Competitiveness benefits of energy efficiency: a conceptual framework

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Abstract

Non-energy benefits—or according to IEA terminology, "Multiple Benefits"—of energy efficiency are attracting more and more attention. This is because of their potential contribution to the business case of energy efficiency.

However, much work has yet to be done on this important subject, and could go in two directions: 1) improving, at the theoretical level, the conceptual framework enabling assessment and description of non-energy benefits. This would make it possible for engineers in charge of energy audits and decision-makers involved in energy-efficiency projects to better take these benefits into account when they make technical, strategic and financial analyses of buildings or industrial processes; 2) collecting data on non-energy benefits in a harmonized way. This would enable the creation of a data base useful to practitioners in the field.

Within this context, the goal of this paper is to propose a methodology to assess and describe the industrial benefits of energy efficiency, one of the five categories identified by the IEA in its recent report (Capturing the Multiple Benefits of Energy Efficiency, Sept. 2014).

To address this goal, the paper is organized into four parts: the first part synthesizes the concept of competitiveness and of its components: value, risks and costs. The second part shows, with concrete examples, how non-energy benefits contribute to competitiveness through increased value proposition and decreased risks and costs. The third part describes the value process mapping tool—a business management tool commonly applied in industrial process analysis—and how it can be used to highlight the unique contribution of energy services to the value stream. The fourth part shows how to translate competitiveness benefits of energy-efficiency into financial calculations.

This new methodology enables a departure from the common view of energy as a commodity (where the goal is to save KWh) and to adopt a new perspective on energy and energy services as a strategic value for businesses.

Introduction

In commercial and administrative spaces, and in manufacturing, energy cost is usually a small portion of the total production cost and, therefore, it receives relatively little attention. Even when energy cost is high, core business considerations come first.

Replacing old equipment with newer, more energy-efficient equipment, translates into energy benefits, i.e. the energy savings induced by the change, translated into monetary terms. But new equipment very often induces non-energy benefits as well. Non-energy benefits (NEBs) include all the benefits entailed by new equipment which is not an energy benefit in and of itself. Often-observed examples of NEBs include maintenance cost reduction, increase in workplace comfort or safety (for instance when an old oven is replaced by a new, better insulated one), increase in industrial productivity (thanks to lower production time or a reduction of the rejection rate), and product quality improvement. A reduction in GHG emissions is another frequently-observed NEB of an energy-efficiency project. Similar to energy benefits, NEBs translate into financial benefits for the investor.

According to the International Energy Agency, if current trends continue in the years to come, two-thirds of the economic potential to improve energy-efficiency will remain untapped until 2035, including 55% of the energy efficiency opportunities in the industrial sector (in 2014, the IEA, in an effort to activate this huge untapped potential of energy-efficiency, issued a report on the "multiple benefits of Energy Efficiency" (IEA, 2014). As emphasized in the report, "identifying the multiple benefits that may be linked to energy-efficiency measures in industry could enhance the business case for action" (IEA, 2014:134).

NEBs have raised the interest of some researchers in the past fifteen years (Cooremans, 2011; Finman and Laitner, 2001; Lilly and Pearson, 1999; Lung, et al., 2005; Mills, et al., 2008; Pye & McKane, 2000; Russell, 2015, Sauter and Volkery, 2013, Worrel, 2003). In its 2014 report, the IEA offers a literature review of the main research findings regarding NEBs' financial contribution: "Work to date indicates the value of these additional benefits can be in the range of 40% to 50% of the value of the actual energy demand reduction per measure" (Lilly and Pearson, 1999; Pearson and Skumatz, 2002) (IEA, 2014:136). "Based on energy cost savings alone, project paybacks in aggregate were 4.2 years. With additional benefits included, the aggregate payback fell by more than half, to 1.9 years. This decrease in pay-back period from 4.2 to 1.9 years also emerged in other studies when additional benefits were included" (Finman and Laitner, 2002) (IEA, 2014:138).

The IEA report divides the multiple benefits of energy efficiency into five categories: 1. macroeconomic impacts; 2. public budget impacts; 3. health and well-being impacts; 4. industrial sector impacts; 5. energy-delivery impacts. This categorization, as usual in NEB literature (with the exception of Russell, 2015), does not distinguish between public and private benefits (or macro and micro benefits according to economics theory terminology). Macroeconomic and public budget are clearly public benefits; health and well-being and energy-delivery impacts can be public or private, although the financial benefits do not fall into the same cash-boxes. Industrial sector impacts are more clearly private benefits, although they can translate into nation-wide competitiveness increase and thus into GDP increase and into additional tax revenues.

