Energy management: a key driver of energy-efficiency investment?

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Keywords

energy efficiency investments, energy management, energy performance, non-energy benefits (NEBs), multiple benefits, organisation behaviour, strategic value

Abstract

Improving energy efficiency is the primary pillar of the Swiss "Energy Strategy 2050". Investments in energy efficiency often remain undecided, however, and there is a large potential for enhancing energy efficiency in the industrial and commercial sectors in Switzerland.

Within this context, the aim of the research project "Management as a key driver of energy performance" (M_Key) is to assess the influence of the level of energy management on companies' energy-efficiency investment decision-making. M_Key is supported by the Swiss National Science Foundation (SNSF) and is part of the National Research Programme "Managing Energy Consumption" (NRP 71; 2015–2017; www.nrp71.ch). The overarching objective of the project is to gain a better understanding of energy-efficiency investment decision-making by large-scale energy consumer companies. With about 35 % of the total Swiss electricity consumption, these companies are an important target group for energy efficiency measures in Switzerland. It is expected that research results will enable to characterize and categorize Swiss large-scale energy companies based on their energy uses and financial behaviours, which will help frame customized policies.

M_Key empirical research applies three research methods chronologically: 1. Survey. 2. Interviews. 3. Case studies. The goal of this paper is to describe the findings of M_Key survey; it will then conclude on the implications of these findings for future energy policy.

Introduction[1]

The easiest, quickest and cheapest way to reduce energy consumption is to improve energy efficiency, the so- called "invisible fuel" of production. However, there is still considerable potential for energy-efficiency improvement and for saving energy in many companies. Investments in energy efficiency often remain undecided, even though they may be highly profitable. A rich literature discusses this under-investment in energy efficiency, known as the "energy-efficiency gap" or "paradox." The main explanation for this gap is the existence of barriers to energy-efficiency investment, which are not necessarily financial at all. The mainstream view – that profitability explains investment choices – does not satisfactorily explain firms' energy-efficiency investment choices.

Within this context, the present research builds upon an important research stream on the reasons explaining the energy-efficiency gap, and tries to answer the core question at the center of the debate: why do profit-seeking companies not consider investment opportunities which are likely to reduce their (energy) costs and thereby increase their profit?

1. This paper is written within the framework of the project "M_Key – Management as a key driver of energy performance," one of the 19 projects which are part of the national research programme "Managing Energy Consumption" (NRP 71, 2013–2018), funded by the Swiss Research Fund. The authors acknowledge research assistance by Dr. Moez Ouni and comments by their colleagues Rita Werle (Impact-Energy, Zurich) and Stephan Hammer (Infras, Zurich).

In order to answer this question, we focus on for-profit companies.[2] We study the drivers of energy-efficiency investments and, more precisely, the influence of energy management as a way to reduce the energy-efficiency gap in companies, and thus increase their energy performance. We formulate two core assumptions in this regard: 1) energy management is not widely disseminated in companies and therefore its influence on energy-efficiency investment decision-making remains low, and 2) energy management acts as an organizational filter which positively influences companies' perception of the strategic character of energy-efficiency investments and in turn, their choices regarding these investments.

The goal of this paper is to describe the results of the first step of M_Key research, a survey based on 3,000 questionnaires sent to large-scale Swiss electricity and energy users (the survey will be complemented by interviews and case studies). The survey collected responses to questions on energy management, barriers and drivers of energy-efficiency investments, investment projects, public energy-policies directed to firms, and the likely effects on investing firms' performance. Specifically, the objective is to document the influence of energy management as a way to reduce the energy-efficiency gap in companies.

The preliminary results reported in this paper are based on the analysis and decomposition of the frequencies obtained from the 305 firms having answered the online questionnaire and of the simple correlation calculated between key variables as shown in the table 1 on the main hypothesis (see below). Simple correlation, even significant, do by no ways imply a causal relationship. Further empirical investigations will include the use of factor analysis – in order to find groups of similar firms with regards to energy management and performance - and econometric analysis. The latter will concentrate on the influence of the level of energy management on investment decision, the determinants of investment decision, and the likely impact of investment on the performance of the firms.

To address this goal, the paper is organized into four sections: the first section synthesizes our conceptual framework. The second section describes our research model and methodology. The third section of the paper is dedicated to our research findings, which are then discussed in the last and fourth section. The findings presented and discussed so far lead to several policy recommendations.

