies** (5 companies)
Hypothesis 3.3:			
▪ Number of energy efficiency investments realised	X	–	X
▪ Influence of the network relations/knowledge exchange within the sector on the number of energy efficiency investments positively decided upon and realised	X	X	X
Hypothesis 3.4:			
▪ Influence of energy policy for large-scale energy consumers (especially CO_2 levy and cantonal requirements) on energy efficiency investment decision-making by companies	X	X	X
▪ Influence of (rising) energy prices (in particular for electricity) on energy efficiency investment decision-making by companies	(X)	(X)	X
Research question 4: Influence of positive energy efficiency investment decision-making on energy performance			
Hypothesis 4.1:			
▪ Energy performance of a company	(X)	–	X
▪ Relationship between the number of energy efficiency investments implemented and the energy performance of a company (measured in energy intensity terms).	(X)	(X)	X

X = The research method collects the respective information; (X) = The research method contributes to collecting the respective information; – = The research method does not collect information concerning the respective topic.

Table INFRAS, Université de Neuchâtel and Impact Energy.

Synthesis of the results generated by the threefold approach

The results of the three approaches were evaluated and compared. At best, they were complementary in the sense that the results of the standardised survey were supplemented (better understood) by the insights of the qualitative analysis. Contradictory outcomes were discussed in a transparent way and open questions were defined if necessary.

The methods applied in the three empirical parts (survey, interviews, case studies) are described in detail in their respective chapters.

Boundaries of the M_Key research project

It should be emphasized, that:

- It was not part of the M_Key research project to analyse and evaluate the performance of activities and programmes in the framework of the implementation of the national and cantonal energy and CO_2 laws and regulations (such as obligations for LSEC and the implementation of the target agreements between the two energy agencies EnAW and act).
- In all three research phases M_Key observed only the perception of the receivers, who are subject to laws and regulations, training, subsidies and information programmes. Based on

the survey, M_Key assessed, the interviews and the case studies, what knowledge the receivers expressed, currently use, need and would like to have, with regard to the aforementioned policy measures. M_Key did not assess the various types of information and service provided by the sender (federal and cantonal level, EnAW and act, further programmes, *etc*.) to large-scale energy consumers and SMEs.

5. Survey

The overall objective of the M_Key research project is to better describe and understand the influence of energy management on companies' energy performance. In order to reach this objective, four research questions and eight hypotheses were formulated (see Chapter 3).
To examine the research questions on energy management by Swiss firms on a larger scale, a survey gathered quantitative data from large-scale energy consumers (LSEC), especially large-scale electricity consumers. The survey focused on the three links of the impact chain: energy management, the perceived strategicity of energy efficiency investment, and energy efficiency investment decisions and spending.

5.1. Methodology

This section provides the most important information about the questionnaire, the identification of the responding firms, the implementation of the survey, and the response rates. The survey was designed to assess these different elements, although at various degrees. It collected information and data from large-scale energy consumers on all four elements of the causal chain. Two hypotheses which have been formulated in relation to the theoretical framework in order to answer the research questions require the definition of an instrument for measuring the concepts. The first hypothesis, which postulates that "the level of energy management in Swiss large-scale energy consumers is generally low", implies defining a tool for measuring the concept "level of energy management". The third hypothesis, which postulates that "the higher the companies' level of energy management, the more strategic they perceive energy efficiency investments to be", implies defining a tool for measuring the concept of the strategic character (or strategicity) of an energy efficiency investment. The tools defined to measure these concepts are described in the third section below. The following section briefly describes the survey questionnaire.

5.1.1. Questionnaire

The questionnaire comprised 38 questions divided into 6 sections.

Section 1: Characteristics of the firms (12 questions)

The first section of the questionnaire identifies the main characteristics of the responding firm (location, number of establishments, part of a group or an independent firm, employment, sector of activity, energy consumption). This information is primarily used as independent factors which are likely to influence the four links, in particular the energy management system in place (and its level), and energy efficiency investment decision.

Section 2: Level and composition of Energy Management (12 questions)
Section 2 evaluates the level of energy management. The twelve questions of Section 2 constitute a simplified audit of energy management, based on the most important elements of national standards on energy management (DK, IR, NL, SW and USA) and of the international norm ISO 50001: knowledge of energy intensity, existence of an energy policy at company level, existence and role of an "energy manager", importance of energy issues within the firm, activities related to energy performance evaluation, allocation of resources in implementing energy performance measures, procedures to evaluate the results obtained, and existence of formal procedures regarding energy policy (*e.g.* training or reward schemes).

The level of energy management is measured empirically by aggregating the answers to six important questions. The answers to the six questions (out of the total number of 12 questions) are used to calculate an index for the level of energy management. A high score (number of points) means a high level of energy management; a lower score means a lower level of energy management. The maximum score that a firm can obtain is 23 points.

Section 3: Level of perceived strategicity of energy efficiency investments and drivers and barriers of energy efficiency investment projects (2 questions)
Section 3 aims to identify the level of perceived strategicity of energy efficiency investments and what the main factors positively and negatively influencing energy efficiency investment decision-making are. Both questions contain a list of 13 positive factors ("drivers") and 15 negative factors ("barriers"). If an important factor is not included in the list, the firm is able to cite it in the questionnaire. The firms are asked to evaluate the degree of influence of these factors on energy efficiency investment decision-making (1: not important at all; 2: unimportant; 3: moderately important; 4: important; 5: very important).

Section 4: Evaluation of Energy Efficiency Investment (6 questions)
There is little information available in the literature on the financial evaluation and the selection of energy efficiency investment projects. The intention of Section 4 is to investigate the financial methods and criteria used by firms to evaluate and select energy-efficient investment (EE-investment) projects. It also contains an important question on the number and size of energy efficiency investments and a list of non-energy benefits (NEBs) the firm might consider when evaluating the attractiveness of EE-investment projects.

Section 5: Public Policy (5 questions)
Public policy is a very important topic in the field of energy efficiency. Therefore, this section of the questionnaire is used to evaluate the impact of public programmes aiming to promote energy efficiency at national and cantonal levels. The questionnaire asks if and how the firms have chosen between the various public policy options available within the framework of the provisions on "large-scale energy consumers" to reduce energy consumption (Federal option-universal or SME, cantonal target agreement, or energy audit), and which partners they choose to implement energy efficiency measures.

Section 6: Impact on performance (2 questions)
The last section of the questionnaire seeks to evaluate, in very general terms, the impact of energy efficiency investment on firms' energy performance and on their financial and economic performance.

5.1.2. Implementation of the questionnaire

In theory, the survey would include all companies which consume more than 0.5 GWh of electricity and/ or more than 5 GWh of thermal energy per year. According to the research plan, the objective was to gather a sample of at least 2,000 large companies out of an entire pool of 10,000. The survey aimed to obtain a response from approximately one-fourth of the companies contacted (500 companies or more). Because the firms contacted were not drawn randomly from a representative pool or the whole population of large electricity/energy consumers, the responding firms are not, or to a very limited extent, representative in a statistical sense of Swiss companies. Table 4 shows the total number of firms to which the questionnaire link was sent (grouped by canton) and the corresponding response rates.

The identification of the participants, the coverage and the precise implementation of the web survey are described and explained in further detail in Annex 1.1, which also includes the entire questionnaire in English (originally in French and German).

Table 4: Number of questionnaires and valid responses by canton

	Total survey			
Cantons	Total number of questionnaires sent	Total number of valid responses	percentage	Total response rate
ZH Zurich	**191**	**25**	**8,20%**	**13,09%**
BE Bern/Berne	263	14	4,59%	5,32%
LU Luzern	**159**	**14**	**4,59%**	**8,81%**
UR Uri	3	0	0,00%	0,00%
SZ Schwyz	217	**27**	**8,85%**	**12,44%**
OW Obwalden	4	2	0,66%	50,00%
NW Nidwalden	6	0	0,00%	0,00%
GL Glarus	23	2	0,66%	8,70%
ZG Zug	20	2	0,66%	10,00%
FR Fribourg/Freiburg	**133**	**22**	**7,21%**	**16,54%**
SO Solothurn	78	4	1,31%	5,13%
BS Basel-Stadt	86	6	1,97%	6,98%
BL Basel-Landschaft	89	4	1,31%	4,49%
SH Schaffhausen	35	6	1,97%	17,14%
AR Appenzell Ausserrhoden	10	1	0,33%	10,00%
AI Appenzell Innerrhoden	5	0	0,00%	0,00%
SG St. Gallen	139	12	3,93%	8,63%
GR Graubünden	97	2	0,66%	2,06%
AG Aargau	**215**	**15**	**4,92%**	**6,98%**
TG Thurgau	**212**	**25**	**8,20%**	**11,79%**
TI Ticino	48	1	0,33%	2,08%
VD Vaud	**363**	**31**	**10,16%**	**8,54%**
VS Valais / Wallis	**330**	**23**	**7,54%**	**6,97%**
NE Neuchâtel	**131**	**12**	**3,93%**	**9,16%**
GE Genève	**240**	**32**	**10,49%**	**13,33%**
JU Jura	**65**	**22**	**7,21%**	**33,85%**
Total	**3'162**	**304**	**99,67%**	
Canton unknown	**500**	**1**	**0,33%**	
Total/average response rate	**3'662**	**305**	**100,00%**	**8,33%**
Max. excluding double accounting	**3'046**	305		**10,01%**

Table Université de Neuchâtel. Source: Survey, Université de Neuchâtel

5.1.3. Concept measurement

The transition from the theoretical to the empirical world is obtained by measurement. The measurement of a concept first implies discovering the components or dimensions of this concept and, second, defining the type of data to be collected for each of the dimensions identified (Thiétart, et al. 1999: 173). Based on our theoretical framework, which defines the concepts' dimensions, the next two sections will be dedicated to defining the data collected to measure the concept "strategic character of an energy efficiency investment", and those related to the concept "energy management level", respectively. Once these two concepts can be measured, one can study the relationship between them, or in other words, the relationship between the level of energy management of an organisation and the perception of the strategic nature of an energy efficiency investment.

Energy management level

Energy management is the process of organisational, technical or human actions enabling organisations to use energy in a more efficient way and to reduce energy consumption in a profitable way. Section 2.1.2 indicated the most important elements composing an energy management system. These components are included in the very ambitious and extensive "Energy Management Checklist", proposed by the Dutch Energy Agency. Based on this Checklist and on the basic components identified by practitioners and by research, Cooremans (2012a) has developed 6 questions, which compose a simplified audit of energy management in companies. M_Key questionnaire re-uses this questionnaire, with one additional question regarding the financial resources allocated to energy management.

As shown in Table 5, the simplified audit of energy management includes the following elements, which compose a sound energy management system:

- diagnostic of current energy consumption, energy policy development;
- presence of an energy manager in the organization;
- definition of performance measurement tools (indicators);
- setting of measurable objectives and consumption reduction measures;
- allocation of resources for implementation of the defined reduction measures;
- procedure for the evaluation of results and revision of objectives, staff training and gratification system.

The possible scores to be obtained by each question vary between 0 and 2 depending on the importance of the question. The total score can vary, theoretically, between 0 and 23 points. Table 5 already includes the number of responses obtained by the 305 firms having completed the questionnaire (in order to avoid replicating the table).

Table 5: Evaluation of the level of energy management

Questions	**Number of firms**	**Percentage**	**Score**
Energy manager			max. 2 points
Does the company have an energy manager?	162	53	yes = 2 / no = 0
Does the energy manager perform other functions in your company?	148	49	yes = -1 / no = 0
Which percentage does the cost of your energy consumption represent?			max. 2 points
Electricity cost, as a percentage of turnover (%)	216	71	2 pts, if at least 1 answer
Energy cost, as a percentage of your turnover (%)	183	60	
Did your company make a commitment of a continuous reduction of its energy consumption?	180	59	yes = 2 / no = 0
Did your company undertake any of the following activities in relation with energy use?			max. 9 points
Evaluation of its energy performance (bench-marking)	135	44	yes = 1 / no = 0
Definition of a baseline	74	24	yes = 1 / no = 0
Definition of key performance indicators	117	38	yes = 1 / no = 0
Definition of energy policy or strategy	108	35	yes = 1 / no = 0
Determination of measurable goals regarding a reduction of energy consumption	166	54	yes = 1 / no = 0
Definition and collection of data related to the achievement of the goals defined	147	48	yes = 1 / no = 0
Definition of measures and actions aiming at achieving the goals	149	49	yes = 1 / no = 0
Regular internal reporting on actions and measures taken and/or on results achieved	146	48	yes = 1 / no = 0
Which (internal and external) resources have been allocated to the implementation of energy efficiency measures?			max 4 points
Financial resources (*e.g.* audit cost)	196	64	yes = 1 / no = 0
Human resources (*i.e.* project team)	188	62	yes = 1 / no = 0
Technical resources (*i.e.* meters)	193	63	yes = 1 / no = 0
IT resources (*i.e.* monitoring)	105	34	yes = 1 / no = 0
Did your company organise the following systems and procedures in relation with its energy policy?			max 4 points
Training system for staff	68	22	yes = 1 / no = 0
Reward/bonus system	24	8	yes = 1 / no = 0
Assessment scheme of the results obtained	107	35	yes = 1 / no = 0
Procedure in revising goals	75	25	yes = 1 / no = 0
TOTAL	305	100	Max score = 23 points

Table Université de Neuchâtel. Sources: Cooremans (2010), adapted from SenterNovem - Netherlands Agency for Energy and Environment - Energy management checklist, 2004, Utrecht and McKane, et al. (2007).

Based on the original Energy Management Checklist" above, four levels of energy management are defined, as described in Table 6.

Table 6: Level of energy management by levels of electricity consumption

	Level and quality of energy management
0-5 points	No systematic EM, or system with serious flaws
6-10 points	EM does not meet the requirements in its applications and collecting of information
11-18 points	Good EM system with possibilities for improvement
19-23 points	High level of EM

Table Université de Neuchâtel.

Strategic character (strategicity) of energy efficiency investments

There are no commonly-accepted and universal definitions of the terms “strategic” and “strategic investment” in the literature or in everyday practice. In the present research, an investment is strategic “if it contributes to create, maintain or develop a sustainable competitive advantage”. Competitive advantage is defined as a three-dimensional concept, formed of the interrelated constituents: costs, value, and risks” (see Chapter 2.4.1). In the survey, the answers to the question on energy efficiency projects and spending, depending on the understanding by the respondents, may also to refer to “core-business” investments with an impact on energy savings.

The questionnaire includes a question on the strategic character of energy efficiency investment, *i.e.* what is the importance of the following factors, which positively influence the adoption of energy-saving technologies or equipment? Among the proposed factors (Table 7), the following eight, related to the three dimensions of competitive advantage (value-cost-risk), exert a favourable impact of energy efficiency investments on the core business of firms:

- enhanced positive image and reputation (dimension “increased value proposition”);
- higher quality or reliability of products and/ or of production process (increased value proposition);
- increased customer comfort (increased value proposition);
- energy-cost reductions (dimension “cost”);
- non-energy cost reductions (cost);
- lower production risks (dimension “risk”);
- lower risk of disruption in energy supply (risk);
- lower risk of disruption in energy supply (risk).

These elements are marked by an "X" in Table 7. One question was related more explicitly to the contribution of energy efficiency investments to companies' competitiveness ("Enhancing competitiveness" marked "Y" in).

Table 7 : Measurement of the strategic character of an investment

Question 3.1 What do you think are the factors that favourably influence the decision to adopt new energy-efficient technologies or equipment in your company?" 1: not important at all; 2: not important; 3: moderately important; 4: important, 5: very important	**Competitiveness drivers of investment decision (X and Y)**
Cost reductions resulting from lower energy use	X
Enhancing the positive image and reputation	X
Enhanced competitiveness	Y
Lower production risks	X
Other non-energy cost reductions	X
Higher quality/reliability of products and/or production process	X
Investment subsidies	
Increased staff comfort	
Lower energy price risks (instability)	X
Tax breaks	
Lower risk of disruption in energy supply	X
Increased customers comfort (*e.g.* commercial surface)	X
Cheaper financing (lower rate)	
Other factors, please specify	

Table Université de Neuchâtel. Source: Survey, Université de Neuchâtel

Having defined eight positive impacts of energy efficiency investments to companies' competitiveness, it is possible to measure the level of strategicity of these investments by aggregating the qualitative responses to Question 3.1 "What do you think are the factors that favourably influence the decision to adopt new energy-efficient technologies or equipment in your company?" It is also important to note that the term "energy efficiency investment" is not used, but rather the formulation "energy-efficient technologies or equipment" in order to minimise problems of understanding or interpretation as well as problems of interpretation related to the absence of this investment category in LSECs.

According to the Lykert scale used, 1 point is attributed to the answer "not important at all", 2 points to "not important", 3 points to "moderately important", 4 points to "important" and 5 points to "very important". The minimum obtainable score is 8 points (if a firm evaluates each of the 8 factors as "not important at all"; the maximum obtainable score is 40, if a company thinks that each of the 8 factors is "extremely important" (5 points).

5.1.4. Presentation of the results

The examination of the data collected and presentation of the results are carried out in three steps.

First, in this following Section 5.2, the frequencies of the responses are reported and discussed for each of the six thematic sections of the questionnaires: characteristics of the firms, energy management system, drivers and barriers as determinants of EE investment project, evaluation of investment projects, public policy and performance of the firms. The simple correlation analysis, which is reported in Annex 1.2, use representative information (variables) of each of the six sections of the questionnaire, to calculate the correlation coefficient for the relationships between the elements of the impact chain, thereby giving a first impression of the empirical validity of the impact chain of an energy management system. However, the values of the correlation coefficients between the variables implied by the research questions and the hypotheses are rather low, albeit some of them are statistically significant, and some have the wrong sign (with regards of the expected relationship between the variables).

Second, in Section 5.3, with the insights of the correlation analysis, explanatory equations on the level of energy management, perceived strategicity of energy efficiency investment, investment spending and energy performance are estimated econometrically and reported. The factors influencing each of the above concepts are to be chosen among the numerous variables (over 60), which are based on the answers to the 38 survey questions.

Finally, Section 5.4 presents and discusses the results with regard to the empirical validity of the research hypotheses and helps to formulate, in comparison with the results of the interviews and the case studies, practical and useful policy recommendations.

5.2. Frequency results

5.2.1. Section 1 – Main characteristics of the responding firms

Size of the firms

Large enterprises—in terms of employment and/ or number of establishments—dominate the sample of responding firms, of which there are few very small firms (Table 8). This is not surprising since the survey focuses on large-scale energy consumers (which tend to be larger firms but not exclusively) known by the cantonal authorities.

Table 8: Number of establishments and affiliates

Per firm 1	Total	Number of firms	Average number
0	123	123	1.0
1-3	164	107	1.5
4-10	230	39	5.9
11-100	1'075	27	39.8
101 +	6'928	5	1'385.6
Total	8'520	301	28.3

Table Université de Neuchâtel. Source : Survey data, Université de Neuchâtel

The table indicates that the survey sample only includes 123 single establishment firms (40%). Thirty-five percent of the firms have one to three establishments or affiliates, or 2% of all establishments and affiliates. On the other extreme, five firms own nearly 7,000 establishments and affiliates. Given this constellation, it is not possible to analyse the firms by cantons and to correlate their behaviour in energy matters with public policy at the cantonal level. Nevertheless, the impact of cantonal policies over all cantons, via an index of the intensity of energy policies, is tested in the section reporting the econometric results (see Chapter 5.3).

In very large enterprises and groups, energy management is often decentralised and the final responsibilities may be delegated to the establishments, branches or affiliates (subsidiary companies or legally independent firms), whereby the headquarters may issue guidelines and policies. Establishments, production sites or firms belonging to a mother company or a group would then be left with the responsibility of organising the details of the energy management system. On the other hand, affiliated firms and establishments in different cantons could be allowed to formulate own energy policy and strategy, depending on local conditions and policies. Energy policy towards large consumers are defined not only at the federal level, but also at the cantonal level, and this decentralised approach can have an impact on the choice of a target agreement and on the organisation of an energy management within large multiple sites enterprises.

Total employment as reported by nearly all firms which participated in the survey (302 firms), amounts to 331,700 employees (see Tables on employment by economic activities in Annex 1.1). However, there are 32 firms with 1,000 or more employees totalling 283,266 full-time equivalents (85%). The remaining 270 firms (89%) employ only 15% of the reported total employment.

Economic activities

The objective was to cover a wide range of economic sectors representing the structure of the Swiss economy according to the number of firms and employment:

- industry: food products and beverages (NOGA codes: 10, 11);
- chemical and pharmaceutical products (20, 21);
- plastic and non-metallic mineral products (22, 23);
- metal and metal based products (24, 25);
- electronic and optical products (26, including watchmaking);
- machinery and equipment (28);
- construction (41, 42, 43);
- service: retail and wholesale trade (NOGA codes 46, 47);
- transport (49-52);
- hotel and restaurant (55, 56);
- bank and insurance (64, 65);
- scientific, technical and, administrative services (70-75, 77-82).

All other activities are classified under “other industries” or “other services”. The primary sector is not included. A little more than half of the responding firms (179 firms or 59%) are active in industry, 11 in construction (4%) and 112 (37%) in the service sector (see Table 39 and Table 40 in Annex 1.1).

Energy consumption

The Swiss federal energy law defines large-scale energy consumers as sites (establishments or buildings) consuming more than 0.5 GWh of electricity or 5 GWh per year of thermal energy. According to Table 9, 265 firms are, according to the legal definition, large-scale electricity consumers. About 13% of the responding firms (37 out of the responding 302 firms), consume less electricity than the official threshold.

Table 9: Number of firms, by electricity consumption per year, and by sectors

	number of firms	percentage	industry and construction	service
below 0,5 GWh/year	37	13%	21	16
between 0,5 and 1 GWh/year	52	17%	32	20
between 1 and 3 GWh/year	94	31%	63	31
between 3 and10 GWh/year	74	25%	47	27
higher than 10 GWh/year	45	14%	28	17
Total	302	100,0%	191	111

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel.

Only 60 of the responding firms (20%) consume an amount of thermal energy higher than the official threshold of 5GWh a year. Thermal energy consumption of all small electricity consumers except one, consume less than this threshold.[26]

Other characteristics of the responding firms

Eighty-nine companies (29%) answered that they belong to an international group. Eighty-eight percent possess their own premises used for at least one of the three following purposes: administration, sales or production. Eighty-nine of the firms operate in a highly or very highly competitive market. Two hundred and twenty firms (72%), participate in at least one program or network which promotes energy efficiency. More than half of the participating firms (121) are in contact with EnAW, 42 are related to energy distributors (19%), and 23 to ACT (10%). Sixteen firms collaborate with the organisations Cleantech or Energo, whereas 53 firms (24%) are part of other networks and partners. About 43% of the firms (131) are privately owned by one person, a family, or several individuals, 30% have multiple private owners (92), and 53 firms are part of a group which is quoted on the stock exchange (18%). Finally, 26 (9%) are owned by a public administration (*e.g.* in public transport).

5.2.2. Section 2 – Energy management

Level of energy management

The 11 questions of Section 2 of the questionnaire aimed to evaluate the level and composition of the respondents' energy management. Half of the questions were used to quantitatively

[26] The results reported, except when mentioned, are those for the entire sample, including the small electricity consumers (less than 0.5 GWh/year). The consumption of electricity (and energy) may vary over time and for some responding firms the (estimated) electricity consumption could be below the official ceiling of 0.5 GWh/year. It is shown that the thresholds defining large electricity consumers have an impact on several links and relationship of the impact chain.

measure the level of energy management, with an index which takes values between 0 and 23 points.

Figure 8 shows the number of responding firms which obtained one of the 24 scores possible. The frequency pattern of the scores looks like a flat bell-shaped curve (resembling normal distribution) with a maximum number of firms for the scores 8 to 11 (except for score 2). The average score (in number of points) is 10.3. Half of the firms have a score of 10 or below (median).

Almost all 27 firms (9% of all responding firms) except three, which obtained two points only, provided a percentage of their energy intensities, but provided no answer to the other five questions, which define the score for energy management. These companies did not commit themselves to reducing energy consumption, nor undertake any actions, nor allocate any resources to energy efficiency, and did not engage in any schemes to promote energy efficiency. Less than half (exactly 11) of the 27 "score 2" firms, are small-scale electricity consumers.

According to Figure 9, there are virtually no differences between the 190 firms active in industry (including construction) and the 112 firms of the service sector, in terms of average and median scores.

Figure 8: Number of firms by level of energy management (N=305)

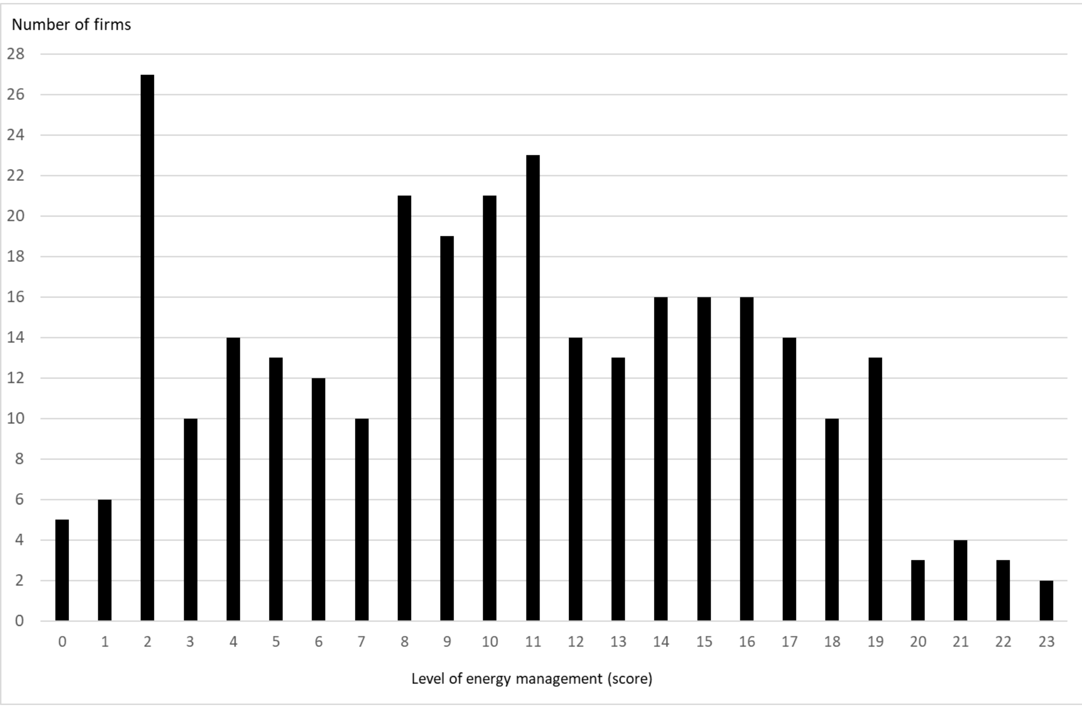


Figure Université de Neuchâtel. Source: Survey data, Université de Neuchâtel.

Figure 9: Level of energy management, by economic activity (number of firms in brackets, total N=302)

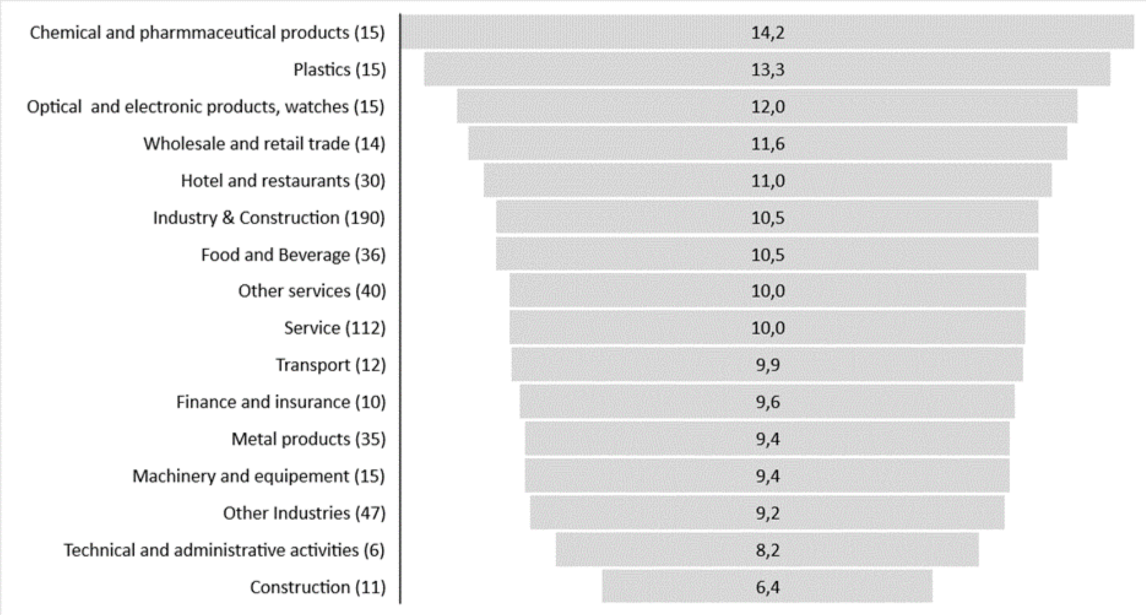


Figure Université de Neuchâtel. Source: Survey data, Université de Neuchâtel.

Elements of the energy management system

A closer look at the main elements which make up the energy management system[27] indicates the variety of behaviour and practices of the responding firms.

Activities:

Two hundred and fourty-five firms (*i.e.* 305 to 57 firms with no activities at all or 81% of all responding firms) engage in at least one of the activities composing sound energy management. The most frequent elements existing in companies are the following, ordered according to Table 10 their occurrence number:

- determination of measurable goals regarding a reduction of energy consumption (undertaken by 166 companies);
- definition of corresponding measures and actions (149);
- data collection (147 firms);
- regular internal reporting (146 firms);
- definition of a baseline (reference situation) (74 firms, 30% only of the 245 responding firms).

[27] We use the term “elements” based on ISO50001 definition: “An energy management system is a set of interacting elements to establish an energy policy and energy objectives, and processes and procedures to achieve those objectives” (ISO50001 – Art. 3.9). Also, see the questionnaire on the Simplified Audit of Energy Management, in the section “Concepts measurement”.

Table 10: Activities undertaken in relation with energy use (N=245)

Multiple answers possible	Number of responding firms	Share of total number of acti-vities	Percentage of all firms
Assessment of the energy performance (bench-marking)	135	13%	55
Reference situation (baseline)	74	7%	30
Energy performance indicators	117	11%	48
Energy policy	108	10%	44
Measurable goals of consumption reduction	166	16%	68
Data collection on the realisation of the objecti-ves	147	14%	60
Measures and actions defined to achieve the objectives of reduction of energy intensity	149	14%	61
Regular internal reporting on the energy actions taken	146	14%	60

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel.

Resources and ways to promote energy efficiency:

As shown in Table 11, 83% of the firms (305-49 = 256) invested some resources, internal or with the help of external partners (sub-contracting), in order to increase energy efficiency, mainly in financial and technical resources, and to a lesser extent in IT resources. Forty-nine firms did not engage in any energy efficiency measures at all.

Table 11: Types of resources used (N=256)

Multiple answers	Internal	External	Total	Number of firms
Financial resources (*e.g.* audit cost)	103	148	251	196
Human resources (*i.e.* project team)	177	60	237	188
Technical resources (*i.e.* meters)	154	74	228	193
IT resources (*i.e.* monitoring software)	81	42	123	105
None	70	116	186	49

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

Asked explicitly on any audit activity in another part of the questionnaire, two thirds of all firms (197 firms) indicated that they had invested in and undertaken at least one energy audit during the last four years, either on the building envelope (113 cases), on its premises and facilities (87) but most of them on the production equipment (164). One hundred and ten firms have undertaken two or even three energy audits. However, only a minority of these firms (less than

20%) have undertaken an audit within the framework of an energy efficiency subsidized program.

Systems and procedures

About half of the firms (156) have implemented at least one procedure in the framework of their energy policy. Two-thirds of these firms introduced some control and assessment on the results obtained by the energy efficiency measures implemented and about half introduced some procedure to revise their energy efficiency objectives (Table 12). Only a small minority rewards their staff in case of an improvement of their energy efficiency. It is important to remember that these results only apply to those companies having introduced at least one energy management procedure (156 out of 305 total number of respondents).

Table 12 also reports that less than one-third of the respondents have allocated technical resources, such as meters (or sub-meters) to support the energy management system.

Table 12: Use of systems and procedures in relation with energy policy (N=156)

Multiple answers possible	Number of procedures	% of procedures	% firms
Training system for staff	68	25	44
Reward/bonus system	24	9	15
Assessment scheme of the results obtained	107	39	69
Procedure in revising goals	75	27	48
Total number of schemes and firms	423	100	156

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel.

Level of energy management, energy consumption, and energy intensity

Table 13 shows that one-quarter (72) of the firms has no systematic energy management (EM). Nineteen of these 72 firms consume less than the legal threshold of 0.5 GWh per year. Small consumers should not be incited to take care of their energy consumption, because of the comparatively low intensity (2.4%, compared to 3.1%), and/ or because they are not part of the cantonal public policy aimed at promoting energy efficiency (see below). But this is by far not true for all small consumers, as only half of the 37 "small" electricity consumers present in the survey sample have no significant level of EM represented. The other half of the small electricity consumers shows at least some significant element of energy management. It should be noted that the average index for the small consumers is 7.4 points.

The 53 large electricity consumers which show no energy management (EM) or faulty EM represent 20% (=53/268) of the all large consumers. They have a slightly higher average electricity intensity of 2.8. At the other end, only about 7% of the firms–and one small consumer–have introduced a full-fledged energy management system which fulfils the criteria of the ISO 50001 Energy management system certification. Their average electricity intensity is 2.5 points, 0.6 percentage points lower than the overall average.

Table 13: Electricity consumption and intensity by level of energy management

	Level of energy management	Less than 0,5 GWh	Higher than 0,5 GWh	Total	%	Electricity intensity (% costs to turnover)
0-5 points	No systematic EM, or system with serious flaws	19	53	72	24	2.9
6-10 points	EM does not meet the requirements in its applications and collecting information	5	78	83	27	2.6
11-18 points	Good EM system with possibilities for improvement	12	112	124	41	3.6
19-23 points	High level of EM	1	22	23	8	2.5
0-23 points	All firms	37	267	302	100	3.1

Table Université de Neuchâtel. Source: Survey data, Université de

Of the 302 responding firms, the average electricity intensity, *i.e.* electricity costs as a percentage of turnover, is 3.1%. Taking into account the size (employment) of the firms, the weighted average electricity intensity falls to 1.4%. The weighted energy intensity (all energy sources including electricity) of all firms having provided the information is 2.1% (compared to the simple average of 4.3, Table 43, Annex 1.3). The responding firms of the survey show a higher level of energy intensity than the national average of all firms, as one can expect for a survey of large energy consumers. Indeed, the weighted average of relative energy costs in a KOF study (Arvanitis, *et al.*, 2016) on energy-related innovation is 1.4 for a survey sample representative of all Swiss firms including energy-intensive firms[28].

Still referring to Table 13, it can be observed that there is no simple increasing (linear) relationship between the level of energy management and electricity intensity. At the company level, the correlation coefficient between the level of energy management of a company and its electricity intensity is comparatively high (0.488) compared to all other correlations re-

[28] The authors of the study use turnover (instead of employment) as a weight for the size of the firms. Note also that the number of observations of the energy intensity (183 in total) falls short by 40% of the number of observations of the level of energy management (302). This could introduce a bias in the estimation of average intensity by level of energy management in the table.

ported in the correlation analysis. The correlation analysis, presented in Annex 1.2, explores the data and possible relationship between the important variables to be explained (*e.g.* the level of management system) and likely explanatory variables (*e.g.* electricity intensity

Table 14 shows the average electricity and energy intensity of the 215 firms having provided the information. The firms are categorized according to the standard classification of size (in terms of full-time equivalent employment). As shown in the table, very small companies have relative electricity costs three times higher than larger firms and relative energy costs two times higher. However, since the number of firms in the survey sample is small and thus not representative of the whole micro-enterprise population, this result is statistically biased. As for the other three categories, their average intensity is much closer to the overall average.

Table 14: Electricity and energy intensity by size category of firms

	Number of firms	**Average electricity intensity (in %)**	**Number of firms**	**Average energy intensity (in %)**
Micro 0-9 FTE	21	7.3	14	9.2
Small 10-49 FTE	41	2.8	35	4.4
Middle 50-249 FTE	87	2.7	75	4.3
Large 250 above FTE	67	2.4	59	3.0
All firms	216	3.1	183	4.3

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

Energy manager support by top management

A little more than half of the firms (162) have designated a person to look after energy issues, but only a tiny minority are appointed energy managers (14) to deal with energy issues on a full-time basis (Table 5 above). Most of the people in charge of energy issues assume other responsibilities in a wide range of fields: general management, technical and production, maintenance and facility management, environment, security and even administration. Ninety-two firms with a person responsible for energy issues (57% = 92/162) have taken a voluntary commitment to reduce their energy consumption[29]. Eighty-two of the latter firms concluded a target agreement to reduce energy consumption with the Confederation (energy, CO_2-emissions, universal) and/ or with the cantons (SME model, cantonal targets).

Around three quarters of the people in charge of energy issues work in a firm in which energy management is supported and supervised by a member of the board of directors. The firms which combine the appointment of an energy manager and the support of top manage-

[29] See Section 2.2.2 for a description of the public energy policy towards firms.

ment show some increase in the level of energy management, meaning they obtain a total energy management score of 13.7 points compared to the overall average of 10.3 points.

The average electricity intensity of these firms is of 3.6%, marginally higher than the overall average intensity of 3.1% (see Table 13). Ninety-one firms (out of 127) concluded a target agreement with EnAW or ACT, and 82 are in contact with the cantonal authorities in charge of large electricity consumers.

Main reasons to engage in energy management

One question of the survey asked for the three main reasons, among a list of six, for engaging in energy management. Fifty-two firms chose more than three reasons (*e.g.* 28 firms chose four reasons) and 32 firms did not provide any answer (zero reasons). According to Table 15, the most important reasons for managing energy consumption, based on the frequency of the answers, are financial benefits (189 or 62% of the total number of firms, which was 305) and environment protection (175 or 57%), followed by regulation and legal constraints (162 or 53%).

Reputation and public image are main drivers for only 38% of the respondents (32 out of the total number of firms). Social responsibilities and competitiveness are the least important reasons indicated by firms for managing energy use. Although most of the firms (270) think they face high or very high competition on their markets, only 31% think that energy management is an advantage for maintaining and developing competitiveness. Five firms give reasons other than the ones suggested: economic, actions initiated by a free-of-charge energy audit, responsibility in managing the facilities, guidelines by the parent company, exemplarity, and coherence with other environmental measures.

Table 15: Main reasons for managing energy use

Multiple answers	Frequency	% Firms
Financial benefits	189	62
Environmental protection	175	57
Regulation and legal constraints	162	53
Reputation/public image	117	38
Competitivity/competition	94	31
Social responsibility	91	30
Other reasons, specify	12	4
Total	840	

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

5.2.3. Section 3 - Energy efficiency barriers and drivers

This section of the questionnaire seeks to identify which factors have a positive or a negative influence (energy efficiency drivers or barriers) on the adoption of new energy-efficient technology or equipment. Almost all firms participated in the evaluation of the impact of the proposed drivers and barriers of energy efficient investment decisions.

Energy efficiency drivers

In Section 5.1.3 we described the measurement tool we developed in order to assess the strategic character (or strategicity) of energy efficiency investments. This measurement tool includes eight positive impacts of energy efficiency investments to companies' core business in the three dimensions of competitive advantage: value proposition improvement, cost reductions, and risk reductions. These elements are marked by an "X" in Table 16. In addition to factors marked "X", one question was related more explicitly to the contribution of energy efficiency investments to companies' competitiveness (*i.e.* "Enhancing competitiveness", marked "Y" in Table 16).