Research has defined NEB categories at the company level based on which areas they impact. As described by Nehler, et al. (2014), most authors in the field (Finman and Laitner, 2201; Hall and Roth, 2003; Laitner, et al., 2001; Lilly and Pearson, 1999; Lung, et al., 2005; Pye and McKane, 2000; Worrell, et al.; 2003) agree on the following categorization of NEBs: Production, Operation and maintenance (O&M), Working environment, Waste, Emissions and Other. Kats, et al. (2003) provide a good description of NEBs in tertiary ("green") buildings. They classify NEBs along similar categories as those of research focusing on industry: productivity and health, water conservation, waste, emissions. Kats, et al. (2003) also mention an interesting category of the "insurance benefits" of green buildings (which they classify into four categories: work health and safety, property loss prevention, liability loss prevention and natural disasters preparedness and recovery; Kats, et al, 2003:81). Regarding company-level impacts from industrial energy efficiency projects, IEA uses the same categorization as those developed by research, with two exceptions: it adds a "competitiveness" benefits category and brings together waste and emissions benefits in a broad "Environment" category (2014:134).

The stance of this paper is that existing categorization remains too vague to fully describe NEBs or to build up a convincing business case for energy-efficiency projects. In addition, considering "Competitiveness" as a distinct category seems conceptually confusing, since any NEB contributes to increasing a company's competitiveness. Identifying and assessing NEBs is not an easy matter. "Hundreds of different benefits for industry have already been identified in past studies and surveys of energy efficiency project implementation, making it challenging to produce a definitive list of the most important ones" (IEA, 2014:134). “Because so few studies have been undertaken in this area, methodologies for quantifying wider benefits from energy efficiency measures in industry are still at the inception stage” (IEA, 2014:137). NEBs vary in terms of the time horizon in which they occur, as well as in terms of their measurability (which has to be made in physical, monetary and strategic terms). In addition, NEBs (the same applies to energy benefits) are not constant in time (as equipment efficiency usually decreases with time). All this complicates NEBs assessment.

NEBs can be identified upstream (to inform energy-efficiency investment decisions) or downstream (after investment decision-making, in a retrospective analysis). It seems that most NEBs reported have been found incidentally, i.e. ex-post, after implementation of energy-saving measures. To reinforce the business case of energy efficiency and increase acceptance of energy-efficiency investments, a method is needed to identify and analyze NEBs upstream, i.e. ex-ante, in early analyses of projects (energy audit analyses, technical, financial and strategic analyses), and to include them in investment calculations.

This paper focuses on upstream assessment. Its general aim is to provide businesses’ internal staff (energy managers, facility managers) as well as the external consultants advising them, with a conceptual and practical tool useful to better identifying and assessing the NEBs, and to better communicating them to decision-makers. This goal implies that the conceptual tool could apply to industrial facilities as well as to commercial/administrative buildings, with any type of business model. Residential buildings could be taken into consideration as part of the value chain of real estate businesses. In order to gather all relevant aspects and to convince all actors involved in decision-making processes, this goal implies bridging energy, operational and strategic aspects of energy-efficiency projects in an integrated analysis.

To address this goal, the paper is organized into four parts: the first part synthesizes the concept of competitiveness; the second part shows how NEBs contribute to competitiveness. The third part describes a business management tool used in industrial process analysis—the value process mapping tool—and how it can be used to highlight the unique contribution of NEBs to the value chain. The fourth part shows how to translate competitiveness benefits of energy-efficiency into financial assessment.

Part 1 - The concept of competitiveness

To identify, analyse and communicate about non-energy benefits in industry, a conceptual framework must be able to “effectively translat[e] and communicat[e] findings so that this performance becomes integral to business decision-making” (Russell, 2015:22) and it must also “provide guidance to facilities that enables staff to recognize and monitor the multiple benefits that manifests in their business process” (Russell, 2015:23). The strategic concept of competitive advantage can be used to translate and communicate the findings related to NEBs: competitiveness is a concept appealing to businesses because if they are not competitive they do not survive. The contribution of an investment to a company’s competitiveness (as it will be described later in this section) is one of the most important decision-making factors, even more important than investment financial profitability (Cooremans, 2011). NEBs contribute to competitive advantage. Therefore they have to be described in the analyses in a way that makes their contribution obvious and attractive to decision-makers in organizations.

Competitiveness arises mostly from core business activities. Energy issues (on the demand side) are generally perceived as being outside core business activities, as not contributing to core business activities. To attract upper management interest energy issues must be brought into core business. Non-energy benefits offer a way to achieve that.

> “Competitive advantage grows fundamentally out of value a firm is able to create for its buyers that exceeds the firm’s cost of creating it.” (Porter, 1985:3)

Competitive advantage means performing better than the competition. “Superior value stems from offering lower prices than competitors for equivalent benefits or providing unique benefits that more than offset a higher price" (Porter, idem). In other words, “it must deliver greater value to customers or create comparable value at a lower cost, or do both” (Porter, 1996:2).