Conceptual framework

Energy management is a type of management system which focuses on a company's energy use. In general terms, an energy management system is based on the management system model of continual improvement developed by the International Standardization Organization (ISO), which makes easier for organizations to integrate energy issues into the overall efforts to improve quality and environmental management (ISO50001). Energy management acts as an organizational filter which positively influences the strategic character of an investment project and, in turn, the investment decision-making process. Yet the importance and modalities of this influence need to be better understood. The positive influence of energy management on companies' energy performance has been demonstrated by several research works (AFNOR, 2015; AFNOR, 2014; Bründl *et al.*, 2012; DENA, 2013; Hirzel *et al.*, 2011; Waide, 2016).

In order to analyse the contribution of energy management to energy-efficiency investment, it is useful to apply a theoretical framework of investment decision-making. According to the framework developed by one of the authors (Cooremans, 2011, 2012a, 2012b), investment decisions are the product of a complex process influenced by many different factors, which can be classified into four broad categories: 1) external context, which refers to a firm's environment, 2) internal context, which comprises structure and management systems, strategy and organizational culture, and revenues/cost relations, 3) actors involved, either individuals or groups, which can be more or less powerful, and 4) characteristics of the investment to be made (Figure 1).

Cooremans' framework of investment decision-making, including the two relationships hypothesized and studied by M_Key research (illustrated by the two arrows), is represented in Figure 1.

In this framework, investment characteristics strongly influence decision-making. Investment characteristics are numerous and diverse. Among these characteristics, an investment's strategic character – i.e. its "strategicity" – plays a paramount role in decision-making. Strategicity, which can be defined as an investment's contribution to a firm's competitive advantage, is more important than profitability in the competition for resources, which exists in any organization.

However, strategic character is not given, it is interpreted. Investments are perceived by companies as strategic, and certain filters influence this perception: cognitive filters within individuals' minds, interpretative filters in organizational systems. Management systems, which are at the same time elements of a firm's structure and an emanation of its culture (an artefact as per Schein's 2004 terminology), are powerful organizational filters. They define the meaning and importance to be attributed to incoming events and information, as well as to new investment proposals, and they define the procedures to treat them.

M-Key research model and methodology

Many factors, internal as well external to the firm, influence an energy-efficiency investment decision. In M_Key research, we focus on the influence of an energy management system—an element of the organizational context which is, at the same time, a control system and an artefact of corporate culture—on the perceived strategic character of the investment. We will also try to confirm the relative importance of some drivers which, according to the literature, seem to play a major role (either fostering or hindering) on the scope and level of energy management: characteristics of the firm, such as its size, energy intensity, activity, elements of the internal organization, as well as external elements (such as market or public policy).

The influence of energy management, based on our theoretical framework, happens through an impact chain which breaks down the influence of energy management on energy performance. In this impact chain, three main relationships 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

2. For-profit companies are defined here as companies which cover their production cost mainly by revenues from the market (thus excluding public administrations or NGOs).

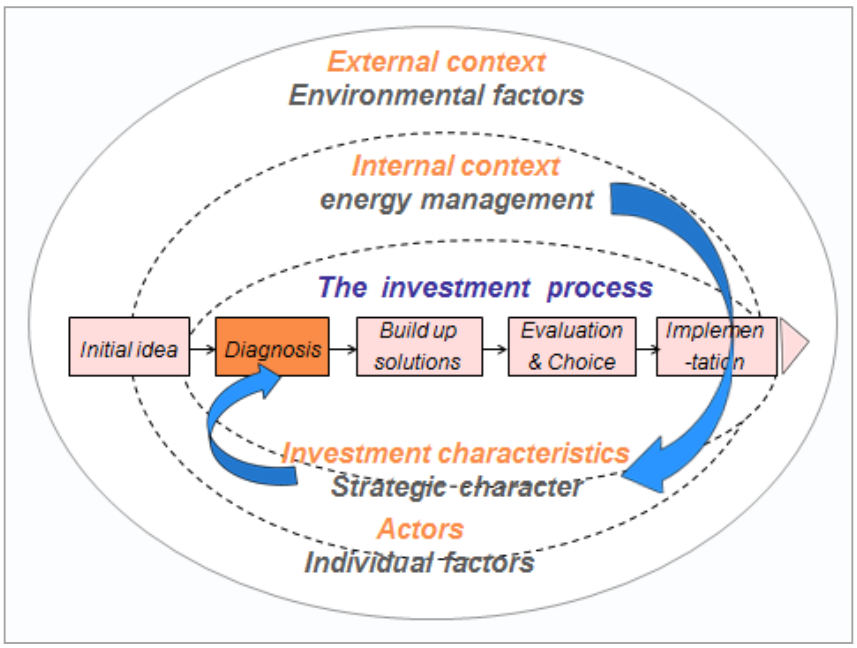

Figure 1. A new model of investment decision-making (Cooremans, 2012a: 499).

