Integrating the non-energy benefits of energy efficiency into business decision-making: results of 23 pilot assessments in European companies

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ABSTRACT

Energy efficiency investments have a wide range of non-energy benefits (NEBs) that far outweigh their energy benefits. Unfortunately NEBs are not included in investment evaluations, due to a general lack of data, methodology and skills. Meanwhile an under-investment in energy efficiency is observable across all countries and business activities. In this context, the aim of this paper is to present the findings of a recent EU research which focused on the evaluation of investment projects at the level of industrial or service companies. The objectives of the research were threefold: 1) to contribute to the knowledge of the non-energy benefits associated with energy efficiency investments 2) to test a new approach to increase the uptake of energy efficiency investment. 3) to build up a solid knowledge base to describe and compare NEBs. In line with the double theoretical framework applied, this research sought to evaluate NEBs in financial terms but also in strategic terms, ex-ante, i.e. before investment implementation, a first in the field.

This paper first synthesizes the literature on non-energy benefits that was extensively reviewed at the outset of the project, and describes the dual theoretical framework for investment decisions that can be used to study NEB. It then briefly describes the methodology for and the results of 23 pilot evaluations in the EU, Switzerland and the US. It is concluded that the new method proposed increases the attractiveness of energy-efficiency investments and opens a concrete way to reduce the energy-efficiency gap.

Keywords: Investment decision-making; corporate strategy; energy-efficiency investment; multiple benefits of energy efficiency; non-energy benefits

Introduction

With a contribution of about 35% of the emissions reduction, energy efficiency is the most impactful solution, on par with increasing renewable energy, in IEA scenarios. Energy efficiency is the technical dimension of energy performance, referring to methods and actions to optimize the operation of existing equipment and installations in buildings or industrial facilities, or to replace them with more efficient equipment. Possible actions to improve energy efficiency, or energy-efficiency measures (EEMs) are identified and assessed by energy engineers, often as part of an energy audit. To be implemented, these actions often require investments,[1] labelled in the literature as "energy efficiency investments".

[1] Capital investments (CAPEX) as opposed to financial investments (e.g. in shares, bonds).

In accounting terms, there is a difference between optimization and replacement: optimization generally translates into operational expenses, which are recorded in the company's income statement; replacing equipment results in an "investment", with the expense recorded as a fixed asset and depreciated over time on the balance sheet. In the conventional approach to energy efficiency improvement actions, the cash inflow of the investment is only constituted by the reduction in energy costs induced by the energy savings.

Traditionally, the energy savings from equipment replacement are indeed the only argument put forward by energy engineers who design investment projects and submit them to the company's management. According to this logic, the greater the reduction in energy costs, in other words the higher the "energy benefits", the more profitable the investment in energy efficiency. This is indeed the case. However, as always in the evaluation of investment flows (whatever the purpose of the investment), the reduction in energy costs is hypothetical because it depends on the future evolution of the parameters considered.[2] In addition, because the case for energy conservation does not generally reflect core business needs and interests, many energy projects lack appeal to senior business executives and are not approved and implemented (Cooremans 2011, 2012).

Yet, as we will see in more detail in the next section, research has shown that improving energy efficiency has a wide range of non-energy benefits (NEBs) that go well beyond reducing energy consumption. At company level, non-energy benefits of energy-efficiency investments include improved product quality, higher flexibility or reduced time of production, reduced production loss, and reduced risks. Often-observed examples of NEBs include reductions of maintenance cost, increases in workplace comfort or safety, increases in industrial productivity and a reduction in GHG emissions. According to research published on the topic over the past twenty-five years, NEBs are valuable to companies not only in financial terms but also because they contribute to the achievement of key strategic business objectives.

However, NEBs are generally not included in energy efficiency investment appraisals, even in energy-intensive or large industrial companies (Iten et al. 2017; Worrell et al. 2003). Similarly, in residential real estate, NEBs are not included in the financial evaluation of energy retrofits by investors (Bragolusi and D'Alpaos 2022; Almeida and Ferreira 2018; Bozorgi 2015).

In this context, this paper presents the results of a recent EU research project,[3] M-Benefits, which focused on investment projects at the level of individual companies rather than at a macroeconomic policy level. The objectives of the research were threefold: 1) to contribute to the knowledge of the NEBs associated with energy efficiency investments in energy user companies; 2) to test a new approach to increase the uptake of energy efficiency investment projects by organizations, especially for medium to very large for-profit businesses operating in the manufacturing and services sectors. 3) to build up a solid knowledge base to identify, evaluate and compare NEBs.

The rest of the paper is organized as follows: Section 2 synthesizes the literature on non-energy benefits that was extensively reviewed at the outset of the research, and describes the dual theoretical framework for investment decisions that can be used to study NEBs, as well as the hypotheses that arise from it; Section 3 describes the empirical research conducted to test the

[2] For energy efficiency investments, these parameters are: the difference in consumption between the old and new equipment; the annual number of hours of use; energy prices; and the loss of efficiency or obsolescence of the new equipment over time.