The table indicates the number of firms which assessed as important or very important the factors listed as positively driving energy-efficient technology or adoption of equipment (in other terms energy efficiency investment decision-making). The factors are presented in descending order depending on the total number of firms having characterised the proposed driver as important and very important.

As shown, cost reduction is by far the factor which most heavily influences the respondents. It is considered as important or very important by 89% of the companies (or 263 out of 296 responding firms, with a strong majority of the firms evaluating this factor as "very important"). Positive image and lower production risks come in second and third places. Positive contribution to market competitiveness is a driver for 62% of the respondents.
Investment subsidies and tax breaks are perceived as important or very important driving factors by about 40% of the respondents.

Table 16: Important and very important drivers of energy efficiency measures

Rank	Drivers	Factors used to assess the strategic character of new energy-efficient technologies or equipment. Factors X and Y	Number of firms considering the factor as "important"	Number of firms considering the factor as "very important"	Number of firms considering the factor as "important" and "very important"	Number of responding firms	% of firms considering the factor as "important" and "very important"
1	Cost reductions resulting from lower energy use	X	97	166	263	296	89
2	Enhancing the positive image and reputation	X	116	68	184	298	62
3	Enhanced competitiveness	Y	109	75	184	295	62
4	Lower production risks	X	93	60	153	294	52
5	Other non-energy costs reductions	X	93	43	136	264	52
6	Higher quality/reliability of products and/or production process	X	82	52	134	293	46
7	Investment subsidies		79	47	126	295	43
8	Increased staff comfort		93	31	124	296	42
9	Lower energy price risks (instability)	X	88	33	121	292	41
10	Tax breaks		73	41	114	294	39
11	Lower risk of disruption in energy supply	X	64	45	109	292	37
12	Increased customers comfort (*e.g.* commercial surface)	X	61	45	106	284	37
13	Cheaper financing (lower rate)		49	21	70	284	25
14	Other factors, please specify		2	3	5	6	83

Table Université de Neuchâtel. Source: Survey.

Level of strategicity

The level of strategicity of energy efficiency investment can be measured by aggregating the qualitative responses to the eight positive impacts of new energy-efficient technology or equipment to companies' core business in the three dimensions of their competitive advantage (value-cost-risks)[30].

Figure 10 shows the distribution of the aggregated scores for the eight drivers considered as strategic, *i.e.* as contributing to companies' competitive advantage. The average and median scores are 27 points, out of a maximum possible of 40 points[31]. The distribution of the drivers' degrees of importance is not different between the industry and service sectors (see the distribution of industrial and construction firms in comparison with the total number of firms in Figure 10).

Figure 10: Number of firms, by level of "strategicity" of the drivers (N=300)

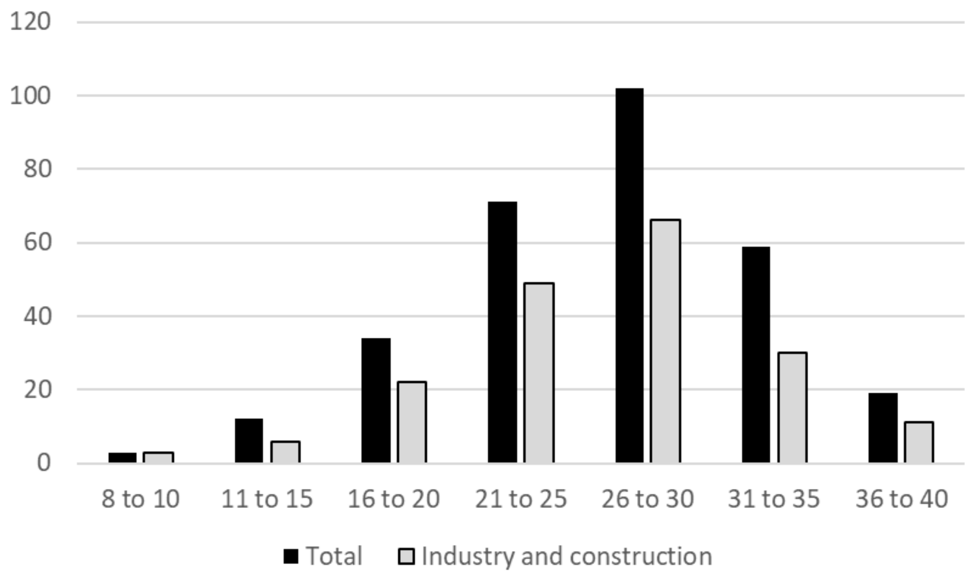


Figure Université de Neuchâtel. Source: Survey data, Université de Neuchâtel.

[30] See Section 5.1.3 Concept measurement

[31] As a reminder, 1 point is attributed to the answer "not important at all", 2 points to "not important", 3 points to "moderately important", 4 points to "important" and 5 points to "very important". The minimum possible score is 8 points (if a firm evaluates each of the 8 drivers as "not important at all" and the maximum possible score is 40, if a company thinks that each of the 8 drivers is "very important" (5 points). On average, the eight drivers, considered as strategic, obtained 27 points, that is on average 3.4 points per driver, in comparison with the average score 3.0 (1 + 2 + 3 + 4 +5)/5) if the answers are evenly distributed among the five possible answers.

Barriers

On the other hand, energy efficiency actions face barriers. Table 17 indicates the number of firms which consider the barriers proposed by the questionnaire as playing an important or very important negative influence on energy efficiency investment decision-making. Over 90% of the firms (approximately 280) answered this question.

Table 17: Important and very important barriers to energy efficiency

Rank	Barriers	Number of firms considering the barrier as "important"	Number of firms considering the barrier as "very important"	Number of firms considering the barrier as "important" and "very important"	Number of responding firms	Percentage of firms considering the barrier as "important" and "very important"
1	Other investments more important	112	88	200	285	70
2	New techno-logy can only be implemented when existing technology is to be replaced (investment cycle)	120	40	160	288	56
3	Internal financial constraint	94	44	138	289	48
4	Low financial attractiveness	98	28	126	289	44
5	Energy costs are not sufficiently important	84	32	116	290	40
6	Current installations are efficient enough	93	17	110	285	39
7	Incompatible with existing production process or products	71	34	105	283	37
8	Uncertainty about the quality of the new technologies considered	73	11	84	288	29
9	Technology will become cheaper in the future	64	18	82	285	29
10	No clear vision or overview of existing technologies	53	22	75	286	26
11	Energy efficiency is of low priority	51	17	68	286	24

Rank	Barriers	Number of firms considering the barrier as "important"	Number of firms considering the barrier as "very important"	Number of firms considering the barrier as "important" and "very important"	Number of responding firms	Percentage of firms considering the barrier as "important" and "very important"
12	Difficult access to external sources of financing (credit)	45	13	58	285	20
13	Difficult to implement due to internal organisation	47	11	58	288	20
14	New technology might not satisfy future regulatory standards	42	14	56	283	20
15	Waiting for subsidies	37	11	48	288	17
16	Others, please specify	6	5	11	19	58

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

For 200 firms (70%), the first barrier mentioned as important or very important is "other investments more important" [than energy efficiency investments]. One hundred and sixty Swiss firms (56%) hesitate to invest in new technology when the existing technology or equipment is not yet obsolete ("new technologies can only be adopted when existing technology has to be replaced"). Financial considerations are the second most important group of barriers preventing firms to invest in energy efficiency. However, less than half of the responding firms consider the financial aspect of energy efficiency as important and very important. Indeed, only 138 firms (48%) see limited internal financial resources as an important obstacle for energy efficiency, and only 126 firms (44%) think that energy efficient investments are not profitable enough (low rate of return of energy efficiency investment). In addition, the lack of external financing is considered as an obstacle only by 58 firms (out of 280 having responded, or 20% of the respondents).

5.2.4. Section 4 – Evaluation of investment projects

Energy-efficient investments

The questionnaire asked about the number of energy efficiency investment projects of different sizes (total investment spending below CHF 20,000, between CHF 20,000 and 100,000, and over 100,000 Swiss francs), including total investment spending over the last four years (see questionnaire in Annex 1.1). Actually, the question was poorly and partially answered incorrectly[32], for at least two reasons:

1) a significant number of the respondents did not know how many projects they carried out during the last four years. In the questionnaire, the responding firm could tick one, two or the three project sizes without stating the number of projects;
2) no explicit definition was provided in the questionnaire of energy efficient investment (EE investment), *i.e.* investments primarily aiming to reduce energy consumption or cost. The numerous examples provided by the respondents suggest that the reported investment projects were decided mainly or at least partially on energy efficiency ground.

However, the available description of the reported projects suggests that a significant proportion of projects are mainly not energy efficiency investments, as per the definition (see Section 2.1.3). Some energy efficiency investment projects may include process aspects and some other reported projects could be process investments taking energy impact into consideration. A message sent to some 80 known responding firms gathered some additional information on EE investment spending and projects to improve the quality of the answers.

Table 18 shows the number and percentage of firms by type of energy efficiency investment projects. Reducing electricity consumption on building and in production is an important rationale of energy efficient investment projects.

[32] A significant proportion of the responding firms contradicted themselves in the same question, answering on one hand that they did not engage in energy efficiency measures during the last four years, but nevertheless gave some information on the number of projects, by size in terms of spending. In general, the firms did not provide information on total spending and more details on the type of energy efficiency measures.

Table 18: Type of energy efficiency projects

Multiple answers	Frequency	Percentage of all 305 responding firms	Percentage of firms having reported at least one investment project
Production of renewable energy	72	24	35
Savings in electricity consumption on buildings and infrastructure	171	56	84
Savings in electricity consumption on production equipment	155	51	76
Savings in thermal energy consumption on building and infrastructure	156	51	76
Savings in thermal energy consumption on production equipment	94	31	46
Total (multiple answers)	648		

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

Financial evaluation

About 41 firms did not answer the question regarding their use of financial methods for investment evaluations. Two hundred and forty-four firms indicated that they use at least one of the three common financial assessment methods: the payback period, the net present value (NPV) or the internal rate of return (IRR) methods. Out of the 264 responding firms, 87% (232/[305-41]) use the simple payback method to evaluate the financial attractiveness of energy efficiency investment projects (Table 19). Twenty-one firms reported not using any of the three proposed methods. One hundred and eighty-one firms use only one criteria (typically the payback method), and 63 firms use more than one method (44 use two methods and 19 firms use all three methods).

Table 19: Financial evaluation of energy efficiency investments (N=264)

Multiple answers	Yes	No	Total
Simple payback (payback period)	232	28	260
Net present value NPV	42	145	187
Internal rate of return (IRR)	52	140	192

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

Out of the 232 firms having declared they use the payback method, 194 firms provided information on the time horizon chosen in their calculation[33]. According to Table 20, the payback method is used not just for a short time horizon of two or four years but for much longer periods (6.8 years on average), in contradiction with finance theory prescriptions. Two thirds of the responding companies assert that they chose a different time period depending on the type of investments (*e.g.* infrastructure vs equipment). However, the differences in years, on average, do not exceed two years.

Nearly 80% of the firms wait up to eight years in order to recover their investment expenses. However, this is probably related to the fact that large-scale energy consumers which entered a federal or cantonal target agreement have an obligation to implement projects with a payback period equal or shorter than four years for production investment and eight years for buildings. About 99 out of the 148 firms using a time horizon of eight years or less concluded at least one target agreement (universal, SME or cantonal agreements).

Table 20: Average time periods (payback method)

Period	**2 years or less**	**3 to 4 years**	**5 to 8 years**	**9 to 10 years**	**Higher than 10 years**	**Total**
Number	15	51	82	29	17	194
Percentage	7.7	26.3	42.3	14.9	8.8	100.0

Table Université de Neuchâtel. Source: Survey data Université de Neuchâtel

The large majority (194) of the 232 firms using the payback method indicate the number of years considered in applying the method, but only a small number of firms using the other two methods could report the parameters used (number of years, and the discount rate or the required rate of return). Overall, it seems that firms tend to neglect the financial or opportunity cost (market interest rate) in their investment decision. This is not very risky in these times of very low interest rate (no interest revenues forgone on the sum invested) and if the chosen payback period is relatively short.

Non-energy benefits (NEBs)

The questionnaire provided a list of 31 Non-energy benefits (NEBs) (see Section 2.1.2.), together with the possibility for respondents to mention NEBs not included in the list. Table 21 shows the number of firms stating they include NEBs in their investment analyses, for each of

[33] The information provided by the firms comes in different forms: one figure for the number of years, although often a range of years, such as three to five years, sometimes stating the maxi-mum length of the period (*e.g.* < 10 years), or some comment stating, for instance, that the period chosen depends on the type of investment or corresponds to the life cycle of the equipment. The figures are either the number of years reported, or in case of a range of years, the average of the lower and upper limits.

the proposed non-energy benefits. The highest scores are obtained by the "reduction of maintenance cost and technical control of equipment", followed by the impact on "corporate image". A high score is also obtained by the "enhancement of security and better working conditions for the staff". Reduction of greenhouse gas emissions and water consumption is also often picked up by respondents. Other important benefits are the improvement of production efficiency and performance.

Of course, the mere existence and the identification of a relevant NEB depend on the energy efficiency investment project and on the production context in which it is implemented. Two hundred and thirty-six firms consider at least one of the proposed NEBs when evaluating energy efficiency investment projects. Of course, not all proposed NEBs concern all firms. About 51 firms (18% of the responding 279 firms) declare they do not consider or only very rarely NEBs in their investment decision-making process, 104 (37%) sometimes, 81 (29%) very often and a minority of 43 (15%) nearly every time.

Table 21: Importance of non-energy benefits (N=236)

Rank	Label of NEBs	Number of firms
1	Reduction of maintenance cost and technical control of equipment	133
2	Better corporate image	115
3	Enhanced security and better working conditions for the staff	113
4	Lower CO_2 tax or tax exemption	110
5	Lower CO, CO_2, NOx, SOx emissions	107
6	Reduction of water consumption	106
7	Better performance of equipment	106
8	Productivity increase	105
9	Enhanced reliability of the production process	103
10	Enhancement of product quality	102
11	Higher equipment security	101
12	Better control over the temperature	92
13	Reduction of raw material	85
14	Enhanced flexibility of the production process	77
15	Extension of the life time of the equipment	75
16	Lower energy prices risk	73
17	Reduction in cooling requirements	65
18	Lower CO2 price risk	64
19	Recycling production waste	54
20	Lower staff expenses	53
21	Lower risk of disruption in energy supply	48
22	Space saving	46
23	Lower legal and regulatory risk	46
24	Reduction of dangerous waste	42
25	Reduction of absenteeism and lower health costs	41
26	Lower dust emissions	39
27	Shorter production cycle	37
28	Lower commercial risk	33
29	Reduction of production rejection rate	27
30	Avoidance or reduction of equipment oversizing	21
31	Lower need (or postponement) of investment	20
32	Others, please specify	5

Table Université de Neuchâtel. Source: Survey.data, Université de Neuchâtel

On average, a responding firm considers nine to ten different non-energy benefits. Figure 11 reports the number of firms combined with the number of NEBs they consider when evaluating energy efficiency investment projects. For instance, 23 firms consider seven different NEBs in their energy efficiency investment assessment.

Figure 11: Number of firms, by the number of NEB considered (N=236)

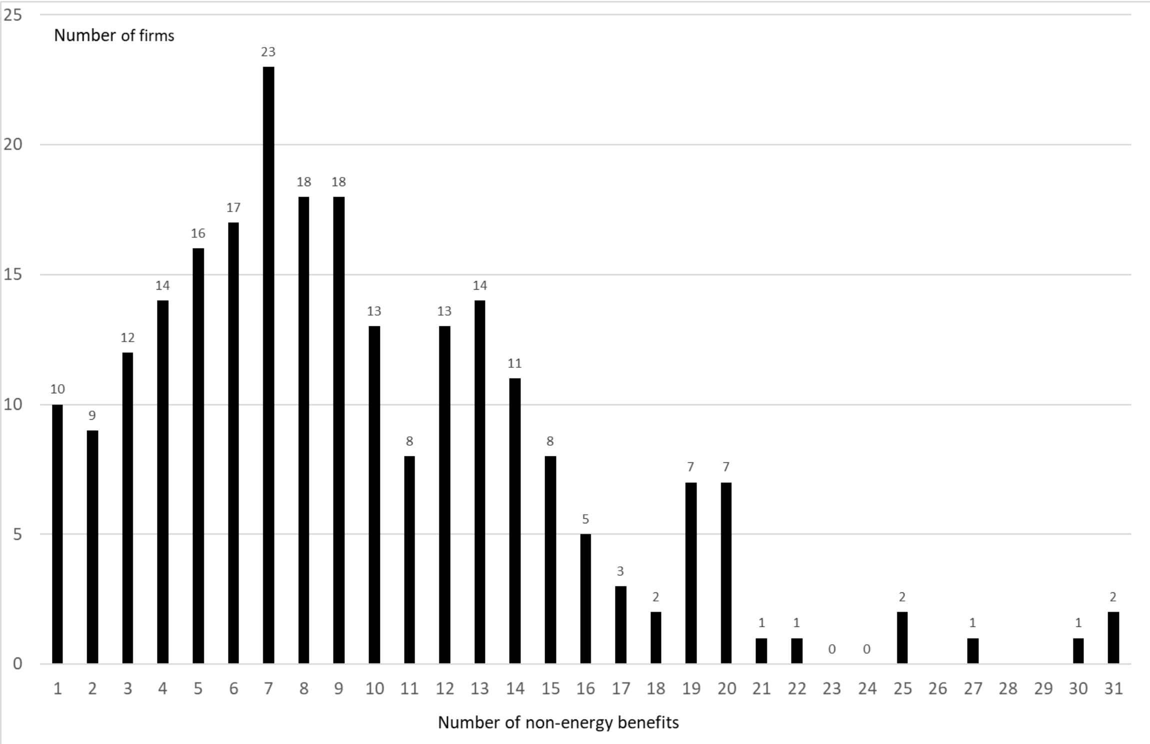


Figure Université de Neuchâtel. Source: Survey data, Université de Neuchâtel.

Other aspects considered when deciding on an investment

Non-energy benefits are closely linked to firms' operations and organisation and mostly accrue to the firm, and only indirectly to society or environment. Other broader aspects may influence the decision to invest in energy efficiency (see Table 22). This is especially the case of social and environmental cost and public policy. The energy sector is traditionally highly regulated for ensuring a safe energy supply. Because of the increasing social and environmental costs linked to the production and consumption of energy, state regulation and policy increasingly focused on energy consumers. The behaviour of the competitors, *e.g.* the attitude towards energy issues, seems not to influence the responding firms.

Table 22: Other aspects influencing energy efficiency decisions

	Frequency	Percent
Social cost, environment	112	31%
Public policy in general	96	26%
Behaviour of competitors	77	21%
Partner networks, employer's organisations	67	18%
Other, specify	11	3%
Total (multiple answers)	363	100,0%

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

5.2.5. Section 5 – Public policy

Types of agreements chosen

Around 85% of the respondents are large-scale energy consumers according to the legal definition. About two-thirds have been contacted by the cantonal authorities in the framework of their large-scale energy consumer public policy.

At least 132 firms have concluded a target agreement on energy consumption or a reduction of CO2 emissions, at the federal level. shows the type of energy target agreements chosen by the responding large-scale energy consumers firms.

Table 23: Types of agreement concluded

	Firms	Percent
Universal target agreement (Confederation)	83	40
Model SME of the universal target agreement	49	22
Target agreement at the cantonal level	39	19
Audit on energy consumption	39	19
Total	209	100%

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

Eighty-three firms opted for a universal target agreement with the Confederation, and 49 firms for the equivalent SME model. Only 39 firms engaged in an agreement at the cantonal level and only 39 firms passed a formal energy consumption audit, which was partially subsidised (see Section 2.2.2).

Small electricity consumers

Thirty-seven responding firms declared they consume less than the legal threshold defined to be a large-scale energy consumer. Some of these self-declared small consumers may be consuming an electricity volume close to the threshold of 0.5 GWh, but are certainly interested in energy issues, given their participation in the survey. Nine of these small electricity consumers have been contacted by the cantons in the framework of their large-scale energy consumer policy. Ten small-scale consumers concluded a universal target agreement with the Swiss Confederation (out of a total of 125 universal agreements), probably in connection with CO2 emissions, none with the cantons, and one declared small consumer realised an audit promoted by the cantons.

5.2.6. Section 6 – Impact on performance

Impact of energy efficient investment on energy consumption

The ultimate impact of energy efficiency investment on the consumption of energy (eventually per output, or costs compared to turnover) may be measured in terms of energy performance. The survey questioned the firms about the impact of their energy investments on energy consumption during the last four years. Twenty-two percent of the firms participating in the survey did not have an opinion on the likely effects of energy-efficient investments. The energy consumption had stabilised or may have increased in 15% of the firms, but most firms stated they could decrease their energy consumption (176 firms). Table 24 indicates that at least 60% of the respondents experienced a reduction in energy consumption. A significant total of 22% of the responding firms state that the impact of energy efficiency investment on energy consumption is for them either impossible to evaluate or unknown.

Table 24: Impact of energy efficiency investment on energy consumption

	Frequency	**Percent**
Increased or stable (*e.g.* because of decrease of the energy price)	42	15%
Tendency to decrease	121	43%
Significant decrease	57	20%
Impossible to evaluate	41	15%
Do not know	19	7%
Total	280	100,0%

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

Impact of energy-efficient investments on company performance

Table 25 shows the self-evaluation of the impact on the economic performance of the energy efficiency investments from about 270 firms. About 40% of the firms estimate that nothing has changed with regard to price or cost and product competitiveness, and about 30% estimate that the investment did not increase their profitability. On average, 30% of the responding firms consider that they experienced some performance improvement due to energy efficiency investments. Only very few companies think that energy efficiency investments have deteriorated their economic performance. Finally, one-third of the firms are either not able to evaluate the impact or do not know what it is.

Table 25: Impact of energy efficiency investment on economic performance

	Deterioration	Unchanged	Improvement	Impossible to evalua-te	Do not know	Total num-ber of responding firms
Price or cost com-petitiveness	6	103	78	47	37	271
Product competiti-veness (innovati-on)	0	118	50	53	44	265
Profitability	5	88	97	41	36	267

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

5.3. Econometric results

The hypotheses of the research model are investigated in Annex A with the help of a simple correlation analysis between variables representing the four links of the impact chain, from energy management to energy performance. Correlation does not, however, imply causality. A high correlation coefficient simply indicates that the two observed variables move closely together in the same and/ or opposite direction. It happens that all values of the correlation coefficient are low or, at best, moderate (maximum 0.6 in absolute values). A large number of coefficients, but by far not all, are statistically significant, but their values indicate only a loose association between the links of the impact chain.

Simple correlation analysis may confirm or reject the pre-determined hypotheses, in addition to conveying information on the consistency and the quality of the data collected, but cannot lead to meaningful statements on the effective determinants of the variable of interest. For instance, the level of energy management might be significantly and positively correlated with the size of the firms (employment), which it is in fact (significant correlation of 0.247), but in the presence of other explanatory variables it might not be. Other variables, such as electricity intensity or energy auditing, are very likely to influence the relationships between the size of the firm and its level of energy management.

Further empirical investigation requires more formal assessment of the validity of the hypotheses. The analysis of the survey based on the frequencies of the answers and the analysis of the correlation coefficients between variables provide some understanding of the subject and may give valuable insights. The analysis and the interpretation of the answers are based on the theoretical base which is explained in Section 2.4.

The goal of econometric methods, *i.e.* the application of statistical methods to economic data, is to statistically analyse the empirical validity of economic relations (or hypotheses), based on the theoretical considerations (which factors influence significantly the phenomenon to be explained, and why). The relationship to be explained must pass statistical tests in order to be recognised, in statistical terms, as likely to be true (for a given probability of error). The method allows consideration of not only a single factor, but also many factors when trying to explain the phenomenon under scrutiny. In many empirical studies, the researchers look for an equation to be estimated, drawing from a list of variables which are, in theory, potentially able to explain at least part of the phenomena observed. The equation relates the variable to be explained with the various factors (also measured by appropriate values or numbers), which are expected to contribute to the explanation.

The explanatory variables are chosen among the responses to the numerous questions of the survey by sections. Annex 1.1 explains the procedure used to find the explanatory variables among the large number of likely candidates derived from the survey.

The result obtained and presented below depends on the combination of the automatic stepwise procedure and the selection of the variables depending on the resulting statistical properties of the model and the variables. Given the relatively large number of potential explanatory variables, even in a specific category (such as the characteristics of the firms, drivers and barriers), it is possible to obtain concurrent estimated models.

Four econometric models are estimated, for the determinants of the level of energy management, of the perceived strategicity of energy efficiency (EE) projects, of the level of EE investment spending, and of the energy or economic performance. The econometric results are described and presented below[34].

[34] Far more of the explanatory variables used are binary (taking only two values 0, 1), given the questions asked in the questionnaire. Binary variables are used as well as explained variables for energy and economic performance. The questions which asked about the importance of some factors, *e.g.* drivers of energy efficiency (notably the aggregate index for the "strategicity" of EE investment projects), barriers, or non-energy-benefits, take only five values at most (1: not important at all … 5: very important). Only a handful of variables have a larger number of values: full-time employment, the index of the level of energy

5.3.1. Determinants of the level of energy management

The level of energy management—the variable EM—is measured by the answers to six survey questions, which include 11 questions related to the main elements composing a sound energy management system (see Section 5.1.1.). The values of EM can vary between 0 and 23. The highest score, between 19 to 23 points, indicates that the firm has implemented a system which comes close to the ISO 50001 norm.

The level of energy management might be hypothesised as dependent upon three categories of variables, namely:

- characteristics of the firms, such as size, sector of activity, or the degree of competition the firm faces on its market (section 1 of the survey);
- perceived reasons for implementing an energy management system and its organisation, such as energy costs, competitiveness or the importance given to energy issues by the hierarchy (Section 2 of the survey). Note that of course we cannot use the six questions which are used to calculate the energy management index;
- public policy (Section 5 of the survey) is likely to impact energy management by influencing the general awareness of energy issues, providing information, or through legal provisions obliging firms to adopt some energy efficiency actions.

Table 26 presents the results of the estimation for the level of energy management, EM. The nine explanatory variables reported in Table 26 Equation 1 have all the "correct" positive signs and are all (except for the public policy variable) highly significant statistically (*i.e.* probability lower than 5%, in parenthesis, compared to higher probability level of reference, say 10%). All variables are binary, except the employment variable (natural logarithm – ln – of the number of full time equivalents), the index constructed for measuring the intensity of the policy measures (values between 1.5 and 6.0), and the electricity intensity (0.1 to 25%). The coefficients of the binary variables indicate the number of points which are added to the average score level of energy management, if the value of the explanatory variable takes 1, *i.e.* if the variable applies to the firms, compared to 0 if it does not apply. The nine variables explain over 60% of the observed variation of the level energy management.

A positive regression coefficient means that the explaining variable has a positive influence on the level of energy management. Strictly speaking, it is not possible to make a conclusion about the presence of a direct causality for all (significant) variables of the table. For instance, it is very likely that the size of the firm has an impact on the energy management systems (be-

management (1 to 23 points), and some aggregated variables such as the index for the stategicity of energy efficiency investment (8 to 40). Their summary statistics are reported in Annex 1.

cause of larger resources available, large production operations and greater possibilities to impact on energy consumption), and is very unlikely that the presence of an energy management system increases the size of the firm. On the other hand, for instance, a voluntary energy audit might trigger the development of more systematic energy management, but the presence of energy management may also be the "cause" of an energy management system. For some of the explanatory variable the causation could go in both directions. The precise interpretation of the results is left to the reader, who should be aware of the context in which the survey has been conducted, as it is not possible to check statistically for the presence of reverse causation in cross-section data.

Table 26: Explaining the level of energy management EM

Explaining variables	**Coefficient (p-value)**	**Description**
intensity of public policy	0.713 (0.126)	Intensity of measures implemented with regards to large-scale electricity consumers: length of period, scope and number of measures (cantons with highest scores among the three groups)
employment (in ln)	0.465 (0.000)	ln of number of employees (full-time equivalent, FTE), unit
thermal energy consumption (> 5 GWh/year)	2.390 (0.000)	large thermal energy consumers, firms consuming more than 5 GWh a year, binary 1 vs. 0
partnership/networking	1.593 (0.005)	firms having a partnership with an organisation whose aim is to promote energy efficiency, binary 1 vs. 0
support by senior management	2.571 (0.000)	firms which designated a member of the senior management to supervise and promote energy efficiency, binary 1 vs. 0
electricity intensity	2.618 (0.000)	electricity cost as a percentage of turnover
energy audit	2.938 (0.000)	firms which performed an audit, binary 1 vs. 0
universal target agreement	1.096 (0.031)	firms having concluded a universal target agreement or having performed an audit (universal, audit), binary 1 vs. 0
legal provisions as opportunity	1.256 (0.008)	firms which believes that legal provisions concerning energy efficiency represents mainly an opportunity (not a constraint), binary 1 vs. 0
	R-Squared (adj) = 0.555 (0.543)	
	Mean dependent variable EM = 10.27	

Table Université de Neuchâtel. Source: Survey (econometric results), Université de Neuchâtel

Characteristics of the firms

In only two words: size matters. The level of energy management is related positively to the level of employment, in terms of number of full-time equivalents, measuring the size of the firms.

Implementing an energy management system would be a first step to get more information about the potential savings and enable companies to conceive, plan, control and execute energy efficiency actions. Firms with thermal energy consumption above the legal threshold of 5 GWh a year show a higher level of energy management (+2.4 points), everything else being equal. This effect is linked to the public policy aimed at large energy consumers (by definition, those firms which consume more than the legal threshold). Indeed, the measures already taken and the changes in the instruments proposed and discussed (*e.g.* introduction of MuKEn 2014, the macro issue of the energy transition) have certainly increased the awareness on energy issues by the firms. It happens that when a firm is in contact with partners promoting energy efficiency, the score increases by 1.6 points, on average. One hundred and forty-four firms receive help and advice from EnAW, as well as ACT for the implementation of official target agreements. Forty-two firms have a partnership with organisations which promote energy efficiency in various ways (with electricity providers, others with Cleantech and others with professional organisations, etc.).

Other factors favourable to energy management

The level of the energy management system implemented by the companies also depends significantly (at 0% error) on the senior management's support or supervision. This management support clearly favours the implementation of a higher level of management. (+2.6 points compared to the firms which do not receive such support). The fact that an energy audit (on buildings and/ or administrative and commercial facilities and/ or on production equipment) was performed, even independently of public policy, is also significantly correlated with the level of energy management (+2.9 points). In this case, it may very well be that the performance of an initial energy audit contributes to some of the activities of energy management, such as the definition of a baseline or the collection of energy data. In this case, the audit may have triggered the energy management system in place. It is however, by no means a substitute to the continuous effort made by the company, which is an essential requirement of a management system. However, the direction of causality is unclear. It is highly possible that in many firms, both support from management and the audit are at least partially a consequence of the presence of a higher level of energy management within the firm.

Electricity and energy intensity: as in the correlation analysis, in which electricity intensity (electricity costs as a percentage of turnover) is significantly correlated with the level of energy management (coefficient: 0.488), the econometric results show a significant impact on the energy management of electricity intensity, but not of the thermal energy intensity (coefficient near zero in the correlation analysis).

Public policy

Public policy is likely to exert some impact on the level of the energy management system implemented. The conclusion of a universal target agreement, performed voluntarily or as an public policy option, indeed promotes energy management (increase of the level of energy management score by +1.1 points, on average). About 126 firms have reported the conclusion of a federal universal target agreement (including according to the SME models, and, surprisingly, six firms reported the conclusion of both). For them, the level of energy management reaches 13 points on average, or 2.7 points above the overall average of the 305 firms in the survey sample. Note that according to the econometric results reported in Table 26 1.1 points from the 2.7 points are due exclusively to the conclusion of federal target agreements, and the remaining 1.6 points are explained by other determinants.

In addition, when firms think that legal provisions for energy efficiency represents an opportunity rather than a constraint—in other words when firms have a positive attitude towards energy efficiency—the level of energy management increases by an estimated 1.3 points. Again, it is true that the causality can go the other way around; a continuous exposure to energy issues and projects, given the energy management system in place, can enlighten the firm to the untapped potential of energy investments.

The delays for implementing the prescriptions of the federal energy law by the cantons are relatively long (about 10 years), and the cantons have some freedom to choose the instruments and measures which suit them best, either politically or depending on efficiency and circumstances. Some cantons react very quickly, by determining an energy strategy and the scope of the measures to be implemented, some other cantons, especially the smaller ones but not only those, drag their feet. The scope and intensity of the energy policy adopted by the cantons may have an impact on the introduction and development of energy management at the firm level. An index is constructed measuring the density and the timely introduction of public policy at the cantonal level, depending on (1) the existence of legal provisions on large energy consumers, (2) the presence of an explicit energy strategy and of territorial energy planning, (3) the length of the period during which the energy efficiency legislation is applied, and (4) the number of proposed MuKEn measures which have been introduced since 2008 (Conférence des directeurs cantonaux de l’énergie & Suisse énergie, 2016). The highest scores are obtained by Ticino, Neuchâtel, St. Gallen, Vaud, Genève, Fribourg, Zürich and Thurgau (which include six out of the 11 cantons having supported the survey). Eleven other cantons, of which two are Aargau and Luzern, have somewhat lower scores, and seven others show very low scores (Valais, Schwyz, and Jura among them). Table 26, above, shows that the estimated regression coefficient is positive but statistically insignificant; a high intensity of public energy policy is associated with higher levels of energy management, but not to a statistically significant extent.

Determinants of the strategicity of investment

There are many factors, identified in the literature and empirical works, which are likely to exert a positive influence on an energy efficiency investment decision (see Section 3 of Frequency results). For instance, the survey shows that the reduction of cost, among all other drivers proposed in the questionnaire, is the prime driver, possibly the best-known driver, which counts when considering an energy efficiency project. Other important drivers are lower production risks or the contribution of energy efficiency measure to a positive image of the firm. Ultimately, all or some of the drivers identified in the literature contribute to the attractiveness of energy efficiency measures because of their impact on the competitiveness.

As presented in Section 5.1.3, the eight drivers considered as strategic for the firms are aggregated in one variable. Table 27 shows the list of significant factors which help to make energy efficiency measures and investment projects strategic, helping to foster the competitive position of the firm on the markets. The value of the adjusted R-squared is rather low and suggests that the eight drivers considered together as important by the responding firms (cost reduction, image and reputation, production risks, non-energy costs, quality and reliably of productions and processes, energy price risk, risk of disruption of energy supply, and customer comfort) are poorly explained. Other variables, unknown and likely not included in the survey questionnaire, would have a more important impact.

Table 27: Aggregate strategic drivers of energy efficiency investment

Explaining variable	Coefficient (p-value)	Description
energy management	-0.126 (0.176)	level of energy management measured by an index (0 to 23 points)
competition on the market	5.75 (0.000)	degree of competition on the relevant markets, very high, high, binary 1 vs. 0 not very high, weak
ownership of building	3.383 (0.005)	firm owns at least one building, binary 1 vs. 0 (rent, lease)
electricity consumption (> 0.5 GWh/year)	4.841 (0.000)	large electricity consumers, firms consuming more than 0.5 GWh a year, binary 1 vs. 0
energy efficiency	9.198 (0.000)	firm considers energy efficiency as rather important, binary, 1 vs. 0 not important
procedure of energy policy	4.319 (0.000)	firms having put in place at least on procedure related to energy policy (training, bonus system, evaluation of results, revision of objectives), binary 1 vs. 0 public policy
legal provisions as opportunity	1.93 (0.035)	firms which believe that legal provisions concerning energy efficiency represents mainly an opportunity and not a constraint, binary 1 vs. 0
	R-Squared (adj) = 0.1498 (0.1692)	
	mean dependent variable 26.12	

Table Université de Neuchâtel. Source: Survey (econometric results), Université de Neuchâtel

Characteristics of the firms

The strategicity of energy efficiency variables is influenced positively by three characteristics of the firms: the stiff competition firms experience on the market (+5.8 of the strategicity index, compared to the average value of 26), the fact of owning at least one building (+3.4), and of being a large consumer according to the legal definition (+4.8). Again, the (positive) estimated coefficients can be interpreted as the increase of the strategicity index if the firm shows the property of the variable, *e.g.* it is a large consumer, everything else being equal.

Energy management

Two factors promote the strategic character of energy efficiency investment: when the firm, *i.e.* its owner, considers energy efficiency as important for any reason, and when the firm devotes some resources to energy efficiency. Note that level of energy management does not contribute independently to enhancing the importance of the eight drivers considered as strategic for of EE investment in the literature.

Public Policy

Finally, the strategicity of energy efficiency can be linked to the positive perception of legal provisions. It seems that for the respondents of the survey, public policy is considered as an opportunity rather than a constraint. This suggests that the promotion of voluntary agreements (the metaphorical "carrots") is more pertinent than the use of compulsory measures and punishment (the metaphorical "sticks"). It is possible that the Swiss approach to public policy based on the possibility to choose the energy efficiency measures and the way to implement them is considered as an opportunity because it gives more arguments to the energy managers to "sell" EE investments to top management.

Determinants of the level of energy efficient investment

The variable to be explained, and for which the following results are presented, is the average investment spending over the last four years (2012–2015), in Swiss francs. Investment spending per employment (and year) was also used but no useful results were found. One should keep in mind when examining the investment equation presented in Table 28, below, that the responses obtained to the questions on EE investment spending in the questionnaire are suspected to be of low quality. First, it is uncertain that the responding firms reported only EE investment projects. Many investment projects are likely to be motivated only marginally by energy savings and efficiency, given the numerous examples which were reported. Second, the response rate to the question on EE investment projects and spending is low and often inconsistent. Nevertheless, it was possible to obtain some plausible econometric results.

The EE investment spending per year is supposed to depend on some of the characteristics of the firms, the factors likely to influence investment decisions and public policy positively ("drivers") or negatively ("barriers"). The following factors have a positive impact on investment spending:

- the level of energy management has a direct influence on investment decisions (but with a significance level above 5%);
- the number of employees (in natural logarithm), *i.e.* larger enterprises, everything being equal, spend more on EE investments. On average, a 1% increase in employment increases investment spending by 0.36%;
- the large thermic energy consumers (above 5 GWh a year) invest more compared to the low thermal energy consumers (20% of the firms);
- as one might expect, high energy costs (all sources included) as a percentage of turnover would tend to incite firms to invest in energy efficiency project (marginally significant);
- when firms think that public energy efficiency policy represents more of a constraint than an opportunity, they tend to invest more.

Table 28: Determinants of energy efficiency investment spending

	Coefficient (p-value)	Variable
constant	8.734 (0.000)	
level of energy management	0.048 (0.073)	level of energy management, scores between 0 and 23 points
employment (in log)	0.364 (0.000)	log of number of employees (full-time equivalent, FTE), unit
thermal energy consumption	0.736 (0.032)	large thermic energy consumers, firms consuming more than 5 GWh a year, binary 1 vs. 0
energy intensity	0.043 (0.108)	energy (including electricity) costs as a percentage of turnover
legal provisions as constraint	0.494 (0.061)	firms which believe that legal provisions concerning energy efficiency represents mainly a constraint (not an opportunity), binary 1 vs. 0
	R-Squared (adj) = 0.311 (0.2830)	
	mean dependent variable = 11.6	

Table Université de Neuchâtel. Source: Survey (econometric results), Université de Neuchâtel

Other potential important (non-)determinants

The R2 statistics of the investment equation (Table 28) indicate that the six explanatory variables (including the constant) account for about 30% of the variation in investment spending. Among the many available theoretically possible explanatory variables, only a few show a significant effect. This could be related to the quality of the reported investment data or simply to other factors which are not available in the survey.