Costs, or prices, are notions commonly and easily understood by every one of us. On the contrary, value is an elusive concept. The value at the source of competitive advantage is not a monetary value. It is “a set of benefits that a product (or a service) promises to deliver” (Kotler, 1999: 152)[1].

To illustrate the concept of a set of benefits, let us take the example of a car. Apart from its basic function—transporting one or several people from one place to another—a car can offer many benefits for its users: design, color, reliability, security, low consumption, low emissions, reactivity, services, branding and image, price. A car manufacturer will propose a set of these benefits to an identified customer segment. The set of benefits offered will differ from one customer segment to another.

Better described by the term “value proposition,” the concept of value lies at the heart of marketing. It is what sets a company apart. The value proposition is channeled to target customers, customers identified as those who will appreciate a particular set of benefits.

Buyers are willing to pay for the value a firm provides within its goods or services. Thus, value proposition translates into invoices and is measured by a firm’s total revenue. If a value proposition is convincing, more customers want the products and services or, even better, customers are ready to pay a higher price for these. The goods or services sold generate a turnover, in other words, revenue. Net income (or loss) is the difference between the costs supported to produce a value proposition and the revenue generated by the sales.

In the conventional view described above, competitive advantage is a bi-dimensional concept. These two dimensions are, on the one hand, value (which a firm is able to create for its buyers) and, on the other hand, cost (of creating this value). When Michael Porter developed the concept of competitive advantage in 1985, he did not consider risk to be included in the concept. Risk management is actually a rather new field in business management, which appeared only in the mid-2000s, or about twenty years after the concept of competitive advantage. In the complex and rapidly changing world of today, as discussed in a previous paper (Cooremans, 2011), one cannot only consider the cost of creating value. Risks of creating this value and of bringing it to customers have to be taken into account as well, for two reasons: 1. competitive advantage cannot be sustainable without risk management. A simple example illustrates this statement: if a company chooses a new, cheaper provider, but this one is unable to guarantee delivery times, the company’s production chain may be disorganized with disastrous consequences. In that case the cost gain on supply would be of no interest. 2. Risk decrease—or increase—impacts on cost and/or on value: for instance, new more energy-efficient equipment reducing the risk of failure will translate into a reduction of the maintenance; it may also generate an additional turnover because the company will be more reliable to its customers. Therefore, competitive advantage should not be considered as a bi-dimensional but as a three-dimensional concept, formed of three interrelated constituents: costs, value, and risks (Cooremans, 2011:19).

An investment is strategic if it contributes to create, maintain or develop a sustainable competitive advantage. This definition implies that an investment, or an investment decision, is not simply strategic or non-strategic. Strategic decision-making is a continuum, where decisions can be non-strategic, weakly strategic, strongly strategic or totally strategic (Cooremans, 2011). I suggested the term “strategicity” to express and describe the strategic character—or strategic nature—of an investment (Cooremans, 2012:503). Figure 2, below, represents this concept in a simplified manner.

By evaluating the positive contribution of an investment to a company’s value proposition, cost reduction and risk reduction, we assess its contribution to competitive advantage; in other words, we assess its strategicity.

[1] « Aujourd’hui, les entreprises performantes ne vendent pas des produits, mais des configurations d’avantages : ce n’est pas la valeur d’achat qui compte, mais la valeur d’usage » Kotler (1999, p. 152).

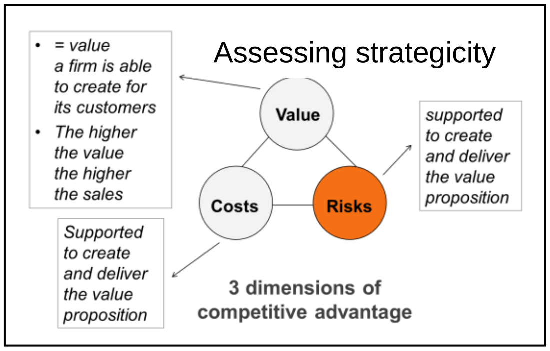

Figure 1 – The three dimensions of competitive advantage (Cooremans, 2011)

As emphasized by Michael Porter (1985:33), “competitive advantage cannot be understood by looking at a firm as a whole. It stems from the many discrete activities a firm performs in designing, producing, marketing, delivering and supporting its product. Each of these activities can contribute to a firm's relative cost position and create a basis for differentiation.”

To conceive and produce its value proposition, and to deliver it to target customers, a firm performs activities. Those activities—primary (or core business activities) and support activities— are integrated and coordinated in the value chain creation process. “The value chain disaggregates a firm into its strategically relevant activities in order to understand the behavior of costs and the existing and potential sources of differentiation” (Porter, 1985:37). Michael Porter’s concept of the value chain is reproduced below in Figure 3. It is called the “generic” value chain, because it must be adapted to any company and any type of business.