[3] An EU research project (March 2018-October 2021) of the EU research program Horizon 2020, TOPIC EE-15-2017 Increasing capacities for actual implementation of energy efficiency measures in industry and services.

hypotheses; in Section 4 we describe the results of the research, before concluding that it is important to better include non-energy benefits in the evaluation of investment projects.

Literature review: methodology and findings

The literature review examined the following areas in the search for innovative approaches to including NEBs in investment evaluation: organizational behavior, individual and organizational decision-making; organizational finance; business strategy and investment decision-making.

Several types of searches were conducted - expert identification, database searching, conference proceedings, snowballing - in order to provide a broad coverage of academic and non-academic literature. The results from the searches result in a database of 295 documents. An iterative selection process finally resulted in 31 documents to be thoroughly analyzed.

The review findings are described thematically in this section. The first part considers energy efficiency investments in the broader context of investment decision-making and identifies two theoretical frameworks applicable to investment decisions that currently exist. The second part focuses on the NEBs of energy efficiency investment, and how they were identified, categorized and valued until today. The third section synthesizes the findings and provides a few key conclusions.

Investment decision-making: two theoretical frameworks to be applied in a complementary manner

The mainstream theory of investment decision-making is the financial theory of investment choices. According to this theory, any investment that meets the investor's predefined financial criteria of profitability should - and will - be decided and implemented. Based on this conventional framework, research interest in NEBs has focused on making financial logic more attractive by including more benefits (expressed as incoming cash flows) in investment flows and calculations (as exemplified by Worrell et al., 2003 and Lung et al., 2005).

However, research works challenge the principle on which financial logic is based, namely that investment decisions are made on the basis of financial returns alone, emphasizing that the contribution of investments to the company's strategic and business objectives is a more important decision-making criterion (UNEP 2017; Russel 2015; Cooremans 2011, 2012, 2015; Banks et al. 2012; Pye and McKane 2000). According to these authors, the strategic nature of an investment, is the primary driver of investment decision-making, before financial attractiveness. Energy efficiency is generally "not a primary driver in industrial decision making […] it is generally the productivity gains that will motivate industry to take action" (Pye & McKane 2000, 175). UNEP (2017) argue that energy-efficiency decisions in companies indicate a low priority for energy efficiency as it is not in line with core business objectives. However cultural and institutional forces influence organizations' behavior and so their energy behavior (Andrew and Johnson 2016; Russel 2013) and their investment decision-making behavior (Cooremans 2012). Bailey et al. (2009) advocate both a better understanding of organizational behavior among energy experts, and the integration of risk and risk management into energy audits.

Cooremans (2011) seeks a theoretical framework to incorporate the findings of this alternative literature on energy efficiency investment decision making and on the importance of the strategic logic; to this end, she explores the research field of strategic investment decision making,[4] a sub-field of the broad research area of organizational behavior. After an extensive review of the literature on "general" investment behavior and the literature on energy efficiency investment decision-making, Cooremans (2011, 2012) proposes to approach energy efficiency investment projects from a strategic perspective rather than from a classical perspective focused exclusively on energy-saving. Any decision is more or less strategic. The more strategic a [investment] decision is, the more it contributes to competitive advantage… Competitive advantage is composed of three interrelated constituents: value, costs, and risks. Thus, by evaluating the contribution of an investment to a company's value proposition, cost reduction (operational and investment) and risk reduction, we assess the more or less strategic nature of this investment (Cooremans 2011, 483 486).

The strategic investment decision-making approach has been validated in different ways: 1) by research studying strategic investment decision-making (in areas of investment other than those related to energy use). 2) by a few research works in the field of energy efficiency (Cooremans and Schoenenberger 2019, Iten et al. 2017, Cooremans 2012). Iten et al. (2017) furthermore showed that: a) the higher the company considers energy to be a strategic resource, the higher its level of energy management; b) the more strategic the nature of the project, the more flexible the financial return requirements for investment projects (a confirmation of a few rare pieces of research which would merit further work).

NEBs, or in other words, the "energy related business outcomes" (Russell, 2015 22) of energy efficiency projects make the link between the fields of energy efficiency and strategic management (Pye and McKane 2000; Cooremans 2011, 2012, 2015; Banks et al. 2012; Russell 2015). They should be integrated and analyzed along the three dimensions – value/cost/risk – of the competitive advantage framework (Cooremans, 2011:487). Russell (2015:5) strongly emphasizes the need to align energy efficiency with business objectives. NEBS should become "integral to business decision-making" (Russell, 2015:23) and inspire larger project investments.

Types and impacts of non-energy benefits and related challenges

Academic interest in NEBs has grown in recent years, although the peer-reviewed literature is still relatively small (Fawcett and Killip, 2017). There has not yet been convergence of the language used. To name non-energy impacts of energy-efficiency improvement actions, various general terms have been used, including: "multiple benefits", "multiple impacts", "non-energy benefits" and "co-benefits".