Characteristics of the firms: aside from the level of thermic energy consumption (which distinguishes the few low thermal energy consumers from the large energy consumers in the sample), and employment, which both are significant at less than 5%, no other characteristic (*e.g.* industry, degree of competition, ownership or certifications) seems to influence investment spending. The level of energy management has a positive influence on EE investment spending, but with a somewhat higher probability of error.

Drivers of EE investment: The most relevant drivers which contribute to an increase in competitive advantage, and hence in EE investment spending, are the following: cost reduction resulting from lower energy use, enhanced positive image and reputation, lower production risks, reduction of other non-energy costs, higher quality/ reliability of products and/ or production processes, lower energy price risks (instability), lower risk of disruption in energy supply, increased customer comfort (*e.g.* commercial surface). These drivers of energy efficiency (as well all barriers proposed), grouped together according to their importance for the firms, are largely insignificant, in the aggregate and at the individual level. Additionally, some of the drivers have a coefficient with a wrong sign, *i.e.* an impact contrary to what a driver is expected to have, namely a positive impact of energy efficiency investment decisions. When used individually, a single driver is either not significant or occasionally shows a negative sign. The numerous resulting equations contradict themselves, or are unstable (when adding or deleting variables). These disappointing results are probably due to the restricted number of values taken by a single driver (from 1 to 5, depending on its importance to the responding firms). The grouping of the eight strategic drivers avoids the problem, as the variable can take any value between 8 and 40).

Non-energy benefits: almost half of the responding firms declare that they consider non-energy benefits (NEBs) very often or nearly every time in their investment decisions. The questionnaire provided a long list of potential NEBs. On average, a firm considered nine to ten different non-energy benefits out of the proposed 31 benefits. However, according to the econometric analysis, non-energy benefits do not influence EE investment decisions. It might be that NEBs are considered in theory by the energy and senior managers, but that, in practice, the cost of identifying the numerous benefits and the difficulties of quantifying them in monetary terms can be a serious obstacle. Moreover, the responsible people for preparing and deciding on investment projects may simply not be aware of the potential contributions of energy efficiency to the core business, especially if their education and training is mainly technical.

Finance seem not to play a role in EE investment decisions, given the absence of any significant effect of financial variables. This can be explained by the fact that a large majority of firms use the simple payback method (rather than present value or the internal rate of return of investment), which is – as a side note – imposed in the target agreements proposed by government. Large-scale consumers which conclude a federal or cantonal target agreement are obliged to implement projects with a payback period equal to or shorter than four years for production investment, and eight years for buildings. Therefore, a positive return from EE investment projects is likely, given the presently very low cost of interest (opportunity). In doing so, the emphasis, put in many cases, on a relatively short horizon of time tends to neglect the (very) long-term effects of investment projects. Moreover, the cost intensity of energy has no impact whatsoever in the whole impact chain, including on the level of energy management, which suggests that energy costs are not important for most of the responding firms. Currently, energy prices are low, and continuously rising prices in the future and the continuing emphasis on environmental issues, as expected during the energy transition period, could notably promote EE investment projects.

Public policy, essentially target agreements or subsidised energy audit in the questionnaire, has no direct effect on EE investment decision. Nevertheless, Swiss firms seem to be open-minded; the measures taken by the federal and state governments regarding large energy consumers are considered, on the whole, as an opportunity for improvement. Indeed, for the most part the measures proposed do not impose heavy constraints. The application of the policy measures chosen is largely decentralised at the cantonal level, taking into account local circumstances and conditions. However, public policy exerts some impact on the level of energy management (conclusion of target agreements, energy audits) and in general on the attitude of the firms toward energy issues.

Determinants of the level of energy (and economic) performance

The last models to be estimated consider the factors which have an impact on energy and economic performance. In the questionnaire, the responding firms have been asked what impact their investment has on energy consumption, profitability, and product (innovation) competitiveness. In consequence, the survey answers reflect the answers of the firms concerning the likely impacts of their investments. There are no factual evidence and estimates on the true performance. Not all responding firms necessarily have a good knowledge of their performance. Indeed, concerning energy, a large number of firms did not define a reference setting nor do they periodically evaluate their energy performance. The impact of EE investment spending could possibly be evaluated by the firms when deciding on the EE investment projects (non-energy benefits), but such an assessment is much more difficult on the financial impact (profitability).

It should be noted that the explained performance variables are binary, taking only two values: 1, if the firm anticipates a reduction of energy consumption and 0, if the respondent firm thinks that consumption has on the contrary increased, or if the firms were not able to evaluate the evolution of energy consumption. A binary variable reflects only two possible answer types: yes or no, true or false or, as in the case of energy savings, the construction of the variable by aggregating the responses (1, for significant reduction or reduction to some extent of energy consumption, versus 0, for an increase or stable consumption). This type of variable, used below for all information on performance, is different from the three former variables to be explained: the level of management with 23 possible values (scores), the aggregate drivers of energy efficiency with values varying from 8 to 40, and EE investment spending with a broad range of values (in Swiss Francs). These variables require a different estimation procedure which cannot assume a normal distribution of values. Instead the estimated value of the variable to be explained is interpreted as a probability (see Annex 1.3).

Energy performance

In addition to investment spending, the characteristics of the firms, as well as the level of energy management, might play a role in their choice of investment projects primarily aimed at reducing energy consumption. Public policies aimed at reducing energy consumption might also be an important factor. Table 29 shows the results of the Logit estimation for the determinants of energy savings, according to the opinion of the responding firms. Note that the variable to be explained is defined as a reduction of energy consumption: a positive sign of the regression coefficient means that the explanation considered effectively reduces energy consumption (in absolute terms).

Table 29 reports the sign only of the impact of the explaining variable (probability p in brackets).[35] The following variables have an impact on the energy performance of the firms: the economic sector, the supervision of energy management by a member of the senior management, the search for competitive advantages, the size of the investment projects, and the contacts of the firms, as large electricity consumers, with cantonal authorities.

Table 29: Determinants of energy savings (reduction of electricity consumption)

Explaining variables	**Sign of regression coefficient**	**P-value**	**Description**
industry	-	0.022	firms belonging to industry and construction sectors, binary variable, 1 if so, 0 if not
support by senior management	+	0.000	firms which designated a member of the top management to supervise and support energy efficiency, binary 1 vs. 0
competitive advantages	-	0.000	enhancement of the competitive advantages of the firms, as a driver of EE investment, binary, 1 vs. 0
large projects	+	0.000	number of large EE investment projects (over 100'000 francs), 1 if yes, 0 if not
contacts with cantons	+	0.001	firm contacted by the cantonal authorities in the framework of their policies towards large energy consumers, binary, 1 if so, 0 if not
	AIC Akaike info criterion = 1.1495		
	Schwarz criterion = 1.2105		

Table Université de Neuchâtel. Source: Survey (econometric results), Université de Neuchâtel

[35] The value of the coefficient cannot be easily interpreted in terms of the size of the significant effect.

Characteristics of the firms

Few differences exist between the companies in the industry and companies in the service sector concerning the level of energy management or energy consumption and intensity as shown in the statistical analysis (frequencies). Here, in terms of energy consumption reduction, the service sector outperforms the industrial sector (see the negative sign).

Energy management

The level of energy management has no direct impact on energy performance, given the low priority attributed to the definition of a reference situation and a baseline, to spending on technical or IT solutions for measuring energy consumption, and given the lack of an energy strategy. The support and supervision by the top management in favour of setting up a system of energy management has, however, shown a favourable impact on its level. It seems also to exert a positive impact on energy performance, via various channels which are, individually, minimally compelling.

Drivers and barriers of EE investment

The sign on the driver "competitive advantages" does not have the expected positive sign. The firms which stress the importance of investment projects in terms of reaching some competitive advantages (contributions to value for customers, cost containment and reduction of various risks) are not those which experienced a reduction of energy consumption. Possibly, overall the firms prefer to spend on investment projects linked to the core business in order to stay competitive in their markets.

Energy efficiency investment projects

As expected, investment appears to have a positive impact on the use of energy. However, the effect seems to be dominated by the firms which tended to implement many large projects, usually the very large firms. It is possible that "normal" small investment projects do not reduce or are not perceived as significantly reducing energy consumption.

Public policy

The contacts established by the cantonal authorities in charge of energy policy with the large-scale energy consumers deploy a favourable impact on energy saving, everything else being equal of course. However, it is not clear how these contacts could, on their own, have an impact independent of investment and other actions taken[36].

Impact on economic performance

In addition to the impact on energy savings, the firms were asked to evaluate the likely impact of EE investment projects on their economic and financial performance. Energy efficiency investment projects are primarily expected to reduce energy consumption, thereby reducing energy costs. Nearly every energy efficiency project includes, at different degrees, non-energy benefits which may contribute to the economic success of the firms.

According to mainstream economics, one main reason for investing in energy efficiency activities and projects is the (high) cost of energy consumption. For given energy prices, a high energy consumption may incite the firms to do something about it. The competitiveness of the firms might be enhanced directly, ceteris paribus, by falling energy costs and/ or consumption, and increasing profitability and price competitiveness. In some cases, non-energy benefits of EE investment projects can have a measurable impact on innovation, quality of the product, production risks and on other elements of the production process.

Table 30 reports the results of the logit regression on price-cost and product competitiveness, as well as profitability.

The level of energy management has a significant impact on all three dimensions of economic performance. Apparently, energy management has some indirect effects which are not linked to investment activities. A well-developed system of energy management may improve the overall management of the firms and help to uncover business and investment opportunities in other areas.

[36] Unless, in the not very plausible case that important EE actions taken by the firms are not considered and reported as investments because of their low or insignificant monetary costs (change of behaviour for instance).

Table 30: Determinants of economic performance

	Price and cost competitiveness	Product competitiveness (innovation)	Profitability
level of energy management	+ (0.003)	+ (0.034)	+ (0.000)
driver of EE investment: competitive advantages	+ (0.007)	- (0.0746)	+ (0.000)
investment spending (last 4 years) per employment	---	+ (0.121)	---
investment spending per year	---	---	- (0.017)
large EE investment projects (last 4 years)	+ (0.057)	---	+ (0.003)
conclusion of a target agreement	--	+ (0.040)	---
legal provisions as opportunity	+ (0.042)	+ (0.012)	+ (0.013)
	AIC = 1.0422	AIC = 0.7966	AIC 1.1049

Table Université de Neuchâtel. Source: Survey (econometric results), Université de Neuchâtel

Overall, investment projects, measured in three different ways, have a positive impact on economic performance. An exception is the negative impact of investment spending on profitability. As investment deploys his impact over time, it is quite possible that investment projects are a financial burden which reduces profit in the short run (in the survey, the reference period for investment is the last four years). The results of Table 30 tend to show that the firms are also seeking a competitive advantage in their energy efficiency investment decisions. It should be noted, however, that the sign of the impact of the driver on product and innovation is negative. Finally, the obligations imposed by public policy in energy management are considered by the responding firms as an opportunity rather than a constraint, with a positive impact on performance.

Main econometric findings

Figure 12 illustrates and summarises the main findings of the econometric section on the survey. Of course, the difficult collection of the data at the firm level limited the representativeness and the scope of the database. But the M_Key survey is the first large database in Switzerland on the energy management in Swiss firms. In total, the results, although incomplete in many respects, make sense and provide valuable insights on the energy management and the (moderate) impact of public policy aiming at inciting large energy consumers to reduce their energy consumption. However, it was not possible to confirm all of the links between the level of energy management and energy performance.

Drivers of energy management level

It was possible to highlight some important determinants of energy management level, notably size of the firm, support and supervision by top management, and the role of public policy (existence of universal target agreements). The electricity intensity has a significant impact on the development of energy management. The significant impact of the level of thermal energy consumption (above the legal threshold) on energy management can be explained by the likely effect of environmental policies (aiming, for example, to reduce CO_2 emissions) and by public policy targeting large energy consumers, thereby increasing the awareness of energy issues. Also, when firms think that legal provisions for energy efficiency represent an opportunity rather than a constraint—in other words having a positive attitude with respect to energy efficiency—the level of energy management increases. It is important to note, however, that the causality can also be reversed: a continuous exposure to energy issues and projects, given the energy management system in place, can act as an organisational filter positively highlighting the potentiality of energy investments throughout the firm. This double-way causality might be true for other relationships and effects.

Energy management level and energy efficiency investment decision-making

The level of energy management may have a certain influence on investment decisions but seems not to directly enhance the role of the usual drivers of energy efficiency identified in the literature. It also has no direct impact on energy performance. A significant number of firms gives low priority to the definition of a reference situation and a baseline, to spending on specific information technology, or to adopting technical solutions for measuring energy consumption, and in general lacks any energy strategy.

A few factors influence the importance given to the eight (aggregate) strategic drivers of EE investment, such as the degree of competition on the market, the ownership of a building, the positive attitude towards energy efficiency and the use of at least one procedure related to the energy policy of the firm: training, the existence of a bonus system, evaluation of the results and the objectives. The last factor—evaluation of results and objectives—is likely to generate valuable information on the potentiality of EE investment. On the other hand, the impact of the strategic drivers on EE investment decisions is not confirmed by the estimations. Possibly, the firms tend to assert that certain drivers are important, but in fact this does not translate to investment spending.

Finance seems not to play a role in EE investment decisions, given the absence of any significant effect of financial variables (*e.g.* financial assessment of investment projects, availability of funding, energy costs). Most of the firms only use the simple payback method to assess the financial attractiveness of EE investment projects. This situation is partly due to the fact that this method is imposed by government in the target agreement system (since companies have to implement energy efficiency measures with a payback lower than four years when measures are related to process and with a payback lower than eight years when measures are related to buildings). However other research (see Literature review, Section 2.3.3, on Investment characteristics, financial evaluation methods and selection criteria) shows that payback is by far the prevailing method in many other countries which do not have the same legal context as Switzerland. Therefore, the Swiss legislation is not the only factor explaining the dominant use of payback. The emphasis put in many cases on a relatively short-time horizon tends to neglect the (very) long-term effects of investment projects. Moreover, the cost intensity of energy has no impact whatsoever in the whole impact chain, including on the level of energy management, suggesting that energy costs are not important for most of the responding firms.

Surprisingly, non-energy benefits (NEBs) do not influence EE investment decisions. The fact that there is no common methodology to identify, in categorising and assessing these benefits on one hand, and that this assessment requires management skills (in the field of strategy, risk analysis and finance evaluation) on the other hand, may explain this situation. NEBs could be considered in qualitative terms by the energy and senior managers, but not include in strategic and financial analyses of the projects. The responsible people for preparing and deciding upon investment projects are simply not aware of the potential contributions of energy efficiency to the core business, especially if their education and training is mainly technical.

Energy efficiency investment and energy performance

The econometric results suggest that there could be a link between EE investment spending and energy performance, at least in the case of larger investment projects and firms. Energy efficiency investment spending is indeed increased, everything else being equal, if the firm does not belong to an international group, if it is large (employment), (ISO) certified, and tends to realise relatively large projects.

Finally, large energy efficiency investment projects rather than the level of spending, and tight supervision of energy management by top management, seem to be favourable conditions for improving energy performance. Energy savings are larger in the service sector, compared to the industry and construction activities. Energy performance is likely to be influenced positively by the possibility to reach or enhance a competitive advantage and by the existence of contacts with cantons in the framework of their large energy consumer policy.

Along with the search of competitive advantage, the level of energy management has a significant impact on all three dimensions of economic performance (cost or price competitiveness, product innovation and profitability). Energy management apparently has some indirect effects, which are not linked to investment activities. A well-developed system of energy management may improve overall management of the firms and help uncover business and investment opportunities in other areas. Large investment projects seem to be important for price or cost competitiveness, as well as for profitability.

Figure 12: Impact of energy management on energy performance

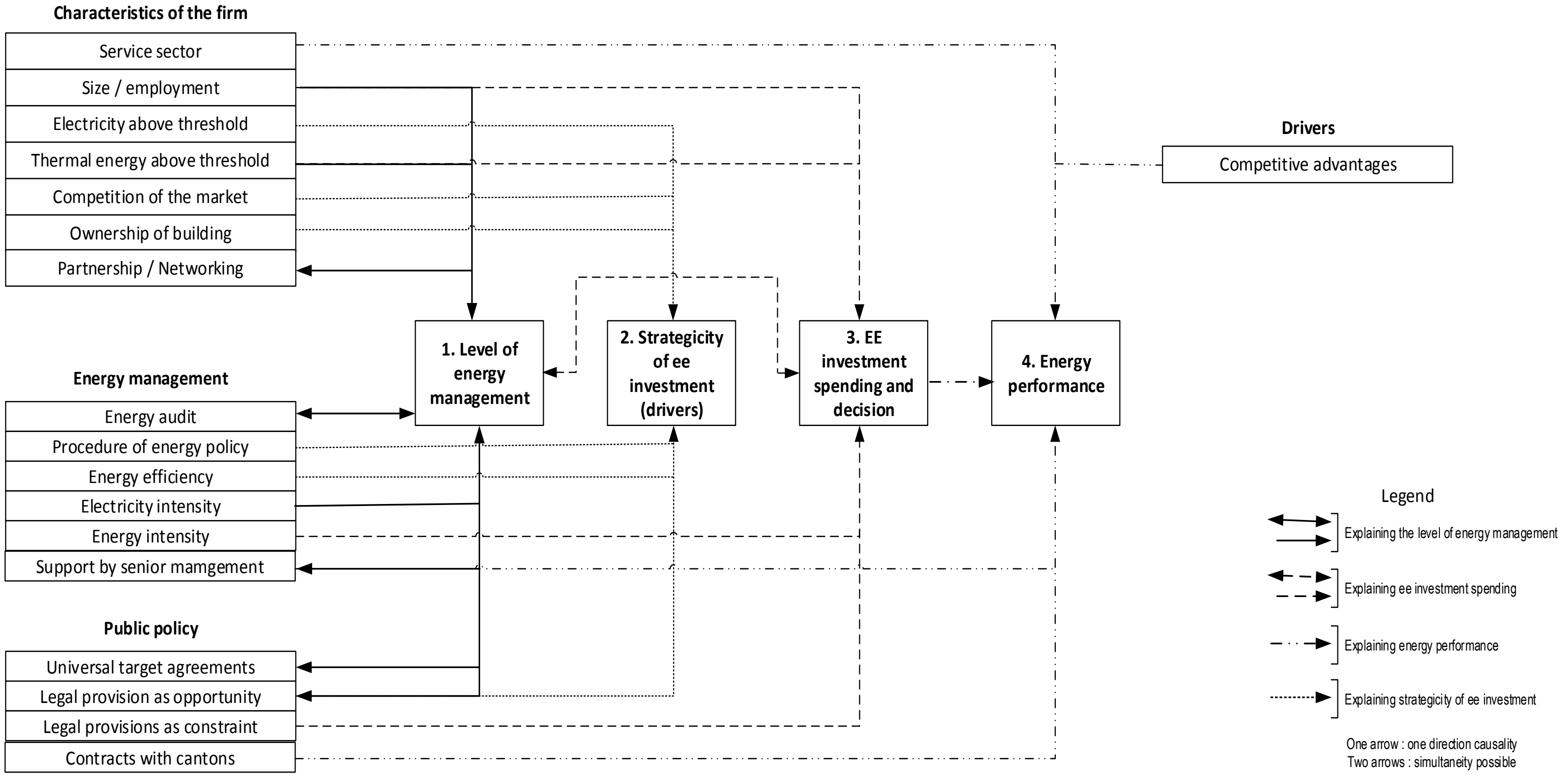


Figure Université de Neuchâtel. Source: Université de Neuchâtel.

For comparison with the results of the interviews and the case studies, the findings of the survey are summarised according to the four research questions.

Research question 1: What is the level of energy management and its determinants in Swiss large-scale energy consumers?

Hypothesis 1.1: The level of energy management in Swiss large-scale energy consumers is generally low.

According to the average and median scores of the index calculated for measuring the level (quality) of energy management systems, the firms having participated in the survey of large energy consumers show an "energy management system with possibilities for improvement". There are, however, very large differences in the scores obtained. The corresponding comparison with a former survey of Geneva-based companies suggests only a slight improvement.

Hypothesis 1.2: The main determinants of the energy management level are company size, company energy intensity, and commitment or support of energy management by top management.

The correlation analysis shows that the level of energy management is weakly correlated with most of the variables chosen to represent different sections of the questionnaire, except for the drivers of energy efficiency investment and the financial criteria. The correlation coefficients for the three determinants considered by the hypothesis are indeed significant statistically, but low. The econometric results indicate that the size of the firms matters. Electricity intensity (and thermal energy consumption) has an impact on energy management, and so does the support of energy management by senior staff. Other impact factors are: the execution of an energy audit and the conclusion of a universal target agreement. However, the direction of causality is not always clear; it might well be that a high level of energy management is also or exclusively the cause of some observed behaviour or decision (auditing, for instance). One cause or consequence of energy management could also be the positive attitude towards public policy on energy efficiency (considered as an opportunity rather than a constraint).

Research question 2: What is the influence of energy management on the perceived strategicity of energy efficiency investments?

Hypothesis 2.1: The higher the companies' level of energy management, the more strategic they perceive energy efficiency investments to be.

The level (or quality) of energy management does not have a significant direct impact, according to the econometric analysis, on the set of factors ("drivers": client satisfaction, cost and risk containment) which are supposed, on aggregate, to make energy efficiency investment projects strategic. Factors which support the energy efficiency drivers are ownership, market competition, positive attitude towards energy efficiency, and public energy policy (as an opportunity). In line with the above results, the correlation analysis does not indicate any impact of energy management on the theoretical drivers of energy efficiency.

Research question 3: What is the influence of the perceived strategicity on energy efficiency investment decision-making?

Hypothesis 3.1: The more strategic an energy efficiency investment is perceived by a company, the better the chances for a positive decision.
The influence of some of the strategic drivers or of the aggregate eight strategic drivers on EE investment spending cannot be asserted.

Hypothesis 3.2: The less strategic the investment, the more restrictive the financial criteria in the selection of investment projects.
In general, energy efficiency investment seems not to be considered as strategic, *i.e.* contributing significantly to the competitiveness of the firms. Financial factors do not play a role in EE investment decisions, given the absence of any significant financial variables in the estimated equations. The large majority of firms use the simple payback method, which is in fact imposed on large-scale electricity and energy consumers having signed a target agreement as proposed by government. These firms are obliged to implement projects with a payback period equal or shorter than four years for production investment and eight years for buildings, at the risk of neglecting thereby the possible (very) long term effects of many energy efficiency investment projects. However, both the energy intensity, as well as the level of consumption of thermal energy above the threshold of 5 GWh, have a positive impact on EE investment spending.

Hypothesis 3.3: The number of energy efficiency investments positively decided upon and realised depends mainly on the network relations/knowledge exchange within the sector.
According to the estimated investment functions, EE investment spending does not depend on the certification of the firms (notably on energy, environment and quality (ISO certifications, but not only), nor on networking and partnership with energy efficiency organisations.

Hypothesis 3.4: Increasing requirements from cantonal energy policies for large consumers and/ or rising energy prices (in particular for electricity) positively influence energy efficiency investment decision-making by companies.
The differences in the level of energy policy levels between cantons have no impact on the level of EE-investment spending. As for the impact of price, the survey cannot provide any results.

Investment in energy efficiency is not correlated to the existence of partnership and networking with organisations promoting energy efficiency, to the holding of a certification (knowledge), nor with any public policy variables. All of these effects may be reflected indirectly in the level of energy management which tends, however, to influence investment spending (significant at 7.3%). EE investment projects are likely to be realised, everything else being equal, when the firms have already a sound energy management system, when they are large and have a high energy intensity.

Research question 4: How does positive energy efficiency investment decision-making influence energy performance?

Hypothesis 4.1: The higher the number of energy efficiency investments implemented, the higher the energy performance of a company (measured in energy intensity terms).
The correlation coefficients between energy savings (falling energy consumption) or economic performance (increasing profitability, competitivity) and the various measures of the EE investment (spending, projects) are small and insignificant; when significant, the negative sign points to an increase of energy consumption due to investment spending in energy efficiency (per year and full-time equivalent) and in the production of renewable energy. In the case of investment in renewable energy, it is theoretically possible to obtain a positive impact on energy consumption (incomplete substitution between the new and traditional source of energy). In the econometric approach, declared EE investment spending leads to a reduction of energy use, as expected, in particular when a member of the top management supports and supervises energy efficiency or when the firm has been contacted by the canton. The effect seems to be dominated by the firms which tend to implement large projects, and is larger in industry. It is conceivable that "normal" small investment projects are perceived as unable to reduce energy consumption significantly. Firms seek to enhance their competitive advantages.

5.3.2. Conclusion

As stated in the research model, the objective of the research project is to analyse the relationships of influence linking energy management to energy efficiency and energy performance. Along the identified impact chain, three relationships of influence are hypothesised, based on the conceptual framework: 1) influence of energy management on the perceived strategic character of energy efficiency investments; 2) influence of investments strategicity on investment decision-making; 3) impact of energy efficient investment project on the reduction of electricity/ energy consumption and economic performance and competitiveness.

M_Key research is rooted in—and is building on—a 40-year research field but applies a different perspective compared to the mainstream. Indeed, according to the dominant view prevailing in the field, energy efficiency investment decision-making is driven principally by investment profitability. Therefore, in order to increase firms' positive decisions regarding energy efficiency investment, it is necessary 1) to inform economic actors about investment opportunities, and 2) to increase the financial attractiveness of these investments, mainly through subsidies per kWh saved or, as in the case of the Swiss CO2 law, through tax exemption. However, the significant energy efficiency potential still existent in most companies and fields of activity, as well as findings of alternative research (to the prevailing economists' view), have shown that this double approach does not bring satisfying or sufficient results (Section 2.3). Within this context, M_Key research looks for other explanations, with a different starting point: the main factor explaining investment decision-making is not profitability but strategicity, *i.e.* the contribution of an investment to a company's competitiveness in performing its core business. Based on this basic assumption (supported by research findings in organisational finance, strategic decision-making and energy efficiency investment), M_Key's goal was to investigate the factors which may raise an investment's strategic character (higher strategic character would then translate into increased positive decision-making). Among those factors, one could be energy management. If a link could be established between energy management and investment strategicity, then increasing energy management would automatically raise energy efficiency investment decision-making in companies and new opportunities would arise for public programs and policies promoting energy efficiency in Switzerland and elsewhere.

Energy management level and composition

Half of the responding firms have no energy management at all or a weak level of energy management, according to the scores obtained by the 305 responding firms of the survey. These firms obtained between 0 and 10 points, out of a total achievable score of 23 points. The average score for all respondents is 10.3 out of a maximum 23 points. This result can be compared to a survey on 35 Geneva-based firms from 2006 to 2007. The average score reached was 8.9 points out of a maximum of 22, or adjusted to the number of maximum points in M_Key research (23 instead of 22 in the 2006–2007 survey). Compared to the average score 12.3 obtained by the 32 large scale energy consuming firms located in Geneva in the Swiss survey, the level of energy management has improved to the lower range of the category "good energy management system". However, these results still leave plenty of room for improvement.

Regarding the composition of energy management, some facts are striking regarding the answers of the 305 responding companies:

- only 44% have an energy policy;
- only 30% have defined a baseline, *i.e.* a reference situation to which they can compare the progress made regarding energy performance;
- according to a good general definition (whatever the field of application), managing means "organizing with a goal". Setting or having a goal is the first step of any sound management. Yet only 54% of the responding companies have defined measurable goals regarding a reduction of their energy consumption and less than half of them have defined measures and actions enabling to reach the goals defined or the data enabling to verify the achievement of the goals defined;
- less than one third have allocated technical resources, such as meters or sub-meters to support the energy management system.

In summary, regarding their energy performance, many companies do not know where they come from and where they would like to be in the future, nor do they have the monitoring and control tools which enable them to check progress and achievements. Thus, it is not a surprise that they are not capable of tracking their energy efficiency investments or of assessing the impact of their energy efficiency projects on their energy performance. Based on the literature review and on the conceptual framework, this situation could be explained by two main factors: 1) a low energy or energy efficiency culture in companies, which translates into a weak interest towards energy issues and energy performance (moderate level of energy management and lack of management skills of the persons in charge of energy issues, and 2) the absence of or low strategic importance of EE issues. As a result "energy managers" promote energy efficiency projects along the classical argument of physical (kWh) and financial savings without taking into account companies' business models or making the link between energy efficiency projects and companies' core business.

Driving factors of energy management

The results derived from the survey seem to confirm previous research findings regarding the influence of size (measured in terms of employment) on energy management. In general, large firms and large-scale energy consumers (*i.e.* above the legal thresholds defining LSEC) tend to be more aware of energy issues. This translates into support by top management (+1.8 points on average of the index of energy management) and to the conviction that public policy on energy, at least in its current state at federal and cantonal levels, constitutes an opportunity rather than a constraint for firms. The support of top management is confirmed as a key stimulus for the energy management system as well as for energy efficiency investment decision-making.

Public policy has an impact on the level of energy management, especially in firms which have concluded a target agreement to partially or completely be exempt from the CO2 tax. Undergoing an energy audit seems also to be a key factor in the process of adopting an energy management system, a finding which can, however, be interpreted in two ways: 1) the audit follows increasing concern regarding energy consumption (motivated by cost, environmental or tax escape reasons), or 2) the audit triggers a more active energy management. The direction of causality is not always clear. This is true not only for some of the results on energy management system, but also for others, on investment behaviour or the strategicity of energy efficient investments for instance. A partnership with public organisations promoting energy efficiency (such as EnAW or ACT) helps cope with the technical and organisational difficulties the firms are likely to face at the beginning of an energy management setting. Electricity (or energy) intensity has an impact on energy management.

Investment in energy efficiency: financial logic versus strategic logic

When asked about their motivation to engage into energy management, 62% of the responding companies first indicate financial benefits. Similarly, cost reduction is assessed as the most influencing factor positively driving adoption of energy-efficient technology or equipment: it is considered as important or very important by 89% of the companies. Energy costs play a role with respect to energy management and investment spending.

The role of financial logic is, however, not as prevailing as it seems at first sight. “Other investment more important” is by far the first barrier to energy efficiency investment identified by 70% of the respondents, a statement probably referring to core business investments (although more research is needed on this aspect). Investment subsidies and tax breaks are perceived as important or very important driving factors by a minority of respondents (40%); similarly low financial attractiveness is a barrier to the adoption of energy efficiency technology for only 44% of the respondents. Internal financial constraint, a factor though often assessed in the literature as one of the most important barriers to energy efficiency investments, is a barrier for less than half of the respondents.

Regarding strategic logic, the level of strategicity of energy efficiency investment, as evaluated by our measurement tool, show average and median scores of 27 points, out of a maximum possible of 40 points, thus a rather weak strategic character for the responding companies (similar in the industry and service sectors). However, firm's positive image and lower production risks come in second and third places as positive drivers of energy-efficient technology adoption. Positive contribution to market competitiveness is a driver for 62% of the respondents and the degree of competition on the market also positively drives energy-investment decision-making. Energy savings are likely to be positively influenced by the possibility of reaching a competitive advantage and by existing contacts with cantons in the framework of their large energy consumer policy.

In turn, according to the estimated investment equation, EE investment spending is not related to the strategic drivers of energy efficiency. Two hundred and twenty-three out of the 305 firms having validly answered the questionnaire (73%) provided meaningful information on their energy-investment projects. Non-energy benefits of energy efficiency investment are very often or nearly every time considered in project evaluation by 45% of the companies only. Fifty-five percent of the companies declare that they never or only very rarely consider NEBs in their investment decision-making process.

Energy management, energy efficiency investment and energy performance

Finally, the ultimate question is the impact of energy management and energy efficiency decisions on the energy performance of the firm. In this regard, the survey had to rely on self-assessment of the energy and economic performance, as a result of energy management and public policy.

Support and tight supervision of the energy management by top management, coupled with the implementation of rather large investment projects, seem to be conditions for significant energy savings. But many companies are not able to assess the impact of energy efficiency investments on their energy performance or on their general performance. This important finding must be related to the lack of important energy management elements (described and emphasized above), *i.e.* the lack of a baseline, goals, energy efficiency measures to achieve the goals defined, and the collection of data to analyse the results obtained.

To conclude, the survey results depict, for the first time, the situation and behaviour of large-scale energy consumers in Switzerland. In this regard, the results confirm the heterogeneity observed by previous research regarding for-profit companies. Heterogeneity is not only due to the variety of business activities, it is mainly due to the intrinsic diversity of behaviour between companies, even between those active in the same sector, with similar characteristics in terms of size and markets.

Above a certain threshold of energy intensity, large companies with a very high level of energy consumption or energy intensity and a high level of management skills seem to attribute a strong importance to energy. These companies organize transversally functioning teams where process people and energy people collaborate, wherever the initial idea for an investment project may come from (energy or process). But in many companies, the level of energy management is low, energy people are relegated out of the process to take care of "support" equipment, monitoring and control are highly imperfect and, even more importantly, there are no objectives regarding improvement of energy performance. In those companies, the conventional "energy-savings" argument is put forward to convince top management to approve energy efficiency projects, but this argument has little weight compared to the many other important investments. The human dimension remains a very important driver of investments with personalities and relationships between people playing an important role. Organisation (management systems) and motivation from top management matter. Public policy, as a package of measures, has no direct impact, but some elements are likely to influence the level of energy management (agreements, possibly audits or the existence of partnership/networking), thereby indirectly helping to promote EE investment and energy savings.

The length of time needed for the cantons to implement the prescriptions of the federal energy law are relatively long—about ten years—and the cantons have some liberty to choose the instruments and measures which suit them most: either political, or efficiency and circumstance-dependent. Some cantons reacted very quickly, by determining an energy strategy and the scope of the measures to be implemented; other cantons, especially the smaller ones but not only they, move ahead with more reticence. A particularly active policy at the cantonal level does not have a very large impact on the level of energy management.

6. Interviews

Based on the survey results from 305 Swiss large-scale energy consumer (LSEC) companies, several of these companies were selected to participate in an interview. The main objective was to gather further information to verify the hypotheses of the research project (see Chapter 3). Furthermore, the interviews served to provide more information about the relationship between energy management (EM) and energy efficiency investments. The objectives of the interviews were:

- to gather additional background information concerning the energy management of the companies and to validate information received from the companies which participated in the survey;
- to clarify causal relationships based on particular answers to the survey questions;
- to clarify open questions concerning the hypothesis and further causal relationships between energy management and energy efficiency investments.

Chapter 6 concerns the interview results, and is structured as follows:

- Chapter 6.2 describes the statements of the interviewed companies according to the topics defined in the interview guide;
- Chapter 6.3 presents the overall conclusions from the interviews, answers the research questions, and verifies the hypotheses based on the interview results.

6.1. Methodology

Selection of companies

The following selection criteria were applied to define the interview sample:

- 26 companies which agreed to be interviewed after participating in the survey, 18 of which were located in German-speaking Switzerland and eight of which were located in French-speaking Switzerland;[37]
- half of the companies held a “rather high” level of energy management and half of the companies a “rather low” one;[38]

[37] As far as possible, there were also a few companies selected that were located in cantons with enforced regulation of large-scale energy consumers in cantonal legislation of 2015 or later.

[38] The information concerning the level of energy management is based on the survey and the corresponding classification (see Chapter 5). “Rather high” encompasses “upper medium” (11–18 points) and “high” (19–23 points) levels of energy management. “Rather low” includes “lower medium” (6–10 points) and “low” (0–5 points) levels of energy management.

- regarding annual electricity consumption, 1/3 of the companies were "small" (0.5–3 GWh/a), 1/3 were "medium" (3–10 GWh/a) and 1/3 were "large" (> 10 GWh/a);[39]
- 2/3 of the companies belonged to the industrial sector, and 1/3 of the companies belonged to the services sector.

As planned, 26 companies were interviewed, of which 18 companies were located in German-speaking Switzerland and eight were located in French-speaking Switzerland. Except for the level of energy management, the predefined selection criteria were met (see Table 31). This is for two reasons. First, there were fewer companies with a rather low level of energy management available from the survey sample and second, several of the contacted companies from this group declined[40] the request to be interviewed. These companies are therefore slightly underrepresented compared to the predefined criteria.

Table 31: Characteristics of the interviewed companies

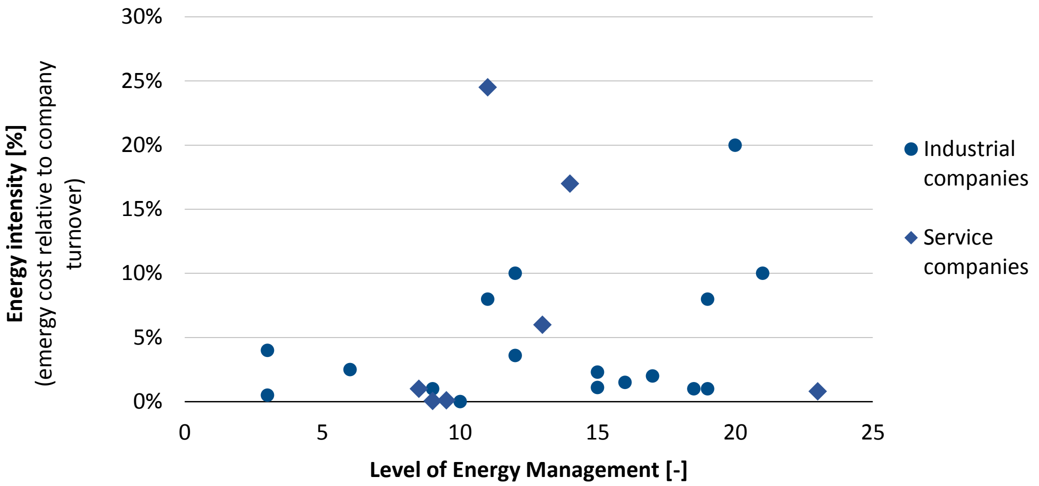
Criteria		**German part**	**French part**	**Total**
Level of Energy Management[1)]	"high" (19-23 points)	3	3	6
	"upper medium" (11–18 points)	9	1	10
	"lower medium" (6–10 points)	6	2	8
	"low" (0–5 points)	0	2	2
Size	> 10 GWh_{el}/year	5	4	9
	3–10 GWh_{el}/year	7	2	9
	0.5–3 GWh_{el}/year	6	2	8
Sector/branch	Industry	11	6	17
	Services	7	2	9
Total		**18**	**8**	**26**

Table INFRAS. Source: Survey.

Seventeen companies belonged to the industrial and manufacturing sector. The remaining nine companies belonged to the service sector. The latter also included companies with professional facility management (as a company unto itself or as a company's facility management department). Figure 13 plots the interviewed companies' energy intensity versus their level of energy management.

[39] Source: data gathered from the survey.
[40] In most cases of declined interviews, the reasons were a lack of interest in participating or a lack of time.

Figure 13: Energy intensity and energy management level of interviewed companies



The energy intensity of two of the 26 companies of the service sector are unknown and therefore not represented in this figure.

Figure INFRAS. Source: Survey.

Qualitative interviews

The interviews were conducted as follows:

- qualitative face-to-face interviews were conducted with the person responsible for energy management (*e.g.* facility management in companies in the service sector) and lasted one and a half to two hours;
- open questions which were based on an interview guide comprising the main questions were included. The interview guide was shared with the person to be interviewed and communicated well ahead of the interviews. Additional questions raised in the interviews were specified in an internal guide:
- the questions from the shared interview guide (and the additional questions from the internal interview guide) were discussed. The interview took the companies' answers to the survey questionnaire into consideration;
- detailed minutes of the interviews were taken and structured according to the questions in the interview guide. The drafts of the minutes were sent to the people interviewed for verification.