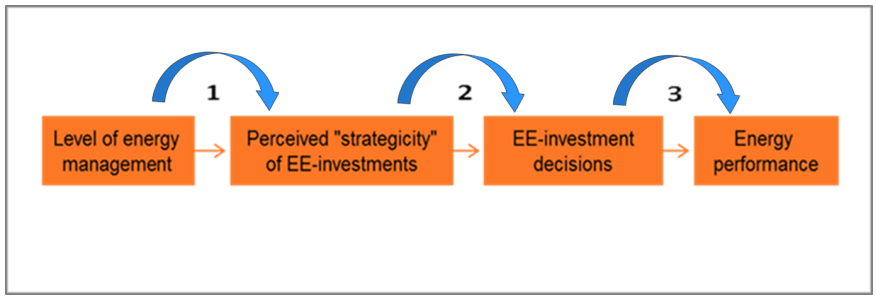

Figure 2. Three relationships of influence.

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 2.

Based on an in-depth literature review and on the chosen theoretical framework, our research questions and hypotheses regarding these relationships of influence had to follow the principle "keep it simple," in order not to fall in the same over-determination and overlap traps as other research works have done, and look only for the likely main determinants. The following principles were applied: 1) limit the number of hypotheses and eliminate redundancy, 2) hypotheses must describe the different parts and relationships of Figure 2, and finally, 3) whenever possible, the different factors of influence are aggregated into groups. The initial research questions and their related hypotheses are described in Table 1.

LARGE ENERGY CONSUMERS ARE THE TARGET OF THE SURVEY AND RESEARCH

According to the Swiss federal energy law, a Large-Scale Energy Consumer ("LSEC") is defined as a site (or "establishment") consuming per year more than 0.5 GWh of electrical energy and/or 5 GWh of thermal energy. Electricity, water and natural gas consumptions are subject to a contract with an energy supplier[3] and measured by a meter at the site's entrance. Buildings (whether residential, tertiary or industrial) are thus the physical vector of LSECs' energy consumption. Legal provisions for energy use in buildings are to be taken by the cantonal authorities.

Several important aspects derive from the legal principles defining LSCE in Switzerland: 1) any site consuming more than the scales described above is concerned by the law, which means that any company with at least one LSEC site is concerned, no matter the activity or size of the site, or no matter the total number of buildings the company owns or occupies. 2) The Swiss concept of LSEC is different from the concept of "energy-intensive companies," which is usually defined by the ratio between energy consumption and turnover, or alternatively energy consumption to value added. Many companies defined in Switzerland as "LSEC" have energy costs that amount to a negligible percentage of their turnover (for instance less than 0.5 %, when energy-intensive companies have generally energy costs amounting to more than 10 % of

3. As from 2009, in the framework of the Swiss electricity market liberalization, large-scale energy consumers can freely choose their electricity supplier.

Table 1. M_Key main research questions and hypotheses.

Research question	Hypotheses
1) Level of energy management and its determinants	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 the company size, the company energy-intensity and the commitment or support of energy management by the top management.
2) Influence of EM on 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) Influence of the (perceived) strategicity on 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 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) Influence of investment decision-making on energy performance, via positive energy-efficiency investment decisions	4.1 The higher the number of energy efficiency investments implemented, the higher the energy performance of a company (measured in energy-intensity terms).

their turnover). Still, altogether, LSCEs represent about 35 % of the total Swiss electricity consumption, which explains why they are an important target group for the Swiss public energy policy. 3) LSECs are present in nearly all economic activities, not only in industrial activities. 4) Very few residential buildings are LSEC because they do not usually reach the thermal threshold of 5 GWh/year or the electricity threshold of 0.5 GWh/year (since each tenant subscribes individually to electricity supply).