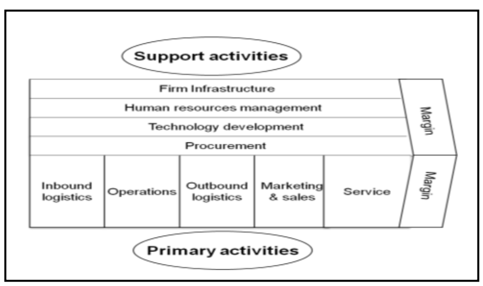

Figure 3 - The Generic Value Chain (Porter, 1985)

Each step of the value creation process is divided into substeps (not represented in the figure above), which have to be considered when analyzing a company’s business, processes, or value chain.

This section has been dedicated to describing the concept of competitive advantage. It has shown that competitive advantage, vital to businesses, is durably built up—or reinforced—through value (proposition) increase, cost decrease and risk decrease. Solutions to achieve that can be found in the multiple steps and substeps of a company’s value chain. NEBs, because they can contribute to corporate competitive advantage in its three dimensions, increase the strategic character and attractiveness of energy-efficiency investments. The next section will show exactly how.

Part 2 - Energy performance and competitiveness

How does energy performance contribute to a company’s competitiveness? The conventional approach offers only one answer to this question: it contributes through energy cost reduction. We can call the conventional approach the “commodity approach” because the only goal it pursues is to save kWh, through reduction of energy carriers consumed. A good example of the commodity approach is given by Kannan and Boie (2002): an energy audit is made in a huge industrial bakery in Germany where a 950 m2 modern production unit consumes annually about 225MWh electricity and 57,700L of furnace oil. The energy audit analyses the bakery process lines in the production unit, as well as energy conversion and management, to determine “which amounts of energy were consumed during a reference period and how this energy was used” (Kannnan and Boie, 2002:948). Based on these analyses, the energy audit recommends several energy-saving measures (conservation in bake ovens, lighting, hot water usage, insulation of pipes, recalibration of thermostat) which could save about 6.5% of the total energy bill—4000DM per year—and bring down the kWh consumed per kg of processed flour from 1.36 kWh/kg to 1.28 kWh/kg.

The audit briefly described above illustrates the commodity approach well because it gives no attention to how energy-efficiency measures could improve the quality of the products or the well-being of the operators, or could reduce production risks and costs (other than energy costs). In other words, no attention is dedicated to NEBs.

Yet many examples attest to the existence and importance of NEBs. Two real examples can be given here: a department store chain has installed LEDS to replace its lighting fixtures in the grocery department. This is because LEDs, contrary to the previous lighting system, do not emit any infrared rays or X-rays. As a result, they do not modify the color of fresh meat and fish and they do not cause the development of bacteria in plastic packaging.[2]

A second example is where a complete renovation of its lighting system in an assembling hall has allowed a bag manufacturer to divide by 22 the number of bags rejected by the quality control (due to color differences between the bags’ handles and the body).[3] In both cases above, the NEBs involved by the energy efficiency measures implemented were much more important than the energy benefits. In both examples, the energy-efficiency investments have entailed high strategic benefits, in terms of increased value proposition (products quality and security), reduced risks (commercial risk for both companies, legal risk for the department store company due to presence of bacteria) and reduced costs (less meat and fish thrown away because rejected by customers feeling they were not fresh anymore, less bags rejected due to color variations between their body and handles). In both cases, cost reductions driven by lower rejection rate are much more important than the reduction of energy costs.

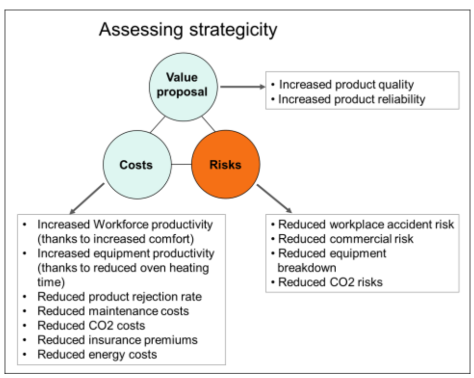

Figure 4 – Non-energy benefits induced by energy performance measures and their contribution to a bakery competitive advantage

In the bakery case described above, based on the information given by Kannan and Boie (2002), we can hypothesize the following NEBs involved by the energy-saving measures identified by the audit: increased product quality and reliability (due to a better heating quality of new ovens and to a better lighting), increased productivity (thanks to a smaller heating time of the ovens) and increased workplace comfort and safety (due to ovens and pipes insulation). Increased comfort leads to employee’s higher productivity and loyalty. Increased work safety reduces the risk of accidents, which can lead to reductions in insurance

[2] Source: the department store chain regional energy manager.
[3] Source: Ilico.ch, designer of the new lighting system.

premiums. CO_2 emissions would be reduced as well, together with possible carbon legal and commercial risk[4]. If adopted, energy performance measures would thus significantly contribute to the three dimensions of the bakery's competitive advantage: increased value (better product quality and reliability), reduced costs (higher productivity of ovens and employees, reduced rejection rate, reduced insurance premiums and maintenance cost), and reduced risks (increased workplace safety). Better product quality and reliability can lead to additional turnover. I have designed figure 4 on the previous page to show the contribution of these (hypothesized in this case) NEBs to the bakery's competitive advantage. It also shows how the three dimensions of competitive advantage are linked: for instance a reduction of the accident risk leads to a cost reduction, a better product quality leads to a lower rejection rate.