The interview guide is structured into the following topics:[41]

- energy management: description, evolvement, strengths and weaknesses;
- decision-making process towards energy-efficient investments: organisation, decision criteria, factors with positive or negative impacts;
- role and influence of the energy management on the decision-making process, especially regarding the influence on the perceived strategic character of energy-efficient investments;
- impact of energy efficiency investments on the companies' energy performance;
- suggestions for improving energy management (including federal and cantonal policies).

The results of the interviews were analysed and interpreted on the base of an interpretative-reductive and comparative content analysis in two steps:

- First, the statements of the interviewees were analysed, compared and described according to the questions listed in the interview guide;
- Second, the answers of the interviewees were interpreted with reference to the research questions and the hypotheses. To verify the hypotheses, direct statements were compared to other statements by the interviewees with respect to the corresponding hypotheses within the companies. Furthermore, the research questions were answered and the hypotheses were verified by comparing the statements of the interviewees between the companies.

The language conventions used in the result description are as follows:

Table 32: Language conventions used in the result description

Wording	Statements by the number (or percentage) of companies (given in ranges)
Most	20 to 26 (> 75%)
Many	11 to 19 (40%–75%)
Several	6 to 10 (20%–40%)
Some / Couple	2 to 5 (<20%)
Individual	1

The absolute numbers are valid for sections of the report, referring to the whole group of interviewed companies. If a section is specifically referring to a subgroup of interviewed companies, the corresponding percentages should be considered, not the absolute numbers (*e.g.* several companies of a specified subgroup is referring to 20–40% of the subgroup and not to 6–10 companies).

Table INFRAS.

[41] The interview guide is documented in Annex 2.

6.2. Results

The interviewed companies are very heterogeneous (*e.g.* regarding their sector, size, core business, energy consumption, cost relevance of energy consumption, organisational structure of energy management (EM), competition situation of the market and available budgets). Furthermore, even though all interviewees are responsible for energy questions, they have different jobs, hold very different positions in the companies (see Table 44 in Annex 2.1), and they face different influencing factors relating to the company, both internal and external. Several of the interviewed companies have a designated energy manager, but only rarely do companies have an energy manager that has no other responsibilities than energy management. In many cases the role of the energy manager is part of the position of the responsible person for security, environment, and health. In some cases, the production manager, the director of a company, a member of the managing board or the top management is responsible for energy issues. Hereafter, the responsible person for energy-related topics is called the "energy manager".

Due to the different positions of the interviewees and the different circumstances of all companies, they have different perspectives on the importance of energy efficiency and energy management, as well as varying priorities toward investment decisions. The attributed strategic character of energy management and energy efficiency investments varies widely. One can generally distinguish between companies that face the importance of energy efficiency of their products, companies that have to or want to produce their products or to provide their services in an energy-efficient manner, and companies that have no time or no interest to invest in energy issues.

6.2.1. Energy management

The interviewed companies cover a wide range of their understanding of energy management. Generally, the interviews focused on all activities of a company that aim to improve energy efficiency and reduce energy consumption. In the following, relevant findings about energy efficiency, different determinants and further plans of energy management development, and the influences of different company external, internal, and individual factors are presented.[42]

[42] For the interviewed companies, in many cases the influencing factors of considering energy efficiency and energy management determinants overlap. As in the interviews, the very broad definition of energy management was used (any action to improve energy efficiency and reduce energy consumption). Consequently, most reasons to consider energy efficiency are also a determinant for energy management.

Relevance of energy efficiency and determinants of energy management development
Generally, in the interview sample, companies with a higher perceived importance of energy efficiency also have a higher level of energy management (as it was assessed in the survey, see Chapter 5). The highest assessed levels of energy management of the companies in the interview sample were achieved by larger industrial companies belonging to a group. Many of the interviewees attribute a high or very high importance to the topic "energy efficiency". However, energy efficiency is not regarded as a part of the companies' culture and neither energy efficiency nor energy management are considered as core business by most of the interviewed companies. There are only some companies in the interview sample with a substantial share of energy cost relative to their turnover (*e.g.* more than 5% or10%). These companies consider energy efficiency in their business activities as financially relevant. But for the other companies the reasons why many of the interviewees state that energy efficiency is an important topic are manifold. There are many ways in which the perceived importance of energy efficiency and the companies' energy management evolved. The most commonly-mentioned determinants for energy management development are shown in Figure 14. In most cases, it is a set of multiple factors that drives energy management. The three most common determinants, mentioned by the interviewees to deal with energy efficiency and start with energy management actions, are laws and regulations, environmental and social responsibility, and energy intensity and cost reductions. Furthermore, several companies are specifically influenced by top-down decisions (top management, group targets/policies), several by bottom-up actions (energy managers), although most companies are influenced by a combination of multiple factors.

Laws and regulations
Most of the interviewees mentioned laws and regulations (including policy instruments) as an important driver for energy management development. Most of all, CO_2 target agreements in combination with reimbursements of the CO_2 levy are important. In the cases in which companies pay CO_2 levies, this serves as an initial trigger to enter a CO_2 target agreement, which in turn helps to establish a more systematic energy management. Cantonal regulations (*e.g.* the legislation governing large-scale consumers) or regional support programs can also influence companies' activities greatly. Several interviewees made it clear that policy instruments such as the CO_2 target agreements, energo, or regional programs were highly relevant in establishing energy management procedures within their company and making the top management commit to energetic optimization. This establishment of energy efficiency as a topic helps energy managers to initiate and realise projects. However, several stated that only very few additional

energy efficiency measures were identified and planned thanks to the CO_2 target agreement or to an energy consumption analysis.[43]

Environmental and social responsibility / top management

Many companies' top management considers energy efficiency for reasons of environmental and social responsibility. Several have sustainability targets or even a sustainability policy, which was established by the company's top management or the group management. Several others have a stronger focus on environmental and social responsibility, as they are smaller local companies. Further results related to company size, for example, are discussed later in this chapter.

The reasons behind this driver of active energy management are different. For some companies, it might have a strong image component. For other companies, it is expected by the customers, the clients, or the investors. This market pressure is already existent for several companies and an environmental management certification is required in some cases. A couple of companies do not face this pressure today, but they do anticipate customer expectations towards energy efficiency and environmental responsibility of the company to gain importance in the future.

Energy intensity and cost reductions

All interviewed companies are classified as large-scale energy consumer companies. The total energy expenses are, correspondingly and for many of the companies, considerably high in absolute terms. Therefore, energy efficiency is seen as an opportunity for cost reduction by many of them. However, energy costs are not a strategic issue for most of these companies. Several interviewees name this as an important determinant of the company's energy management development. Typically, energy intensity and cost reduction are part of multiple factors that are considered and are not the most important determinants on their own.

[43] It is not within the scope of this study to analyse the effectiveness or additionality of energy and climate policy instruments. It is unknown whether all the measures would have been realised without policy instruments as well, or in what time interval the realisation would have taken place.

Figure 14: Most frequently-mentioned reasons and triggers for energy management development by the interviewees

Font size indicates the number of mentions by companies. Laws and regulations and the support of the top management were cited by most of the companies as an important determinant.

Figure INFRAS. Source: Interviews.

Findings related to company size, sector, and organisational structure

The general findings discussed above are hereafter differentiated in findings related to company specifications. The four specifications selected represent the following percentages of the interview sample. Roughly half of the interviewed companies can be accounted to SMEs or other businesses with local rooting and the other half to companies belonging to national or international corporate groups. The sector split of the interview sample is approximately one-third belonging to the service industry (mainly facility management) and two-thirds belonging to the manufacturing industry.

The relevant mix of energy management drivers is very much dependent on different factors, one of which is company size (as discussed below – SMEs and corporate groups).

Businesses with local roots, particularly small and medium-sized enterprises (SMEs)

SMEs tend to have a high self-understanding of their social and environmental responsibility. Several SMEs argued that this should be natural for a locally-rooted business. Companies with this perception usually follow less strict financial criteria compared to companies that belong to international groups.

The organisational structure of SME's energy management and the decision-making processes are in most cases relatively lean. Standardized elements or targets for the energy management were developed in many cases by entering a CO_2 target agreement or some other participation in a voluntary agreement (*e.g.* with a power utility or with energo). In most cases, the people responsible for energy management in SMEs also have other tasks and responsibilities (this is not only the case in SMEs, but can also be the case in larger companies). Therefore, one of the major barriers of energy efficiency improvements within SMEs (aside from restricted financial budgets) is the limited capacity of personnel resources.

Companies which are part of corporate groups

Most of the companies which were part of a corporate group have a sustainability policy or even energy reduction targets set by the group. Many corporate groups set targets or develop strategies because of the market and public pressure on the companies to act sustainable. This is also a reason for certification (ISO 14001 or ISO 50001). Particularly, many companies in the manufacturing industry are certified to cope with this market or customer demand (certification is very relevant for tenders). Most corporate groups or companies belonging to one have designated people responsible for energy management or environmental management and safety (often covering energy management as well). The decision processes and the financial criteria for investment decisions are mostly standardized and the profitability criteria are strict for many companies. A couple of the corporate groups have separate budgets for energy efficiency or generally for sustainability projects with less strict financial criteria. This is also the group of interviewed companies with the highest energy management level (as it was assessed in the survey).

Service industry—professional facility management

A third of the interviewed companies are professionally-managed facilities or have their own facility management department. Cost reduction through efficiency measures is perceived as an important driver by energy managers for many of these companies or departments. However, they are also focused on energy efficiency improvements, driven by motivated energy managers. The technician's or energy manager's capacity and know-how, as well as the support of the top management, are important success factors for energy efficiency projects. In individual cases, when a company operates a site for its clients, the clients benefit from reduced energy prices and not the operating company. However, they still want to optimise the site due to their environmental responsibility (image, strategy, site attractiveness, or conviction).

Manufacturing industry

Two-thirds of the interviewed companies belong to this sector. The energy management in the manufacturing industry is, in many cases, strongly influenced by laws and regulations. In several cases, it is also positively influenced and supported by the need of certificates (*e.g.* ISO 14001) and customer expectations (market demand). The certification leads to an environmental manager being appointed (often summarized in environmental, health and safety management) and pushes the companies to deal with their environmental impact. ISO-certification can help to establish processes and start dealing with the topic of energy efficiency. The assessment of the company's energy consumption and thoughts about its optimisation subsequently follow.

Individual factors

In many cases energy managers promote energy efficiency measures. They are keen on improving the company's efficiency and are often personally motivated and have a technical flair. In many cases, motivated energy managers ask for further development of monitoring possibilities. The push for greater efficiency and more projects also raises awareness of the top management and the collaborators of energy efficiency topics. The main factors supporting or hindering the successful implementation of new projects are available finances, available time, other strategic or urgent investment priorities, and support of the management.

In several of the smaller companies, the energy management is located at the management level, where a managing partner takes the responsibilities of an energy manager. This has advantages and disadvantages. The largest positive effect is that the topic of energy management and energy efficiency is present directly on the management level. The downside is the limited time budget of these people to deal with energy management and to start new projects, as they have other priorities.

Further energy management development plans and self-assessment of EM by companies
Most of the interviewed companies do not have specific plans to further develop their energy management. Many of the companies self-assess their energy management level as sufficient as it is. However, there are several that state that they do not have an actual energy management or that their energy management level is very low. However, most of these companies do not have existing plans of further EM development, whereas individual companies plan to improve their monitoring system (*e.g*. measurement network to assess energy consumption). It is also one of the most often-mentioned weaknesses of the companies' energy management that the impact of energy efficiency measures often cannot be measured. In the cases of companies with very lean and direct organisational structures (between energy managers and top management or, for example, if a person in the top management is responsible for energy topics), this is often mentioned as a positive aspect of the companies' energy managements. However, this is often coupled with a lack of personal resources and time. On the other hand, companies with more established energy management structures and procedures face the issue that the decision-making process is often lengthy. The positive aspects mentioned concerning this organisational structure are top management support, as well as available budgets and personal resources.

6.2.2. The decision-making process

The interviewed companies follow different decision-making processes regarding energy efficiency investments. They span from very little-established organisational processes to strict and standardized processes. In most cases, small projects relating to maintenance can be decided upon by the energy manager, facility manager, or production manager. Regarding small infrastructural investments, most of the interviewees state that a slightly more expensive—but more efficient—solution would be chosen if a replacement has to be made (*e.g.* lighting). Process-related investments are more difficult, due to complexity and quality requirements.

Many interviewees point out that most investments are not only energy efficiency projects, but have other purposes and benefits as well.

Short and direct decision-making processes
Many of the companies, particularly the smaller ones, have few established processes. The decision-making processes are short and direct. The energy manager or the project leader presents the idea to the relevant managing partner or director. After positive feedback the project is elaborated in more depth and an estimate of the cost and the payback time is again presented to the relevant manager. If a managing partner him- or herself is responsible for energy efficiency related topics, the project ideas and investment decisions are directly dis-

cussed within the management and the managing board. In either case, the collaboration and trust between the parties is one of the most important success factors, in addition to the financial capabilities of the company. Within this context the investment decisions are mostly based on rough payback time calculations and on additional non-energy benefits, such as the need for an investment and the contribution to production reliability and quality.

Established and standardised decision-making processes

On the other end of the spectrum of the decision-making processes, there are the larger companies, or companies which are part of a corporate group, with rather strict and standardized processes. Many of the interviewed companies have strict processes and project funding application steps. The projects can be initiated by different people. Depending on the project scope and cost, project proposals have to be approved at different organisational levels. In individual cases, budgets are separated into different investment categories (*e.g.* sustainability, core business, innovation) and have different requirements to the projects. In another case, the projects are discussed in a team of people from technical, financial, and purchasing departments. Individual companies also have specialized teams or departments dealing with energy management and optimization, but these are rather outstanding cases.

Most of the larger companies have defined financial criteria. However, many of them can apply flexible thresholds if an investment is perceived as strategic (*e.g.* production reliability and quality), or if it implies additional non-energy benefits (*e.g.* sustainability and environmental friendliness). Several companies apply strict financial criteria, the same ones for all projects of a category (typically there are different thresholds for process and building/infrastructure related investments).

Decision criteria for energy efficiency investments

Companies apply different criteria for decision-making. Several of the companies have formal and more standardized criteria set, several others apply criteria in a more subjective manner. In most cases, an investment decision is based on multiple criteria.

- Many of the interviewed companies state that financial aspects or profitability are the most or among the most important decision-making criteria. This was stated whether or not cost reduction was mentioned as a driver for energy management development.[44] The companies always act within their market environment and their financial capabilities. Hence, there are financial restrictions for most of the companies. Several companies are facing very

[44] Cost reductions are one of the determinants for energy management development and influence the perceived strategicity of energy efficiency in many, but not all, of the interviewed companies.

short-term oriented markets, or in individual cases the corporate group can also greatly restrict the financial investment criteria. This makes long-term investments much more difficult to realise.

- For several companies, quality and equipment safety or reliability are key criteria. These factors represent components that interfere directly with the core business of the companies. Therefore, they attract a high level of attention and are crucial arguments in a decision-making process, much more than energy efficiency. For instance, the production reliability in a manufacturing company—or in one individual case, the occupants' comfort in an office building—are rated as more important than energy or cost benefits.
- Non-energy benefits and sustainability criteria are valued differently among the interviewed companies and are not quantified in most cases. Some give these criteria the same weight as the financial criteria, some value them even higher, and still others do not give them any weight at all compared to financial criteria.
- Most of the interviewed companies consider core business relevant criteria for investment decisions. Typically, for the interviewed companies, these factors are difficult to financially assess. This is also the case with non-energy benefits.

Drivers and barriers for energy efficiency investments

Cost reductions, by increased energetic performance, are energy management and energy efficiency investment drivers for several of the interviewed companies. A situation with low energy prices counteracts this driver. It reduces the profitability and attractiveness of energy efficiency investments. Policy instruments, such as the CO_2 tax levy reimbursement[45] or subsidies, create financial incentives that make energy efficiency investments more attractive. In addition to these external factors, there are important internal drivers and barriers. For instance, in many of the companies, a lack of project budgets and/or higher priority investments (*e.g.* because the investment is more urgent or more strategic) are the main barriers to energy efficiency projects. Furthermore, several companies mention availability of time, internal personnel resources, and technical skills as limiting factors.

Some companies in the manufacturing industry, as well as also a couple of companies in the service industry, feel they are in a field of conflict between long-term investment decisions and short-term business operations, market pressure and development.

[45] The energy efficiency investment itself does not become more attractive by this instrument (different to subsidies, for example); rather, the energy costs of the company are reduced indirectly by reimbursements from the CO_2 levy.

Learning from network contacts and exchange is a helpful source to identify new efficiency potentials and measures. However, it does not generally influence energy efficiency investment decisions, but serves more as a welcome idea source and benchmarking opportunity.

In addition to the financial and personal resource aspects, the main drivers have already been discussed in Chapter 6.2.1 and are summarized in Table 33. As most investments are not strict energy efficiency projects, the role of energy management within the decision process of investments has the potential to be very important. This topic is subsequently discussed in Section 6.2.3.

Table 33: Main drivers and barriers for energy efficiency investments grouped in external and internal factors.

External factors	Driver	Barrier
Laws and regulations / policy instruments	Obligations or incentives to act and improve energy efficiency	Complexity, administrative barriers, and insufficiently informed companies (energy managers and top management)
Market demand	Push or obligation for companies to act sustainable, customer expectations, and image benefits	Short term market and demand results in investment insecurities and short payback time demands for investments
Current energy prices	Cost reduction / profitability for some measures also given with current prices (this potential is in several companies already exploited)	Insufficient profitability of pure energy efficiency projects (with current, low energy prices)

Internal factors	Driver	Barrier
Energy intensity	Generally, better understanding and consciousness in companies with higher energy intensity (energy expenses are a known part of the budget)	Generally, no relevant cost factor in many companies with lower energy intensity (no specific accounting of energy expenses)
Commitment of top management or corporate group	Energy management receives top-down targets, entitlement to act, and (usually) financial support	A lack of commitment or support by the group or management makes project realisations harder for energy managers
ISO certification	Tendering requirements, supply chain and quality requirements can be reasons for certification. ISO 14001 requires companies to deal with their environmental impacts, ISO 50001 requires energy management anyway (however, this is not widespread in interview sample)	Companies have reservations about certification because of anticipated administrative and bureaucratic effort *(this is not a barrier to energy efficiency investments, but a barrier to a positively influencing factor)*
Bottom-up actions by energy managers	Motivation, engagement, encouragement, technical flair, communication skills, financial and personal resources are positively influencing energy efficiency investments	Limited financial and personal resources, lacking motivation, support or time to realise projects within a company negatively influence energy efficiency investments

Many of the listed factors are linked to energy prices and can be a driver or a barrier, depending on the current situation.

Table INFRAS. Source: Interviews.

6.2.3. Role and influence of energy management

In most cases energy management serves as a tool to provide facts and data, to identify potentials, and to develop project ideas. The resulting transparency and understanding of energy flow and related costs can play an important role in investment decision-making processes. In many cases, where energy efficiency is not the main purpose of an investment, facts about energy consumption, the related costs, and potential savings, can influence an investment decision or the final project design or product choice.

From a strategic perspective, most companies state that the strategic importance of energy management and energy efficiency measures is defined, for example by top management or the corporate group). The resulting transparency, through monitoring of energetic development and assessment of efficiency measures' impacts, improves trust and support in energy management and corresponding investments. A couple of interviewees state that this can also trigger positive feedback on the perceived strategicity of energy efficiency measures and energy management itself. However, most interviewees do not see this strategicity reinforcement. One company faced a clear increase in strategic perception of energy management. Large cost reduction potential was identified once the unknown, effective energy consumption and costs had been assessed. In this specific case in the facility management field, energy management has become an important component of the decision-making process. The decisions are based on energy consumption data, expressed in costs per square meter for refurbishment or new construction. The facility or energy management is involved in the planning and building processes.

There are a couple of other cases in which companies' energy management carries out a special role in investment decision-making and project-planning processes. For example, the energy manager or the purchasing manager is involved in investment projects at an early stage; or, a couple of companies apply life cycle cost assessment for at least some of their projects. In these cases, energy managers are very much involved in providing the information for decision-making, or are directly involved in the decision-making itself. In most of the interviewed companies, energy management is not involved in decision-making processes as a standard. The role and involvement depends more on a combination of top-down or external requirements and individual initiatives, known potentials, and personal capacities. As such, energy management can hold different roles in a company: a passive role or a more proactive one, in which energy management becomes an important observatory for potential projects and the energy manager develops and promotes energy efficiency projects.

6.2.4. Impact on energy performance

All interviewees agreed that energy management and investments in energy efficiency do generally have a positive impact on the energetic performance of the company. Most state that energy management activities help to make the performance increase measurable and visible, as well. This is important for lasting (or increasing) support by decision makers (top management or corporate group).

Most of the companies do have some sort of monitoring equipment—at least one or more electricity meters—and know their energy consumption. The monitoring system of many companies, however, is not detailed enough to assess the impact of a single energy efficiency measure. The companies face the problem of fluctuating production or employee numbers, which can dominate the measured energy consumption. This is one of the most often-mentioned improvement potentials for the companies' energy managements.

6.2.5. Improvement potential and requirements towards policy makers

Energy management improvement potential

Most interviewees state that the current level of energy management is sufficient. Improvement potential is mainly detected with regards to personal and financial resources. The need for personnel resources arises on different ends. In many of the companies the energy manager him- or herself could use more support. They often have various responsibilities in addition to energy management. Furthermore, energy management may not be the top priority on their work schedule. On the other hand, the personnel resources to implement and run the projects are scarce in many of the companies. On the technical level, the most often-mentioned improvement potential is the measuring network to assess and monitor energy consumption and the impact of efficiency measures. This supports the main role of energy management as a tool to identify optimisation potentials and to make impacts of energy efficiency measures visible.

Requirements towards policy makers mentioned by interviewees

The interviewed companies have very different perspectives towards laws, regulations, or other interventions by public authorities. In the following, an overview of the most important mentions by the interviewees is given. Because of the diversity of the perceptions and requirements, no quantitative statement about the amount of companies sharing a perception is made in this section.[46]

[46] The methodological approach and the interview sample is neither appropriate to evaluate laws, regulations or other policy instruments, nor would it be appropriate to claim the right to define a list of priorities of what the real needs of companies are in general. However, the interviewees' opinions and requirements can be presented.

- Laws and regulations, and energy policy in general, are very important drivers for companies to start dealing with the topic. Besides the initial trigger, to deal with energy efficiency, there are many more factors that companies do or do not appreciate. Even within a single company there is typically no logic as to what is preferred. Energy managers are supported in their actions by regulations or, for example, the CO_2 levy. The financial officers and top managers are usually not in favour of levies and taxes, because it interferes with the market and the companies' competitiveness. For instance, internationally active companies are very sensitive about domestically increasing energy prices or taxes. If they increase, this should not be only within Switzerland.
- There are many regulations or incentive and subsidy mechanisms in place. Companies often lack personnel resources to be informed about the many support and steering mechanisms by local, regional, or national authorities or other institutions. The simplification and better coordination of instruments carries a lot of improvement potential. Regarding subsidies, the opinions are very different. Some see no additional effect of subsidies at all, while others experience it as a very important driver for investment decisions.
- Many of the companies appreciate external support and a second opinion about their actions or inputs for new projects. According to several interviewees, independent energy consulting could support their energy management or could help other companies to overcome initial barriers to develop energy management. Individually, some mentioned that this should be free of charge.

6.3. Conclusions

In the conclusion, we analyse the interrelations between the results discussed in the previous section. The following section summarises the interdependencies of key elements, such as the companies' perceived importance of energy efficiency, the level of energy management, and the factors that eventually influence energy efficiency investments. Section 6.3.2 provides conclusions regarding the research hypotheses according to the interview results. Section 6.3.3 describes the main findings and conclusions regarding the research model and the influence of energy management in general.

6.3.1. Main findings related to key elements

The **importance of energy efficiency** to a company is perceived differently among the companies. Energy efficiency is typically more important for companies with a higher share of energy costs on the companies' total expenses and/ or if top management defines it as an important topic for the company. There are different reasons that energy efficiency becomes an important, or even a strategic topic for top managements. For example, environmental and sustainability policies, market demand for sustainability by clients, investors or supply chain requirements, laws and regulations, or image factors are reasons for companies to deal with energy efficiency, aside from purely the cost factor. In many cases, it is a combination of several of these reasons.

Typically, companies that perceive energy efficiency within the company as a more important topic for them, attribute a certain strategicity to it and therefore have more standards, routines, financial and personnel resources allocated to this, resulting in a higher **level of energy management**. In these cases, energy management serves as a tool and pacemaker; in effect, a guideline for the identification and implementation of energy efficiency investments.

The companies' needs due to market and customer demand, as well as the age and reliability of equipment are important determinants for new investments and replacements. It turns out that it is often difficult to define investments as pure **energy efficiency investments**, especially larger investments. This is because typically, other non-energy factors and benefits are considered as well, or may even be the actual decision-making factors of an investment (*e.g.* if the production reliability is of high strategic importance). Besides these factors, the bottom line for investment decisions by most interviewed companies' top management seems to be the financial profitability of an investment and the available budget. Therefore, if energy efficiency investments are profitable enough (regarding the financial criteria applied by a company), the support of the top management is much more likely. However, energy efficiency measures have to be identified first, and subsequently a project has to be initiated as well. This requires technical know-how and personnel resources.

Companies with sustainability policy or energy efficiency targets set by top management or the corporate group often perceive energy efficiency as an important topic. This kind of "given importance" of energy efficiency by top-down strategies or targets and established energy management procedures consequently leads to a higher level of energy management.

For companies without this given importance, such as smaller companies or ones with lower energy intensity, other drivers determine energy efficiency investments. In these cases, the actions and the motivation of energy managers (or other people) are key factors for active energy management and for making energy efficiency investments happen. It is the internal dedication of individual people to identify potentials and initiate projects that could be influential. Furthermore, external drivers such as energy prices, subsidies, levies, or other regulations can be important triggers of energy efficiency investments for these companies. For instance, laws and regulations may therefore be particularly effective to companies who do not have top management which is specifically interested in energy efficiency. The chances of energy managers realising energy efficiency projects can be increased by the importance given to the project *via* an external driver. An example is if a company enters a CO_2 target agreement, the top management makes a commitment towards energy efficiency measures. Once a company commits itself to increasing its energy efficiency or to achieving a CO_2 reduction target, they tend to be keen on achieving their targets.

6.3.2. Conclusions regarding the hypotheses

This section presents the results and conclusions about the research hypotheses,[47] based on the 26 interviews.

Research question 1: What is the level of energy management and its determinants in Swiss large-scale energy consumers?

Hypothesis 1.2: The main determinants of the energy management level are company size, company energy intensity, and commitment or support of energy management by top management. Most of the interviewed companies show a different set of main determinants than these three factors. However, in many of the cases, at least one of these factors is mentioned as a major determinant.

- Company size is not predominantly identified as a main determinant for energy management. Depending on the company size the arrangement of the energy management and the reasons for it can be very different (see Chapter 6.2.1).
- Even though the interview sample consists of LSEC companies only—companies with high energy demand—energy intensity is not the main determinant for energy management activities in most companies. Only the companies with a substantial share of energy cost in relation to the company's turnover (*e.g.* more than 10%) consider energy intensity as a main determinant for energy management. In other words, if energy is an important cost factor, energy efficiency investments are perceived as more strategic and energy intensity becomes a more important determinant of energy management.
- Support from top management appears to be one of the most important factors. If the top management generally supports energy managers and perceives energy efficiency investments as relevant, projects have a higher chance of coming to fruition. In this regard, the interaction of the energy manager with the management level is a very important interface. Interpersonal relations are often significant in the investment decision-making process.

The main determinants for energy management development in the interviewed companies are policy instruments and financial incentives (laws and regulations), sustainability policies or

[47] Hypothesis 1.1 "The level of energy management is generally low" was investigated in the survey only.

corporate social responsibility thinking (support by top management), cost reduction, and the people (energy managers' motivation and collaboration, involvement of top management in energy efficiency topic or energy management).

Research question 2: What is the influence of energy management on the perceived strategicity of energy efficiency investments?

Hypothesis 2.1: The higher the companies' level of energy management, the more strategic they perceive energy efficiency investments to be.
The hypothesis is not confirmed by most of the interviewees. The main contribution of energy management is that it improves transparency. By providing facts and making impacts of measures visible, it strengthens the support in energy efficiency investments. It does not make energy efficiency investments generally more strategic, but does make them more established and trusted. In most cases the influence is converse to what was stated in the hypothesis. A certain level of strategicity is assigned to energy efficiency investments and accordingly to energy management. However, some interviewees state that the proof of effects and, for example CO_2 levy reimbursements, can have positive effects on the perceived strategicity of energy efficiency investments.

The role of energy management in the investment decision-making process is a tool to collect data, analyse potential, and define project ideas. It helps to deliver fact-based argumentation for project proposals and to monitor the impact of energy efficiency projects. By doing so, it increases the chances of a project proposal to be accepted and realised, but not the strategicity. The strategic relevance of investments is typically defined by core business (value proposal and risk reduction of an investment) and financial profitability. Different factors, such as sustainability policies or market demand (customer expectations or investors), can make energy efficiency and energy efficiency investments more strategic. Low energy prices, however, prevent energy efficiency measures from becoming more strategic.

Research question 3: What is the influence of the perceived strategicity on energy efficiency investment decision-making?

Hypothesis 3.1: The more strategic an energy efficiency investment is perceived by a company, the better the chances for a positive decision.
This hypothesis is confirmed by almost all interviewees. For instance, it is the case that core business investments are perceived as very strategic. In most cases, they are more strategic

than energy efficiency investments. Companies that attribute higher priority to sustainability or environmental topics are more likely to decide positively on energy efficiency projects.

Many of the interviewees stated that one of the most important investment decision-making criteria is the profitability of an investment. Most companies also consider additional, non-energy benefits of projects in the decision-making process. However, the importance of the additional benefits for the final investment decision spans a large gap. If several projects are competing for the same budget, core business investments and more strategic projects will have priority. The reasons for an investment's strategic relevance are discussed under Hypothesis 2.1.

Hypothesis 3.2: The less strategic the investment, the more restrictive the financial criteria in the selection of investment projects.

Most of the companies support the hypothesis but conversely. Financial criteria are often less restrictive if a project is more strategic (*e.g.* because of additional non-energy benefits such as environmental contributions or production reliability and quality). Usually, the companies have minimal financial requirements for payback duration or return on an investment. If a project is considered strategic, most companies will still realise the project, even if the financial criteria is not met.

Some of the companies do not vary the thresholds for different project types. The financial criteria then have to be met by all kinds of projects in the same way. This means energy efficiency investments are rated the same as all other investments.

Only one company applies more restrictive financial criteria to energy efficiency projects. This company considers most other investments as more strategic than energy efficiency investments. Therefore, these projects have to be more profitable than other projects.

Hypothesis 3.3: The number of energy efficiency investments positively decided upon and realised depends mainly on the network relations or knowledge exchange within the sector.

The hypothesis is not supported by most of the interviewees. Only three interviewees experienced that the network and knowledge exchange positively influenced the number of decided and implemented projects. Many companies participate in networks and exchange knowledge with other companies, but the decision whether or not to implement a project is independent of this exchange. However, it serves as a pool for ideas and innovation which helps to identify potential and to give way to new projects.

Hypothesis 3.4: Increasing requirements from cantonal energy policies for large consumers and/ or rising energy prices (in particular for electricity) positively influence energy efficiency investment decision-making by companies.
Requirements (laws and regulations) have an effect on companies' actions in energy efficiency investments. Generally, legal compliance is an important topic for companies. Furthermore, it appears that the CO_2 target agreements and the levy reimbursements push and support many companies to deal with energy efficiency and realise energy efficiency projects. What is more, today's cantonal energy policies for large-scale energy consumers positively influence companies located in regions where the act is effective, particularly if they do not have a target agreement. Although some of these companies question the additional effect, others see a positive effect on energy efficiency investment decisions.

The companies do not generally anticipate increasing requirements from cantonal energy policies for large consumers. Consequently, today's decision-making does not consider this. The same holds true for energy prices. Potentially rising energy prices are not taken into consideration by most companies. Many of the interviewees expect energy prices to rise, but the financial assessments are based on today's prices. Only in individual cases, are slightly rising energy prices considered in the financial assessment of investments.

Laws and regulations, as well as energy prices are important factors. However, future development is rarely considered and as long as energy prices are low, the effect on energy efficiency investments will be limited.

Research question 4: How does positive energy efficiency investment decision-making influence energy performance?

Hypothesis 4.1: The higher the number of energy efficiency investments implemented, the higher the energy performance of a company will be (measured in energy intensity terms).
The hypothesis is supported by almost all interviewees. However, as discussed in Chapter 6.2.4, in most cases the realised impact of a measure is not exactly known.

6.3.3. Conclusions regarding the M-Key research model

A direct and causal relation between the level of energy management and the perceived strategicity of energy efficiency investments was not found in the interviewed companies. In fact, the perceived or actual strategicity of energy efficiency investments is very much dependent on a set of both external and internal factors. Hence, the level of energy management is a result of these factors. A company with a higher energy management level typically has more knowledge about their actual energy consumption and costs, as well as the potential impact of energy efficiency investments. This can be an important factor in the investment decision-making process and can increase the chances of a positive investment decision because of the energy management. The perceived strategicity of the energy efficiency investments, however, stays the same. If an investment is attributed higher strategic value by considering additional, non-energy benefits (*e.g.* because it does not only reduce operational cost, but also increases production capacity, reliability, or quality), it increases the chances of a repeated positive investment decision. In this case, it is due to the fact that the investment is perceived as more strategic and therefore has a higher chance for a positive investment decision.

It is perceived that energy efficiency investments increase energetic performance. However, a monitoring system or measurement network to assess the real impact of an energy efficiency investment is often lacking (*e.g*. energy consumption of one appliance, production quantity or temperature adjusted).

In summary, it can be said that energy management is an important tool to identify energy efficiency potentials and measures. It is a necessity for the continuous and sustainable improvement of a company's energetic performance. The importance of energy efficiency investments, however, is typically defined by factors other than the level of energy management. The most important of these is the company's perception of the importance of energy efficiency within itself. In turn, this is influenced by many other factors, such as laws and regulations, the support of top management (which may be internally or externally triggered), and energy intensity or cost reductions. Typically, an investment decision takes multiple factors into consideration, such as an investment's strategicity, the financial profitability, and other (non-energy) benefits.

7. Case studies

M_Key tries to better understand the decision-making process for energy efficiency investments in the Swiss industry and service sector. To achieve this, the research team has introduced a three-step analysis model. Based on the M_Key project phase I (the survey results from 305 Swiss large-scale energy consumer (LSEC) companies), and project phase II (a selection of 26 interviewed companies), in project phase III, detailed case studies were conducted with five companies.

7.1.1. Objectives

The goal of the case studies of five carefully-selected companies was to verify the findings of the preceding survey and interviews, and complement them with practical observations concerning energy consumption, energy performance and energy efficiency measures implemented. By analysing the energy consumption and cost data, the list of planned, realised and unrealised improvement measures of the company, a relatively clear picture of the stage of development of their energy management and its influence on energy efficiency and energy performance can be described. Also, with a "walk through audit" by two energy efficiency experts on the case study team, a first-hand evaluation was possible that clarified the fraction of accomplished versus open opportunities for efficiency improvement.

The case studies do not deliver quantifiable nor representative results. They show the individual situation of the five companies with an in-depth qualitative analysis, allowing identification of additional complexities in the decision-making process and serving as a "reality check" of the effect of all the national and cantonal programs, financial incentives and legal requirements. They provide punctual, "anecdotal evidence" statements and their interpretation by the research team as well as observations in the context of real factories. The detailed case study questions are described in Section 7.

7.2. Methodology

7.2.1. Characteristics of research phase III

The research methodology of the case studies differs from the methodologies of the first two phases of the project.

In phase I, companies answering the survey could be only identified if the person filling in the online questionnaire gave his or her contact details and the name of the company. Respondents had limited possibilities to ask questions or clarify misunderstandings immediately when filling in the online questionnaire due to the nature of the research, which was not face-to-face). To evaluate these survey results, it has to be assumed that a relevant person answered the survey in a competent and complete way.

In phase II of the interviews, one contact person answered questions related to energy management with one a researcher, in person. These answers were later recorded in writing and reported. Also, for the evaluation of the interview results, it has to be assumed that the person interviewed was the most competent person in the company dealing with energy matters (which does not necessarily equate to being competent in energy management matters). In this sort of research, which encompasses a survey and interviews, it should also be taken into consideration that the person interviewed wants his company to appear in a favourable light and to look compliant, meeting all the required obligations.

In phase III of the case studies, a visit by three researchers at the company site entailed an initial discussion with one or more people from the company, followed by a visit of the company factory and facilities including two energy efficiency experts. In the case studies, the researcher, as "expert observer", has a more specific role: he analyses the energy, cost and performance data provided by the company, verifies these data, if necessary researches additional data sources and experts that have analysed and advised the company, and finally makes his own observations and evaluates the status quo of the energy-consuming elements (machines, buildings, internal energy programs/targets, *etc*.) and the stringency of the company's energy efficiency program. This evaluation is "bottom up", which means it is based on facts and real evidence (measured and calculated savings, diagrams and details of the production process, *etc*.).

Within the M_Key research approach, phase III with the five case studies is the first and only time when the companies and their energy-using equipment are examined, their energy efficiency data evaluated, and their past and future plans of energy efficiency measures observed. Because of this highly valuable and additional level of exchange and information, the findings of the case studies—though neither representative nor quantifiable—deliver additional qualitative, in-depth evidence of the decision-making process for energy efficiency investments.

7.2.2. Selection of companies

The following criteria were applied in order to choose the sample of the case study companies:

- Five companies which participated in the preceding survey and interview and agreed to be contacted for the case studies;
- Four companies located in the German-speaking part of Switzerland and one located in the French-speaking part;
- Different levels of energy management (a contrast with high and low was planned):

  - Two companies with a high level of energy management
  - Two companies with a low level of energy management
  - One company with a randomly chosen level of energy management;
- Within the case study sample, at least one occurrence of each of the following company sizes (defined by annual electricity consumption):
  - small: 0.5 to 3 GWh/year
  - medium: 3 to 10 GWh/year
  - large: above 10 GWh/year;
- Two-thirds of companies from the industrial sector and one-third of companies from the commercial sector.

It was clear to the case study research team from the outset that within a sample of five companies, it would be challenging to fulfil all the above criteria.

7.2.3. Contact persons

In addition to the above selection criteria, the aim was to conduct the case study with several people from the company on different hierarchical levels and with different responsibilities:

- One person at management level (decisions / financing);
- One person at technical management level (project planning and implementation);
- One person at operating level (production / energy manager).

For some companies, especially the smaller ones, these different levels of responsibility were incorporated in one person. Hence, the case study was, in three out of five cases, conducted with this one person.

In the large companies, several contact people took part in the discussion where their expressed opinions sometimes differed slightly.[48] This was not considered as having a significant impact on the findings.

Table 34 gives more details regarding the position and responsibilities of the case study contact people.

In the end, as planned, the case studies were conducted with five companies and all of the above criteria were met. The only difference concerned the proportion of companies in the industrial and services sectors. The original intent was to work with two-thirds of the companies from the industrial sector and one-third of the companies from the commercial sector.

[48] For example, in one company the individual approach of the respondents for calculating the savings potential of specific efficiency improvement measures was either more conservative or less conservative.

However, this proportion changed slightly as the case study sample included four companies from the industrial sector and only one from the services sector. This change was partly due to the fact that some companies which were contacted declined to participate in the case studies because of a restricted availability of resources. Table 34 summarises the main characteristics of the case study companies and details regarding the contact person or people.