According to the Helbling survey 2011 (Swiss Federal Office of Energy, FOE, 2011), there are about 10,000 private for-profit companies in Switzerland which consume electricity above the threshold of 0.5 GWh/year.[4] Our objective regarding the survey was to build up a database of 500 questionnaires out of this population. The main difficulty was to identify the large consumers. Large (electricity) consumers can be easily identified by energy suppliers, but the data are not publicly available. In some cantons, energy suppliers agreed to provide the list of LSECs to the cantonal energy authorities, but under a strict condition of confidentiality. Some cantonal energy authorities agreed to support the survey by sending the questionnaire, along with a support letter, directly to their LSECs. The number of firms contacted during the spring of 2016, with the help of eleven cantons[5] (out of a total of 26), was about 2,140. Two hundred and two completed questionnaires were collected during this phase. In a second phase, some 1,200 other companies all over Switzerland were contacted during the autumn. The addresses were obtained through various sources.[6] It was possible to receive some 100 additional questionnaires. Altogether the definitive sample includes 305 validly completed and usable questionnaires. Questionnaires were filled in by people in charge of energy issues in companies.

The distribution of respondents between economic sectors and sizes is given in Annex 1. The annual electricity consumption is indicated in Table 2, which shows that 261 firms, out of the 302 having completed our questionnaire, are large consumers of energy. The results reported in this paper, except otherwise mentioned, are those for the entire sample including the small consumers (*i.e.* with annual consumption below 0.5 GWh).

Among other characteristics, 88 companies (29 %) answered that they belong to an international group; 87 % possess their own premises used at least for one of the following purposes (administration, sales or production); 90 % operate in a high or very highly competitive market; 75 % participate in at least one program or network promoting energy efficiency. About 44 % of the firms (130) are owned by one private person or a by a family, 30 % have multiple private owners, and 52 firms are part of a group which is traded on the stock exchange. Finally, 25 firms (8 %) are owned by public administration (*e.g.* in public transport, contrary to our goal to collect only data from for-profit companies).

The structure of the questionnaire is described in Annex 2.

4. A significant percentage of LSEC are only "electrical LSEC," some of them are at the same time "electrical" and "thermal LSEC;" very few LSEC are "thermal LSEC" only. This distribution explains why we could focus on "electrical LSEC" to build up our database.

5. Six French-speaking and five German-speaking cantons.

6. The Energie-Agentur der Wirtschaft (EnAW), the Federal office for environment, various sources on the internet and the list of TOP 500 companies in Switzerland.

Table 2. Electricity consumption per year.

Level of electricity consumption	Number of responding firms	Percentage
below 0,5 GWh/year	38	13 %
between 0,5 and 1 GWh/year	51	17 %
between 1 and 3 GWh/year	93	31 %
between 3 and10 GWh/year	75	25 %
higher than 10 GWh/year	43	14 %
Total	300	100 %

Table 3. Level of energy management by levels of electricity consumption.

	Level and quality of energy management	Less than 0,5 GWh	Higher than 0,5 GWh	Total	Percentage
0–5 points	No systematic EM, or system with serious flaws	19	56	75	24.7
6–10 points	EM does not meet requirements regarding data collection and implementation	6	78	84	27.5
11–18 points	Acceptable EM system with room for improvement	12	111	123	40.3
19–23 points	High level of EM, which meets ISO50001 requirements	1	22	23	7.5
0–23 points		38	267	305	100.0

Research findings

The description of our research results will follow the sequence of relationships of our research model (illustrated by Figure 2).

ENERGY MANAGEMENT LEVEL

In order to assess the level of energy management in LSEC, the survey included nineteen questions (based on Cooremans, 2012a et 2012b, the Energy Management Checklist by BESS project[7]; McKane *et al.*, 2004, ISO50001, 2011), which simulates a simplified audit of energy management. These questions concern the following elements: diagnosis of current consumption, energy policy, presence of an energy manager in the organization, key performance indicators, measurable objectives and monitoring of energy consumption reduction, resources allocated to achieve the energy savings measures, evaluation and revision of energy savings goals, and staff training and rewards. The maximum attainable score was twenty-three points. The higher the score obtained by a company, the higher the level of energy management. Based on the BESS concept, the companies are divided into four categories according to the scores obtained, shown in Figure 3.

The distribution of the 305 responding firms along these categories is as follows: 24.7 % have no systematic energy management (EM), 27.5 % have a weak EM, 40.7 % have an acceptable EM, 7.5 % have a high level of EM. If we consider only LSECs' EM, the percentages are as follows: 0–5 points, 21.1 %; 6–10 points, 29,2 %; 11–18 points, 41.5 %; 19–23 points, 8.2 %. The average score is 10,7 points out of a maximum of 23 points. There are no significant differences between industrial sector and services sector (73 firms) in terms of average score.