In order to fully take NEBs into account and to be able to convince all actors involved in energy efficiency projects, it is necessary to link the strategic analysis described in this section with two other analytical levels: the energy and operations levels. Such an approach requires including the energy services associated with the different stages or sub-stages of the value chain in the analysis.

Part 3 - Value process mapping

Since core business and competitiveness considerations drive businesses' choices, a business management tool (as opposed to an energy tool) has to be used as a starting point for the operations level analysis. Indeed, a business management tool is more likely to attract upper management interest and entail positive choices regarding energy-efficiency investment.

One suitable tool in this regard is the value chain analysis described in the previous section. Value chain analysis can be applied to different scales of analysis: to a whole company's value chain, to the whole logistic chain of an industry or to the level of a production process. To analyze energy efficiency and its potential improvements, the process line level seems the appropriate level of analysis, because it is the level at which we can fully integrate energy and operational analyses.

A process or a part of a process can be described using a "process map." Process mapping consists of identifying all steps (and/or substeps) forming the process, and representing them in a chart. A process map is a helpful tool not only to represent a process but also to gain a critical perspective on it. A good process map must have carefully defined boundaries. An illustration of process mapping is given in Figure 7, below:

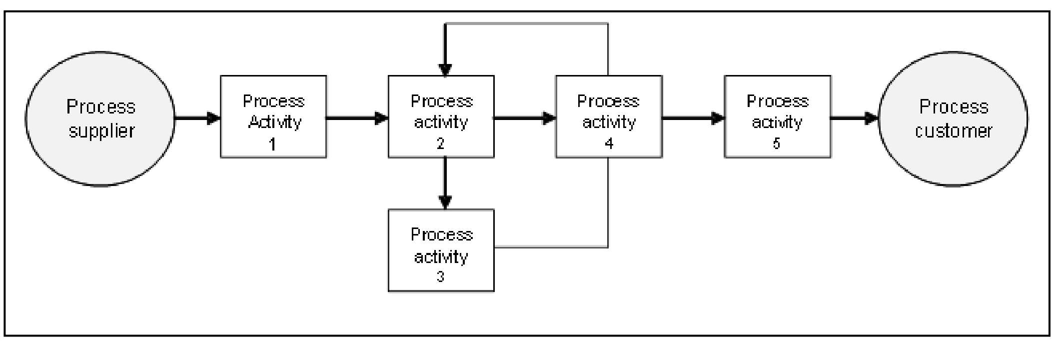

Figure 7 – Process mapping (George et al., 2005:40)

The above representation is not only valid for a factory. It can also be used for an administrative building or a commercial building. In the case of a commercial building for instance, all steps of the service production processes performed in the building have to be represented (in a large grocery store, the different steps could be reception, storage, display, and sales for each line of products).

In the case of an approach which takes into account both energy and operational aspects, the boundary of energy-efficiency projects must include both dimensions. Several elements have to be considered in this regard.

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[4] Depending on each country's legal context regarding climate change.

On the operational or manufacturing side, the most important aspects to be analysed for each process are the following: what the goals of the process are (defined to meet the expectations of the process customer), what the key factors are (production conditions), and what the risks of the process are. What are the (technical and organizational) means enabling improvement of its productivity, in terms of quality, time and cost?

On the energy side, different aspects could be taken into the analysis as well. Energy use in industry can be classified in direct and indirect energy use (Ramihisard et al., 2010), as energy is used in production/ manufacturing processes (direct) and in supporting processes (indirect) such as ventilation, lighting, heating and cooling, etc. Duflou et al. (2012) also mention auxiliary support processes (such as compressed air supply or centralized cooling). This terminology of "auxiliary" or "support" processes should not cause us to forget that ventilation, lighting, heating or cooling directly contribute to the quality of the manufacturing process in industrial facilities, and create direct value for the customer. Other aspects to be taken into account are waste energy and emissions emitted on-site in energy combustion.

The numerous factors to be taken into account in an integrated analysis of energy and operational (production) are well described by Duflou, et al. (2012:594) in their representation of a multi-machine eco-system.