In business-sector activities, at project level, they were named "productivity benefits" (Finman and Laitner 2001; Worrell et al. 2003); "ancillary and production benefits" (Lung et al. 2005); "non-energy benefits" (Pye and McKane 2000; Hall and Roth 2003; Cooremans 2011; Banks et al. 2012; Nehler and Rasmussen 2016; Cooremans and Schoenenberger 2017), "business benefit" (Russell 2015). The positive bias of the word "benefit" can be questioned but the observed impacts seem to be predominantly positive (Killip et al., 2018 304). In this paper, we use indifferently "non-energy benefits" (NEBs) or "business benefits" to describe the positive non-energy impacts of an investment project for organizations, the expression "Multiple Benefits" being reserved to describe all the energy and non-energy benefits of projects.

[4] Research in strategic decision-making investigates the topic from two angles: on the one hand, the 'processual' angle, which examines the decision as a process consisting of several steps and looks for the factors influencing this process; on the other hand, the 'content' angle, which seeks to assess the impact of the content and characteristics of the investment on the outcome of the decision-making process (which can be a positive decision, a negative decision, or a no-decision).

Many NEBs have been identified in business-sector activities, at project level (UNEP 2017; Cooremans 2015; Russell 2015; Nehler et al. 2014; Banks et al. 2012; McLain, Skumatz and Jennings 2007; Lung et al. 2005; Hall and Roth 2003, Worrell et al. 2003; Finman and Laitner 2001; Pye and Mc Kane 2000). They are described as having considerable influence and in certain cases even being the real reason for adopting an energy efficiency measure (Fleiter, Hirzel and Worrell 2012; Skumatz and Gardner 2005; Worrell et al. 2003). They are often quantifiable (Lung et al. 2005) but rarely quantified and included in industrial project assessments (Iten et al. 2017; Cooremans & Schoenenberger 2017; Worrell 2003)

NEBs were mainly studied in manufacturing industries like food manufacturing, building materials, steel manufacturing, paper manufacturing, chemicals manufacturing and textile manufacturing. Other streams of research analyze NEBs in commercial buildings and residential real estate. There is no agreed classification regarding NEBs categories, but many authors have classified NEBs as follows (with variations): Operations and Maintenance; Production or Productivity; Work environment; Natural environmental (a category which includes waste and emissions); Other.

In the literature, most attention has been given to quantitative assessments of NEBs and methods for extending the range of cost-benefit assessments. NEBs range from those which are quantifiable with good quality data and agreed indicators, to those which are intangible and hard to value. NEBs can be equal to or exceed the value of the direct energy savings (Christiansen et al. 2016; McLain, Skumatz and Jennings 2007; Lung et al. 2005; Worrell et al. 2003). Studies show that NEBs' value can be much higher than direct energy cost savings, with monetized 'non-energy' effects up to several times the magnitude of the energy cost savings (IEA, 2014, Urge-Vorsatz et al., 2015, Hall and Roth, 2003). The payback time drops significantly when including all the effects on productivity that the implementation of the investments entails in investment projects (Worrell et al. 2003); it falls from 4.64 to 1.64 years on average according to Lung et al. (2005). However, studies have all been conducted ex-post, after the investments had been implemented, which increases the difficulty of the financial evaluation[5] and decreases its interest.[6]

Challenges regarding including NEBs in investment project assessment, as described in more details in the research official reports (Fawcett 2018: Killip 2018), are the following:

A general lack of data. There is a general lack of both time-series and plant level data to assess the productivity impacts more accurately (Russell 2015; Hall and Roth 2003; Worrell et al. 2003; Skumatz and Gardner 2005). "Most survey respondents can be characterized as being interested in the concept of multiple benefits and any future findings, but are currently able to provide little data, if any" (Russell, 2015:6).

There are variations between the benefits observed and not all of them are easily quantifiable in monetary terms. Converting the value of qualitative benefits into a unit, such as dollars, that can be compared to other more quantitative benefits for further cost/benefit analyses may be difficult (Worrell et al. 2003; Lung et al. 2005; McLain, Skumatz and Jennings 2007). Many of the benefits are not a function of the EEM, but of site-specific or sector-specific factors

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[6] for three reasons: 1) to improve the financial attractiveness of energy-efficiency investment, NEBs must be included ex-ante to support and facilitate investment decision-making; 2) the collection of data for the evaluation is easier 3) if an ex-ante evaluation has not been carried out, it cannot be compared to the ex-post evaluation and the relevance of the hypotheses made on the investment return prior to its implementation cannot be assessed.

(Worrell et al. 2003); therefore the same benefits are not obtained each time an EEM is implemented (Lung et al. 2005).