There seems to be a relationship between the level of energy consumption and the level of energy management: 50 % of the "small" electricity consumers (below the threshold of 0.5 GWh per year) have no EM or a weak EM, whereas only 21 % of LSEC are in these categories. At the other end, only one "small consumer" out of 38 has a high level of EM, which fulfils the requirements of the ISO50001 Energy management system certification.

About half of the responding firms (160) have designated an energy manager to look after energy issues, but only 14 of them are dealing with energy issues on a full-time basis. They assume other responsibilities in a wide range of fields: general management, technical and production fields, maintenance and facility management, environment, security and even administration.

188 firms (62 %) have designated a senior manager to support the energy management system and 178 firms (60 %) have decided to actively and voluntarily reduce their energy consumption.

As a first step towards a complete statistical and econometric analysis to come, simple correlation analysis suggests that the level of energy management might depend on the fact that the observed firm is part of an international group, on the size of

7. See BESS project, Energy management checklist NOVEM, initially developed by senternovem.nl.

the firm (in employment terms) and on the level of energy and electricity consumption or intensity. Other factors are the set of strategic drivers of energy efficiency (see the section below on perceived strategicity) and public policy (through the existence of target agreements with the authorities). One factor seems to be particularly important, *i.e.* the realization of an energy audit.

PERCEIVED STRATEGICITY OF ENERGY-EFFICIENCY INVESTMENTS

According to hypothesis 3.1, "the more strategic an energy-efficiency investment project is perceived by a company, the better the chances for a positive decision." The strategic character of an investment—its "strategicity"—depends on the perceived contribution of this investment to a firm's competitiveness in its three dimensions: value proposition, costs and risks. The seven strategic drivers identified as potentially contributing to a firm's competitiveness are listed in Table 4. Energy-efficient investments can increase a company's value proposal through enhanced image and improved product quality and reliability; they can decrease energy and non-energy costs; they can lower several risks, such as the risk of disruption of energy supply, the risk of equipment break-down and the risk of energy prices (instability or increase).

By aggregating these 8 "value-cost-risk" strategic drivers (labelled X in Table 4), the minimum score which can be obtained is 8 points (if a company evaluates each of the eight drivers as "not important at all") and the maximum score is 40 (if a company evaluates all drivers as "very important"). Table 4 shows how many companies think each driver is important or very important. The average and median scores are 27 points out of a maximum possible of 40, *i.e.* 3,4 points on average. Table 4 also reveals that "Lower energy costs" is by far the most important driver of investment decisions for the responding companies. Note that the scores obtained at the firm level for the eight drivers are significantly correlated with the driver "Enhanced competitiveness" (line 3 of the table, labelled Y) by a coefficient of 0.49.

Table 5 lists the five most important barriers and shows that, by a great deal, the first barrier is "Other investments more important" (for 70 % of the respondents), followed by "Investment cycle." "Energy costs not important enough is the fifth barrier in the list, mentioned by 40 % of the respondents.

LEVEL OF ENERGY-EFFICIENCY INVESTMENT

Four variables measure the energy-efficient investments undertaken by LSCEs over period studied (2012–2015: 1) investment expenditure per year and per person employed (FTE), 2) number of projects undertaken, 3) number of large projects undertaken (i.e. ≥100,000 Swiss Francs) and 4) number of project size categories for each company.

Table 4. Important and very important drivers of energy-efficiency investment strategicity.

Rank	Drivers	Strategic considerations for investment decision (X and Y)	Important	Very important	Important and very important	Number of responding firms
1	Cost reductions resulting from lower energy use	X	96	164	260	296
2	Enhancing the positive image and reputation	X	116	68	184	298
3	Enhanced competitiveness	Y	108	75	183	295
4	Lower production risks	X	93	60	153	294
5	Other non-energy costs reductions	X	92	43	135	264
6	Higher quality/reliability of products and/or production process	X	83	52	135	293
7	Investment subsidies		79	47	126	295
8	Increased staff comfort		93	31	124	296
9	Lower energy price risks (instability)	X	88	33	121	292
10	Tax breaks		73	41	114	294
11	Lower risk of disruption in energy supply	X	64	46	110	295
12	Increased customers comfort (e.g. commercial surface)	X	61	46	107	287
13	Cheaper financing (lower rate)		50	21	71	284
14	Other factors, please specify		2	3	5	9

Table 5. Important and very important barriers of energy efficiency.