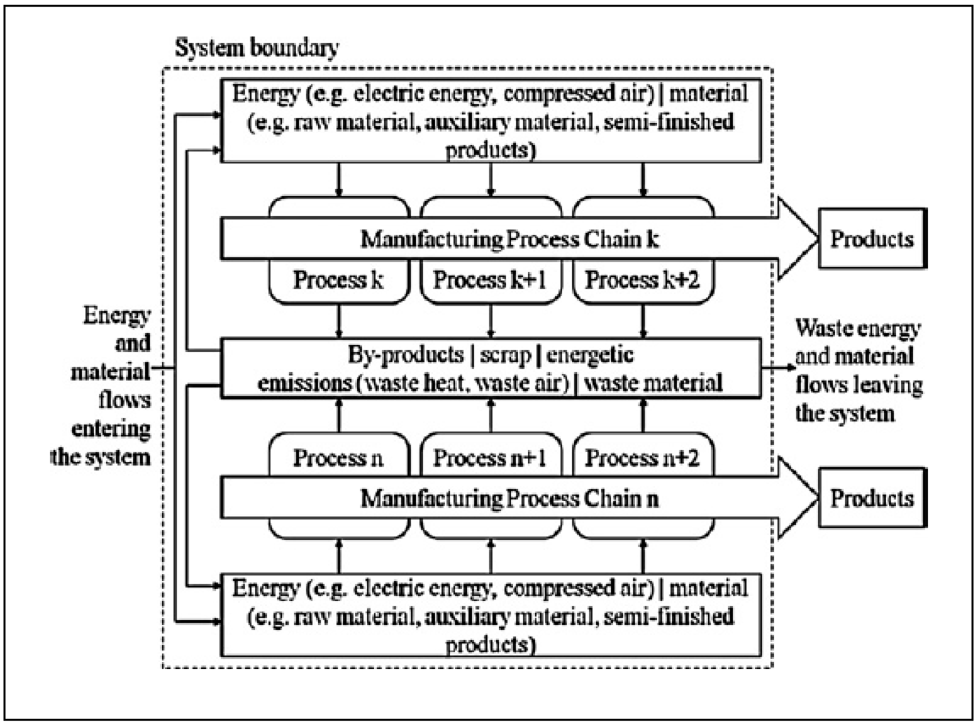

Figure 8. Multi-machine ecosystem (Duflou et al., 2012:594)

As shown in the figure above, energy and material inputs (raw materials, semi-finished products and consumables) are processed by each manufacturing line to produce outputs (semi-finished products, to be delivered to the next activity or process step, or final products to be delivered to outbound logistics). The transformation process from inputs to outputs also results in by-products (scrap), energetic emissions (waste heat, waste air) and waste materials. At each step of the process, many factors have an impact on energy and operational aspects of the transformation process: machinery and equipment used and their location in areas of production; work organization and sequencing; the quality of the building and of the technical services it provides; strategic goals, investment decisions and financial criteria defined by upper management. Energy services are not represented or mentioned in Figure 8, above; "energy flow" is only taken into account, a terminology which references energy carriers, such as electricity, heating fuels, etc.

Among the many aspects potentially impacted by an energy-efficiency project, the following aspects are the most important to analyze, taking into account operational, energy and strategic dimensions:

- production process time (speed)
- production process flexibility
- consumables (energy carriers, compressed air, lubricants, etc.)
- energy services
- materials (output quantity and quality)
- waste and emissions (by-products)

This analysis goes well beyond an analysis of the energy impacts of a project. Such a broad analysis requires multidisciplinary competences. Energy auditors, energy managers and operational staff in charge of the process have to join their skills and experiences.

To analyse the impact of an energy-efficiency investment, bridging energy, operational and strategic approaches, also implies a consideration of which energy services are involved in the various substeps of an industrial or commercial process. Energy services are the essential link between energy consumption (the conventional kWh commodity approach) and a value creation process (the strategic approach). This is illustrated by the example of aluminum foil production, described in the next paragraphs.

Figure 5, below, represents the value chain process of aluminum foil production. The first step of the process is casting, which involves pouring liquid aluminum into a mold and then allowing it to cool and solidify as an ingot. During the second process step, the pusher furnace reheats and homogenizes ingots, preparing them for the third step, hot rolling. During hot mill, foil is produced from the aluminum sheet stock by rolling it between heavy rollers. In step 4, cold mill, aluminum foils are further milled to the desired thickness. Even though this deformation process is called “cold” rolling, the strip is heated up to approximately 100°C during each pass and large quantities of coolant have to be poured over the rolls to keep a thermal equilibrium. Finally, in a fifth step (not represented in Figure 5), heat treatment of aluminum foil coils is applied for degreasing and final annealing of foil “wounds.”