Time and skill are required to track NEBs accurately; Industrial plants need to develop baselines of their ancillary costs [and NEBs] and doing so may be outside of an investment project's scope of work. If the ancillary savings turn out to be minor, then tracking them may not be worth the expense (Lung et al. 2005). Newberger et al. (2007) find that companies' staff lack the knowledge and experience to identify NEBs ex-ante, consistently and fully. A lack of data is also an issue, but the bigger problem is with people and skills

A lack of methodology may be the main reason for the lack of inclusion of NEBs in evaluations. Overall, to the exception of the methodology proposed by Cooremans (2015), there is no tool for evaluating the many potential benefits of energy efficiency investments. Work is on-going to develop assessment methodologies of NEBs in building retrofitting (Leskinen et al. 2020; Almeida et Ferreira 2018). As summarized by Russel (2015, 23-25): "Information documenting the project-level coincidence of energy and non-energy value creation is derived mostly from case studies that are prepared independently of each other and without reference to a standard methodology. Case studies are inconsistent in project definition… Facility-level data for actual projects are not only scarce, but also fraught with inconsistent definitions and contextual interpretations of both energy and non-energy improvements. Available project data are limited to a handful of isolated examples, quantities far below the threshold needed for reliable statistical inference. The potential for synthesizing existing project data for inferential purposes is almost nil". Therefore, "the task of developing a protocol for quantifying facility-level multiple benefits is daunting"; …a consistent analytical approach must be developed to "provide guidance to facilities that enables staff to recognize and monitor the multiple benefits that manifests in their business process" (Russell 2015, 23).

Conclusions from the literature review

Four general lessons can be drawn from the literature review: 1) NEBs of energy-efficiency improvement actions do exist, but are generally not reported in project assessment. 2) NEBs positively and significantly impact financial attractiveness of energy efficiency investments. 3) The conventional financial approach on energy-efficiency investments prevails although a strategic approach is needed to meet business priorities and to match the interests, and languages of top decision-makers in firms. This implies the need for energy experts training, so that they are better able to analyze and present decision options in ways that resonate with decision-makers. 4) There is a general lack of tools for evaluating the many potential benefits of energy efficiency.

The literature review concludes that more research is needed to better understand and describe the types and impacts of NEBs and the associated quantification problems, and that the narrow approach to evaluating energy efficiency investments that is practiced by companies must be broadened, in two directions: 1) non-energy cash flows (i.e. NEBs) need to be included in financial evaluations; 2) the conventional technical-economic evaluation needs to be complemented by a strategic evaluation linking energy efficiency improvements to the objectives and constraints of the companies' core business.

Theoretical frameworks and research hypotheses

In line with the conclusions of the literature review, NEBs must be analyzed using two different conceptual frameworks: the financial theory of investment choices, still the dominant perspective on capital investment decision-making, and the theory of strategic investment decision-making. Research works conducted so far show that NEBs are important for the acceptability of projects, whether they fit into one or the other conceptual frameworks.

According to the neo-classical finance theoretical framework of investment choices, any investment decision depends on a single criterion, profitability. NEBs seem to have a strong potential to increase the profitability of energy efficiency investments compared to energy savings alone, thereby strongly increasing their financial attractiveness. However, their impact on investment profitability needs to be better assessed, and possibly *ex ante*, before a decision is made, using the conventional DCF valuation methods.[7]

According to the alternative theoretical framework of strategic investment decision-making (SIDM), the strategic character of an investment is key for the acceptability of investment projects, more important than financial return. The SIDM approach leads to an investigation of how and to what extent NEBs increase the strategic character of energy efficiency investments. In line with Cooremans' theoretical framework (2011), the strategic character of an investment can be assessed by evaluating the investment impact on the three components of a company's competitive advantage: value; cost; risk. Results of the strategic analysis can be translated into financial form in the DCF flows, since the impacts of an investment on value and costs are mostly quantifiable and monetizable. This illustrates the fact that strategic analysis encompasses financial analysis. On the other hand, some of the results of strategic analysis are qualitative in nature (for example, the contribution of an investment to the realization of the company's decarbonization strategy).

Based on the literature review and on the double theoretical framework applied, the research project formulated two hypotheses to assess the importance of including NEBs in investment valuations: HYP. 1: NEBs strongly increase the financial attractiveness of energy efficiency investments. HYP. 2: NEBs strongly increase the strategic character of energy efficiency investments.

Results

The hypotheses and the tools[8] developed to value NEBs of energy efficiency investments in financial and strategic terms have been tested in 23 pilot assessments conducted by the 8 implementing partners of the research project, in collaboration with 20 pilot companies located in 6 EU countries, Switzerland and the US.

The aim of each pilot evaluation was to identify and value, in financial and strategic terms, the NEBs induced by an energy efficiency investment project. To this end, the analysis methodology proposed by Cooremans (2015) was completed and finalized by the University of Lausanne as part of the M-Benefits research project. In particular, the method includes a

[7] Discounted Cash Flows (DCF) methods and its traditional financial valuation metrics (Net Present Value, NPV; Internal Rate of Return, IRR).
[8] The 4-step methodology created by Cooremans (2011, 2015) was completed, and applied to test these hypotheses and value the financial and strategic benefits of energy efficiency in the pilot assessments.

checklist of potential NEBs, as identified to date through academic research or fieldwork.[9] The checklist was provided to the research partners as a guide for identifying potential NEBs. The NEBs identified were subjected to a double analysis: their contribution to the investment strategicity was assessed by evaluating the impact of each NEB on the three dimensions of competitive advantage: value proposition, cost, and risk; their contribution to the investment profitability was assessed using traditional financial theory valuation techniques.