Rank	Barriers	Important	Very important	Important and very important	Number of responding firms
1	Other investments more important	111	87	198	282
2	Investment cycle: new technology can only be implemented when existing technology is to be replaced	121	40	161	288
3	Internal financial constraint	92	43	135	287
4	Low financial attractiveness	98	28	126	289
5	Energy costs are not important enough	84	32	116	290

Table 6. Average time periods (payback method).

	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

The survey questionnaire asked about the number of energy efficiency investment projects realized, in three categories (total costs ≤CHF 20,000; ≥20,000 and ≤CHF 100,000; ≥100,000). It was rather difficult to collect valid answers to this question. Some ex post verification was done on the responses of 80 firms (self-identified in the questionnaire).

Seventy-one firms could not indicate the number of energy efficiency investment projects by size, and 39 firms reported that they did not invest in energy efficiency over the period. However, 195 firms (*i.e.* 64 % of the total responding firms) reported such investments. The total number of reported projects over the four years is 1,665. On average, one of these firms carried out eight projects for 1.5 million Swiss francs, that is two projects a year worth about CHF 400,000. Fifty percent of these investments are aimed at reducing electricity and thermal energy consumption in buildings, 39 % at reducing electricity and thermal energy consumption in process, and the rest (11 %) are dedicated to renewable energy.

The preliminary correlation analysis suggests at first that there is no strong link between the drivers analysed and the investments reported by companies. However, it seems highly likely that the figures collected are biased because of the exceptionally large numbers of projects by very large firms. Another problem is that a number of investment projects reported may have been realized mainly for another reason than energy efficiency improvement (they were motivated by process improvement goals). This is suggested by commentaries made in the questionnaire by respondents. Empirically, it is very difficult to know if an "energy" project is undertaken firstly to reduce energy consumption and costs, or foremost for technical and commercial reasons. This is why empirical research should also investigate more closely the non-energy benefits (NEB, see below) of energy-efficiency investments. Multiple regression analysis might mitigate some of the measurement problems regarding energy-efficiency investment.

FINANCIAL APPRAISALS OF INVESTMENT PROJECTS

The three most common methods advised by investment finance theory to evaluate the financial attractiveness of investment projects are the payback time, the Net Present Value (NPV) and the Internal Rate of Return (IRR). Surprisingly 20 firms reported no use of any of the three methods for their financial evaluation of energy-efficiency investment projects, and about 10 other firms did not answer the question. Out of the 266 responding firms, 83 % use the simple payback method to evaluate of energy-efficiency investment projects. NPV or IRR methods are only used, respectively, by 42 and 50 companies (*i.e.* 15.7 % and 18.8 % of the respondents). One hundred seventy-nine firms only use one criterion (typically the payback method), and 57 firms use more than one method: 38 use two methods and 29 firms use all three methods.

In contradiction with finance theory prescriptions, the payback method selection criterion is not a short time horizon (less than two or three years), but often much longer periods (as shown in Table 6)[8]. Seventy percent of the firms are prepared to wait more than four years to have their initial investment paid back.

8. The information provided by the firms comes in different forms: one figure for the number of years, often a range of years, such as 3 to 5 years, sometimes stating the maximum 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 in Table 6 are either the number of years reported, or in the case of a range of years, the average of the lower and upper boundaries.

In addition, the period considered for the financial evaluation of energy efficiency projects often depends on the types of investment (building, production equipment, *etc.*). This is the case for 188 firms having answered this question (out of 266 responding firms).

NON-ENERGY-BENEFIT

NEBs is an important issue as they often raise investment strategicity through their contribution to a better value proposition, lower costs and lower risks. Of course NEBs vary from one investment project to another and between business activities. Not all proposed NEB concern all firms.

The questionnaire provided a list of 31 potential NEBs to choose from. Two hundred fifty-six firms answered the question; on average, a firm considers 9 to 10 non-energy benefits. The highest score was obtained by "reduction of maintenance cost and technical control of equipment" entailed by energy-efficiency investment (selected by 133 companies out of the 305 having answered the questionnaire), followed by "impact on reputation and corporate image" (115 companies). "Improved security and working conditions" comes in third position (113 companies) and "Lower CO_2 tax or tax exemption" in fourth position (110 companies).