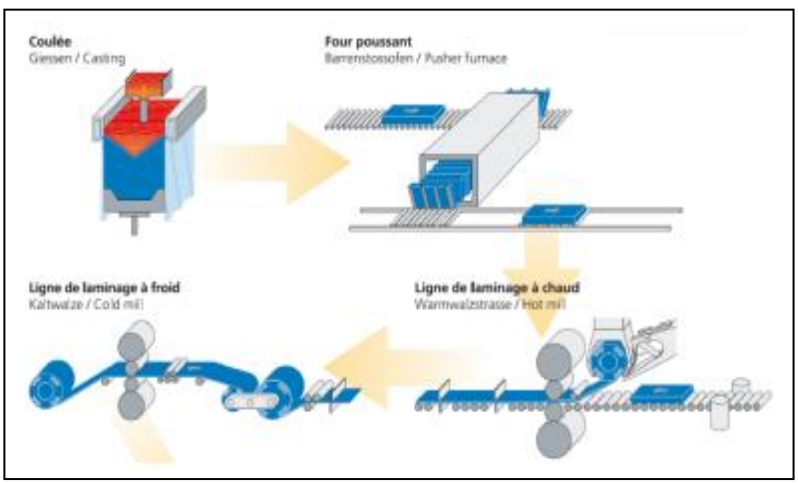

Figure 5 – Aluminum foil production process map (Germanier, R., Novelis Switzerland SA, Certificate of Advanced Studies in Energy Management – May 2014)

In order to represent energy services’ contribution to a production process, we have to identify which energy services contribute to which substeps of the process analyzed. The table below is a helpful tool in this regard. The second column on the left lists the main energy-operational services necessary for industrial processes in all industries. Each subsequent column to the right is dedicated to each substep of the aluminum foil process. Note that a conventional analysis (such as one made by an energy audit) would only focus on the energy carriers (listed in the first column on the left of the table), to investigate how their consumption by equipment and machineries could be reduced, without taking into consideration the essential contribution of energy services to core business and competitiveness.

At my request, Mr. Germanier, energy and project manager at Novelis Switzerland SA (a major world aluminum foil producer) indicated with a cross which energy services are necessary to each step of the aluminum foil production process, out of the main industrial energy services listed. I have built Figure 6, below, to include the required energy services in aluminum foil process mapping.

Table 1 – Cooremans C. - Germanier, R, Novelis Switzerland SA – "Energy-operational" services in the aluminum foil industry – Questionnaire received back on Jan. 27, 2015

ENERGETIC CARRIERS Primary / secondary	VALUE CHAIN ACTIVITIES OF ALUMINUM FOIL PRODUCTION ENERGY SERVICES - Primary / secondary	Casting	Pusher furnace	Hot mill	Cold mill	Thermal treatment
Combustible fuel	Air conditioning	x	x	x	x	x
(diesel fuel for worklift)	Automation (electronic regulation)	x	x	x	x	x
Natural gas	Atomization	--	--	--	--	--
Low-voltage electricity	Cleaning	--	--	--	--	--
Medium-v. electricity	Compressed air	x	x	x	x	x
High-v. electricity	Electric induction	--	--	--	--	--
(not used in aluminum	Electrolysis	--	--	--	--	--
foil production)	Heat - low temperature	--	--	--	--	--
Water	Heat - medium temperature	--	x	--	--	x
	Heat - High temperature	x	--	--	--	--
	Humidification	--	--	--	--	--
	Hydration	--	--	--	--	--
	Lighting	x	x	x	x	x
	Motive power - fixed (propulsion, electric drive system)	--	--	x	x	--
	Motive power - mobile	x	x	x	x	x
	Refrigeration - positive cold	x	x	x	x	x
	Refrigeration - negative cold	--	--	--	--	--
	Ventilation	x	x	x	x	x

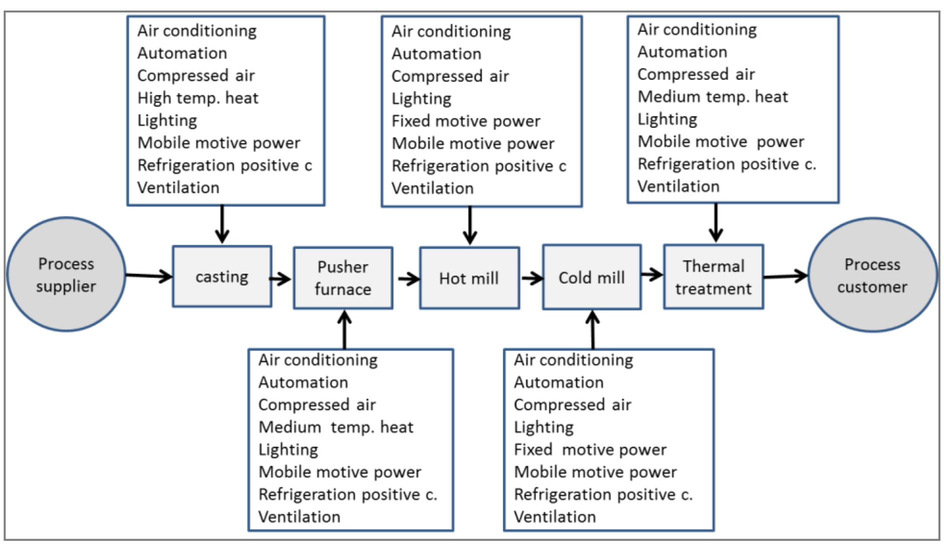

Figure 6 – Aluminum foil process mapping including energy services contribution

Once energy services involved in the process are identified, they can be analyzed using the following questions:

- Which energy services are common to all process steps or substeps?