Table 34: Main characteristics of case study companies and details of contact people

No.	Code	Region	Canton	Sector	Size	Level of energy management	Contact person/s
1	A	German part	TG	services	medium	4 (low)	1) head of building equipment, unofficial energy manager [T, O]
2	B	German part	BE	industry	small	9 (lower medium)	1) head of technology, unofficial energy manager [T, O]
3	C	German part	TG	industry	small	15 (upper medium)	1) energy manager, factory manager, member of the board [M, T, O]
4	D	French part	VS	industry	large	19 (high)	1) production, energy management, project planning and implementation [T] 2) head of manufacturing unit "hot rolling"* [O] 3) energy purchase: gas, electricity, carbon certificates for Europe [O]
5	E	German part	VS	industry	large	19 (high)	1) factory manager, highest decision capacity on site [M] 2) head of energy management/electricity supply, head of energy team [T, O] 3) head of energy- and waste management, member of energy team [T, O] 4) head of manufacturing unit "cracker"* [O]
Declined to participate:							
		German part	SH	industry	large	17 (upper medium)	-
		German part	AG	industry	large	20 (high)	-
		German part	AG	services	large	10 (lower medium)	-

Notes:
[M]: person at management level (decisions / financing)
[T]: person at technical management level (project planning and implementation)
[O]: person at operating level (production / energy manager)
*For both companies these manufacturing units represent the most significant production processes from an energy point of view

Table: Impact Energy. Source: Case studies.

7.2.4. Procedure

The case studies were conducted in a sequence of analyses as described below, and included preparation beforehand, observations in person, and follow-up after the visit.

Preparation: case study questions

The case study guide, with open questions to be addressed during the case study, was sent to the company before the case study, to allow the company to prepare for the discussion. The case study questions addressed the following issues:[49]

- Investment categories and budgets;
- Investment priorities;
- Investment decisions and implementation of measures;
- External and in-house know-how;
- Influencing factors;
- Energy efficiency improvements, status of implementation;
- Monitoring and quantification of energy savings and costs, *ex ante* and *ex post* evaluation;
- Reporting;
- Equipment maintenance practices;
- Role of public policy, opportunities and constraints, improvement potentials.

An essential question was also to assess the energy efficiency performance of the case study companies in relation to their level of energy management. For this, the following data and information for the period of the past five to ten years was requested from the company before the case study, which allowed the research team to prepare for the discussion, of which the main themes were:

1. Annual energy cost (electrical & thermal energy);
2. Annual energy consumption (electrical & thermal energy);
3. List of implemented efficiency measures;
4. Main elements of commitments (*e.g.* target agreement / energy consumption analysis);
5. Goals, duration, intermediate results, status of target achievement;
6. Incentivized measures, if any (*e.g.* through ProKilowatt,[50] canton, utilities *etc*.).

[49]The case study guide is shown in Annex 3.2.

[50] ProKilowatt is the agency managing the public tenders of the Swiss Federal Office of Energy. The public tenders are announced each year supporting programs and projects that reduce electric energy consumption in the industrial, services and household sectors. The financial incentive is given to programs and projects with the most favorable cost-effectiveness (proportion of financial incentive compared to energy saved). More information on: www.prokilowatt.ch.

The research team also analysed the company's answers given in the phase I survey and the phase II interview to prepare for the case study. All companies (except company A) provided the above information to the research team before the visit.

Face-to-face visit on site: discussion and walk through audit

The case study on site was comprised of two parts:

- Face-to-face discussion with the contact person or persons (as described in the Section, Contact persons), which lasted one and a half to two hours, during which the questions of the case study guide were discussed in detail. Questions related to the data provided regarding energy cost, consumption, efficiency measures, commitments and financial incentives were also discussed and clarified. In addition and if relevant, the company's answers to the phase I survey or the phase II interview were clarified;
- "Walk through audit" following the discussion with the contact person(s) which lasted one to two hours. During this walk-through audit, the most important installations and machines were shown, explanations and background information to the production process and recent changes were provided. If allowed, pictures were taken only for internal use within the M_Key research project.

Follow up: minutes and technical report

Subsequent to the visit on site, the results of the observation produced minutes and a technical report, detailed respectively, below.

- Minutes of the discussion were structured according to the questions in the case study guide. Main observations of the discussion were listed at the end of the minutes. The draft of the minutes was sent to the contact person(s) for verification.
- A technical report was produced, based on the data provided, the observations during the walk-through audit, and additional research. The technical report summarised the following information:
  - Main production process;
  - Changes in production;
  - Main technologies used;
  - Energy consumption and costs;
  - Commitments status (energy consumption analysis, energy reduction target, *etc*.);
  - List of energy efficiency improvement measures;
  - Measures implemented;
  - Measures planned;
  - Evident efficiency potentials not yet dealt with

- Open questions.

Additional information was gathered from company documents. Also, further clarifications were received from discussions with present and former external energy advisors for the company. The draft technical report was sent to the contact person/s to ensure that all information and data was correct and to clarify any open questions.

7.2.5. Framework for analysis of findings

The findings of both the discussion with the contact person(s) and the walk-through audit were analysed.

Analysis of responses to case study questions

The results of the discussion based on the case study guide were analysed as follows:

- First, the statements of the contact person(s) to the questions in the case study guide (see Annex 3) were summarised. The results of all five companies were collected, analysed and compared to each other.
- Second, the answers of the contact person(s) were interpreted with reference to the research questions and the hypotheses. The research team interpreted the statements of the contact person(s) and drew conclusions with regard to the research questions and hypotheses (see Chapter Conclusions regarding the M_Key hypotheses) according to Table 35, below.

Table 35: Framework of evaluating the responses to the case study questions in relation to the research questions

Research question	**Additional questions***	**Question number in case study guide**
1) level of energy management and its determinants		3, 4
2) influence of EM on strategicity of energy efficiency investments	Does the investment category "energy efficiency" exist? Is there a continuous learning/improvement process in place?	2, 7, 8, 9, 10, 11, 12, 13
3) influence of the (perceived) strategicity on investment decision-making	Is public policy a constraint/opportunity? How/why? How could it be improved to be a strong motivation?	5, 6, 14
4) influence of investment decision-making on energy performance, *via* positive energy efficiency investment decisions		1

*Additional questions raised during the case study based on findings during the survey and interview phases.

Table Impact Energy.

Technical analysis

Following the walk-through audit and the technical report, the research team also made a qualitative analysis of the energy efficiency performance of the companies. This was based on 13 questions with which a qualitative scale for comparison of the five case study companies was established, allowing comparison of their level of energy management (see the Section, Energy efficiency performance in relation to level of energy management).

7.3. Case Study results

7.3.1. General data of case study companies

Table 36: General data of the five case study companies

General data	A	B	C	D	E
Level of energy management	4 low	9 lower medium	15 upper medium	19 high	19 high
Sector	services	industry	industry	industry	industry
Type of ownership	family-owned	family-owned	several private owners	shareholders (company on stock market)	shareholders (company on stock market)
Product	photos, books, calendars, phone cases	cosmetics	yeast	aluminium sheet metal	pharmaceutical, chemical
Degree of competition in the sector	not so high	not so high	not so high	not so high	very high
Number of employees on site	168	110	30	500	2,700
Location of company top management	on site	on site	on site	USA	Switzerland, different location
Energy intensity (Energy cost/turnover)*	2-3%	1%	1.1%	10%	7-12% ***
Energy cost (million CHF/year)	0.5	0.2	0.2	12.9	57 to 78 ***
Energy consumption GWh/year (thermal/fossil)	Gas 1	oil 0.4 wood 0.7 total 1.1	gas 2.8	gas 184	gas 466 steam (waste) 86 total 552

General data	A	B	C	D	E
Energy consumption GWh/year (electric)	3.3	0.7	2.3	77	492 +48 own production total 540
Trend in production	continuous development of technology, additional products, overall increase	increase of production and shift to specialty products	amount constant in last 10 years, growing share of energy-intensive product	almost doubled since 2012	heavy fluctuation due to market demand
Trend in energy consumption	large fluctuations due to summer temperature and change of cooling technology	heat decreasing, electricity constant	constant in last 10 years	strong increase in the last 10 years, strong increase also in efficiency per production unit	heavy fluctuation
Energy manager	1 part-time	1 part-time	1 part-time	1 energy manager (part-time) plus team	1 energy manager (part-time) and team of 6 people
Commitments	energy consumption analysis (cantonal large-scale energy consumer obligation), target agreement with local utility	target agreement (act)	target agreement (EnAW)	ETS, KEV reimbursement (temporarily), ProKilowatt, until 2013 target agreement (EnAW)	ETS, target agreement (EnAW), KEV reimbursement, ProKilowatt and other financial incentive programs
External support	project oriented energy consulting, engineering companies for implementation	energy consulting company for analysis of savings potential, start of support from act from 2016	energy consulting company for analysis of savings potential, continuous support from EnAW, Lemon Consult (Pinch** analysis)	EPFL (Pinch** analysis), sometimes specific external know-how	HSLU (Pinch** analysis)

General data	A	B	C	D	E
Certificates	ISO 9001 Swiss Climate: "CO2 neutral"	ISO 9001 ISO 14001	ISO 9001	ISO 14001 ISO 50001	ISO 9001

*The definition of "energy intensity" is not used in the same way by the five companies: energy cost is compared to either to tal cost, *The definition of "energy intensity" is not used in the same way by the five companies: energy cost is compared to either total cost, turnover (*i.e.* sales volume), or gross value added (official criterion for KEV reimbursement). These data (total cost, turnover, gross value added) are kept confidential in most companies. Therefore the energy intensity values shown give an indication, despite the fact that the values are not directly comparable.
It was observed that the case study companies had difficulties with understanding and correctly addressing the question regar ding their energy intensity in the survey (phase I). This could be clarified in detail and further specified during the case study, as reflected in the above Table 36.
**Complex thermal process performance analysis, see https://pinch-analyse.ch/de/ for more details.
***Range in the last five years

Table Impact Energy. Source: Case studies.

Of the five companies, two are considered small, one medium-sized and two are large-sized. For the purposes of further analysis, we will distinguish between the group of small and medium sized enterprises SMEs (companies A, B and C) and large enterprises (companies D and E). The large enterprises have a high energy intensity with around 10%, while the SMEs' energy intensity is low, ranging from 1% to 3%.

7.3.2. Summary of responses

The following section summarises the five case study companies' responses to the questions in the case study guide. The research team would like to emphasise that this section reflects the views that the companies have of themselves.

Investment categories and budgets

In three out of five companies, the category "energy efficiency investment" does not exist. They have a general budget for all types of investments, such as for capital expenditure or building modernization, ranging from 0.6 million Swiss francs per year (*ca.* 3% of gross value added) to 100 million Swiss francs per year (*ca.* 14% of gross value added), depending on company size. This means that investments have to compete to get a part of this general budget. These budgets are typically determined on an annual basis, depending largely on the economic performance of the company or company group. In the large companies the budget is determined by the even larger mother company.

In two out of five companies (both SMEs), there is a specific investment category and budget for "energy efficiency investments":

- In company B, a budget of 20 to 30 thousand Swiss francs per year (0.1 % of turnover) was made available, as a direct consequence of implementing the target agreement to which the company committed itself.
- In company C, a budget of 50 thousand Swiss francs per year (0.3% of turnover) was established by the energy manager, who is also a member of the board. Hence, he has the authority for making such a decision. The reason for setting up this budget was out of his personal motivation and interest for energy efficiency.

Table 37: Energy intensity, investment budgets and financial criteria for selecting investments of the case study companies

Company	Energy-intensity	Budgets				Financial criteria for selecting investments
		Total investment		Energy efficiency		
	%	mln CHF/a	%	k CHF/a	%	
A	2-3%	0.6	3%	-		more restricitve for efficiency improvement investments
B	1%	n.a.		25	0.1%	same for all investments
C	1.1%	n.a.		50	0.3%	same for all investments
D	10%	n.a.		-		same for all investments
E	7-12%	100	14%	-		more flexible for efficiency improvement investments

Table Impact Energy. Source: Case studies.

Investment priorities

All companies indicated that while energy efficiency is not a priority for investment decisions, for all investments energy (and energy efficiency) is taken into account. Safety, product quality and production quality were mentioned as the top priorities. Other priorities were equipment replacement, production improvement and innovation, and investment profitability.

As for conflicts with other parts within the organisation concerning energy efficiency investments, the responses were mixed. Some case study companies did not experience conflicts; others did, generally with the finance (purchase) and production units (*"If the production runs well, why installing new equipment?").* No obvious pattern could be observed within the case study sample regarding this question.

Investment decisions and implementation of measures

In the SMEs, energy efficiency improvements were in all cases initiated and implemented by the energy manager. Sometimes an external company was hired to analyse the savings potential, propose improvement measures, and support the implementation of efficiency improvements. In all three SMEs, company management was involved in the decision about energy efficiency improvements, although in different ways. In company A, the energy manager can make his own decisions concerning investments up to ten-thousand Swiss francs; for investments up to 50-thousand Swiss francs, he collaborates with the production manager. For investments above 50-thousand Swiss francs (0.3% of gross value added) the decision is made by the company management.

In company B, the company management decided on a multi-annual plan, which comprised a package of measures. In company C, the energy manager is a member of the management board and has a budget for energy efficiency investments. In this company, whereas the management decides on the implementation, the energy manager has a significant influence on it, as he is a member of the board. His credibility, stemming partly from positive experience with projects implemented in the past, adds to his influence.

In the larger companies, the decision-making process is more complex, due to company size.

- In company D, an energy committee is responsible for initiating and deciding on energy efficiency improvements. The energy committee is composed of the manufacturing unit heads and facility and maintenance directors. There is also regular interaction and exchange with the other factory sites of the international company group, which is a source of project ideas. The implementation of the accepted projects is left to the person who is assigned the responsibility to by the energy committee.
- In company E, energy efficiency improvement can be initiated by the manufacturing units or by the energy team itself. The energy team, a separate team dedicated to energy issues only, consists of seven people. All seven people dedicate their time to different topics. According to company E, five full-time equivalents[51] are responsible for the power grid and power procurement and two full-time equivalents for energy efficiency (including CO_2). Depending on project size, different levels of management have the authority to decide on project realisation. Implementation is left to an assigned project manager, or, in the case of bigger or more complex projects, to a steering committee. The company also has a reward system: five to 20% of the employees' salary is coupled to achievement of certain goals that are being defined annually. For energy projects this means, for example, achieving the planned savings within the planned costs by the set deadline.

External and in-house know-how

Especially in the SMEs, energy managers have a crucial role for implementing energy efficiency improvements. All SMEs said that they work together with external consultants to benefit from their specific know-how. For company C in particular, the EnAW-moderator was mentioned as an important point of contact and the group of EnAW companies as a source for project ideas.

The large companies reported that they have a solid level of energy knowledge within the company. Therefore, company D seldom works with external companies, and if so, only with specialists for certain processes. Company D had a target agreement with EnAW until 2013 but decided to discontinue it for the next commitment period. Company E said its production process is so complex that it built up the necessary energy and production process know-how in-house and therefore does not substantially work together with external companies (as externals would not be able to provide the needed support). It also mentioned that the support in the framework of its target agreement from EnAW is rather administrative, although useful for this purpose.

[51] *i.e.* a full-time position which can mean several people working part-time on the respective subject.

Three companies conducted a Pinch[52] analysis to assess their thermal processes and potential energy savings. The two large companies undertook the Pinch analysis in collaboration with a university. One SME relied on an energy consulting company. All companies stressed that the Pinch analysis did not bring new findings and was more theoretical than practical or helpful for identifying new savings opportunities.

Influencing factors

One SME (company A) mentioned that customer demand is the most important influencing factor that affects the replacement of production machines. Notably, this company operates in a business environment with fast technological development both on the side of the machine suppliers and the end customers. Thus, the majority of their production machines are replaced every five years. This short planning horizon makes some energy efficiency improvements (with longer payback times) unreasonable to implement.

Companies B and C did not indicate the presence of any specific influencing factors. Company D mentioned customer demand as one of the most important influencing factors as well, determining the overall economic performance of the company, and thus the available budget for investments (including energy-related investments). Also, sensitivity to energy prices was mentioned by company D.

Company E is affected by the fluctuation of the currency exchange rate, as 95% of its products are exported. If the exchange rate is low (strong Swiss franc), the product revenue declines, simultaneously with energy costs, since energy is bought on the European market (paid in Euros). Within this context, overall it is more beneficial for the company if the exchange rate is high, generating higher revenues, even if this means higher energy costs.

Energy efficiency improvements, status of implementation

All companies had a list of energy efficiency investments from the past few years available. The larger companies maintained this list for internal purposes. In the case of the SMEs, such a list was compiled as a result of their response to the cantonal obligation of large-scale energy consumers or federal policy (CO_2 tax). Company B decided to enter a target agreement with EnAW and company C with ACT (Cleantech Agentur Schweiz). Both companies compiled and reported their investments to the respective bodies (EnAW/act). Company A conducted an energy consumption analysis in response to its large-scale energy consumer obligation, which resulted in a list of identified potentials. It also established a target agreement with a local utility company, instead of EnAW/act, coupled with financial incentives.

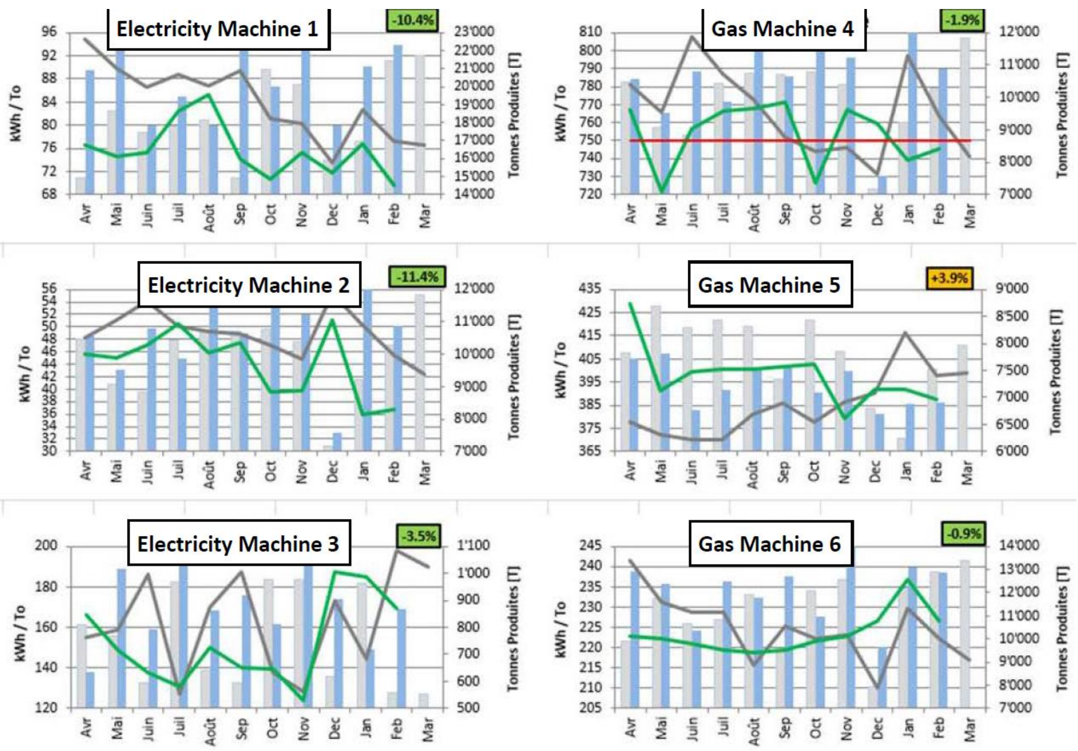
[52] Complex thermal process performance analysis, see https://pinch-analyse.ch/de/ for more details.

Companies A and B reported that they are planning to implement the majority of the identified measures and have already started with the implementation. Companies C and D reported that most of the planned investments were implemented. Company E stressed that due to a systematic, continuous improvement process, their equipment is state-of-the-art, and they struggle to identify further cost effective optimization potentials.

Monitoring and quantification of energy savings and costs, ex ante and ex post evaluation
In the three SMEs (companies A, B, C) only one or two submeters were installed to monitor the electric energy consumption. In the larger companies D and E a more significant number of submeters were installed (company D: 26, company E: 500) in order to monitor the electric energy consumption of specific parts of the factory or of specific production processes or machines. Company E added that the monitoring and evaluation of the energy consumption is to a large extent automated, thanks to the extensive electric metering system. Based on this, the research team found that the case study companies generally have one submeter per one to two GWh/a of electric energy use installed.

Energy managers of two SMEs mentioned their intent to improve the metering system within their factory in order to have more reliable energy data and increase the transparency forming the basis of energy-related decisions. One of these energy managers also mentioned that he plans to establish a system where the specific energy cost could be attributed to each product, so as to demonstrate the cost of energy on a product level.

Figure 15: Example: monthly monitoring of KPIs



Monthly monitoring update of Key Performance Indicators KPI (kWh/ton) for the current year (blue bar) and comparison with the previous year (grey bar). Large number of submeters for individual processes for electricity and for gas consumption and comparison with output volume (current year: green line; last year: grey line).

Figure Impact Energy. Source: Case studies

The SMEs estimate potential energy and cost savings before the implementation of energy efficiency improvements based on calculations. In some cases, measurements are done through external companies. Only company C has measurement equipment available in-house. The large companies report that they regularly calculate and measure before implementation (and have measurement equipment and qualified, in-house staff).

The SMEs do not check or evaluate the results of the energy efficiency improvements after implementation, or do not check systematically, as in the case of company C. In the large companies, results are at least partly checked (company D). Company E reported systematic *ex post* evaluation, especially for bigger projects. Companies B, C, and D reported that the results of energy efficiency improvements are mostly as planned.

Reporting

In all companies, reporting about the energy efficiency improvements happens internally, taking into account the hierarchical structures and affected relevant staff within the company.

External reporting is mostly to the relevant authorities associated with meeting the obligations of the target agreement or the requirements under the emission trading system. Company D mentioned reporting through their company's sustainability report. Company D and E mentioned an exchange of experience with other sites of the mother company.

Equipment maintenance practices

All companies reported that they have a maintenance plan for their production process machines. However, the practices of equipment replacement differ, being determined by the business environment. The larger the company, the more sophisticated is the approach to equipment replacement. Smaller companies reported the influence of client needs or technology cycles, larger companies reported stocking critical equipment and – in the case of company E – a maintenance strategy of installations. Company E explained that all installations are regularly checked and that appropriate measures decided on this basis as adequate.

Role of public policy, opportunities and constraints, improvement potentials

In the SMEs, public policy seems to be an important driver for energy efficiency investments, even if it is not perceived in some cases as a positive driver, but rather as an obligation.

One beneficial aspect of the target agreement was mentioned. Namely, once a company decides to enter into a target agreement, it creates an obligation of meeting the set goals. This means pressure to implement projects in due course and less chance to postpone or abandon planned measures.

All SMEs expressed the wish for receiving relevant and structured information on incentive programs. For them, it is currently a (disproportionate) effort to find information on incentive programs. Instead, a central contact which actively informs them about financial incentive opportunities would be appreciated. Only company C mentioned that they receive this information *via* the EnAW-moderator.

In addition, SMEs mentioned that (partly) subsidised energy consulting would be welcome, as well. All five companies stressed the importance of keeping administrative burdens associated with financial incentives at a low level. One SME mentioned that the financial incentive should be a minimum of 10% to 20% to make it attractive enough to take up the administrative burden associated with it (application, reporting, *etc*.). The large companies also stressed the importance of not impeding competitiveness *via* regulatory measures.

Only the larger companies profited from the financial incentives of ProKilowatt. They confirmed that while the financial incentives were helpful, most investments would have been implemented anyway, although probably only later (free-rider effect[53]). One large company added that it does not see the current financial incentive mechanism with ProKilowatt as macro-economically beneficial. It would rather welcome a free market, *i.e.* allowing the market to regulate itself through costs and prices (*e.g.* higher energy prices) instead of regulations which it perceives as an intrusion into the internal company decision-making process. While the company gains with ProKilowatt, through making less profitable investments into energy efficiency more profitable, it would prefer to use the financial resources that it now pays with the electricity tariff surcharge in another way. Also, the company reported challenges in association with setting the benchmark for its specific production process—due to using a unique production process and technology—and its CO_2 emissions to its significant financial disadvantage.

Possible additional policy instruments were also mentioned for increased implementation of energy efficiency improvements, such as:

- More or higher quality training in the field of environment, energy, energy management, and implementation of ISO 14001. This idea is associated with having more technical know-how in-house and was mentioned by an SME (company B).
- Working together on concrete projects (*e.g.* an equipment measurement campaign) with external companies who have a profound technical know-how, not just theoretical training, was mentioned by company D.
- Providing a financial guarantee (*i.e.* through a funder) that covers all or part of the salary of staff working on energy issues was mentioned by company D.

7.3.3. Interpretation of responses and observations

The following section describes the interpretation of the case study companies' responses and the observations made by the research team. As the sample of the five case study companies is not considered large enough to derive representative conclusions and quantitative results, the main observations, analysis, and conclusions are presented here as anecdotal evidence, which is empirical and verifiable.

Investment categories and budgets, investment priorities

1. The category "energy efficiency investment" does not exist in all companies. In three case study companies an overall general budget for all investments is available. Two SMEs apply the category "energy efficiency investment" and set up a separate, specific budget for energy

[53] Free-rider effect as it is used here means that the companies would have made the investments anyway. It is not likely that the financial incentive convinced them to make the investment, but that they used the financial incentive to reduce their costs, which in the end makes the value of the financial incentive questionable.

efficiency investments. One of them set up this budget as a direct consequence for meeting its cantonal large-scale energy consumer obligation.
The order of magnitude of these budgets differs. The **general budgets**, with 3% to 14% compared to the gross value added, are **in line with** the corresponding **energy intensity** values (2% to 12%) of these companies. The energy efficiency **budgets**, with 0.1% to 0.3% compared to turnover/gross value added, represent a **smaller** dedicated budget of companies with an energy intensity around 1%.
2. Energy efficiency measures are a small part of general investment programs and annual expenditures. The numbers get lost within the "noise"[54] of much larger data.
3. Energy efficiency does not appear to be a priority when deciding on investments; however, it is considered in all investment types.

Investment decisions and implementation of measures

An important finding is that the energy manager has a key role with regard to energy efficiency improvements and their implementation. Specific observations by the research team are:

1. The person in the role of the **energy manager** is certainly a **crucial** element in the decision-making process and in the subsequent implementation, especially in SMEs. All energy managers seemed more or less to be well in charge of their task, but only some acted as "champions": sources of inspiration, pulling the company forward. With regard to fulfilling the policy-induced commitments of their companies, they felt more like administrators and book-keepers.
2. If the **energy manager** is **part of the management**, this gives him or her more authority and opportunity to positively influence decisions and implementation of energy efficiency improvements. This is especially valuable in SMEs.
3. In the SME with the lowest level of energy management, the energy manager was **not sufficiently supported by top management**. This put him in a very lonely position, needing much effort for persuasion and good argumentation, which constituted a real challenge for implementing efficiency improvements. In the other SMEs and the large companies, management support was stronger, paving the way for effective work by the energy manager.
4. The SME with the lowest level of energy management from the five case study companies was not able to provide the requested data and information in advance. The **energy manager** was **completely occupied** with other daily business.

[54] The term noise is used in statistics for irregular variations in a small sample: deviations from the mean which can neither be avoided nor explained.

5. The exchange between the energy manager of one SME and his peer group (in the EnAW moderation model) was mentioned but did not seem to be a strong source of new project ideas.
6. All **energy managers** worked on a **part-time** basis with regard to energy efficiency issues. In the SMEs, their main responsibilities were building and production maintenance. In the larger companies, they shared the energy efficiency issues with team members and had other responsibilities, as well.

External and in-house know-how

1. **Internal competence and external support insufficient**. The lists of measures that were developed for the sake of the target agreement or the cantonal requirements for large-scale energy consumers were not up to date. Many lists were old, outdated, superseded, incomplete, or contained erroneous and sometimes absurd measures and data (*e.g*. measure listed with payback time of 69 years). This shows that their external support (canton and power utility) and supervision (EnAW-moderator, *etc*.) were not able to help update the lists of measures to a higher level of quality and to advise on improvement. It seems that **after the companies make a commitment to save energy, they are left alone** and do not receive the necessary support, quality check, data and information for implementing well-defined energy efficiency improvements in a systematic manner.
2. Large companies only occasionally depended on external experts for energy efficiency projects. Their experience was mixed:
   a. Negative experiences: both large case study companies claimed, for example, that the Pinch analysis of thermal processes was too theoretical and not practical enough for their purposes.
   b. Receiving foremost administrative support from the EnAW moderator for the annual data management of the target agreement was seen as valuable, although no technical support was received.
   c. Large companies claimed that external experts lacked real knowledge of the relevant industry with their special technological needs. The repeatedly-heard statement of the companies, "nobody knows better than we do", could not be sufficiently checked by the energy efficiency experts in the research team, but left some doubts as to whether this was truly the case.

According to the research team, large and intensive energy users with complex energy processes **need** up-to-date national and international know-how to improve their **energy efficiency**. Researchers and test installations are needed to serve as pilot projects for improvement.

3. All the SMEs mentioned their appreciation of qualified external experts, especially in the case of the two smaller companies, to have access to know-how and a contact person in case of questions.
4. Companies that spend more than 1 million Swiss francs per year for energy generally address this topic and its economic effects in their company, and more so if they are energy-intensive. This leads to a build-up of qualified staff to deal with energy and energy efficiency. In the large companies several people were in charge of energy and energy efficiency issues.

Influencing factors

The research team found that along with the factors mentioned by the companies mostly related to market and customer demands, energy prices may or may not play a role, depending on the company:

1. All companies pay relatively little for electricity and gas, which has been stable or has decreased in the last five years. This is a clear disincentive: no fear of increasing energy prices as a driver for efficiency investments. Several SMEs mentioned of their own accord that energy prices are too low.
2. The large enterprises buy their electricity on the international market. The sole decision criterion is the low price at a given moment for a specific capacity. No certified electricity from renewables ("Naturemade Star", *etc.*) is bought, because this is slightly more expensive. The CO_2 law does not account for CO_2 emissions from electricity generation. Thus, the CO_2 plan and balance with imported electricity is biased.
3. An additional finding is that interest in renewable heat and electricity was generally low. Many companies use renewable energy for heat: steam from a local waste incineration plant, they give excess heat to a local swimming pool, or use water from river for cooling, *etc*. No combined heat and power systems were used. No renewable electricity was generated or bought through certified products.

Energy efficiency improvements, status of implementation

1. **Focus on fossil energy savings**. In all of the five case study companies, in-house competence and capacity of CO_2 emission reduction, fossil energy and cost savings was far more developed and had been practiced for a long a time, due to long standing Swiss CO_2 emission-reduction policy (CO_2 law, tax, target agreements, emission trading system).
2. **Energy efficiency measures in the field of electric energy were less present**. The attention and competence of the energy managers, and the lists and plans of electric efficiency measures were less complete than for fossil energy. The focus on electric efficiency measures has been stimulated recently by both ProKilowatt (financial incentive for electric efficiency pro-

jects) and the KEV-reimbursement. Only the large companies had the capacity to participate in ProKilowatt tenders, whereas the SMEs were sometimes not even aware of this opportunity. The KEV-reimbursement was not fully applicable for the large companies, because one did not reach the threshold of 5–10% electricity cost compared to gross value added, and the other only reached it temporarily.

3. Companies C, D and E mentioned that "the lemon is squeezed", meaning that their perceived low-hanging fruits of profitable energy efficiency measures had been implemented and they have fewer opportunities now. In fact, they have to go back, re-analyse and find new opportunities because evidence is to the contrary: the **walk through audit showed open opportunities**[55] in all five companies. Since the energy efficiency analysis and its subsequent improvement lists were made, new opportunities have arisen which have not been addressed. For example, several rotating machines with more than 30 years of operation were never analysed and simply considered "not economically replaceable". However, their status was never re-evaluated considering up-to-date technology.
4. The companies did not feel like pioneers with an environmental mission while implementing energy efficiency improvements; it seemed to be more like "business as usual".
5. An additional observation is that all five companies are **located in rural areas**, partly because of cheaper labour cost. At the same time, they are all oriented towards a Swiss or an international market, not a local market only. Transport issues only entered their energy and environmental rationale in the case of two companies: company D, which delivered the raw materials for production *via* railway, and company A, which tracked and accounted for the CO_2 emissions from employee transportation.

Monitoring and quantification of energy savings and costs, *ex ante* and *ex post* evaluation, reporting

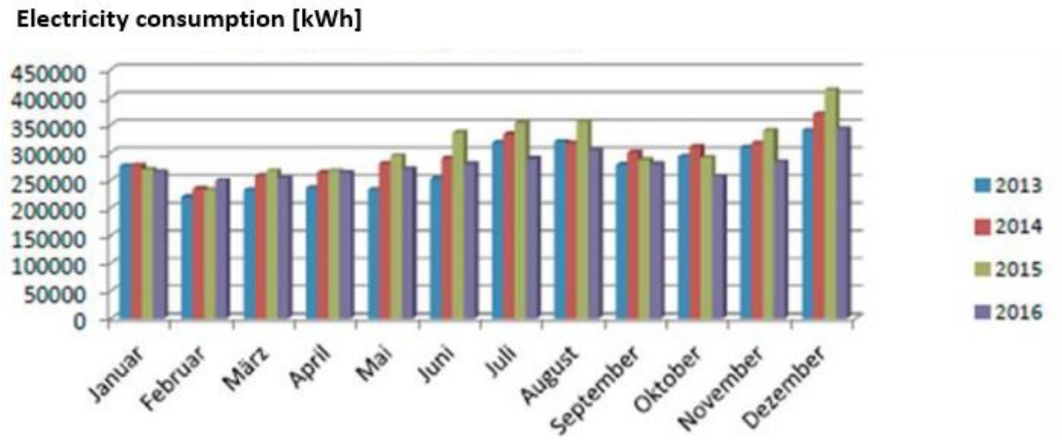
The research team observed that monitoring, especially the verification of savings, is a challenging and neglected area in many case study companies. In particular:

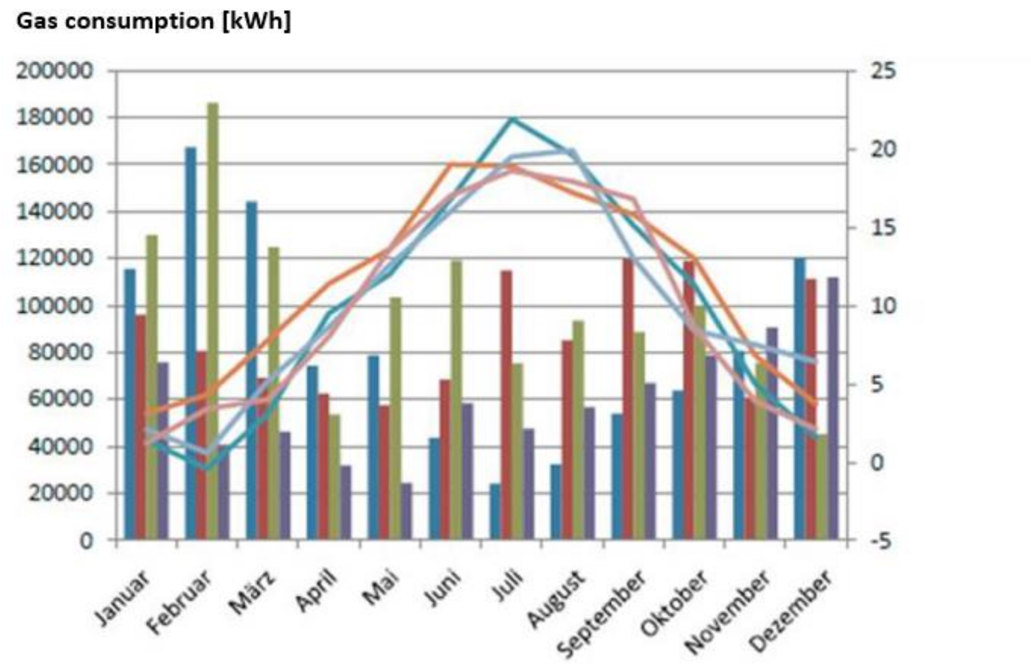
1. Many enterprises use a calculation method to determine their CO_2 emission reductions and energy savings for their annual reporting (based on the method developed by EnAW). However, after the implementation of the efficiency improvements, most companies do **not verify whether** all the **planned savings correspond to** the **actual** savings. The companies assume that the resulting savings are according to plan.

[55] The term "open opportunities" is used here specifically for old and amortized machinery that is kept running without any analysis while new technology is available that can save considerable amounts of energy in a cost effective way.

2. **The energy savings of individual measures are not well monitored**. For specific measures the engineers usually make an *a priori* estimate of the cost and the energy savings. After the implementation of the energy efficiency improvements, they can relatively easily check the cost, but not the energy savings. They generally assume that it happened according to plan.
3. All companies reported that the results of energy efficiency improvements were as planned. However, it is questionable how they came to this conclusion. None of them had a strict and systematic savings verification policy for all significant energy efficiency improvements. Some companies were equipped with measuring instruments (the higher the level of energy management, the more likely). Few occasionally used measuring equipment before and/ or after energy efficiency measures.
4. **Before and after comparison is challenging**. It is very difficult to gain comparable and reliable data to determine the energy savings (fossil and electric) and their cost, resulting from the energy efficiency measures in the case study companies. Changing energy prices, changes in production (output volume, product type and quality), weather and climate changes (summer or winter) *etc*. affect energy consumption and eventual energy and cost savings (see Figure 16). A disproportionately large effort is necessary to recreate the same conditions at two different points in time (before and after implementation) and to determine the influence of these individual factors. Therefore, companies have no interest, incentive or need to undertake this effort.
5. **No**ne of the companies reported a systematic **continuous learning** and improvement **process** with regard to their energy efficiency improvements, except company E which reported *ex post* evaluation of its projects.
6. None of the five companies was able to establish a "**Key Performance Indicator**" (KPI) to easily compare multi-annual results. They mentioned the change of production volume and the characteristics of the products that do not allow a global KPI. One company used a KPI for a few specifically-identified products (see Figure 17). If KPIs were established, it would be much easier to evaluate the progress of energy efficiency improvements.

Figure 16: Sample of a four-year report of total electricity and gas consumption

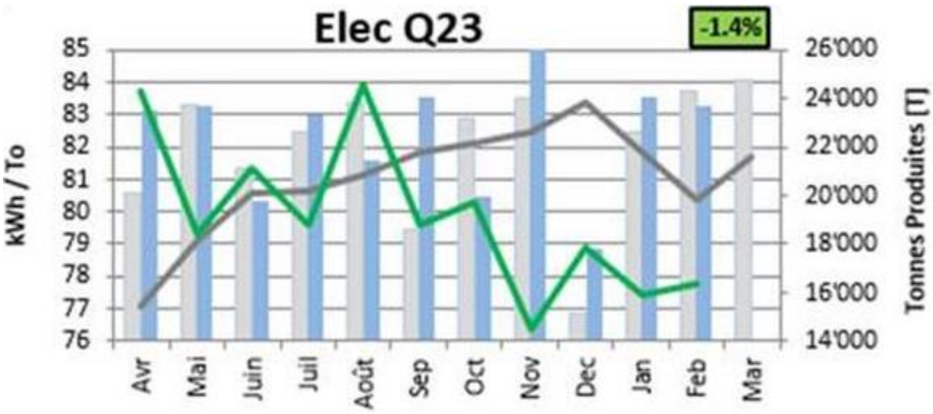




Sample of a four-year report of total electricity and gas consumption: no easy and clear interpretation of overall results is possible; no verification of success of on-going energy efficiency projects is possible.