IMPACT ON PERFORMANCE

Energy performance is of course the primary objective of energy-efficiency investments. However, rather surprisingly, 22 % of the firms participating in the survey did not have an opinion regarding the effects of energy-efficiency investments on their energy consumption. Energy consumption was stabilized or increased for 15 % of the firms, but most firms experienced a decrease of their energy consumption (176 firms or 63 % of the respondents).

Energy investment may enhance the performance of the firms through various channels (*i.e.* apart from their impact on energy performance). Besides an immediate effect on profitability (through cost reduction), energy-efficiency investment may also increase product competitiveness (through, for instance, improved product quality or reduction of costs other than energy costs), especially in the medium (one to four years) or long run (more than four years)

About 271 firms self-evaluated this impact. As shown in Table 8, about 40 % of them estimate that nothing has changed for them 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 have experienced some performance improvement. Very few enterprises think that energy-efficiency investments have deteriorated their economic performance. Finally, a significant third of the firms are not able to evaluate the impact, or do not know.

Generally, the impact of energy-efficiency investments on energy-efficiency and on general performance is positive regarding the level of energy consumption but neutral regarding general business performance. This could be explained by the different main scope of investment projects (energy and non-energy investments) as well as by the time lag existing between the initial spending (CAPEX) related to an investment and the investment impact. Of course, the general economic performance depends very much also on external factors such as market demand and competition.

Main results and conclusion

As stated in our research model, our aim was not only to assess energy management level, energy-efficiency investment strategicity, energy-efficiency investment decision-making and energy-efficiency/business performance in LSECs, but to above all, evaluate the relationships between these different variables or, more precisely, the influence of each variable on the successive ones: influence of energy management on the perceived strategic character (or "strategicity", defined as the contribution of investment to firm competitiveness), of energy-efficiency investments, influence of investments strategicity on investment decision-making and influence of the level of investment on energy performance. Energy-efficiency investments are likely to become strategic if they contribute to core business, e.g. in taking into account non-energy benefits of the investment project.

Table 7. Impact of energy-efficiency investment on energy consumption.

	Frequency	Percent
Increase 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 %

Table 8. Impact of energy efficiency investment on economic performance of the firm.

	Deterioration	Unchanged	Improvement	Impossible to evaluate	Do not know	Total
Price or cost competitiveness	6	103	78	47	37	271
Product competitiveness (innovation)	0	118	50	53	44	265
Profitability	5	88	97	41	36	267

M_Key research results give a mixed image of energy management systems in LSEC: 50 % of them have no energy management or a weak energy management (with a maximum of 10 points out of a total achievable score of 23 points). The results show no significant improvement compared to Cooremans (2012b) survey, based on the same measurement tool submitted to 35 major Geneva electricity consumers (LSEC consuming more than 1 GWh/year), between June 2006 and June 2007. This is a surprising result, since it can be interpreted as a sign that energy issues did not gain importance in firms over the past 10 years.

Results seem to confirm previous research findings regarding the influence of size on energy management, since companies below the LSEC threshold, seem to have a lower level of energy management. In this regard, it would seem likely that small consumers are less incited to take care of their energy consumption, because of their comparatively low energy intensity (energy cost), or/and because they are not involved in a cantonal public program aiming at promoting energy efficiency. But this is by far not true for all small consumers.

In general, the simple correlation results support the hypothesis that large firms and energy consumers tend to be more aware of energy issues which translate into support by top management and into setting up monitoring and control of energy consumption. Being a member of an international group is likely to be another positive driver of energy management. Public policy has also an impact on the level of energy management, especially in firms which have concluded a target agreement in order to partially or totally escape the CO_2 tax (significant correlation coefficient of 0.41). Undergoing an energy audit seems also to be a key factor in the process of adopting an energy management system (0,66 correlation), a finding which can be interpreted in two ways: 1) the audit follows an increasing concern regarding energy consumption (motivated by cost, environmental or tax escape reasons), or 2) the audit triggers a more active energy management.

An important finding is that the better the energy management system is, the more likely the chances for a positive decision on energy-efficiency investment are. 223 out of the 305 firms having validly answered our questionnaire (73 %) provided meaningful information on their energy-investment projects. An analysis of energy management level in relation to the volume of energy-efficiency investments realised reveals that the correlation coefficients between energy management and energy-efficiency investment are low but significant. On the contrary the correlations between the energy-efficiency investment variables and the group of eight drivers used to measure investment strategicity are small and insignificant. This negative result could be due, as mentioned in the previous section, to measurement problems of energy-efficiency investments; alternatively it could express a low influence of energy management on the perceived strategic character of energy-efficiency investment. This finding has to be further analysed and refined in the coming statistical and econometric analysis, as well as in the next research steps (interviews and case studies).