Pilot projects were chosen in consultation between the implementing partners and the organizations they had contacted, without seeking to be representative in terms of sectors of activity and categories of action. Despite difficulties and delays caused by the covid pandemic, 22 exemplary pilot assessments have been completed and are documented in this paper, plus a 23rd project in partnership with 3M in the USA. Key elements were collected and analyzed for each pilot project by the lead author of this paper after the end of the pilot programme, based on reports provided by the implementing partners, which contain information about the pilot organization and the project itself, as well as energy and non-energy benefits.

Results are presented in the following order: 1) EEMs scope and organizations; 2) NEBs types and quantifiability; 3) strategic assessment of the NEBs identified; 4) financial assessment of the NEBs identified.

Project scope, energy efficiency improvement action category and energy benefits

The pilot assessments covered a very wide variety of technologies, sectors, and scales of intervention. Sectors featured included the glass, aluminum and micromechanical industries, furniture makers, food factories, supermarkets, sport and administrative buildings. The energy efficiency investments analyzed also differed considerably in the economic case for adoption.

Pilot organizations are very different in sizes, ownership and level of energy consumption. They are split among a variety of sectors, both in industry and in services activities. 20 pilot organizations were involved in the 23 pilot assessments (i.e., 3 organizations conducted 2 pilots each), of which 5 are SMEs, 6 are medium-sized companies and 9 are large organizations10. In terms of ownership, 14 organizations are private (5 of which are listed on the stock exchange, 4 are family businesses and 2 are cooperatives of the same large Swiss group) and 3 organizations are public companies or administrations. The level of energy management[11] is overall quite high (with 12 out of 20 organizations scoring 18 points or more out of a maximum score of 22), but very low in 4 SMEs out of 5, ranging from 2 to 7 points. Some data are not available for confidentiality reasons.

EEM categorization is based on the subsidized energy audit programme of the Etat of Vaud, Switzerland (2019). 10 pilot projects are in the Category Replacement of the existing system by a more efficient one (CAT10), by far the most frequent category. 3 projects each concern Heat / cold recovery and/or reuse (CAT8) and Improvement of the monitoring, control, and regulation system/concept (CAT6). The 4 renewable energy projects (REN) are in the same Category "Energy switch", involving a switch of primary energy source to produce secondary or useful energy. Energy consumption and savings potentials are very different from one site and pilot assessment to another: the energy saving potential ranges from 0.04% of total site

[9] The energy-efficiency projects assessed could include from 1 to 8 energy efficiency improvement actions (also labelled energy efficiency measures, EEM).
[10] SMEs have more than 10 and less than 250 employees, medium-sized companies have more than 250 and less than 5'000 employees and large companies have more than 5'000 employees.
[11] Energy management is evaluated on the basis of a 19-question questionnaire (Cooremans, 2012).

consumption (IND-1), to a massive reduction of 81.3% (IND-7). The energy consumption of the pilot sites involved in service activities is generally much lower than that of industrial sites.

Types and quantifiability of the non-energy benefits identified

Table 1 below lists the 10 most frequently identified NEBs in the pilot projects carried out in industry, classified by number of occurrences and by type, i.e., quantitative, or qualitative. Of the 10 NEBs listed, 5 are quantitative and 5 are qualitative. All the benefits identified (with the exception of the reduction in maintenance costs) are closely linked to the organization's core business, through their positive impact on safety, quality, contribution to the value proposition or risk reduction. NEBs identified in pilot assessments made in service activities are broadly the same as those identified in industry.

Of course, impacts are interrelated: for example, a reduced risk of work-related accidents will increase employee satisfaction and loyalty; a reduction in breakdowns may contribute to better product quality or consistency. Quantitative impact does not automatically mean monetizable: for example, air quality improvement of ambient air will be expressed in humidity rate, CO2 rate, pollution rate (CO, NOx, Sox). It is only at a second stage that the impact of an improvement in air quality on absenteeism, for example, is assessed, a NEB that has a monetizable value. Similarly, better thermal comfort, a non-monetizable NEB, has an impact on employee productivity, a monetizable NEB, thus valuable in monetary terms. This "cascade" effect is quite frequent and requires rigor in the assumptions and analyses.

Table 1. 10 first business benefits, by number of occurrences, identified in the 13 industrial pilots.

NON-ENERGY - BUSINESS - BENEFIT	Number of occurrences	Type
Reduced CO2 and energy price risks	11	Qualitative
Reduced maintenance cost	10	Quantitative
Contribution to company's vision or strategy	10	Qualitative
Improved staff satisfaction and loyalty	9	Qualitative
Reduced CO2 emissions	8	Quantitative
Reduced risk of accident and occupational disease	7	Qualitative
Improved image or reputation	7	Qualitative
Reduced malfunction or breakdown of machinery and equipment	6	Quantitative
Reduced unplanned downtimes	5	Quantitative
Improved product quality /consistency	5	Quantitative

A total of 251 non-energy benefits were identified across all projects, 58% of which /146//251) are quantifiable and 42% are qualitative. However, only 53% of the quantifiable NEBs were quantified across all 23 pilot assessments (but only 17% in the REN pilot assessments). On average, 11.6 NEBs per project were identified in the IND and TER projects.