Figure Impact Energy. Source: Case studies

Figure 17: KPI used by one company only (kWh/tonne of output) for individual processes



KPI used by one company only (kWh/tonne of output) for individual processes. Monthly monitoring update of KPI (kWh/tonne) for the current year (blue bar) and comparison with the previous year (grey bar). Energy consumption and comparison with output volume (current year: green line; last year: grey line).

Figure Impact Energy. Source: Case studies

Equipment maintenance practices

No further observations were made by the research team concerning the equipment maintenance practices other than what the case study companies reported.

Role of public policy, opportunities and constraints, improvement potentials

1. In the case study companies, the **CO_2-tax** and the **cantonal requirements** for large-scale energy consumers have in all cases **triggered actions** for implementing energy efficiency measures. Policies are therefore an important driver. This was particularly visible in the SMEs.
2. At the same time, the **reception** by the companies is **mixed**: many admit that the CO_2 tax and its target agreements helped in their awareness and in the build-up of in-house capacity and competence and the subsequent implementation of efficiency improvements. On the other hand, many lament the administrative effort, the many forms to fill, the data required to satisfy annual reporting, and the effort needed in order to benefit from financial incentives.
3. Many case study companies, especially the large enterprises, are in an **area of conflict between** competing in their respective fields to keep their markets, and their commitment to meet all the legal obligations and targets they set for themselves under the current policy framework.
4. Setting a goal seems crucial to obtain results. This aspect of the target agreements is helpful to convince company management to agree to energy efficiency improvements. Once the

company commits to its **goals**, there is a certain **obligation to fulfil** them (instead of postponing or abandoning investments).

5. All companies **reached their agreed targets easily**. None complained about severe measures and costly investments. One company (company A) mentioned that it chose not to commit to a target agreement with EnAW or act, as it would not have been able to meet the required efficiency improvement targets. Instead, it chose to make an energy consumption analysis and to conclude a target agreement based on a short list of improvements with a local utility company, coupled with financial incentives.
6. A paradox was observed with large energy consumers and energy-intensive users. Both the CO_2 tax model on fossil fuel and the KEV electricity surcharge give exemptions for large and/ or intensive users. This means they get reimbursed for taxes and surcharges while all medium and small companies have to pay the full amount. It is necessary and beneficial that especially this small group (which has a considerable share of the total Swiss energy consumption and its CO_2 emissions) gets special attention regarding energy efficiency measures. In reality, it is fairly much up to the large and energy-intensive what they implement. A specific focus on energy efficiency in these large and/or intensive energy consumers is to be considered.
7. The large enterprises benefitting from **financial incentives** said that they would have implemented the energy efficiency improvements anyway, though extended over a longer time period (free-rider effect). Incentive programs do not seem to reach SMEs.
8. All case study companies stressed the importance of **keeping administrative** efforts associated with policies and especially financial incentives at the **low**est possible level.
9. **SMEs** experience the implementation of energy efficiency improvements more challenging than larger companies and **need more support**. They signalled interest for the following areas:
   a. Qualified external know-how for initial analysis and identification of potentials (partially or entirely subsidised) as well as the implementation of energy efficiency improvements and follow up.
   b. Training of energy managers.
   c. Information on relevant financial incentives.

Energy efficiency performance in relation to level of energy management

In an attempt to match the level of energy management (see Table 46 in the Annex), based on the results of the survey with the level of energy efficiency performance, a qualitative comparison was made (see In total, 13 questions (see Table 38) were answered by two independent experts as a basis for the qualitative analysis, with ratings for each question (10 points: best; 1

point: worst). The independent ratings of the two experts per company were averaged for each company (see Figure 18 and Figure 19). Overall, three experts were engaged: one expert evaluated all five companies, one four, one only one company. All of them had only a short briefing about their task and did not communicate with each other for the individual evaluation and rating. The three experts had a fairly good overall match of their average rating of the five companies and the 13 questions: the result differed by +11% and -18%.
Figure 18 and Figure 19). This evaluation is based on an independent rating of two energy efficiency experts present at the "walk through audit" and the subsequent technical report of the five case studies. The observations by the energy efficiency experts were benchmarked with other project experiences in similar Swiss industrial companies (Tieben et al, 2015).

Table 38: Rating of the level of energy efficiency performance of the case study companies

Level of energy efficiency performance		A	B	C	D	E	all	all		
Nr	Question	average	average	average	average	average	average	min	median	max
1	Are all thermal processes and their energy efficiency potential analyzed?	6.5	6.5	8.5	7.0	8.5	7.4	6.5	7.0	8.5
2	Are all electric processes and their energy efficiency potential analyzed?	5.0	5.0	4.0	3.5	6.5	4.8	3.5	5.0	6.5
3	Is the implementation of the cost effective thermal efficiency measures planned systematically?	6.0	5.0	7.0	4.5	7.0	5.9	4.5	6.0	7.0
4	Is the implementation of the cost effective electric efficiency measures planned systematically?	4.5	4.0	2.5	3.5	4.5	3.8	2.5	4.0	4.5
5	Fraction of thermal measures implemented?	5.0	5.0	7.0	4.5	7.0	5.7	4.5	5.0	7.0
6	Fraction of electric measures implemented?	3.0	4.0	3.0	4.0	5.5	3.9	3.0	4.0	5.5
7	Do they have a good plan* for fossil measures for the next 5 years?	4.5	3.5	5.0	5.5	5.0	4.7	3.5	5.0	5.5
8	Do they have a good plan* for electric measures for the next 5 years?	3.5	3.5	2.0	4.5	5.0	3.7	2.0	3.5	5.0
9	Does the energy manager give the impression of being competent?	5.0	7.5	8.5	7.0	8.0	7.2	5.0	7.5	8.5
10	Did the company use external experts?	7.0	7.5	6.5	4.0	3.0	5.6	3.0	6.5	7.5
11	Did the company take individual measurements before a machine was changed?	3.0	2.5	5.0	5.0	6.5	4.4	2.5	5.0	6.5
12	Did the company take individual measurements after a machine was changed and compared with the outset?	2.5	2.5	4.5	4.5	6.5	4.1	2.5	4.5	6.5
13	Are the calculations for the effect of the energy efficiency measures shown in their plan plausible?	4.0	5.5	2.5	5.5	6.5	4.8	2.5	5.5	6.5
average		**4.6**	**4.8**	**5.1**	**4.8**	**6.1**	**5.1**	**3.5**	**5.3**	**6.5**
percentage		46%	48%	51%	48%	61%	51%	35%	53%	65%

Rating of the level of energy efficiency performance of the case study companies, based on qualitative analysis (10: best; 1: worst) by energy efficiency experts after walk-through audit and technical report.
*Note: a good plan for measures for the next five years is defined as complete, comprehensive, systematic, and credible.

Table Impact Energy. Source: Case studies

In total, 13 questions (see Table 38) were answered by two independent experts as a basis for the qualitative analysis, with ratings for each question (10 points: best; 1 point: worst). The independent ratings of the two experts per company were averaged for each company (see

Figure 18 and Figure 19). Overall, three experts were engaged: one expert evaluated all five companies, one four, one only one company.[56] All of them had only a short briefing about their task and did not communicate with each other for the individual evaluation and rating. The three experts had a fairly good overall match of their average rating of the five companies and the 13 questions: the result differed by +11% and -18%.

Figure 18: Rating range of qualitative evaluation by energy efficiency experts after walk through audit and technical report

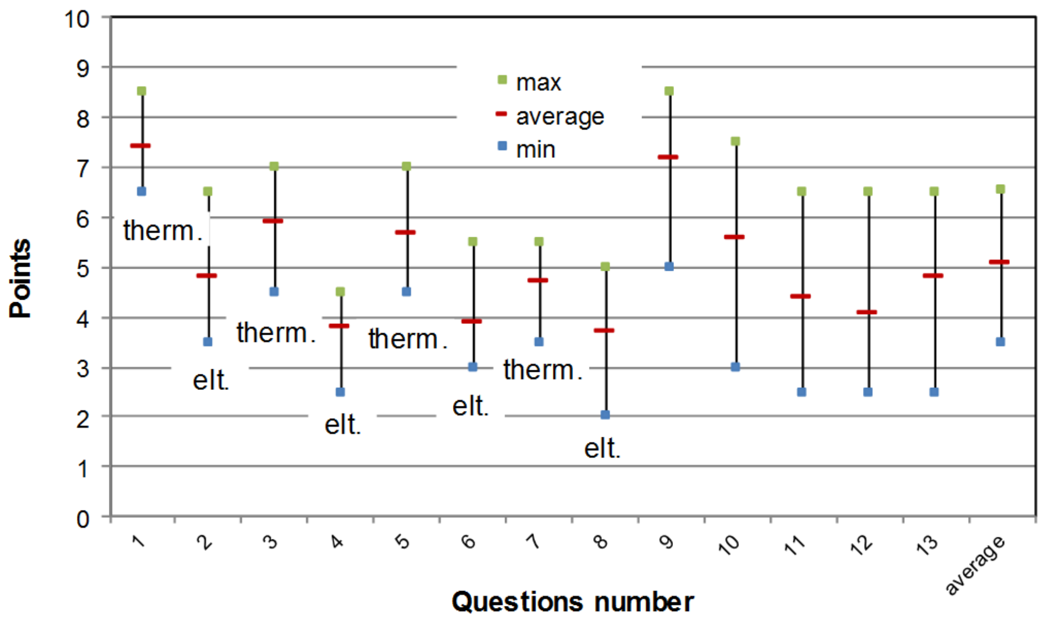


Figure Impact Energy. Source: Case studies

The level of energy efficiency performance shows a much higher rating for all questions related to thermal energy (Questions 1,3, 5 and 7; average 4.7) as opposed to questions related to electric energy (Questions 2, 4, 6 and 8; average 3.2). Question 1 (analysis of thermal measures) and Question 9 (competence of the energy manager) have the highest rating. The lowest rating is given to Questions 4, 6 and 8 (all related to electric energy).

[56] The expert that was visiting and rating the level of energy performance of only one company had the disadvantage of not being able to compare his result with the other case study, so his calibration can be somewhat off. Nevertheless, the research team did not consider this as major fault of the qualitative analysis.

Figure 19: Comparison of level of energy management with level of energy efficiency performance

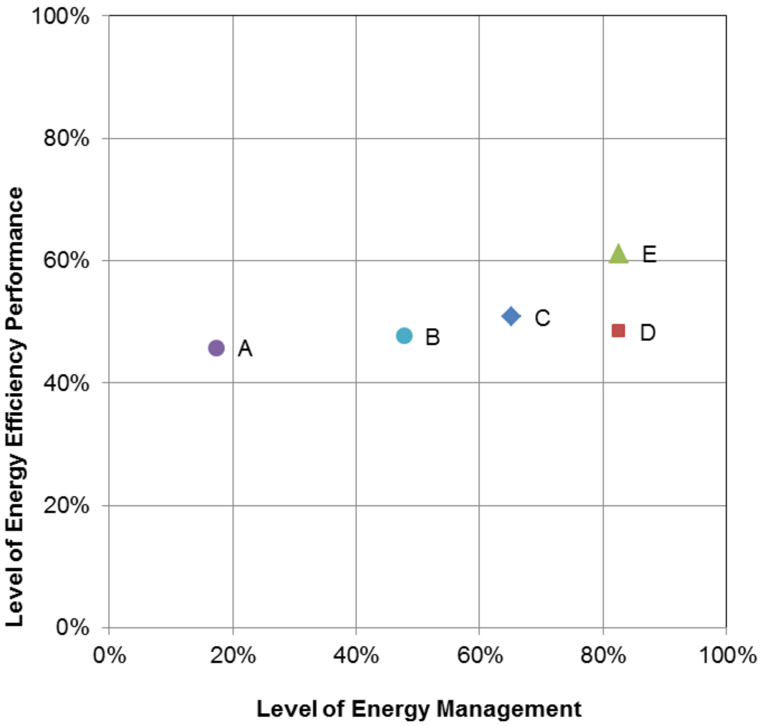


Figure Impact Energy. Source: Case studies

The comparison in Figure 19 of the very wide band of the level of energy management[57] of the five companies (between 4 and 19 points out of 23 points) to the relatively narrow band of the level of energy efficiency performance (between 4.1 and 6.1 out of 10 points) shows no clear specific pattern between these two criteria. Also, the sample of the case studies is not large enough to plot any conclusions being representative for a larger group of companies.

Companies A and B clearly started to analyse their energy consumption and identify efficiency improvement measures in response to the cantonal large-scale consumer obligation. They did not deal with improving their energy efficiency before. From this point of view, having reached a fairly high level of energy efficiency performance, one comparable to companies with a high level of energy management, is positive news. It shows that policies have an effect and can stimulate companies to a favourable level of energy efficiency performance within a

[57] See Annex 3.1 for the questions based on which the level of energy management of the companies was determined during the survey (phase I).

short period of few years (compared to the status with no or very little efficiency improvements before).

7.4. Conclusions

The energy data from the companies, the "walk through audit", and the discussion with the contact person(s) has given a well-rounded picture of how they see themselves and their stage of energy efficiency decision-making and implementation of investments. This allows for discussion of the results. The case studies have shown more precisely whether the contact person or energy manager had a good overview of the efficiency potential within the company, and to what extent and how systematically he or she was exploiting these potentials through implementation of efficiency improvements.

7.4.1. Conclusions regarding the M_Key hypotheses

Research question 1: What is the level of energy management and its determinants in Swiss large-scale energy consumers?

Hypothesis 1.1: The level of energy management in Swiss large-scale energy consumers is generally low.

This hypothesis was assessed on a large sample during the survey (project phase I). In the case studies, the sample is not large enough for making relevant conclusions regarding this hypothesis, which was also not foreseen.

Hypothesis 1.2: The main determinants of the energy management level are company size, company energy intensity, and the commitment or support of energy management by top management.

Energy cost seems to play a significant role and its share to total cost/ turnover (**energy intensity**). This was especially observed in the two large companies. Both were energy-intensive, *i.e.* their energy costs around 7% to 12% of their gross added value. Due to this—in addition to a highly **competitive business environment,** especially in the case of company E—dealing with energy and implementing energy efficiency improvements was an intrinsic goal, followed by the companies already on their own.

In the SMEs of the case study companies, energy costs were not significant enough in all cases, as stated by the companies themselves. They also mentioned finding energy prices generally low. Here, policy played a key role in bringing them to action. This was met with the personal motivation of the energy managers, who in some cases were supported by top management, though in others not. It was much easier for those with support from the management to propose and implement measures.

To conclude, the **main determinants** of the energy management level observed during the case studies are:

- **high energy cost/ intensity**, observed in the large companies, and even greater in a competitive business environment;
- **policy and regulations**, most significant for SMEs;
- **motivation, skills and knowledge of the energy manager,** important especially in SMEs;
- **support from top management**.

Research question 2: What is the influence of energy management on the perceived strategicity of energy efficiency investments?

Hypothesis 2.1: The higher the companies' level of energy management, the more strategic they perceive energy efficiency investments to be.
Based on the observations in the case studies it seems that **the more strategic companies perceive energy, the higher their level of energy management**. This is a reverse causality compared to the above hypothesis. The higher levels of energy management were observed in the large companies who also happened to have high energy intensity (around 7% to 12%). In the SMEs, the cost of energy was not significant (energy intensity between 1% and 3%) and energy was not perceived as strategic. Company E, with exceptionally high energy consumption (and cost), explained that since energy and energy costs are significant, and as the company operates in a highly competitive business environment, it is an intrinsic motive of the company to be as energy efficient as possible.

Research question 3: What is the influence of the perceived strategicity on investment decision-making?

Hypothesis 3.1: The more strategic an energy efficiency investment project is perceived by a company, the better the chances for a positive decision.
This hypothesis assumes the investment category "energy efficiency". While in two SMEs this investment category with its dedicated budget exists, in the other companies it does not.
All companies reported, that while energy efficiency is not the highest priority in their investment decision-making, it is always considered when investments are made. The highest priorities named were safety, production and product quality, reliability of equipment, and profitability. Thus, investment priorities are related to core business.

In the SMEs energy is not seen as strategic, while in the larger companies it is seen rather as strategically important. The evidence from the case studies is not sufficient to confirm or deny this hypothesis.

Hypothesis 3.2: The less strategic the investments, the more restrictive the financial criteria in the selection of investment projects.

In the case of energy efficiency improvements, the situation in the five case study companies is mixed. Three companies use the same financial criteria for all investments (no differentiation). In company A, an SME with the lowest level of energy management, the financial criteria for efficiency improvements are more restrictive than for other investments. In company E, a large energy consumer for which energy is a strategic topic, the financial criteria can be more flexible than for other investments.

Taking into consideration the findings related to hypothesis 2.1., *i.e.* the more strategic companies perceive energy, the higher their level of energy management, the level of energy management can be seen as a manifestation of the strategic importance given to energy by companies. This means that a low level of energy management can be translated into low (to none) strategic value of energy efficiency and a high level of energy management into a higher strategic value of energy efficiency. While the sample of case study companies is too small to draw conclusions regarding this hypothesis, it could be argued that if in company A energy efficiency is not strategic and in company E it is (so in company E there are other investments which are less strategic), more restrictive financial criteria are applied by these two companies to less strategic investments.

Hypothesis 3.3: The number of energy efficiency investments positively decided upon and realised depends mainly on the network relations and knowledge exchange within the sector.

The case studies do not support this hypothesis. The observations show that for SMEs, external know-how is important, but this is different from a knowledge exchange within the sector. In the case of the large companies, they stated that the necessary know-how is already available in-house. There is an exchange within the company subsidiary network with other sites; however, this serves rather as a pool of potential project ideas and is only one—and not a major—element for positive decisions. An exchange outside the company is considered to be difficult due to confidentiality issues.

Hypothesis 3.4: Increasing requirements from cantonal energy policies for large consumers and/or rising energy prices (in particular for electricity) positively influence energy efficiency investment decision-making by companies.
The case studies confirm that requirements from cantonal (or federal) energy policies have a significant role (and in the case of SMEs, a key role) in inciting companies to action. Most companies do not anticipate increased stringency of these requirements. In SMEs, rising energy prices are generally not considered, because their energy cost is not significant. In the two large companies, the price and cost of energy is an important issue. Both companies have staff who procure energy on the European market under the best possible conditions.

Hypothesis 4.1: The higher the number of energy efficiency investments implemented, the higher the energy performance of a company (measured in energy intensity terms).
The observations from the five case study companies do not provide sufficient data for a quantitative analysis and hence this hypothesis cannot be confirmed. In addition, the sample of the case studies is not large enough to plot any conclusions being representative for a larger group of companies.

The section about Energy efficiency performance in relation to level of energy management (*cf.* Chapter 7.3.3) shows a qualitative analysis to evaluate this hypothesis. According to this qualitative analysis, no clear specific pattern can be observed between the level of energy management and the level of energy efficiency performance of the five case study companies. They all seem to be more or less on the same level of energy efficiency performance.

One observation concerns Companies A and B, which started to analyse their energy consumption and identify efficiency improvement measures in response to the cantonal large-scale consumer obligation. As a result, they reached a relatively high level of energy efficiency performance which shows favourable progress compared to their previous status, with no or very little efficiency improvements, and hence low efficiency performance. This shows that regulations have a tangible effect.

7.4.2. Conclusions regarding the M_Key research model

Based on the observations and evaluation of the case studies, the following conclusions can be made with regard to the M_Key research model:

1. Several factors determine whether a company perceives energy as a strategic issue. Based on the observations made in the five case study companies, the most significant variable in this equation seems to be the energy intensity (energy cost compared to total costs/ turnover/ gross value added of the company). If energy intensity is high (more than 5%), energy issues seem to be perceived as strategically important. The business environment and especially

the level of competitiveness within the sector play an important role, as well. If energy intensity is low, policies can have a key role in inciting companies to action.

2. If energy is perceived as strategic, then the company has a high(er) level of energy management, as it creates the structures that allow it to address energy issues adequately. This means establishing in-house capacities, a more sophisticated approach for evaluation of savings potentials and a more systematic implementation and verification of savings. At the same time, external support is used increasingly seldom.
3. Energy management has the function to deliver reliable, fact-based data and information as a basis for investment decisions.
4. All of the five companies have implemented energy efficiency measures, more so in the thermal/ fossil area than in the electric. Many energy managers said that the planned list of measures was complete. In the current CO_2 and electricity policy, once the target is fixed and the measures to achieve this target are identified, no new measures are studied, no update is made, and there is no incentive to do so. The list of efficiency improvement measures is fixed and frozen for the duration of the agreement and its implementation.
   In most of the five case study companies visited, untapped efficiency potentials in thermal and electrical energy were observed of which the energy manager was not always aware. For example, electrical machines like pumps, fans, compressors for air and cold were beyond a typical machine age, did not have load control and seemed to be oversized. These untapped efficiency potentials and additional savings[58] were not analysed in detail by the research team compared to the planned list of measures. To conclude, in most of the five companies the ceiling of possible, feasible and profitable energy efficiency improvement measures is not reached.
   Monitoring of energy consumption and especially verification of energy savings within the companies remains a challenge, hindering a fact-based evaluation of progress and a continuous improvement process.

[58] Based on comparable industrial energy efficiency projects (Tieben et al, 2015), their cost effectiveness was assumed to be favorable (payback below four years).

PART III – SYNTHESIS

8. Discussion

This chapter is designed to highlight common grounds, illustrate differences and explain the discrepancies between the findings of the survey (Chapter 5), interviews (Chapter 6) and case studies (Chapter 7). In order to do so, the differences in conditions of the framework between the survey and the following substudies are analysed. In addition, difficulties concerning the application of the research model, the availability, possible limitations, and conflicting interpretation of the data is discussed. Moreover, this chapter presents additional findings, *i.e.* additional results observed during the research project but not directly linked to the hypotheses. Finally, overall conclusions of the entire research project, either endorsing or contradicting the individual conclusions of the empirical sub-studies survey, interviews, and case studies complete the discussion.

8.1. Findings regarding the hypotheses

To obtain harmonised findings for the entire M_Key research project, the individual findings of the survey, the interviews and the case studies will be summarised, compared and discussed in this subchapter. The backbone for this comparison is, again, the research model with its eight hypotheses. For each hypothesis, the following key elements will be presented and discussed:

- whether the main findings confirm or contradict the hypotheses;
- common features and discrepancies between the findings of the survey, the interviews, and the case studies;
- additional information, interpretation and differentiation for the survey, the interviews, and the case studies;
- methodological difficulties, differences, and limitations of samples.

8.1.1. Level of energy management and its determinants

Hypothesis 1.1: The level of EM in Swiss LSEC is generally low.

This hypothesis could be confirmed.

The level of EM was assessed on a larger sample during the survey. In the subsequent phases of interviews and case studies, the level of EM as assessed based on companies' answers to the survey questionnaire was used as a criterion for the selection of the companies for the interviews and case studies. Depending on the results of the survey, the sample was diversified into companies with low, medium and high levels of EM.

Based on the answers to the survey questionnaire, the EM of the respondent companies is at a rather low level of 10.3 points on a maximum reachable score of 23 points (see Figure 8: rating of EM in four categories on a scale from 0 to 23 points). Thus, the average level lies at about 40% of the maximum reachable score as assessed by the survey's methodology. There are no significant differences between the industrial and services sectors. Responses indicate many opportunities for improvements in the companies' level and composition of energy management.

The interviews revealed that companies' understanding of EM covers a wide range of possible interpretations. Generally speaking, EM includes all activities of a company that aim to improve energy efficiency and reduce energy consumption. As the interviews and the case studies showed, companies with a higher perceived importance of energy efficiency also have a higher level of EM, which confirms the results of the survey.

Hypothesis 1.2: The main determinants of EM are company size, energy intensity and the commitment/ support of the top management.

This hypothesis could not be fully confirmed.

The set of main determinants of EM is larger than expected and the companies are widely diverse in this regard. In most cases, one of the three factors cited (company size, energy intensity, support of top management) is considered to be dominant. A common result of the three empirical sub-studies is that top management support seems to be the most important factor. There is, however, no clear consensus with regard to the significance of the size or the energy intensity of a company. While the correlations examined for the survey results indicate that support of the top management and energy intensity are more relevant than size, the interviews identified the support of the top management as the most decisive factor. Based on the interviews, other highly relevant factors are laws and regulations and, to a certain extent, energy intensity (see chapter 6.2.1.). The influence energy intensity influence seems not to be linear. There appears to be a threshold effect: above a certain level, where consumption becomes very high, energy consumption becomes strategic.

As per the case studies, energy costs and energy intensity seem to play a dominant role. This was especially observed in the two largest companies, both energy-intensive, with energy costs in the range of 7% to 12% compared to their total cost/ gross added value,[59] and was even more important for companies in a highly competitive business environment. The assessment is different for the SMEs visited, where energy costs were not significant enough, as

[59] As the interviews and case studies have shown, companies apply very different references as bases for the definition of their energy intensity. While some compare energy costs with total costs, for others the reference is the gross added value. For details please refer to Table 36 in the case study report (chapter 7.3).

stated by the companies themselves. For them, policies and regulations play a key role in bringing them to action. Another main determinant, especially in SMEs, turned out to be the personal motivation and skills of the energy managers. Generally, energy managers are most successful at implementing energy efficiency improvements if they are supported by their top management. The significance of the skills and motivation of the energy managers was also confirmed by the findings of the interviews.

8.1.2. Influence of energy management on perceived strategicity of energy efficiency investments

Two major challenges made the analysis of the assumed influences difficult:

- The different views and understandings of companies in classifying investments – especially EE investments – as strategic.
- The fact that, in most cases, the personal perception of a sole person, the energy manager, was taken as representative of the entire company's understanding of strategic EE investment, when other actors, with other functional positions in companies, may have very different views on the same issues.

Hypothesis 2.1: The higher the level of EM, the more strategic energy efficiency investments are perceived

None of the results of the three sub-studies could confirm this hypothesis.

As part of the evaluation of the survey responses, a correlation analysis was done to examine the correlation between the level of EM (rated on a scale of 0 to 23 points) and the strategic character of EE investments (or, more precisely, the energy managers' perception of the strategic character of EE investments, assessed on the basis of eight drivers considered as strategic, scored on a scale of 0 to 40 points). The analysis revealed that the correlation between the level of EM and the stated importance of the eight strategic drivers is not significant.

According to the interviews and the case studies, the main contribution of EM is the increased information it normally generates. By providing reliable facts and figures, it makes impacts of EE measures gaugeable and visible. According to the interviews, the resulting transparency improves trust and support in EM and corresponding investments. This can also trigger positive feedback on the perceived strategicity of EE measures and EM. However, most interviewees do not see this strategicity enforcement.

There is strong agreement between the interviews and the case studies, that in most cases the direction of the observed impact was found to be the reverse: the more strategic EE investments are perceived, the more importance is attributed to EM and, in many cases, the higher the energy management level. This was noticed in most of the companies interviewed and particularly confirmed by the case studies in the large companies, which also happen to have the highest energy intensities.

8.1.3. Influence of the perceived strategicity on investment decision-making

Hypothesis 3.1: The more strategic an energy efficiency investment project is perceived, the better the chances for a positive decision

This hypothesis could be largely confirmed.

Within the M_Key research project, energy efficiency investments are defined as investments whose first objective is the reduction of energy consumption. This means that a company can take decisions on energy efficiency investments with or without having a dedicated investment category for them. Interviews and case studies have clearly shown that this is common practice: in some companies such a dedicated EE budget exists, in other companies it does not. Moreover, companies apparently have difficulties assessing investments into EE. They often do not even know exactly how many projects were carried out over the preceding years, are not able to name the investment characteristics, and are not even able to identify which of them would qualify as strategic EE investments. In many companies, no budget category "investmensts to reduce energy consumption" exists at all.

The results of the survey and the case studies do not explicitly confirm the above hypothesis but do not indicate a clear contradiction, either. During the analysis of the survey responses, the above hypothesis was tested by comparing the perceived strategicity of energy efficiency investments with the volume of energy efficiency investments realised by companies over the last four years. The companies' EE investments were measured using four variables. All correlation coefficients were small and insignificant.

To a large extent, the results of the interviews confirm the hypothesis. For most companies, investments driven by efforts to strengthen the core business are generally considered as being more strategic than EE investments. It is noteworthy, however, that most interview partners, while assessing the strategic relevance of their investments, seem to have enlarged the focus from EE to general investment projects. Strictly speaking, the interview partners therefore confirmed that the chances for a positive decision are related to investment strategic character. Another finding was that in companies that attribute high priorities to environmental or sustainability topics, EE investments are in a favourable position to generate positive decisions.

In the case studies, all companies reported that, while energy efficiency is not the highest priority in their investment decision-making process, EE is always considered when investments are planned and realised. The highest priorities in the investment decision-making are safety, production and product quality, reliability of equipment, and profitability: all issues related to core business.

In the companies involved in the case studies, SMEs do not see energy as strategic, whereas the larger companies see it as strategically important.

Hypothesis 3.2: The less strategic the investment, the more restrictive the financial selection criteria

This hypothesis could largely be confirmed.

Almost all companies apply at least one of the common methods for the financial evaluation of EE investment projects. However more than 80% use solely the simple payback method, while a minority of the enterprises (also) uses the Net Present Value (NPV) or the Internal Rate of Return (IRR) methods.

In the survey, energy efficiency investments are in general not considered as strategic, *i.e.* contributing to the competitiveness of the firms. Financial factors such as the availability of funds, subsidies or tax breaks, or the effective rate of return, do not play a role in EE investment decisions, given the absence of any significant financial variables in the estimated equations. Most firms use the simple payback method, which is in fact imposed by the target agreements proposed by the government to large-scale consumers. These firms are obliged to implement projects with a payback period equal or shorter than four years for production investment and eight years for buildings, at the risk of neglecting thereby the possible (very) long term effects of many energy efficiency investment projects. In the framework of the target agreements, firms are asked to carry out the EE projects when the latter satisfy the simple payback criteria. However, both the energy intensity, as well as the level of consumption of thermal energy above the threshold of 5 GWh, have a positive impact on EE investment spending.

The interview results show that most companies support the above hypothesis, although they tend to formulate it in the positive sense: the more strategic a project or investment is considered, the less restrictive are the financial criteria applied. When projects are considered as truly strategic, most companies will implement concrete measures even if economic viability is not met. A minor share of the companies does not differentiate: all investments must fulfil the same financial criteria. This means that EE investments are rated the same way as all other investments. Only one company applies more restrictive financial criteria to energy efficiency projects. This company considers most other investments as more strategic than energy efficiency investments. Therefore, these projects have to be more profitable than other projects.

The results of the five case studies support the interview findings. It appears that the more strategic a project or investment is considered, the less restrictive are the financial criteria applied. Different approaches were observed: three companies use the same financial criteria for all investments (no differentiation), one company applies financial criteria for efficiency improvements which is more restrictive than for other investments (a SME with the lowest level of EM, where EE is not considered strategic), and the largest energy consumer (for whom energy is a strategic topic) applies financial criteria which can be more flexible than for other investments.

To summarise, the results of both the interviews and the case studies largely support this hypothesis that the less strategic the investment is, the more restrictive are the financial selection criteria. The results derived from the survey suggest that energy efficiency investments are in general not considered as strategic, and that financial factors, including the rate of return, do not play a role.

Hypothesis 3.3: The number of energy efficiency investments positively decided upon and implemented depends on the network relations/knowledge exchange within the sector

None of the results of the three sub-studies could confirm this hypothesis.

Although many companies exchange relevant information and experience with other companies and participate in networks, most companies claim that decisions regarding energy efficiency investment projects are made fully independently. Rather, the exchange of ideas is considered to be one of many elements – certainly not a major one – influencing positive decisions.

The correlation analysis of the survey results has shown that the correlations between the number of partners and certifications and EE investment variables are low and insignificant. During the case studies, the large companies stated that they hardly profit from technical knowledge exchange with external parties for two reasons: a) the necessary know-how is already available in-house, and b) confidentiality concerns with regard to specific technical know-how. However, the exchange of ideas, which for large companies occurs inside the company between different sites, and for SMEs with external companies, is seen as a pool of ideas and innovation to stimulate the identification of potentials and new projects.

Hypothesis 3.4: Increasing requirements from cantonal energy policies for large consumers and/or rising energy prices positively influence companies' energy efficiency investment decision-making

There is a need to differentiate between the two aspects this hypothesis comprises.

Aspect 1 – the influence of (cantonal) energy policies has been directly confirmed by interviews and case studies and indirectly by the survey.

According to a majority of the interviewees (whether in interviews or in case studies), public requirements (laws and regulations at the national and cantonal level) have a strong impact on companies with regard to EE investments. First, public policy strongly influences EM and indirectly EE investments. Second, public policy has a certain impact on EE investments, since it often triggers EE investments and/ or speeds them up. The most relevant national policy appears to be the CO_2 target agreements, supported by levy reimbursement agreements. Today's cantonal energy policies for large-scale energy consumer companies also seem to have a positive effect on energy efficiency investment decisions, particularly if these consumers do not have a target agreement at the national level.

Additionally, the case studies indicate that for SMEs, policy requirements do have a key role in inciting companies to action. However, companies do not generally anticipate increasing requirements from cantonal energy policies.

According to the survey results, correlations between public policy and EE investment variables are insignificant. Yet the survey has shown that energy audits (which are in some cantons subsidised by public EE policies) trigger energy management systems, and that voluntary agreement with EnAW increases the level of energy management. Accordingly, the survey also shows that public energy policies do have an impact.

Aspect 2 – the influence of rising energy prices has not been confirmed.

As for the impact of price, the survey cannot provide any results. The survey report points out, however, that for a long time relative energy prices have been falling.

According to most of the interview partners (in the framework of both interviews and case studies), their companies make financial assessments and investment decisions based on current energy prices, which are taken for granted to remain constant in the future. The possibility of energy price increase in the future is not taken into consideration by most companies. Many of the interviewees expect energy prices to rise, but financial assessments are based on current prices. Only in individual cases are slightly rising energy prices considered for the financial assessment of investments. While this applies to almost all SMEs, it is not true for the large (energy-intensive) companies investigated in the case studies. For these companies, energy prices are a very important issue. Therefore, both of the large companies studied have specialised staff who procure energy on the European market at the best possible conditions.

8.1.4. Influence of EE investment decisions on energy performance

Hypothesis 4.1: The higher the number of energy efficiency investments implemented, the higher a company's energy performance

This hypothesis could not be confirmed because of the lack of empirical evidence.

According to the survey, around 60% of the companies that have implemented EE projects over recent years claim to have experienced a reduction of energy consumption. About 40% of the companies estimate that nothing has changed with regards to cost, price, profitability and competitiveness. However, correlation coefficients between EE investment and the energy performance of the companies are low and insignificant. Therefore, the companies' statements have to be classified as qualitative evaluation. About 30% of the companies say that they are not able to effectively assess any impacts since they do not have the monitoring and controlling instruments to produce the exact data that would in fact prove the positive appraisal.

The interviews showed similar results. Although almost all interview partners expressed positive influence of EE investments on energy performance, they had to admit that, in fact, they cannot reliably confirm a direct causal relation between EE measures implemented and energy consumption of the concerned partial systems, since no specific measurements are available. The case studies confirmed this inability to prove the impact of specific measures since companies can generally not provide sufficient data for a quantitative analysis.

8.2. Additional findings

The results of the survey, interviews and case studies do show some relationships and directions of influence that are additional, *i.e.* not directly linked to the eight hypotheses. These additional findings are presented in this subchapter.

8.2.1. Reverse direction: Influence of EE investments, qualified as strategic, on level of energy management

The predicted positive influence of (the level of) EM on the perceived strategicity, EE investment decisions, and ultimately energy performance could not be confirmed. However, according to the interviews, with representatives from 26 companies, and the case studies with five companies, there is very often an impact in the reverse direction. The more significant the energy costs, the more strategic energy and energy efficiency investments decisions are perceived to be. There is not sufficient data and evidence, however, to confirm a linear relationship between energy costs (or energy intensity) and EE investments. Rather, there seems to be a threshold effect: *i.e.* above a certain level, energy costs and ultimately the EE decision-making process may become strategic. The more energy is recognised as strategic, the higher the chances are that a company's management will realise the need to reinforce its structures and processes, and allocate more financial and human resources. In doing so, companies build up a more sophisticated EM (system) that delivers reliable, fact-based data and information as a basis for investment decisions, helps analyse potentials, define projects and assess the impact of management decision and of specific EE investments on particular (sub-) systems and processes.

The level of EM is therefore not the independent variable as input to the impact chain *as per* the research model, but rather the result of a process that has identified EE investments as strategic for a company. A high level of EM, therefore, is a manifestation of the fact that the company attributes strategic importance to energy issues and thus increases the chances of a project proposal of being accepted and realised.

8.2.2. Differences between large companies and SMEs

While formulating the research questions and the eight hypotheses, no differentiation was made concerning the size and other characteristics such as industry of the large-scale energy consumers. All sub-studies have shown, however, that there are significant differences between the perceived strategicity of EE investments and EE investment decisions in SMEs and large companies. The main differences are highlighted below.

Relevance of sustainability policies, market and public pressure

SMEs tend to have a high self-understanding of their social and environmental responsibility. Several SMEs argued that this should be natural for a locally-rooted business. Companies with this perception usually follow less strict financial criteria compared to companies that belong to international groups.

Most (large) companies, being part of a corporate group, have a sustainability policy or even energy reduction targets which are set by the group. Many corporate groups set targets or develop strategies because of the market and public pressure on the companies to act sustainably. This is also a reason for certification (ISO 14001 or ISO 50001). Particularly, many companies in the manufacturing industry are certified to cope with this market or customer demand (certification is very relevant for tenders).

Energy manager(s)

For SMEs, the organisational structure, the EM, and the decision-making processes are in most cases relatively lean, to state this positively. In fact, SMEs generally lack the personnel resources bound to EE and EM. In most SMEs, the post of the energy manager is a part-time job. Small companies normally do not have an energy manager at all, but someone (from management or within the staff) who deals with energy issues, takes care of EE and EM, as well. The person, role, and decision-making authority of the energy manager is certainly a crucial element in the decision-making process and in the subsequent implementation of energy efficiency investments. Being a member of the SME’s top management gives an energy manager more authority and opportunity to positively influence decisions and implementation of EE improvements.

Most large companies and/ or companies belonging to a corporate group have a team of designated responsible persons for EM or environmental management and security (often covering EM as well).

Budgets and decision-processes for EE investments

According to the interviews, few SMEs have a specific budget for EE investments. EE measures are a small part of the general investment programme and of annual expenditures. The figures concerning EE projects and their financial budgets tend to get lost in the bulk of activities. SMEs typically apply strict financial criteria for their investment decisions.

According to the interviews, most large companies have dedicated budgets for EE improvements. They have more precise data and a better overview of their EE improvement activities. The decision-making processes and the financial criteria for investment decisions are mostly standardized.

In-house competence and external support

In the case studies, the SMEs said that they work together with external consultants to benefit from their specific EE know-how. Furthermore, large companies involved in the case studies reported that they have a solid level of energy knowledge within the company. Therefore, they seldom seek support from external companies, or if so, only with specialists for certain processes. An often-heard argument was that the production process was so complex and its stability of such utmost importance, that a) it was a necessity to build up the necessary energy and production process know-how in-house, and b) external experts lacked current and specific knowledge of the relevant industry with their special technological needs ("nobody knows better than us!").

Relevance of energy prices, energy supply

For almost all companies, the electricity and gas prices they pay are relatively low, have been stable, or have even decreased over the last five years. During the interviews and the case studies, several SMEs mentioned spontaneously that energy prices are too low. This is a clear disincentive: lack of fear of increasing energy prices will not be a driver for efficiency investments.