In conclusion our survey's results seem to suggest no correlation between energy management and energy-efficiency investment strategicity, but a positive correlation between energy management and energy-efficiency investment. The last relationship of our research model – the influence of energy-efficiency investment on LSCEs' energy performance – cannot be – on the basis of the survey – properly assessed. More information on this relationship will be provided by the second and third phases of the research project, i.e. through interviews and case studies.

Our results extensively depict, for the first time, large-scale energy consumers in Switzerland. They confirm the diversity observed by previous research regarding for-profit companies. This is not only due to the variety of business activities included in the Swiss legal category of LSEC, it is also 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.

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, to have a high level of energy management and, more importantly, to have bridged energy and process issues in investment decision-making process. This means that process people and energy people work hand-in-hand and that all advantages of the projects – energy benefits *and* non-energy benefits – are taken into consideration. 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 weighs little compared to the many "more important investments." The human dimension remains

a very important driver of investments with personalities and relationships between people playing an important role.

Governmental public policies, as an important complement to the usual financial instruments, should help firms in adopting and developing energy management systems. Reference can be made to ISO50001. In addition to encouraging e.g. energy audit (usually by some lump subsidies), government may opt for training present and future energy managers in their managerial, analytical and communication skills.

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Annexes

ANNEX 1

Table A1. Number of firms by size and sectors.

NOGA code	Label	Micro (0–9 FTE)	Small (10-49)	Middle (50-249)	Large (≥ 250)	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 products, and other non-metallic mineral products	0	3	8	4	**15**
24, 25	Manufacture of basic metals and fabricated metal products	1	6	17	11	**35**
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	10	24	11	**48**
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**	**54**	**119**	**105**	**302**

ANNEX 2 – STRUCTURE OF M_KEY QUESTIONNAIRE

Section 1. Characteristics of the company (12 questions)

The first section of the questionnaire identifies the main characteristics of the responding firm (location, number establishments, group or independent firm, employment, sector of activity, energy consumption). The data will be used to compare and derive a typology of the responding firms, and if possible to check the representativeness of the respondent firms. This information is used for determining the independent factors and characteristics which might influence the (level of) energy management and energy efficiency investment.

Section 2. Energy Management (12 questions)

Section 2 evaluates the level of energy management. The level of energy management is measured empirically by the method proposed by Cooremans (2012b). The questions in Section 2 constitute a simplified audit of energy management, based on the most important elements of the international norm ISO50001 and national standards for energy management (DK, IR, NL, SW and USA). The questions in this simplified audit comprise the following items: diagnosis of present consumption, definition of an energy policy at company level, existence and role of an "energy manager," importance of the energy issues within the firm, activities related to energy savings, 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, reward schemes). The answers to a selection of 5 questions (out of 12) are used to calculate a scale for measuring the level of energy management. The maximum score that a company can obtain is 23 points. A high number of points means a high level of energy management; a low number means that less attention is given to energy management.

Section 3. Drivers and barriers of energy efficiency investment projects (2 questions)

Section 3 tries to identify what the main factors positively and negatively influencing energy-efficiency investment decision-making are. Both questions of Section 3 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 has the possibility 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 = completely unimportant; 2 = unimportant; 3 = moderately important; 4 = important; 5 = very important).

Section 4. Evaluation of Energy Efficiency Investment Projects (6 questions)

There is little information available in the literature on the financial evaluation and the selection of energy-efficiency investment projects. Section 4 comprises the financial methods and criteria used by firms in evaluating and selecting 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 (NEB) the firm might consider when deciding ee-investment projects.

Section 5. Public Policy (5 questions)

Public policy very likely has an impact on the awareness of energy issues and on the level of energy management. This section asks if and how the firms are participating and sharing the various public policy models which can be chosen and implemented (audit, target agreement to reduce energy consumption, *etc.*) and which partners they chose to implement energy efficiency measures.

Section 6. Impact on performance (2 questions)

This last section aims to evaluate, in very general terms, the impact of energy-efficiency investment on firms' electricity consumption and on their financial and economic performance.