Strategic assessment of NEBs

The research implementing partners evaluated the impact of each NEB on the strategic character of the investment project (or strategicity), distributed on the dimensions "Value

Proposition", "Costs" and "Risks" of the competitive advantage. The same NEB can impact one, two, or three dimensions at the same time.

In IND assessments, 54% of NEBs contribute to a reduction in pilot companies' costs, while 52% contribute to a reduction in risk and 48% contribute to an improvement in their value proposition. In TER assessments, NEBs contribute first to an improved value proposition (for 62%), secondly to cost reduction (57%) and thirdly with the contribution to risk reduction coming in third place (49%,). NEBs identified in REN projects contribute firstly to risk reduction (36%) and, secondly, to strengthening the value proposition (33%), cost reduction comes in third place.

The positive impact of energy efficiency improvement actions on product quality (goods or services) and employee safety is noteworthy: 24% of NEBs identified in IND assessments and 32% of those identified in TER assessments contribute to an improvement in product quality; 18% of NEBS identified in IND assessments and 26% of those identified in TER assessments contribute to an improvement in employee safety. Since switching to another primary energy source does not, in general, have an impact on the energy services used by companies, the REN assessments show little impact of this energy efficiency improvement action on product quality and employee safety.

Financial assessment of NEBs

The results of the financial analysis for the 23 pilot assessments are displayed in Table 2. The valuations are based on financial parameters provided by the pilot organizations' own finance departments: investment duration and discount rate, accounting depreciation time, tax rate. The initial capital expenditure (CAPEX) illustrates the wide diversity of the pilots, ranging from € 2,300 (REN-23) to €18 million (IND-6). The duration of the investment (set by the financial managers) ranges from 5 years to 25 years, with 10 pilot projects applying an investment duration equal to or less than 10 years. The discount rate applied by the companies and by public administrations ranges from 3% to 9% (the highest rate is applied by the Swiss group Migros). Regarding discount rate levels, it should be recalled that at the time the pilot assessments were carried out, interbank rates in Europe were negative. On average, the duration applied for valuing REN investments is longer than that of the IND and TER projects (20 to 25 years) and the discount rate is lower with a maximum of 6%, but the small number of REN assessments means that these results can only be generalized with caution.

Another important finding is the proportion of NEBs to EBs: on average, energy and non-energy cash flows represent 34% and 66% respectively of the total cash flows in the pilot evaluations. This means that NEBs constitute about 2/3 of the financial flows generated by the energy efficiency improvement actions that were analyzed in the 23 pilot evaluations.

As for the profitability of the investment, if only the EB (i.e. energy savings) are taken into account in the calculations, the internal rate of return (IRR) is not high enough to lead to the acceptance of the project on a strictly financial basis in more than half of the 23 pilot assessments. In fact, the IRR is even negative in 7 out of 23 of them. On the contrary, when NEBs are included, the IRR becomes positive in all but one case, and it is very closely below or (much) higher than the profitability requirements set by the company's financial management.

Table 2. NEBs in financial terms

ORGANIZATION	FINANCIAL FIGURES											
ANONYMIZED NAME	CAPEX in €	Investment duration in years	Discount rate %	ENERGY BENEFITS (EBs)		BUSINESS BENEFITS (NEBs)		TOTAL EBs + NEBs	FINANCIAL METRICS			
				Cash-flows 1st year	%	Cash-flows 1st year	%	Total cash-flows 1st year	IRR EBs only	IRR NEBs incl.	PAYBACK EBs only	PAYBACK NEBs incl.
ORG IND-1	100 000	10	7.5%	1 452	6%	24 000	94%	25 452	-20%	20%	43	4
ORG IND-2	900 000	9	7,5%	173 440	99%	1 000	1%	174 440	7%	7%	7	7
ORG IND-3	270 000	9	7,5%	124 017	58%	90 000	42%	214 017	50%	100%	3	2
ORG IND-4	330 000	5	3,0%	81 915	88%	11 300	12%	93 215	6%	11%	5	4
ORG IND-5	87 000	6	4,0%	21 939	74%	7 873	26%	29 812	16%	27%	4	3
ORG IND-6	18 000 000	20	6,4%	1 694 000	36%	3 054 000	64%	4 748 000	6%	15%	11	6
ORG IND-7	1 200 000	13	5.5%	230 000	82%	51 132	18%	281 132	8%	16%	8	6
ORG IND-8	500 000	20	6,4%	8 000	23%	27 347	77%	35 347	-6%	6%	N/A	N/A
ORG IND-9	24 500	10	8,0%	21 840	65%	11 590	35%	33 430	77%	118%	2	1
ORG IND-10	Confidential	15	9,0%	28 950	6%	436 000	94%	464 950	-9%	9%	32,9	8,3
ORG IND-11	30 000	8	6,0%	2 415	38%	3 998	62%	6 413	-8%	12%	13	4,7
ORG IND-12	Confidential	15	9,0%	210 877	78%	60 000	22%	270 877	7%	11%	11	9
ORG IND-13	16 500	15	8,0%	119 092	70%	50 008	30%	169 100	570%	781%	1	1
TOTAL IND NEBs		12	6,8%	2 717 937	42%	3 828 248	58%	6 546 185	54%	87%	11,7	4,7
ORG TER-14	375 000	15	2,0%	63 949	22%	226 263	78%	290 212	8%	55%	31	1,9
ORG TER-15	32 000	10	6,0%	11 605	55%	9 323	45%	20 928	16%	39%	5	3
ORG TER-16	107 000	10	4,0%	59 865	29%	144 830	71%	204 695	73%	334%	2	1
ORG TER-17	18 200	25	9,0%	2 929	64%	1 638	36%	4 567	2%	17%	21	6
ORG TER-18	N/A	25	8,0%	380 000	10%	3 391 200	90%	3 771 200	-12%	11%	49	8
ORG TER-19	3 395 000	10	4,0%	43 199	27%	114 689	73%	157 888	-26%	-10%	50	19
TOTAL TER NEBs		16	5,5%	561 547	13%	3 887 943	87%	4 449 490	10%	74%	26,3	6,5
ORG REN-20	1 525 000	20	3,0%	468 000	96%	18 150	4%	486 150	27%	28%	4	4
ORG REN-21	180 000	25	6,0%	83 229	100%	0	0%	83 229	5%	5%	14	14
ORG REN-22	280 000	25	6,0%	126 970	100%	0	0%	126 970	6%	6%	13	13
ORG REN-23	2 300	20	5,0%	222	6%	3 200	94%	3 422	-5%	27%	38	4
TOTAL REN NEBs		19	5,0%	678 421	97%	21 350	3%	699 771	8%	16%	17,3	8,8
TOTAL NEBs		16	6,0%	3 957 905	34%	7 737 541,33	66%	11 695 446	24%	59%	18,4	6,6