The case studies found that large companies generally buy their electricity on the international market. The sole decision criterion is the low price at a given moment for a specific capacity. No certified electricity from renewables ("Naturemade Star", *etc.*) is purchased, because this is slightly more expensive.

8.2.3. Lack of monitoring and control tools

Although many of the people interviewed (during interviews and case studies) claimed a positive impact of EE investments on energy performance, they mostly had to admit that they neither had the required specific equipment nor the precise data that would allow them to effectively measure and assess the impact of a particular EE measure. This statement comprises two aspects: first, few companies monitor and verify whether effective savings comply with the planned and expected savings; second, few companies have the equipment (*i.e.* meters and sub-meters and/ or software) necessary to prove the impact on performance of a specific energy efficiency measure. This finding is supported by the survey’s empirical results as well.

8.2.4. Non-energy benefits of energy efficiency investments

Many benefits other than the simply energy savings accrue in energy efficiency projects. Commonly referred to as the “multiple benefits” or “non-energy benefits” of energy efficiency, they include important core business benefits for companies (see Chapter 2.1.2).

Non-energy benefits have the capacity to raise the strategic as well as the financial attractiveness of energy efficiency investments: strategic attractiveness because they contribute to a better value proposition, lower costs and lower risks (*i.e.* to the three dimensions of companies’ competitive advantage in performing their core business), financial attractiveness because they translate into financial benefits for the investor.

Non-energy benefits were not at the core of M_Key research project investigations but nevertheless some interesting findings were collected in this regard. The results of the survey showed that 45% of the responding companies take non-energy benefits of energy efficiency investments into account “very often” or “nearly every time” in their project evaluation. Very few are monetized and included in the financial analysis.

This situation could be explained by the fact that energy managers find it difficult to include monetized non-energy benefits in their investment project analysis. The energy manager is normally responsible for the project design and has to find any means of leverage to sell the project to the top management. To be successful, energy managers tend to limit the purely technical aspects because hardly anybody will understand them. Projects proposed must be related to the company's strategic objectives. For example, a perfect product quality is a strategic objective. Thus it must be emphasised that if chilled water production is changed, there will be no quality problem in the future.

Some interviews show that large companies with a very high level of energy consumption or energy intensity and a high level of management skills have bridged energy and process issues in investment decision-making. This means that process people and energy people work hand-in-hand and that all advantages of the projects – both energy benefits and non-energy benefits – are taken into consideration.

Furthermore the interviews and case studies showed that:

- It is often difficult to define investments as pure EE investments, especially with a view to larger investments. In most cases, EE is taken into account as only one of many aspects.
- Non-energy-benefits are valued differently among the companies and are not quantified in most cases.

Key non-energy-benefits are improvements in safety, product and production quality, and reduction in equipment replacement. Energy efficiency investments showing these types of non-energy benefits (which means, according to our theoretical framework, that they have a high strategic character) are prioritized, and in most cases and win the competition for resources.

8.3. Biases and limitations

There are a number of factors that might have led to a bias or must be seen as limitations to affect the interpretation of the findings in the following sub-chapter. These possible biases and limitations are summarised below.

Population, database

We do not know the exact population size for the survey. Officially, large-scale energy consumers (LSEC) are defined as sites or establishments consuming more than 0.5 GWh per year of electrical energy and/or 5 GWh per year of thermal energy. According to the 2011 Helbling survey on energy consumption in the industry and services sectors, there are about 10,000 (private) enterprises in Switzerland which qualify as LSEC. Those companies may have in total as many as 14,000 establishments (factory, plant, administrative or commercial building, *etc*.). The group of LSEC in Switzerland makes up a very heterogeneous population and sample. This is not only due to the variety of business activities, but also to the intrinsic diversity of behaviour between companies, even between those active in the same sector, and with similar characteristics in terms of size and markets.

In theory, the survey population would have included all companies qualifying as LSEC. In practise, according to the research plan, the objective was to gather a sample of at least 2,000 large companies and establishments. The survey was targeted to obtain a maximum response from about one-fourth of the companies contacted (*i.e.* at least 500 companies).

In quite a sophisticated step-wise process, 3,670 companies were contacted during the survey. About 900 companies reacted to the request of responding to the questionnaire, having at least started to fill it in. This was approximately the 25% response rate expected, although this required much more intensive efforts than initially anticipated. Unfortunately, only a fraction of the companies completed the procedure, filling in the questionnaire in a manner that could serve as a basis to enable the research team to scientifically analyse and interpret their answers. A careful evaluation process resulted in the final selection of 305 valid responses: answers that were qualified as being comprehensive and solid enough for the detailed analysis of the answers, of the correlation between determining factors and the interpretation of results. The effective response rate therefore lies in the range between 8.3% (ratio of questionnaires returned to the sent questionnaires) and 10% (excluding double counting of sent questionnaires). The results of the survey are not representative for Swiss industry but valid for the companies which answered the questionnaire.

Common Bias

Due to the research focus and the nature of the empirical approach in three phases (survey, interviews and case studies), the answers tend to have a bias towards companies that express a higher awareness and stronger efforts regarding energy issues and energy efficiency investments than the average LSEC.

Furthermore, all three phases of the empirical research included questions that asked for an assessment of attitudes, activities, investments and ultimately performance by the companies themselves. It can be conceded that companies (in particular the contact person that is generally responsible for energy issues and EM) will show efforts and achievements in a rather positive light.

9. Overall Conclusions

The M_Key project depicts the situation and behaviour of LSEC in Switzerland with regard to EM systems, EE investment decision-making processes, and ultimately energy performance. The results of the empirical sub-studies confirm the heterogeneity of the private, profit-oriented organisations already observed by previous research. This is due not only to the variety of business activities, but also to the intrinsic diversity of behaviour between companies, even those active in the same sector, with similar characteristics in terms of size and markets.

Based on the evaluation and discussion of the survey results, the interviews and the case studies, the following general conclusions can be drawn:

Relevance of energy, in particular energy efficiency

- Typically, energy issues are not a priority for companies. Since the share of annual energy costs, compared to the gross value added is mostly in the range of 1% to 3%, the energy intensity is normally too small to be an issue of high relevance.[60] The higher the energy intensity of a company, the more likely energy – and in particular EE – is considered to be a relevant issue when discussing and deciding upon investments. This is particularly true for LSEC with high energy intensity. The threshold is different from one company to another, depending on the importance of energy costs, on strategy (based on low costs or on quality) and on the competitive landscape. It depends on relative terms (costs in proportion of turnover, of production costs or goss value added.
- In most of the five case study companies, the ceiling of possible, feasible and profitable energy efficiency improvement measures was not reached. When visited, untapped efficiency potentials in thermal and electrical energy – of which the energy manager was not always aware – were observed in most companies. For example, electrical machines like pumps, fans, and compressors for air and cooling were beyond a typical machine age, did not have load control and seemed to be oversized. These untapped efficiency potentials (Tieben, *et al*, 2015) and additional savings were not analysed in detail by the research team *as per* the planned list of measures.
- Investments to strengthen the competitiveness of a company are normally driven by core business. Energy efficiency investments are seldom driven purely by their potential to improve EE and hence reduce energy consumption. Most of the reasons identified for investment strategic character are improvement of production safety, product quality and reliability, cost savings, environmental benefits, and ultimately an expected increase in profitabili-

[60] Infras calculations based on Nathani *et al.* (2013) and Iten *et al.* (2015): Average energy intensity = 1.5%, median value = 0.9%.

ty. These non-energy benefits carry more weight than the energy benefits (*i.e.* a decrease in energy consumption and costs) in convincing top management to invest in energy-efficient equipment measures. Increased EE is therefore often seen as only one benefit of investments among others.

Role, significance and influence of EM

- The concept of EM (based on ISO 50001) is not yet wide spread: Many companies remain at a low level of resources, capacity and competence, their main effort being to collect annual energy consumption data.
- The case studies and the interviews found that the person and role of the energy manager is certainly a crucial element in the decision-making process and in the subsequent implementation of energy efficiency investments. Being a member of the SME's top management gives an energy manager more authority and opportunity to positively influence decisions and implementation of EE improvements. However, energy managers often lack know-how, time, resources, and influence.
- Whenever investments are – at least partly – classified as investments to reduce energy consumption, companies face a particular challenge to identify which of them qualify as strategic EE investments. The perceived strategic relevance of EE investments is determined by many factors, whereby the level of the EM is typically not an important one.
- The predicted positive influence of (the level of) EM on the perceived strategicity of EE, on investment decisions, and ultimately on energy performance could not be confirmed. Instead, the impact is often the contrary: if energy (efficiency) is perceived as strategic, then companies tend to have a high (or higher) level of EM.
- EM is mostly understood as an instrument for the identification and implementation of energy efficiency investments. The better the EM, the better the procedures to collect and analyse data and to define project ideas. In turn, this increases the chances of a project proposal being accepted and implemented. Therefore, EM has an important role in companies' EE investment decision-making process.
- Large companies, or companies that are part of a corporate group, often have sustainability strategies and/ or EE targets set by the top management or the corporate group. They place higher emphasis on EE and consequently on EM. This is different in SMEs, where the motivation and skills of the energy manager often are the main drivers of EM.

Relevance of laws and regulations, agreements and targets set

- Requirements of national or cantonal energy policies have a very significant role (in the case of SMEs a key role) in inciting companies to action. The empirical substudies have shown that they often act as triggers for EE investments. Public policy supports EM and influences EE investments. Most companies do not, however, anticipate an increasing stringency of these public policy requirements.
- Laws and regulations seem to be particularly effective for companies in which the top management does not have any specific interest in energy efficiency. The chances of EM of realising EE projects can be increased through the importance given to the project *via* an external driver. This increases the chances of creating a commitment from the top management towards EE measures.
- Companies, once committed to increasing their EE and/ or of achieving a CO_2 reduction target, tend to be keen on reaching their goals.

Influence of EE investments on energy performance

- Although it seems logical that the higher the number of EE investments, the higher a company's energy performance, the empirical part of the M_Key project could not prove that this is true, due to lack of sufficient evidence.
- Sixty percent of the survey responses and almost all interviewees expressed a positive influence of EE investments on energy performance. They had to admit, however, that they cannot prove any direct causal relations between the EE measures implemented and the energy consumption of the technical sub-system or the production line/ area where the EE measure was undertaken, since no specific measurements are available. The case studies confirmed the inability to prove the impact of specific measures, since companies can generally not provide sufficient data for quantitative analysis.
- The case studies have shown that many companies use a method of calculation to determine their CO_2 emissions reduction and energy savings for their annual report. However, few companies actually verify whether the planned savings correspond to the resulting savings from the energy efficiency improvements. Companies simply assume that the savings obtained are in line with the expectations.
- The case studies have shown that energy savings of individual measures are not well monitored. For specific measures, the engineers usually make an *a priori* estimate of the cost and the energy savings. After the implementation of the energy efficiency improvements they can relatively easily check the cost, but it is much more demanding and costly to verify the energy savings.

10. Policy Recommendations

Based on the results and experiences of the three substudies, in this final chapter the M_Key project team outlines an approach thought to be suitable for promoting EM and EE improvement measures in LSEC.

This approach structures the individual recommendation *as per* the headings given below.

Reinforcement of information, education and training; additional technical support

1. Support given to LSEC and energy-intensive companies regarding the understanding of the federal and cantonal regulation and incentive mechanisms should be improved (better structured and more specific information).
2. Efforts should be taken to better define the position of an energy manager, including common tasks and duties. Once done, syllabuses of instructions/ reference manuals for EM should be produced and programmes set up to train energy managers.
3. Additional support should be provided to LSEC through qualified external know-how, in particular:
   - intensified, specific expertise in the electrical field for initial analysis, identification of energy efficiency potentials, and implementation of energy efficiency improvements;
   - illustrative and and easily-understandable information and practical tools regarding the identification, evaluation, and communication of the non-energy benefits of energy efficiency projects;
   - methods and tools for setting energy management and energy consumption goals, systematic before/ after measurements of EE measures, improved monitoring, verification and quantification of energy savings.

Expansion and intensification of national and cantonal regulations

4. The extent of the goals of the target agreements related to the CO_2 levy and the cantonal requirements for large-scale energy consumers should be critically assessed. If there is room for improvement, options should be explored to set targets at a higher level. Furthermore, potential for strengthening the supervision, monitoring and control of the target agreements should be assessed.

Additional instruments

5. A common obligation for energy audits, as is the case already in the European Union (see Energy Efficiency Directive 2012/27/EU), should be checked. If, despite the fact that the EU

system is different from the Swiss system, such a common obligation turned out to be reasonable and realisable, it should be established. It should be further examined if the obligation for energy audits should be combined with a financial incentive system.

6. The empirical results of this study confirm the relevance of energy cost as a driver for the strategic relevance of EE investments. Accordingly, a stepwise and foreseeable increase of prices for conventional energy sources by levies would be an effective measure to promote the implementation of energy efficiency measures in LSEC.

Annex

Annex 1: Additional materials survey

Annex 1.1: Conception and implementation of the survey

Target population and identification of the participants

Officially, large-scale energy consumers are defined as sites or establishments consuming more than 0.5 GWh per year of electrical energy and/ or 5 GWh per year of thermal energy. According to the Helbling survey (2011) on energy consumption in the industry and service sectors, there are about 10,000 (private) companies in Switzerland which consume electricity above the defined thresholds. These firms may have as many as 14,000 establishments in total (factory, plant, administrative or commercial building, etc.). The research focuses on the behaviour of “market producers”, according to the terminology and definition of the system of national accounts, which include publicly owned and controlled companies, where at least half of the production cost is covered by the sales of goods or services to clients on the market.

In theory, the survey would include all companies consuming more than 0.5 GWh of electricity and/or more than 5 GWh of thermal energy annually. According to the research plan, the objective was to gather a sample of at least 2,000 large companies or establishments out of an entire enterprise population of 10,000. The survey was targeted to obtain a response from approximately one-fourth of the companies contacted, at best (*i.e.*, at least 500 companies). If the number of respondents turned out to be low, a second round of the survey planned to concentrate on companies with characteristics that were under-represented.

The possibility of covering large energy consumers and the representativeness of the survey depends on how the firms were identified and on the number of responding firms. Unlike the KOF study (Arvanitis, *et al.*, 2016) on the creation and adoption of energy-related innovations, it was not possible to use an existing database of companies (which would have contained mainly large energy consumers). The KOF Study used a large representative panel of companies that this institute uses regularly, especially for regularly occurring innovation studies sponsored by the federal government. Accordingly, the KOF institute could count on a very high response rate – *e.g.* 34.4% in industry and 29.4% in the service sector. By contrast, a survey which is addressed to unknown firms can expect a good response rate of 10%.

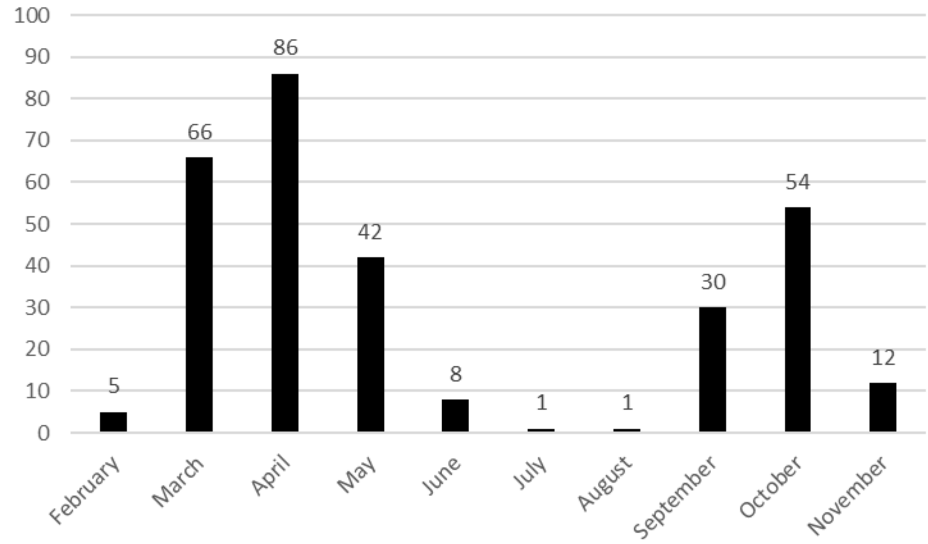
It was intended to cover at least the most important cantons (by number of establishments and concentration of economic activities), while still aiming for “representativeness” and a diversity of locations (cantons). Given the absence of a list of large-energy consumers available for the whole country, the research group decided to ask the cantonal authorities in charge of energy policy to provide the addresses or contacts of the LSECs. Most of the cantons, but not all (*e.g.* Valais, Jura, Basel-Stadt), have contacted their large consumers in the framework of their energy policies. The cantons were approached for collaboration at two of their energy offices' meetings: Energiefachstellen in Berne (all cantons), and Conférence régionale des directeurs cantonaux de l'énergie (CRDE, regional conference of the six French speaking cantons) in Fribourg. A significant number of Swiss German-speaking cantons refused to promote the survey for various reasons. Some had not yet identified their large-scale energy consumers nor defined their energy policy towards these consumers, some did not want to burden firms, and others wished to preserve complete privacy of their relationships with firms.

It was possible to secure the collaboration of 11 cantons: all six French-speaking cantons (Geneva, Vaud, Valais, Neuchâtel, Fribourg, and Jura) and five German-speaking cantons (Aargau, Lucerne, Schwyz, Thurgau and Zurich). The cantonal authorities did not provide a list of large consumers but directly contacted the firms through a letter of support including the link to the electronic survey, a short description of the research project, and a letter of recommendation from the SNF. From late March to April 2016, five French-speaking cantons contacted about 800 companies. Valais provided a list of 410 supposedly large-scale energy consumers from all sectors, but without e-mail addresses. The research group looked up the addresses via the internet and telephone. The final Valais list contained about 280 firms including an e-mail address and contact person. The five participating German-speaking cantons sent the survey to about 550 large energy consumers. In addition, one of the research partners had the opportunity to send the internet link of the questionnaire to some 500 industrial companies included in the database of Top Motors, which focuses its activity in promoting energy efficiency of electrical motors. In total, the number of firms contacted was approximately 2,140 throughout the 11 participating cantons.

The implementation of the web survey

Due to the complexity of the search for LSECs' addresses, the survey was carried out during a lengthy period of eleven months (Figure 20). In the first phase (including the test firms), from February to July 2016, 209 valid questionnaires were registered, with the clear majority (202) originating from the 11 participating cantons. In the second phase, 96 additional validly completed questionnaires were secured, of which 44 originated from the participating cantons.

Figure 20: Number of firms (valid questionnaires) by month, 2016



Source: Université de Neuchâtel

The second round of questionnaires sent in September/ October 2016, was based on a list of firms provided by the Energie-Agentur der Wirtschaft (EnBW) as well as one compiled by the Federal Office for Environment, dated June 2016. The 723 firms of the EnBW list contracted an agreement on energy efficiency in the framework of the different options which are available: federal universal agreements or target agreements defined by the cantons, and audits. This list was merged with the list of the Federal Office for Environment (BAFU), which contained 534 firms completely or partially exempted from the CO2 tax (because of the measures they have taken to reduce their CO2 emissions). The consolidated EnBW/ BAFU list includes 730 companies, of which a very large majority are presumably large-scale energy consumers. The consolidation of the two lists excluded about 500 firms which were present on both lists. Ten firms were excluded because they had already responded to the questionnaire, and 20 government organisations were also excluded. In addition, it was possible to collect the e-mail addresses of about 700 additional companies from various sources on the internet and on the list of Top 500 companies in Switzerland.

Special attention was given to very large companies with numerous establishments throughout Switzerland. We anticipated a problem of double counting, since it was possible for large enterprises to answer the questionnaire more than once through their various establishment and affiliates. The survey aimed to gather the opinions and experiences of the headquarters, and not of a subordinated production site or subsidiary. This is checked in the questionnaire by a question about the parent company and/ or the number of other establishments of the firm.

A message was sent in December 2016 to 76 companies to obtain more (precise) information on the energy-efficient investments (number of projects/ total amount of investment, short description of the projects). About 40 firms replied with very valuable information, which also allowed us to estimate, when not reported, total investment spending in Swiss francs per firm, year, and employment for the firms having reported investment projects.

About 90 firms were contacted in December 2016 to collect missing information about the characteristics of some firms (Section 1 of the questionnaire), but mainly to obtain more detailed and complete data on the number of realised investment projects (number of projects of below 20,000 Swiss francs, between 20,000 and 100,000 francs, or above 100,000 francs during the previous four years, including the estimated amount spent on EE investment during the previous four years).

Seventy-two firms did not indicate the number of energy efficiency investment projects by size (answer: “Do not know”), and 40 firms reported that they had not invested in energy efficiency during the last four years. On the other hand, 194 firms (64%) reported at least one such investment project. The total number of reported projects over four years is 1,665, totalling 260 million Swiss francs. On average, one of these investing firms carried out eight projects for a total of 1.5 million Swiss francs, that is, two projects a year worth some 400,000 francs. However, these averages are biased because of the exceptionally large numbers of projects of some very large firms. About 1,100 projects (66%) were reported by the 100 largest firms of the sample (one-third of the firms employing more than 250 FTE). The estimated amount spent on ee investment projects over the four-year period considered and per employment vary for the 234 responding firms from 0 to 340,000 francs. The average amount invested (per employment) is around 10,000 francs and the median amount is about 2,000 francs.

Responses to the survey and database

Based on the methodology described above, the total number of enterprises having been contacted during the first and second phases was around 3,670. Up to an estimated 600 firms are likely to have received the questionnaires twice. In total, about 900 firms reacted to the request of responding to the questionnaire, having at least started to fill in the questionnaire. The final selection of the 305 valid responses is based on the number of questions having been answered and their coverage by section, especially regarding Sections 1 to 3 (Characteristics of the firms, System of energy management, and Various drivers and barriers of EE investment projects, *i.e.* the perceived level of strategicity). The eight firms of the test phase conducted in February 2017 are included in the final database.

About half of the responding firms (149) left an e-mail address in the questionnaire for further contacts (either for questions about the answers given, or because they were interested in the survey results, or because they agreed to be contacted for interviews and further inquiries). For all those known firms, the information on the sector of activity and on the employment (full-time equivalent) in Switzerland were checked and corrected if needed. It was also necessary to check the number of (full-time equivalent) employees by using various sources (survey of large companies, direct mail, newspaper articles, or internet site). In a few cases the level of employment (in Switzerland) was changed (*e.g.* when the figure referred to worldwide employment instead of employment in Switzerland only, or in case of missing data).

Given the difficulties of identifying individual large electricity and energy consumers, only the large energy consumers of the participating cantons were covered to some significant extent by the survey. This is true for the cantons of Jura, Fribourg, Geneva, Zurich, Schwyz, and Thurgau. Average or below average response rates were observed for the other five participating cantons and all other non-participating cantons. The effective response rate lies between 8.3% and 10% (Table 4, p. 64) The firms are classified by cantons according to the location of the headquarters, independently of the number of subsidiaries and establishments in other cantons.

Unfortunately, the data on employment was not very reliable, as the responding firms seem to be confused regarding the definition of employment: number of employees versus full-time equivalent employment. The questionnaire referred to the second definition of employment. Moreover, some firms may have reported consolidated employment at the group level, or even, in some case, international employment. Whenever possible, *i.e.* among the 164 firms (54%) which identified themselves in the survey, the level of employment, as well as the reported economic activity was checked and corrected when needed.

Table 39 and Table 40 provide detailed information on the number of firms and on employment (full-time equivalent) of the responding firms by size (employment) categories and by economic activities. The size categories and the selection of 14 aggregated economic activities (following the NOGA nomenclature) are those used by Swiss statistics in its company statistics.

Table 39: Number of firms by size and sectors

NOGA Code	Label	Micro (0-9 FTE)	Small (10-49)	Middle (50-249)	Large (250 above)	Total
10-12	Manufacture of food products, beverages and tobacco products	5	9	15	7	36
20, 21	Manufacture of chemical and of pharmaceutical products	2	1	4	8	15
22, 23	Manufacture of plastics, and other non-metallic mineral products	0	3	8	4	15
24, 25	Manufacture of basic metals and fabricated metal products	1	6	18	11	36
26	Manufacture of computer, electronic and optical products (watches and clocks)	1	0	4	10	15
28	Manufacture of machinery and equipment	0	3	7	5	15
	Other Industries	3	9	24	11	47
41, 42, 43	Construction	1	8	0	2	11
46, 47	Wholesale and retail trade	1	0	6	7	14
49-52	Transport	1	2	1	8	12
55, 56	Accommodation and food service activities	2	6	14	8	30
64, 65	Financial and insurance activities	0	0	2	8	10
70-75, 77-82	Scientific, technical and administrative activities (incl. consulting)	1	2	1	2	6
	Other Services	6	4	16	14	40
	Total	24	53	120	105	302

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

Table 40: Employment by size and sector

NOGA Code	Label	Micro (0-9 FTE)	Small (10-49)	Middle (50-249)	Large (250 above)	Total
10-12	Manufacture of food products, beverages and tobacco products	24	260	1,632	39,923	41,839
20, 21	Manufacture of chemical and of pharmaceutical products	10	22	475	9,575	10,082
22, 23	Manufacture of plastics, and other non-metallic mineral products	-	80	1,011	3,180	4,271
24, 25	Manufacture of basic metals and fabricated metal products	1	225	1,517	20,815	22,558
26	Manufacture of computer, electronic and optical products (watches and clocks)	5	-	633	18,480	19,118
28	Manufacture of machinery and equipment	-	103	1,182	6,775	8,060
	Other Industries	20	327	2,637	11,132	14,116
41, 42, 43	Construction	6	186	-	600	792
46, 47	Wholesale and retail trade	6	-	756	75,932	76,694
49-52	Transport	7	52	75	9,323	9,457
55, 56	Accommodation and food service activities	9	161	1,695	4,789	6,654
64, 65	Financial and insurance activities	-	-	160	33’848	34,008
70-75, 77-82	Scientific, technical and administrative activities (incl. consulting)	1	52	172	651	876
	Other Services	38	101	1,536	83,851	85,526
	Total	127	1,569	13,482	318,874	334,051

Table Université de Neuchâtel. Source: Survey data, Université de Neuchâtel

Full Questionnaire

M_KEY – Management as a Key Driver of Energy Performance

Survey Questionnaire Determinants of energy efficiency investments

Survey of Swiss firms

Translated into English from the original French version

CONFIDENTIALITY

The data collected are strictly confidential, and all data collected by this survey is used only for the project “Determinants of energy efficiency Investments” by the researchers at the University of Neuchâtel in charge of implementing the survey.
Transmission of data is done anonymously. The data and responses are collected in a secure database and treated anonymously.
The data will not be made available, even anonymously, to persons and institutions outside of the project including to the sponsors of the project and the providers of the addresses of the large energy consumers.
The results published are based on aggregate data only, which does not allow the respondents to be identified.
Introducing the questionnaire

Objective of the survey

This survey is part of the project “Determinants of energy efficiency Investments”, funded by the National Research Program 71 “Managing Energy Consumption“ and carried out jointly by Infras, Zurich, the Institute for Economic Research of the Université of Neuchâtel, and Impact Energy AG, Zurich.
Improving energy efficiency is the primary pillar of the new "Energy Strategy 2050" decided upon and implemented by the Federal government. There is still untapped potential to reduce

energy consumption in many Swiss companies. The aim of this project is to examine—in Swiss large-scale energy-consuming companies—both the main reasons for more efficient use of energy resources, and obstacles to it.

To whom is the questionnaire addressed?

The main targets of this questionnaire are private firms in Switzerland with relatively large energy consumption either in terms of electricity (above 0.5 GWh per year) or of thermal energy (above 5 GWh per year) (large-scale energy consumers as defined by the Federal energy law). The firms may be small, mid-sized or large and cover all major industrial and service activities.

Who should respond?

It is expected that the firm contacted will fill in one questionnaire only, for all its establishments, branch offices and affiliates in Switzerland, which are supposed to implement the energy policy decided upon by the headquarters. If a firm is part of a group, either Swiss or international, it is invited to respond to the relevant questions, if it is relatively independent in its energy management.

Avoiding multiple responses

It is possible that your company has already received a request to complete the questionnaire. If this is the case, please excuse us for the inconvenience. In this case, this questionnaire is redundant and should then be discarded in order to avoid multiple responses from your company. Please answer "NO" to the question below to terminate the questionnaire.

Are you either the headquarters of your company in Switzerland or a firm which is part of a group, but relatively independent in your energy management?

If YES, please answer the questionnaire directly

O yes, I will respond O no

If NO,

please direct the questionnaire (*i.e.* the internet link) to a competent person in your headquarters or within your group,

OR

send us, by e-mail, the name of the person at your headquarters or within your group who may be able to answer the questionnaire for the whole group or affiliate firms.

O I now leave the questionnaire.

The survey comprises 6 main sections with a total of 38 questions

SECTION 1: Characteristics of the company (12 questions)
SECTION 2: Energy Management (11 questions)
SECTION 3: Determinants of energy efficiency investment projects (2 questions)
SECTION 4: Evaluation of energy efficiency investment projects (6 questions)
SECTION 5. Public Policy (5 questions)
SECTION 6: Impact on performance (2 questions)

- Most of the questions have multiple answers, and some questions require comments or further details.
- The questions are not focused on technical aspects of energy efficiency.
- Answering the questionnaire will take 20 to 30 minutes.
- We are happy to help in case of questions and we welcome any comments:
- Thank you for your invaluable participation.

General information about the respondent

Please state your function in the company.

____

To whom are you directly subordinate (in terms of hierarchy or organisation)?

____

What is your professional training and education?

____

What is your professional experience?

____

SECTION I: Characteristics of the company

1.1 In which canton is your company headquartered? *(please select one canton)*

1.2 Does your company belong to an international group?
O yes O no

1.3 How many subsidiaries or establishments (headquarters not included) does your company have in Switzerland? _____________

1.4 Who are the owners of the company? *(please choose one answer only)*

- a private owner (family or a majority shareholder)
- multiple private owners
- public stockholders (company quoted at the stock exchange)
- government, state

1.5 What is your company's main sector of activity? (please choose only one activity among the 14 activities proposed, excluding primary sector)

1.6 What is the number of full-time equivalent (FTE=100%) employees in your company in Switzerland? ______________

1.7 What is the degree of competition that you face in your main activity?

- very competitive
- competitive
- mildly competitive
- not at all competitive

1.8 Does your company own the buildings or premises? *(please tick the appropriate answer only for premises you use)*

- administrative, offices
- commercial, shops
- production, plants
- none

1.9. What is your company's current annual electricity consumption? (*please tick the appropriate answer)*

- below 0.5 GWh/year
- between 0.5 and 1 GWh/year
- between 1 and 3 GWh/year
- between 3 and 10 GWh/year
- above 10 GWh/year

1.10. What is your company's current annual consumption of thermal energy? *(please tick the appropriate answer)*

- below 5 GWh/year
- above 5 GWh/year

1.11. Is your company part of a program or network which promotes energy efficiency? *(multiple answers are possible)*

- act (www.act-schweiz.ch) O yes O no
- Cluster energy & building (www.energie-batiment.ch) O yes O no
- EnAW / AEnEc (www.enaw.ch) O yes O no
- Swiss cleantech (www.swisscleantech.ch) O yes O no
- Energy provider (electricity) O yes O no
- Emergo (www.energy.ch) O yes O no
- others, please specify____
- none

1.12 Is your company certified? *(multiple answers are possible)*

- ISO 14001 - environmental management O yes O no
- ISO 9001 - quality management O yes O no
- ISO 50001 - energy management O yes O no
- other(s), please specify: ______________________________ _____________________
- none

SECTION 2. Energy Management

2.1 How important is the issue of energy efficiency for your company? (1: not important at all; 2: not important; 3: moderately important; 4: important; 5: very important)

1_________5

2.2 Do you have an “energy manager”?

O yes O no

If yes, does he/she cumulate this function with other functions in the company?

O yes O no

If so, which one? ____

2.3 Is there a senior manager appointed to supervise and to support energy management and/or energy efficiency investment projects?

O yes O no

2.4 What is the energy intensity of your company?

- the cost of electricity, in percentage of turnover: __________ %
- the cost of energy (all energy sources, including electricity and thermal energy, when not used for mobility), in percentage of turnover: __________ %

2.5 Did your company commit itself (voluntarily) to continuous reduction of its energy consumption, in addition to the commitment taken towards the federal or cantonal authorities in the framework of their energy policies?

O yes O no

2.6 Does your company undertake any of the following activities in relation with energy use? *(multiple answers possible)*

- evaluation of energy performance (benchmarking)
- definition of a reference situation
- definition of key performance indicators on energy
- definition of an energy strategy
- setting of measurable goals regarding the reduction of energy consumption
- definition and collection of data regarding the achievement of the goals
- definition and implementing of measures to reach the goals defined
- regular internal reporting on actions taken or on results achieved in energy matters
- none

2.7 At what levels of the company is energy performance measured and accounted for? (*please choose the corresponding answer)*

- senior management, directors

- energy manager
- technical or facilities director, division or department chief or manager
- no performance measurement

2.8 Which resources did your company allocate to energy performance measures (without investments)? *(multiple answers possible)*

	internal	**outsourcing**
financial resources (*e.g.* audit cost)	O	O
human resources (*e.g.* project team)	O	O
technical resources (*e.g.* electricity meters)	O	O
resources in information technology (*e.g.* monitoring software)	O	O
no specific resources	O	O

2.9 Did your company carry out an energy audit at some point during the last four years? *(multiple answers possible)*

- on buildings O yes O no
- on premises (administrative, commercial, stock) O yes O no
- on production equipment and infrastructure O yes O no
- none

2.10 Did your company introduce any of the following systems or procedures in relation to its energy policy and objectives? (multiple answers possible)

- a training system for staff
- a reward/bonus system in case of attaining the goals
- a system of assessment of the results obtained
- a procedure to revise the objectives
- none

2.11 What are the three (3) main reasons of the company for actively managing energy use? (does not apply if your company does not actively manage the use of energy - multiple answers possible, but maximum 3)

- regulation and legal constraints
- environmental protection
- financial benefits
- reputation/ public image
- social responsibility

- competitiveness/ competition
- others, please specify: ____

SECTION 3: Determinants of energy efficiency investment projects

3.1 In your opinion, among the items proposed below, which factors positively influence the adoption of new energy-saving technology or equipment in your company? *For each item below please answer 1 to 5 according to your evaluation (for all factors proposed); 1: not important at all; 2: not important; 3: moderately important; 4: important; 5: very important.*

- cost reduction resulting from lower energy use 1_________5
- non-energy cost reductions
- lower risks of disruption in the energy supply
- lower risks on future energy price instability
- lower risks in production
- higher quality/reliability of products or of production process
- increased staff comfort and well-being
- increased customer comfort and well-being (*e.g.* in commercial surfaces)
- enhancing the company's positive image and reputation
- increasing competitiveness
- tax breaks
- investment subsidies
- lower finance costs, low interest
- others, please specify: ____

3.2 In your opinion, among the items proposed below, which factors hinder the adoption of new energy-saving technologies or equipment in your company? *For each item below please answer 1 to 5 according to your evaluation (for all factors proposed); 1: not important at all; 2: not important; 3: moderately important; 4: important; 5: very important.*

- other investments more important 1_________5
- new technology can only be introduced when existing technologies must be replaced (investment cycle)
- energy costs are not sufficiently important
- energy efficiency has low priority
- current installations are efficient enough
- difficult to implement due to internal organisation
- internal financial constraint

- difficult access to external sources of financing (credit)
- uncertainty about the quality of the new technologies considered
- waiting for subsidies or tax breaks
- technology will become cheaper in the future
- no clear vision or overview of existing technologies
- low financial attractiveness
- new technology might not satisfy future regulatory standards
- incompatibility with existing production process or products
- others, please specify: ____

SECTION 4. Assessment of energy efficiency projects

4.1 How many energy efficiency investment projects did your company undertake during the last four years? *(please tick the appropriate answers)*

- O do not know
- O none
-
- number of projects with an amount spent for each of below CHF 20’000______________
- number of projects with an amount spent for each of
  between CHF 20’000 and CHF 100'000 ______________
- number of projects with an amount spent for each above CHF 100'000 ______________

Remarks on your investment policy in energy efficiency. If available, please indicate the total spending on all energy efficiency investments projects during the last four years:

____

4.2 What kind(s) of projects have been undertaken? *(multiple answers possible)*
- production of renewable energy
- electricity savings on building/ infrastructure
- electricity savings on production equipment
- thermal energy savings on building/ infrastructure
- thermal energy savings on production equipment

4.3 Which financial criteria do you use for the financial appraisal of an energy efficiency investment project? *(multiple answers possible; please indicate the information requested below)*

- simple payback period O yes O no
- net present value (NPV) O yes O no
- internal rate of return (IRR) O yes O no
- others, please specify: ____

For each of the criteria, what are the parameters used?

- payback Number of years:________________
- NPV: Number of years:________________ : Discount rate (%):_______
- IRR Number of years:________________ :
-

4.4 When you assess an investment project, does the number of years considered depend on the category of investment (*e.g.* building, plants or production)?

O yes O no

4.5 Does your company consider non-energy benefits when evaluating energy efficiency investment projects? *(please chose the answer which best corresponds)*

- no, or very rarely
- yes, sometimes
- yes, very often
- yes, always or nearly always

If yes, what are the non-energy benefits you consider when evaluating energy efficiency investment and potential energy savings? *(multiple answers possible)*

- enhancement of product quality
- enhanced reliability of the production process
- enhanced flexibility of the production process
- better control over temperature
- higher equipment safety
- better corporate image and reputation
- productivity increase
- valorisation of production waste
- shorter production cycle
- reduction of the need of raw material
- reduction of water consumption
- better performance of equipment
- reduction of maintenance cost and of technical control of equipment
- avoidance or reduction of equipment oversizing

- extension of the lifetime of the equipment
- lower need (or postponement) for investment funds
- lower CO2 tax or tax exemption
- lower dust emissions
- lower CO, CO2, NOx, SOx emissions
- reduction of production rejection rate
- lower staff expenses
- reduction of absenteeism and lower health costs
- increasing security and better working condition for the workforce
- reduction in cooling requirements
- savings of space and surface area
- reduction of hazardous waste
- lower commercial risk
- lower legal and regulatory risk
- lower risk of energy prices
- lower risk of CO2 price
- lower risk of disruption in energy supply

others, please specify: ____

4.6 Does your company consider other aspects of energy efficiency or energy-saving projects?
public policy

- competitors' moves
- partner network, professional bodies
- social cost or environment
- others, please specify: ____

SECTION 5. Public Policy

5.1 Did your company conclude a target agreement on energy consumption and/ or CO2 emissions with an organisation mandated by the federal government (*e.g.* EnAW/AEnEC or ACT)?
O yes O no

5.2 Has your company been contacted by the cantonal authority in charge of energy policy towards large-scale energy consumers?
O yes O no

Including at the level of your establishments and affiliates?

O yes O no

5.3 As a large-scale energy consumer, did your company already make a choice between the three available options in implementing energy performance measures?

O yes O no

If yes, which option did you choose? *(multiple answers possible)*

- federal universal target agreement
  - O Energy model
  - O SME model
- cantonal target agreement O yes
- cantonal energy audit O yes
- none

If so, what are the main reasons explaining your choice?