Table 2 above shows that, when including NEBs in the financial calculations, only 4 pilot investment projects out of 23 don't match companies' IRR requirements. The average IRR increases from 24% to 59% when NEBs are included. Similarly, the average payback is divided by 3 when NEBs are included, going down from 18 years (EBs only) to 6 years (EBs + NEBs). In two extreme cases, it drops from 43 to 4 years (IND-1) and from 33 to 8 years (IND-10).

Results about the impact of NEBs on the IRR and payback of the analyzed improvement actions are similar for the 4 REN assessments. Again it must be emphasized averages mask large differences in situations.

Discussion

Results are discussed in the following order: 1) NEBs in strategic terms; 2) NEBs in financial terms; 3) Theoretical framework and relevance of the strategic approach.

Non-energy benefits in strategic terms

Of all the 19 IND and TER pilot assessments carried out, cost reduction is the primary impact of NEBs, as 55% of the NEBs identified lead to a reduction in the non-energy costs of organizations that invest in energy efficiency. This result again illustrates that NEBs are generally not qualitative.

However, almost as many NEBs (117/122) contribute to strengthening the value proposition of organizations, enabling them to make a better offer to their customers. This improvement is likely to result in higher turnover (however, no assumptions about higher turnover were made in the pilot assessments). NEBs contributing to a better value proposition are sometimes quantifiable, others of a qualitative nature, such as contributing to the achievement of the organization's strategic objectives, or an improvement in the comfort and loyalty of employees.

Half of the NEBs identified also result in reduced risk for organizations investing in energy efficiency, risks that threaten the proper performance of the core business, such as risks of quality problems, risks of accidents at work, risks of unscheduled production stops. Risk reduction is a consequence of the frequent positive impact of EEMs on product quality and employee safety.

These results clearly confirm the strong and positive impact of energy efficiency investments on the productivity and competitiveness of organizations. Energy efficiency improvement actions, through cross-cutting organizational impacts, strengthens all the strategic resources of the core business.[12]. Based on these results, we can therefore consider that HYP. 2 stating that NEBs strongly increase the strategic character of energy efficiency investments is validated.

Non-energy benefits in financial terms

When only the energy financial flows are included in the calculations, the internal rate of return (IRR) is not high enough to lead to acceptance of the investment in more than half of the pilot assessments. On the basis of strictly financial criteria, these investments would therefore be rejected. When NEBs are included, the projects' IRR is always positive, ranging from 6% to 781%. 15 out of 19 projects have an IRR equal to or greater than 10%. On average, NEBs double the profitability of the energy-efficiency investments analyzed and divide the simple payback by 3, from 16 to 5 years. These findings meet those of previous studies (Worrell et al. 2003; Lung et al. 2005). Indeed "studies show even higher savings when MBs are monetized; up to 2-3 times greater than the financial benefit of energy savings" (Fawcett and Killip, 2020:23). However,

[12] Strategic resources include human, organizational, physical, technological, reputational, and financial resources.

previous studies have only been conducted *ex post*, after the investments have been implemented. The research program described in this article is the first to identify and evaluate *ex ante*, in a comparable, clear, and documented manner the non-energy benefits of clean energy investments.

The positive impact of NEBs on the financial evaluation of the pilot projects assessed is, overall, considerable, moving projects from unprofitable to profitable, or even highly profitable. These research results validate HYP. 1 stating that NEBs strongly increase the financial attractiveness of energy efficiency investments.

The discount rate applied by organizations to energy efficiency investment projects is between 3 and 9% and the duration of the investment[13] between 5 and 25 years. 10 pilot assessments out of 19 apply an investment duration equal to or less than 10 years, which is much shorter than the life of the equipment. Large differences in investment duration and discount rates between companies illustrate again a constant finding in organizational finance research: the diversity of financial practices and requirements of organizations.

Quantification of quantifiable NEBs must increase. This depends among other things on the availability and quality of the data collected from companies. Two explanations seem to explain the fact that about 50% of the quantifiable benefits were not quantified in the pilot assessments: 1) The implementing partners were not yet sufficiently experienced in applying the method. 2) Data was lacking in the companies (and data collection was often slowed down or even interrupted by the covid epidemic). But in the future, with training and better data collection, the percentage of quantifiable benefits actually quantified should increase, which will further increase energy efficiency investment profitability.

Theoretical framework and relevance of the strategic approach

Strategic considerations take precedence over financial criteria in investment decisions. The pilot assessment done at the 3M plant in Cynthiana, USA (IND-13), is emblematic in this regard: in spite of excellent financial figures - the energy-saving payback was less than one year - the project was blocked due to production constraints (the plant operates on a just-in-time basis, and it is difficult to divert production during the two days necessary for the EEM implementation). Taking NEBs into account allowed the project to be unblocked, not for financial reasons (although including NEBs made the payback even shorter), but due to the reduced risk of accidents, unplanned downtime and loss of raw materials, which were highlighted by the NEBs pilot analysis.

The financial criteria applied by companies to evaluate and select investments also highlight the predominance of strategic considerations over financial ones: investments in renewable energy production strengthen the company's reputation and reduce pressure from financial markets, making them more strategic than energy-saving investments in the eyes of decision makers. This results may explain why the duration applied to calculate the NPV and IRR is longer for renewable energy pilot assessments (20-25 years) than for energy efficiency pilot assessments (5-25 years) and the discount rate shorter (3-6% for REN projects, 6-9% for energy-efficiency projects). A shorter investment period and a higher discount rate, i.e. more stringent financial requirements, mechanically make the investment appear less profitable in the financial evaluation. Tougher financial criteria as a routine means of eliminating projects initially perceived as unattractive, no strategic, is thus illustrated again here.

[13] i.e., the number of years taken to calculate the NPV and IRR.

Projects must first be of strategic interest to a company's core business. When this is the case, access to financial resources is facilitated. This is a confirmation of previous research (Cooremans 2011 and 2012; Cooremans and Schoenenberger 2019, Iten et al. 2017) in three respects: 1) firms categorize investments; 2) firms apply different treatment (i.e., routines and procedures) to different categories; and 3) some categories are favored over others for strategic reasons and obtain easier access to financial resources.

Conclusion

Compared to previous works, this research was original for three reasons: 1) the analysis of energy efficiency investments and associated NEBs was related to the business model and decision-making processes of investing companies; 2) BNEs were assessed in financial and strategic terms, in accordance with the theoretical frameworks applied; 3) the NEBs of energy efficiency investments were evaluated *ex-ante*, i.e. before investment implementation.

The alternative theoretical framework of investment decision making and barriers to energy efficiency is again confirmed as relevant to better explain the investment behavior of organizations than the dominant theoretical framework of neoclassical economic theory.

The pilot assessments described are representative of the huge variety of companies and of energy efficiency investments that can be carried out in industry or service sectors: they are very different in scope and objectives, as are the pilot organizations. This diversity and the small number of projects analyzed do not allow for the generalization of the results presented here. However, these results appear to be valid insofar as they are consistent with the theoretical framework underlying the empirical research and consistent with the findings of previous (*ex post*) studies.

This is the first time that a method for evaluating non-energy benefits has been applied *ex ante* in an applied research project involving a significant number of pilot assessments in industrial and service companies. It enabled description and analysis of the non-energy benefits of energy-efficiency investment projects. In a systematic way, it considers the various impacts of these investments for the investing organization. This framework is applicable to any business activity, project, or energy audit to better inform energy-efficiency investment decisions. The methodology has been developed to equip energy consultants and auditors with the skills, language and tools needed to make visible the operational and strategic impacts and improve the financial valuations of energy efficiency investments. Th M-Benefits research demonstrates that there are many benefits of energy-efficiency investments, going well beyond the obvious primary objective of consuming less energy. These benefits, mostly quantifiable, have the potential to improve the business case for energy efficiency, to raise the attractiveness of energy efficiency investments for companies and, in turn, to reduce their energy efficiency gap. However, the NEBs of energy efficiency improvement have to be better identified and evaluated *ex ante*, to better document investment decision-making, and a knowledge base developed. With a bigger knowledge base and a larger community of experienced practitioners, the non-energy benefit approach would raise more interest from businesses' upper management with regard to energy efficiency and increase the number of energy efficiency investments chosen.

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