____

5.4 If your company entered a universal target agreement, with whom did your company conclude the agreement? *(please choose the appropriate answer)*

- EnAW/AEnEc
- ACT
- Energy
- others, please specify: ____

5.5 For your company, do you consider (present or future) legal obligations regarding energy consumption in the context of the measures on large-scale energy consumers:

as a constraint? O yes O no

OR

as an opportunity? O yes O no

SECTION 6: Impact on performance

6.1 What is the likely impact of the energy efficiency investment undertaken during the last four years (2012-2015) on your company's energy consumption? Did your energy consumption: *(please tick the appropriate answer)*

- increase or did it stay unchanged (*e.g.* because of an effective decrease in energy prices)?
- show a tendency to decrease?
- decrease significantly?
-
- impossible to estimate
- do not know
-

6.2 What is the likely impact of your energy efficiency investment undertaken during the last four years (2012-2015) on your company's profitability and competitiveness? (*please chose the appropriate answer for each of the three performance indicators)*

	deteriorated	**unchanged**	**improved**	**impossible to estimate**	**do not know**
price or cost competitiveness					
product competitiveness (innovation)					
profitability					

Thank you very much for completing this questionnaire.

Do you have any comments or remarks which could be useful in understanding the situation of your company with regards to energy or to specific questions?

Your remarks:

Follow up

The second step of this research project on energy management in Swiss companies (2016/2017), involves interviewing some of the companies which responded to this survey for further details, to better understand their motivation, experiences, and energy performance. Personal interviews could last up to 90 to 120 minutes.

Companies willing to participate in the second phase (interview) may obtain certain results upon request. Please contact us by email.

Do you agree to be contacted for the following reasons?

- if we have questions about some of your answers O yes O no
- to provide the results of this survey O yes O no
- to deepen our understanding of certain responses and to ask you additional questions about energy O yes O no

If so, please leave your contact information below:

Company
Name
Telephone
Email

We treat all your requests and questions with the utmost confidentiality.

Please accept our sincere thanks for your kind collaboration.

Annex 1.2: Correlation analysis

The overall objective of the M_Key research project is to better describe and understand the influence of energy management on firms' energy performance. Based on the theoretical framework outlined in Section 2.4, this influence of energy management on energy performance is hypothesised to take place through an impact chain which breaks down the influence of energy management along three relationships of influence:

- influence of a company's energy management level on its perception of energy efficiency investment strategicity;
- influence of energy efficiency investments' strategicity on energy efficiency investment decision;
- influence of energy efficiency investment decisions on the energy performance level.

As described in the report, four research questions and eight hypotheses are formulated with respect to the relationships of influence between the four links of the impact chain. If there is an effective impact between the links of the causal chain, it should be possible to reveal a correlation between one link and the subsequent links, or a link further down the chain.
This annex presents the results of the correlation analysis, which examines the hypotheses of the research model by using simple correlation coefficients. Correlation does not imply causality; a high correlation coefficient simply indicates that the observed two variables move closely together in the same and/ or in opposite direction.

The strength of the correlation between two variables is measured by the correlation coefficient. The latter takes the value of 0 when no correlation at all exists at all and the value of 1 (or -1 for the opposite direction), if there is a perfect correlation along a straight line. Table 41 gives one possible and reasonable interpretation of the values of the correlation coefficient.

Table 41: Interpretation of the size of the correlation coefficient

Value of the correlation coefficient	**Interpretation**
.90 to 1.00 (-.90 to –1.00)	Very high positive (negative) correlation
.70 to .90 (-.70 to -.90)	High positive (negative) correlation
.50 to .70 (-.50 to -.70)	Moderate positive (negative) correlation
.30 to .50 (-.30 to -.50)	Low positive (negative) correlation
.00 to .30 (.00 to -.30)	Little if any correlation

Table Université de Neuchâtel. Source: D. Hinkle, W. Wiersma, & St. Jurs (2003). Applied Statistics for the Behavioral Sciences (5th ed.)

It is possible to test the statistical significance of the simple correlation coefficient, for example, to assert that the estimated value of the coefficient is likely to be different from zero (no correlation at all). If the coefficient passes the statistical test, it only means that a correlation, weak or strong, is very likely to exist.

Each link is measured at least by one variable derived from the answers to the survey. The level of energy management is represented by the index EM, which takes a value between 0 and a maximum of 23 points. The perceived strategy depends on how the companies perceive the importance which is given to eight drivers of EE investment decision-making (costs, risks, value propositions to the clients, or a combination of the eight relevant drivers). All these drivers are supposed to enhance the competitive position of the firm. Positive investment decision can be measured by the number or the amount of ee-investment spending reported in the survey by the participating 305 firms. Finally, investment in energy efficiency is expected to have an impact on energy (and economic) performance.

Below, we report for each of the four research questions and their hypotheses some of the most pertinent (bivariate) correlation coefficients. The correlation coefficients which are used are shown in the synthetic Table 42 at the end of this annex. When written in bold, the value of the correlation coefficients is significant at 5%. The cells which are shaded in grey show the intersection of the two sets of variables which are concerned by the hypothesis. The presence of a simple significant correlation coefficient is only an indication that there is a relationship in one direction or the other. Other variables than the only one chosen may have an impact on the relationship. Looking at the values of the significant correlation coefficients in Table 42, the correlations are overwhelmingly low and very low (below 0.50), with one exception: the moderate positive correlation between the level of energy management and the realisation of an energy audit (required by target agreements, or done independently).

The correlation analysis helps to explore the data and may suggest some relationship between what the researcher wants to explain and a large number of possible explanatory factors. The objective of the econometric analysis (section 5.3) of the report is to look for statistically significant determinants of each of the four links of the chain of energy performance. As it is shown, the problem of interpreting the causation between the variable to be explained and some of the explanatory variables remains.

Research question 1: What is the level of energy management and its determinants in Swiss large-scale energy consumers?

Hypothesis 1.1: The level of energy management in Swiss large-scale energy consumers is generally low.

The average level of energy management measured on a scale between 0 and a maximum reachable score of 23 points is about 10.3. There is no significant difference between industry/ construction and service sectors. This result can be compared to Cooremans (2012b), who conducted a survey in 2006 and 2007 on a much smaller sample of 34 firms, all located in the canton of Geneva. Cooremans used nearly the same procedure to measure the level of energy management. The average score reached was 8.9 points out of a maximum of 22. When adjusted to the number of maximum points, the average score is 9.3. Note that the average score of the 32 firms located in Geneva present in the survey under review is 12.3 (+32%): exactly the average level attained by all firms. For the Geneva firms, in comparison between the two surveys, it is an improvement.

However, in absolute terms, the measured level of energy management of the entire sample of firms, including the firms located only in Geneva, have an “acceptable EM system with possibilities for improvement”. The public discussion on the energy transition and the slow phasing in of public policy measures during the last decade may explain an increasing awareness of energy issues and some progress made in energy management by Swiss firms.

Hypothesis 1.2: The main determinants of the energy management level are company size, company energy intensity, and commitment or support of energy management by top management.

Correlation coefficients between the level of energy management (EM) and the level of employment, the electricity intensity, and the presence of the support of EM by a member of the board of directors are respectively of 0.247, 0.488, and 0.442. All these correlation coefficients are significant at 5% but still low. On the other hand, the correlation coefficient between EM and energy intensity (as opposed to electricity intensity excluding thermal energy) is near zero (no correlation at all). Other variables which are likely to determine the level of energy management in Swiss firms could be the fact that the firm belongs to an international group (0.218, low correlation), and that it has already performed an energy audit (significant moderate correlation of 0.663).

The summary table of correlations shows other significant correlation coefficients for the level of energy management, notably with the number of (large) investment projects undertaken (but not with EE investment spending). Public policy is also related to the level of energy management, especially the use of target agreements aimed at reducing the CO2 tax and CO2 emissions (significant correlation coefficient of 0.413). This is also true for the audits promoted at the cantonal level (0.382 correlation) and as a measure taken in the framework of energy management (moderate positive correlation: + 0.663)[61]. Auditing is likely to be a key factor in the process of adopting an energy management system. It is part of the energy management system and its index (level), as an extremely useful instrument of diagnosis and implementation. On the other hand, it might be the consequence of increasing concern for energy issues and savings, as well.

It turns out that the level of energy management is weakly correlated to two-thirds of the 39 variables which are shown in the correlation Table 42. From this perspective, the level of energy management might play an important role in companies to promote energy efficiency or not. However, EM is not correlated to the drivers of energy efficiency (except the ones on value propositions, not shown) or to financial criteria of investment projects.

The reader should be aware that the causal direction can work in two directions (which in principal can be true for all bivariate correlations). The level of energy management might be related, but in most cases not fully explained, by the variable considered or vice versa. As the survey does not provide any information on the chronology of events, it is not possible to conclude by observing a significant coefficient on the causal relationship. For instance, public policy can increase companies' awareness and interest in energy issues, which explains the introduction or development of an energy management system. On the contrary, the mere existence of energy management at the firm level can lead to the conclusion of ambitious target agreements. A firm's belief that legal provision in energy efficiency represents an opportunity (significantly related to EM: 0.249) rather than a constraint can be interpreted either way. Legal provisions can lead to a positive stance on energy issues, and hence to energy management. Alternatively, the existence of energy management provides useful internal information about the potential of energy investments, ultimately leading to the conclusion of a target agreement and energy efficiency actions.

Research question 2: What is the influence of energy management on the perceived strategicity of energy efficiency investments?

Hypothesis 2.1: The higher the companies' level of energy management, the more strategic they perceive energy efficiency investments to be.

[61] A distinct question on audit activities is included in the survey questionnaire ("Did your firm realise an energy audit in the last four years, regarding building, premises and offices, (production equipment or none?)", but only indirectly in the questions used to calculate the scores of the level of energy management. Auditing activities are part of the energy management system, as a necessary instrument of diagnosis and implementation. Note that the 148 firms having reported the realisation of at least one energy audit show an average level of energy management of 12.5 (compared to the average score of all firms: 10.3). The modest impact on the average level of energy management suggests that audits are realised at any level of energy management.

The synthetic correlation table shows the value of the coefficient between the level of energy management, evaluated on a scale of 0 to 23 points, and the strategic character of energy efficiency investments (or, more precisely the energy managers' perception of strategic character). A scale from 8 to 40 points measures the strategicity of energy efficiency investment for eight drivers—factors favourable to energy efficiency investments—considered as strategic. The correlation coefficient between the stated importance of the eight strategic drivers and the level of energy management is close to 0 (slightly negative but insignificant).

The correlations are equally low and insignificant for the two groupings of drivers (binary variable, with 1 when considered important by firms) on risks (energy supply, energy price, production) and cost reduction (energy cost and non-energy costs). However, this is not the case for the third grouping on value propositions (quality of product and process, clients' comfort, image and reputation), with a low but statistically significant coefficient of 0.174 at 1%, not shown in the correlation table.

Research question 3: What is the influence of the perceived strategicity on energy efficiency investment decision-making?

Hypothesis 3.1: The more strategic an energy efficiency investment is perceived by a company, the better the chances for a positive decision.

This relationship is examined by comparing the strategic drivers to the volume of energy efficiency investments realised by the firms over the last four years. The energy-efficient investments undertaken by the firms are measured by four variables (investment expenditure per year and per employment, number of projects undertaken, number of large projects undertaken (over 100,000 CHF) and number of the different sizes of the projects). It turns out that the reduction of cost, as well as the reduction of risks, and all drivers of EE investment aggregated, are not correlated with investment spending. The latter two variables are, however, correlated negatively with the number of projects. An increase in the importance of these strategic factors would, in consequence, tend to reduce the number of EE investment projects.

Hypothesis 3.2: The less strategic the investment, the more restrictive the financial criteria in the selection of investment projects.

In other words, the hypothesis supposes that harder financial selection methods and criteria are applied to investments perceived as non-strategic by companies, *i.e.* energy efficiency investments. In general, three evaluation methods (NPV, IRR and payback time) are commonly applied together to assess investment projects. On the contrary, the payback time method seems to be, most often, the only financial method used by firms to estimate the attractiveness of energy efficiency investments. The hardest selection method is the payback time method, since it requires often an extremely short time period to get the initial investment back, which means a very high IRR.

The payback method is not favourable to energy-efficient investments which, in general, develop their financial benefits over the long term. 83% of the 266 firms which responded to the questions use the payback time method to select energy efficiency investments, and only a minority of 20% respectively use NPV or IRR methods. However, the payback time method is applied in an unorthodox way by companies,[62] since only 8% require a payback of less than two years. Half of the firms are waiting eight years for the payback of EE investments. This long waiting time in Switzerland is likely to be explained by legal provisions which oblige large energy consumers to implement investment projects with a payback time of less than four years in the case of process investments, and less than eight years in the case of construction investments.

Looking at the correlation coefficients, it appears that the drivers of EE investment are not correlated with investment spending and projects. All corresponding coefficients are small, and insignificant.

Hypothesis 3.3: The number of energy efficiency investments positively decided and realised depends mainly on the network relations/knowledge exchange within the sector.

Hypothesis 3.4: Increasing requirements from cantonal energy policies for large consumers and/ or rising energy prices (in particular for electricity) positively influence energy efficiency investment decision-making by companies.

The network effect is measured by the number of networks and programs to which the firm is affiliated and by the number of ISO certifications (three are proposed in the questionnaire). Note that only six of the responding firms are certified ISO 50001 Energy Management System. The investment in energy efficiency is not correlated to certification, to the existence of a partnership with an organisation promoting energy efficiency, or with any public policy variables. All corresponding correlation coefficients of EE investment are low and insignificant.

Research question 4: How does positive energy efficiency investment decision-making influence energy performance?

[62] As a reminder, the payback time method consists of calculating the time necessary to entirely recover the capital initially invested (Capex) or, in other words to realise at least an operation with zero sum. Expressed in years or in months, it is calculated by dividing the initial cost of the investment by its cumulated net annual income. The selection of investment projects with the payback period method is not primarily based on profitability (which is not assessed for the total life of the project) but on risk, which is expressed by duration (in years). Thus, the payback time required should be shorter than three years.

Hypothesis 4.1: The higher the number of energy efficiency investments implemented, the higher the energy performance of a company (measured in energy intensity terms).

At least 60% of the respondent firms experienced a reduction in their energy consumption. Fifteen percent of the responding firms experienced stability in or an increase of energy consumption. Energy consumption, despite the EE investment, may increase because of an increase of output, given energy prices, or because of an independent fall of energy prices. This rebound effect is likely to occur in the medium or long run if the initial energy savings are important (and prices high). About 22% of the respondent companies are not able to evaluate this impact or do not know.

The correlation coefficients between the different measures of the EE investment and the performance of the firms are low and insignificant, with two exceptions for the latter characteristic. Investment spending in energy efficiency (per year and full-time equivalent) and in production of renewable energy increases energy consumption (negatively correlated with the reduction of energy consumption). This direction of the correlation was not expected. The corresponding values of the correlation coefficient are small: -0.214 respectively -0.254.

Table 42: Table of correlations, according to the research hypothesis

		questions		1,2	1,3	1,5	1,6	1,6	1,7	1,8	1,9	1,10	1,11	1,12	2,1	2,3	2,4	2,4	2,9	3,1	3,1	3,1
				characteristics of the firms											**energy management**					**drivers of ee**		
hypotheses		**Coefficient in bold = significant at 5%**		Part of an internati onal group	Number of establishm ents	Activity (industry & constructi on)	Employm ent (FTE)	Large firms with > 1000 FTE (32 firms)	Degree of market competiti on	Ownershi p of at least one building	Level of electricity consumpt ion (> 0,5 GWH threshold)	Level of thermal energy consumpt ion (> 5 GWh threshold	Partners in energy efficiency	ISO certificati ons	Energy as an importan t subject	Support by a senior member of manage ment	Electricity intensity in %	Energy intensity %	Energy audit	Stategic drivers: cost reduction	Stategic drivers: risk reduction	Strategici ty if ee investme nt
				V1_2	V1_3	V1_5A	V1_6	V1_6A	V1_7a	V1_8D	V1_9A	V1_10A	V1_11I	V1_12F	V2_1A	V2_3	V2_4B	V2_4D	V2_9D	V3_1C	V3-1R	V3_1AS
1,1 -1,2 - 2,1	**energy management**	Level of EM (index)	EM	**0,218**	**0,212**	-0,014	**0,247**	**0,273**	0,025	**0,145**	**0,155**	**0,360**	**0,454**	**0,131**	**0,191**	**0,442**	**0,488**	0,078	**0,663**	0,107	0,035	-0,060
3,1-3,2	**drivers of energy efficiency**	Stategic drivers: cost reduction	V3_1C																			
		Stategic drivers: risk reduction	V3-1R																			
		Strategic drivers (agregate)	V3_1AS																			
3,3 -3,4	**energy efficency investment projects**	ee investment per year (last 4 years) and EFT, in CHF	V4.0										0,092	-0,160								
		ee investment per year (last 4 years), in CHF	V4_01										0,099	0,222								
		ee investment (number of projects)	V4_10										0,171	0,061								
		ee investment (number projects over 100K)	V4_1H										0,128	-0,095								
		Investment in production of renewable energy	V4_2										0,173	0,038								
3,4	**public policy options**	Target agreement (energy, CO2 emissions)	V5_1																			
		Contacted by the cantonal authorities	V5_2A																			
		Universal target agreement or SME Model canton	V5_3																			
		Energy audit	V5_3A																			
		Legal obligations as a constraint	V5_5A																			
		Legal obligations as an opportunity	V5_5B																			

		questions		4,1	4,1	4,1	4,1	4,2	4,3	4,3	4,3	4,4	4,5	5,1	5,2	5,3	5,3	5,5	5,5	6.1bis	6.2bis	6.2bis	6.2bis
				energy efficency investment spending or projects					**financial criteria (investment projects)**					**public policy**						**energy and economic performance**			
hypotheses		**Coefficient in bold = significant at 5%**		ee investment per year (last 4 years) and EFT, in CHF	ee investment per year (last 4 years), in CHF	ee investment (number of projects)	ee investment (number projects over 100K)	Investment in production of renewable energy	Use simple payback period	Use of NPV method	Use of Internal rate of return	Appraisal (years) depending on type of investment	Significance of non-energy benefits	Target agreement (Co2 energy, emissions)	Contacted by cantonal authorities	Universal target agreement or SME Model canton	Energy audit	Legal obligations as a constraint	Legal obligations as an opportunity	Reduction of energy consumption	Price competitivity	Product competitivity	Profitability
				V4.0	V4_01	V4_10	V4_1H	V4_2	V4_3A	V4-3B	V4-3C	V4_4	V4_5A	V5_1	V5_2A	V5_3	V5_3A	V5_5A	V5_5B	V6-1bis	V6_2Abis	V6_2Bbis	V6_2Cbis
1,1 -1,2 - 2,1	**energy management**	Level of EM (index)	EM	0,024	-0,044	**0,281**	**0,239**	**0,183**	0,096	0,138	0,171	-0,013	**0,326**	**0,413**	**0,298**	**0,180**	**0,382**	-0,068	**0,249**	**0,373**	**0,265**	**0,187**	**0,302**
3,1-3,2	**drivers of energy efficiency**	Stategic drivers: cost reduction	V3_1C	0,034	0,062	0,059	0,038	-0,083	-0,008	0,051	-0,011	-0,025	-0,092										
		Stategic drivers: risk reduction	V3-1R	0,027	0,066	**-0,281**	-0,028	-0,126	0,083	-0,069	0,032	0,011	0,120										
		Strategic drivers (agregate)	V3_1AS	0,191	-0,303	**-0,504**	**-0,365**	-0,043	0,183	0,109	-0,023	-0,076	-0,160										
3,3 -3,4	**energy efficency investment projects**	ee investment per year (last 4 years) and EFT, in CHF	V4.0											0,061	-0,226	-0,032	-0,230	-0,170	0,042	**-0,214**	-0,035	-0,027	-0,041
		ee investment per year (last 4 years), in CHF	V4_01											0,062	-0,039	-0,212	0,360	-0,037	0,049	-0,060	-0,151	-0,158	-0,097
		ee investment (number of projects)	V4_10											0,103	0,179	-0,128	0,310	-0,103	0,197	0,169	0,015	-0,045	-0,035
		ee investment (number projects over 100K)	V4_1H											0,038	-0,015	-0,158	0,255	-0,045	0,021	0,160	0,088	0,038	0,070
		Investment in production of renewable energy	V4_2											-0,043	-0,127	0,025	-0,153	0,025	0,233	**-0,254**	0,075	0,065	-0,064
3,4	**public policy options**	Target agreement (energy, CO2 emissions)	V5_1	-0,096	0,062	0,167	0,139	0,074															
		Contacted by the cantonal authorities	V5_2A	-0,050	-0,039	0,112	0,120	0,017															
		Universal target agreement or SME Model canton	V5_3	0,202	-0,212	-0,113	-0,039	0,093															
		Energy audit	V5_3A	-0,155	**0,360**	**0,244**	0,152	-0,037															
		Legal obligations as a constraint	V5_5A	-0,036	-0,037	-0,102	-0,031	0,020															
		Legal obligations as an opportunity	V5_5B	0,055	0,049	0,138	0,054	0,137															

Table Université de Neuchâtel. Source: Survey data, own calculation, Université de Neuchâtel

Annex 1.3: Econometric approach

Table 43 gives the summary statistics of the most important quantitative variables used in the econometric approach.

Table 43: Summary statistics of main variables (with multiple values)

Code	V1_6	V3_1AS	EM -V2	V2_4B	V2_4D	V4_0	V4_01	V4_10
Label	Number of full-time employees	Aggregate strategicity Factors	Level of energy management	Electricity intensity (in %)	Energy intensity (in %)	EE investment spending, in CHF per employment (last 4 years	Average EE investment spending, in CHF (last 4 years)	Number of projects in EE investment, in CHF (last 4 years)
Mean	1'106	27	10.3	3.1	4.3	10'161	403'917	7
Min	1	8	0	0.1	0.1	0	0	0
Max.	62'341	40	23	25	25	341'589	5'000'000	220
Std-dev	5'241	6	5.6	4.1	5.2	33'359	643'856	18
N. obs	302	300	305	216	183	233	231	233

Table Université de Neuchâtel. Source: Survey data, own calculations, Université de Neuchâtel

How to get econometric results

The following estimation procedure was applied to analyse the determinants of the level of energy management, the importance of energy efficiency drivers, energy efficiency investments and the energy and economic performance of the firms.

There are many explanatory variables which can be derived from the answers to the survey questions. In addition, in some cases, several variables can be constructed for measuring one activity or characteristics, *e.g.* the size of the firm. Based on theoretical considerations and the literature review, a first list of available potential determinants can be made, which in the present case includes at least all the available variables describing the characteristics of the firms and some from other sections of the questionnaire (*e.g.* public policy variables).

The different models estimated are initially derived by applying the Stepwise procedure implemented in the econometric software (Eviews, version 7). The Stepwise regression procedure automatically selects the potentially most significant explanatory variables from the given set of variables using various statistical criteria. It verifies the significance and acceptability of a given determinant by using statistical criteria, such as a predetermined p-value, and looks for a combination of variables with the highest adjusted coefficient of determination (adjusted R-Squared) possible. The R-Squared (residuals squared, eventually adjusted by the number of variables) represents the proportion of the variance of the variable to be explained, which are explained by the selected variables in the estimated equation. The algorithm stops adding additional variables when none of the remaining variables are statistically significant (depending on the chosen error levels "p-value", which are chosen to be relatively large, *e.g.* 10% or 20% in order to avoid eliminating potentially important variables). In doing so, the Stepwise procedure eliminates the variables which overall have the least chances of being significant in any circumstances. Alternatively, one can use statistical procedures for the pre-selection of explaining variables, such as factor or cluster analysis. These procedures were not very effective, however.

All variables added before or during the procedure are checked at each step if their statistical significance has been reduced below the tolerance level. If a non-significant variable is found, it is removed from the model. After a few steps, the resulting model includes several variables with statistically significant and non-significant coefficients. However, it might well be that one of the significant variables has the "wrong" sign, meaning that the direction of the estimated impact, positive or negative, on the explained variable is contrary to the findings in the literature, and a priori to intuition or common sense. It might be possible to find some explanations for a priori counter-intuitive results in the precise context of the study.

The main goal of applying the Stepwise procedure is to reduce the number of variables to be included in the explanatory model, not to get an estimated final model (equation). To arrive at an empirical model with good or at least satisfactory statistical proprieties, one selects the variables which are most likely to influence the phenomenon to be explained, on theoretical grounds at first. The analysis of the bivariate correlations between the explained variable and the potential explanatory variables can help in selecting the most likely significant variables.

Logit: logistic estimation of the performance

The estimation of the performance models requires the use of a specific econometric procedure which can deal with an explained variable in a binary form (the variable takes either the values of 1 or 0).

Let the variable be Y, which takes the value 1 or 0. These values describe the results of a choice, if an event or a choice has occurred. Consider a sample of n individuals (firms), i = 1…n. For each firm, one can observe if a certain event has occurred or not:

$$\begin{cases} \text{Y} = 1 \text{ if the event has taken place,} \\ \text{Y} = 0 \text{ if the event has not taken place.} \end{cases}$$

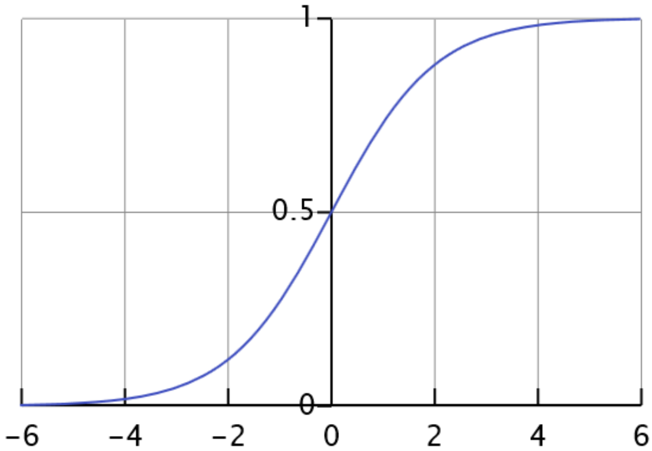
The codification used for the variable Y (0, 1) is the characteristic of dichotomous models. Such models explain the probability of the occurrence of the event as the expectation of variable Y, *i.e.*

E(Y$E(Y_i) = \Pr(Y_i = 1) * 1 + \Pr(Y_i = 0) * 0 = \Pr(Y_i = 1)$

Dichotomous models try to explain the occurrence of the event in terms of probability, by u-sing an undetermined number k of observable variables (Xi1,…., Xik), *e.g.* the characteristics of firms, drivers and barriers and public policies.

An ordinary linear model, $Y_i = \theta_0 + \theta_1 X_{i1} + \theta_2 X_{i2} + \cdots + \theta_k X_{ik} = X\theta$, cannot be used for estimation, because the value of the variable to be explained takes only two values, which do not follow normal distribution. Therefore, one must use a method which estimates the proba-bility of the event. The logit model stipulates for the distribution of the values of Y, the logistic function Λ:

$$F(X_i\theta) = \Lambda(X_i\theta) = \frac{e^{X_i\theta}}{1 + e^{X_i\theta}} = \frac{1}{1 + e^{-X_i\theta}}$$



Note that the estimated coefficients cannot be used directly to evaluate the impact of the ex-planatory variables. The values of the estimated parameters (θ) must be interpreted. The essen-tial aspect is the marginal effect of the j-th variable Xij, on the probability of the event Y = 1 for the firm i. Written as a continuous variable, the effect if Xij is the change of the probability (for a qualitative explanatory variable, it is necessary to consider a rate of increase):

$$\frac{\partial F(X_i\theta)}{\partial X_i} = f(X_i\theta)\theta_j$$

where f is the density function of the logistic function, F (see picture above).

The direction of the effect of a change in Xij depends on the sign of the coefficient. Positive values of θ_j imply that an increase of Xij will raise the probability of the response; negative values imply the opposite:

If θj > 0, Xij has a positive effect on the event considered.
If θj <0, Xij has a negative effect on the event considered.

The marginal effect of a variable Xj on Y can be eventually calculated in order to know the relative importance of each of the determinants.

Annex 2: Additional materials interviews

Annex 2.1: Attributes of interviewed companies and interviewees

Table 44: Attributes of interviewed companies and position/function of interviewees ("energy managers")

Sector	Product/Subsector	Company structure	Ownership	Region of Switzerland	Electricity consumption in GWh /year	Thermal energy consumption in GWh /year	Energy management level	Position/function of interviewee (besides "energy management")
Industry	Food, beverages and tobacco processing	Group	Private (multi)	French part	> 10	> 5	high, 19	Engineering
	Manufacturing / Basic metals and fabricated metal products	SME	Private	French part	0.5 to 1	< 5	low, 3	Owner and executive director
	Manufacturing / Plastic, other non-metal products	Group	Listed company	German part	> 10	> 5	upper medium, 17	Head of quality and sustainability management
	Food, beverages and tobacco processing	SME	Private (multi)	German part	1 to 3	< 5	upper medium, 15	Operations manager and member of executive board
	Manufacturing / Plastic, other non-metal products	Group	Listed company	German part	> 10	> 5	high, 20	Energy Specialist and controlling (2 interviewees)
	Manufacturing / Printing	SME	Private	German part	3 to 10	< 5	lower medium, 6	Facility management and technology
	Chemical pharma	Group	Listed company	French part	> 10	> 5	high, 19	Head electrical power supply and head energy and water management (2 interviewees)
	Manufacturing / Basic metals and fabricated metal products	SME	Private (multi)	German part	3 to 10	< 5	upper medium, 12	Executive director
	Manufacturing / Basic metals and fabricated metal products	Group	Listed company	French part	> 10	> 5	high, 21	Project manager
	Manufacturing / Basic metals and fabricated metal products	Group	Private	French part	1 to 3	< 5	low, 3	Maintenance responsible, coordinator environment and workplace safety
	Manufacturing / Plastic, other non-metal products	SME	Private (multi)	German part	1 to 3	< 5	upper medium, 12	Purchasing and technology manager

	Manufacturing / Basic metals and fabricated metal products	Group	Private	German part	3 to 10	< 5	upper medium, 15	Energy, environment, and sustainability management
	Manufacturing / Machinery, equipment	Group	Listed company	German part	1 to 3	< 5	upper medium, 11	Head of management systems
	Manufacturing / Machinery, equipment	Group	Private	German part	3 to 10	> 5	upper medium, 16	Head of quality, environmental, and workplace safety management
	Food, beverages and tobacco processing	SME	Private	German part	0.5 to 1	< 5	high, 19	Operations manager
	Chemical pharma	SME	Private	German part	0.5 to 1	< 5	lower medium, 9	Head of engineering, environment, and workplace safety
	Chemical pharma	Group	Listed company	French part	3 to 10	< 5	lower medium, 10	Head of Engineering Fribourg, Director
Services	Finance and insurance activities	Group	Listed company	German part	3 to 10	< 5	lower medium, 9	Head of facility management
	Facility management / Energy sector	Group	Public	German part	3 to 10	< 5	lower medium, 9	Head of facility management
	Finance and insurance activities	SME	Private (multi)	French part	> 10	< 5	lower medium, 10	Head of engineering and energy
	Wholesale and retail trade	Group	Private	German part	> 10	> 5	high, 23	Head of energy/CO2 department
	Accommodation and food service activities	SME	Private	French part	3 to 10	< 5	upper medium, 11	Head of quality and energy
	Facility management / Office, wellness, medical facilities	SME	Private	German part	> 10	< 5	lower medium, 10	Executive director and head of facility management
	Finance and insurance activities	Group	Listed company	German part	> 10	< 5	lower medium, 9	Head of facility management
	Facility management / Industry	SME	Private (multi)	German part	0.5 to 1	< 5	upper medium, 13	Head of facility management
	Wholesale and retail trade	SME	Private (multi)	German part	3 to 10	< 5	upper medium, 14	Executive director

Table INFRAS.

Annex 2.2: Interview guide

(1) Energy management[63]

- What is the relevance of energy efficiency for your company (incl. rationale)? Is the energy efficiency a part of the corporate culture of your company (incl. rationale)?
- Could you please describe the energy management of your company (strategy, organisation and resources, activities incl. monitoring)? What are the strengths and weaknesses of the energy management?
- How did the energy management of your company evolve? What were the reasons for the development?
- Is a further development of the energy management planned or envisaged? In what ways and why?

(2) Decision-making process toward energy efficiency investments[64]

- How is the decision-making process towards investments into energy efficiency projects organised (structures, process and instruments)? Are there any differences regarding the nature and the amount of the investments?
- Which are the decisive criteria for investments into energy efficiency (incl. rationale)? What are the advantages/disadvantages of these criteria?

(3) Role and influence of the energy management on the decision-making process toward investments into energy efficiency

- Which role, tasks and duties does the energy management have in decision-making processes toward investments into energy efficiency?
- What are the specific impacts that the energy management does have on the decision-making process and on the decision towards energy efficiency investments?
- To what extent can the energy management augment the perceived strategic relevance of energy efficiency investment in the decision-makers' heads? What are the concrete impacts on the decisions?
- Would a higher level of energy management have a positive influence on energy efficiency investments, in particular due to a significantly raising of companies perceived strategic character of energy-efficient investments?

[63] «Energy management» is defined as the process of organisational, technical or human actions enabling organizations to use energy in a more efficient way and to reduce energy consumption in a profitable way.

[64] Investments in projects that aim at providing an energy service using less energy (*e.g.* adoption of energy-saving technologies/ equipment). Investments can be energy efficiency investments (*i.e.* the main goal is to save energy) or "core activity" investments (*i.e.* investments to increase production quality or improve processes, etc.) with a special attention given on energy efficiency.

(4) Impact on (energy) performance

- How did the energy efficiency performance evolve in the last couple of years (incl. rationale)? Is your energy efficiency performance – according to your own estimate – normal/better/lower than average compared to your competitors in your sector?
- What is the impact of the energy efficiency investments on the energy performance and on strategic targets of your company?

(5) Improving energy management

- Should the energy management of your company be improved? Why and how?
- What relevance do company-internal (*e.g.* relationship between top management and energy manager) and -external factors (*e.g.* their network and competitors) have in improving the energy management?
- How could the regulator (in particular federal and cantonal politics) support the improving of energy management?

Annex 2.3: Summary table

Table 45: Summary of main results from the interviews and main conclusions

Reasons for energy management development	Policy instruments / financial incentives	Sustainability policies / Corporate social responsibility (also SMEs)	People (motivation and collaboration, involvement of top management)
Role of energy management in the decision-making process	A tool for: data collection / potential analysis / project ideas	Fact based argumentation for project proposals	Monitoring of energy efficiency projects' impact
Investment decision-making criteria	Profitability / Cost reductions	Priority of core business investments	Additional non-energy benefits
What determines the strategicity of energy efficiency investments?	Core business defines strategic relevance of investments	Sustainability policies and market demand (customer expectations, investors) can make energy efficiency more strategic	Finances are strategic relevant for companies. Low energy prices prevent energy efficiency measures from becoming more strategic

Table INFRAS. Source: Interview analysis.

Annex 3: Additional materials case studies

Annex 3.1: Level of energy management

Table 46: Level of energy management (based on M_Key Survey)

Level of Energy Management		Survey questions	Max points	A	B	C	D	E	Avg group
1	**2.2 Energy manager**	- does the company have an energy manager?	2	2	2	2	2	2	50%
2		- does the energy manager perform other functions in your company?		-1	-1	-1	-1	-1	
3	**2.4 Which percentage do your energy consumption total costs represent?**	- electricity cost, percentage of turnover (%)	2	0	2	2	2	2	80%
4	**2.5 Did your company make a commitment of a continuous reduction of its energy consumption?**		2	0	2	2	0	2	60%
5	**2.6 Did your company undertake any of the following tasks in relation with energy use?**	- evaluation of its energy performance (benchmarking)	9	1	0	1	1	1	64%
6		- definition of a baseline		0	0	0	1	1	
7		- definition of key performance indicators		0	0	2	2	0	
8		- definition of energy policy or strategy		1	0	0	1	1	
9		- determination of measurable goals regarding a reduction of energy consumption		0	1	1	1	1	
10		- definition and collection of data related to the achievement of the goals defined		0	1	1	1	1	
11		- definition of measures and action aiming at achieving the goals		0	1	1	1	1	
12		- regular internal reporting on actions and measures taken and/or on results achieved		0	1	1	1	1	
13	**2.8 Which (internal and external) resources have been allocated to the implementation of energy-efficiency measures?**	- financial resources (e.g. audit cost)	4	0	1	1	1	1	70%
14		- human resources (i.e. project team)		0	1	1	1	1	
15		- technical resources (i.e. meters)		1	0	1	1	1	
16		- IT resources (i.e. monitoring software)		0	0	0	1	1	
17	**2.10 Did your company organize the following systems and procedures in relation with its energy policy?**	- training system for staff	4	0	0	0	1	0	30%
18		- reward/bonus system		0	0	0	0	1	
19		- assessment scheme of the results obtained		0	0	0	1	1	
20		- procedure in revising goals		0	0	0	1	1	
		TOTAL	**23**	**4**	**11**	**15**	**19**	**19**	**59%**
		Percentage of max	**100%**	**17%**	**48%**	**65%**	**83%**	**83%**	

Table companies A-E with 20 questions and max 23 points

Table Université de Neuchâtel. Source: Survey

Annex 3.2: Case study guide

The case study comprised of a discussion along the questions below and a "walk through audit" on site.

The focus of the case studies was on asking open questions and getting a deeper understanding of the practices of the companies. *Additional comments (for internal use only) are in italics.*

Case study questions:

1. Which **investments** into energy efficiency has your company made during the past 5 - 10 years?
   Goal: go through list of measures and gain a better understanding of the intensity of interventions and the magnitude of the investments and types of technologies improved

7. Does your budgeting allow **identifying energy efficiency investments** as a specific category?
   The subject of our research is investments into energy efficiency, but does this investment category exist at the companies? How do they categorize their efficiency improvement investments?

8. Who has **initiated, decided** and **implemented** the specific investments?*
   How are the responsibilities between different investments defined? Do differences exist?

9. Was the **engagement of one or more particular persons** within or outside your organisation crucial to execute these investments?
   If so, how? Is there sufficient internal know-how in-house? Is the external support satisfactory?*

10. Did you experience **conflicts between the different parts of your organisation** during the decision process of the specific energy efficiency investments? If so, could you elaborate?*
    Split incentives: technical department looking at energy / technical performance, purchase department at first cost (instead of life cycle cost).

11. Were these investments into energy efficiency in **significant competition** with other investments?*
    How big is the competition between the different types of investments? Is there a notable competition between investments into energy efficiency and core business investments? Are different criteria applied? If yes, why?

12. Did **internal/external factors** (*e.g.* expansion of production, deteriorating economic situation – CHF exchange rate) have an influence on your specific energy efficiency investments? If yes, what kind of influence and to what extent?
    Did intrinsic motives and/or a business philosophy also play a role?

13. Which **energy efficiency investments** has your company **planned**? Have all planned investments been **implemented**? If not, why?
    "Failure rate"?

14. How do you **quantify the costs and savings** (investment, energy) before and after the implementation of the efficiency measures? Does it involve measuring of equipment performance?
15. For which investments were the **resulting costs and savings** (investment cost, saved cost, saved energy, payback) the same / smaller / larger as planned?
16. Do you **evaluate** the results of the efficiency measures after their implementation? Do you take this into consideration for future investments?
    Does the company have an established follow-up and learning cycle? Do they assess what did not go so well? What they can learn and make better in the future?
17. How do you **report your efficiency measures and results** (internal, external)?
18. Do you have a **regular improvement plan for your equipment**? Which technologies are affected? Is it part of a regular maintenance?
19. Do you consider **your target agreements** / article for large-scale energy consumers an effective policy tool for fostering energy efficiency investments in your company? Could this policy instrument be improved for the benefit of your company? How? Do you see alternative policy measures that could positively affect energy efficiency investments in your company?
    Is public policy a constraint or an opportunity? Why?

*Questions already raised during the survey / interview phase, during the case study looking for more specific details.

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