- Which are the most important?
- What are the related constraints (or limits) and risks associated to each energy service?
- What the value contribution of each energy service is to each substep?

For instance, for lighting, a minimum of 300 lux is necessary in the production area of the factory and a minimum of 200 lux in the storage area. For high/medium temperature heat, minimum and maximum levels are necessary to ensure product quality. For compressed air, a certain level of humidity is required for product quality reasons[5]. Finally, the most important questions of all must be assessed: how can relevant energy services be improved in terms of reliability and quality, in ways bringing an improvement in production quality as well as a reduction in production time, waste, input materials and, last but not least, energy consumed.

The conventional commodity view, based on energy carriers (electric or thermal kWh) consumed, and not on energy services, does not allow this analysis, which is at the crossroads of energy services and operational constraints. At the process level, energy services are considered *not* as an energy issue but as a process control issue. This is confirmed by an interesting comment[6] from Mr. Germanier regarding what would happen if energy services were not supplied within the pre-defined limits: "In my mind, process control is essential to the quality and safety of the installation. A drift would cause an increase in energy consumption, but this would be treated as a second priority. To me, this is not a specific energy issue, but a process-control issue". This comment confirms that, at the process level of analysis, energy services are considered as being part of operations and not as energy issues. As a process control issue, energy services enter right into core business and gain the importance needed to be taken into consideration, opening the way to energy efficiency. Therefore, energy services are the right level of analysis to make the link between "commodity energy" and production process or operations. In other words, this level of analysis highlights the decisive contribution of energy services to a company's core business.

In order to bridge energy, operational and strategic levels, the last analytical step consists of translating the findings of the operational analysis in strategic terms. Once the different aspects of an energy-efficiency investment project have been analyzed following the conceptual framework described in the previous pages (value process mapping, identification of main energy services implied in the process and their contribution to this process), the project strategicity, i.e. its contribution to competitive advantage, can be assessed. This is made through an analysis of the contribution of each element analyzed to value increase, and risks and costs decrease. In the case of aluminum foil production, this contribution is synthesised in Figure 7, below. This figure shows one energy benefit (a reduction in the energy costs) and many important non-energy benefits.

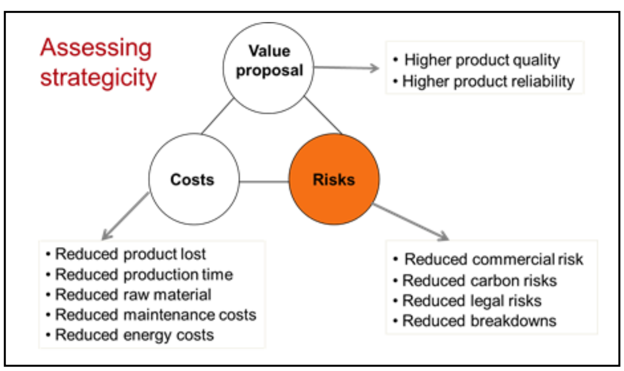

Figure 7 – Strategicity of an energy-efficiency investment based on energy services improvement

[5] The full analysis for each energy service and for every substep cannot be made here, for reasons of space and confidentiality.
[6] Made on January 27, 2015 as an accompanying note to the questionnaire.

In summary, section 3 has described a four-step methodology to bridge energy, operational and strategic analytical levels in an industrial energy-efficiency project. These four steps are the following:

1. Process mapping;
2. Identification of energy services involved in the process;
3. Analysis of the contribution of improved energy services to key process aspects (production time and quality, input materials, waste and emissions by-products, consumables);
4. Translation of operational improvements into strategic terms, through an assessment of their contribution to better value proposition, risk reduction and costs reduction. In doing so, non-energy benefits are emphasized.

Part 4 – Translating competitiveness benefits into financial calculations

Once the strategic aspects of an energy-efficiency project have been assessed, the last part of the analysis consists of translating strategic aspects into financial terms. As described in Section 1, a strategicity analysis is a good basis for financial assessment, since (as described in Section 1 of the paper), its three components can have impacts on investment profitability: improved value proposal will bring additional turnover; risk reduction can translate into additional turnover or reduced costs. On the cost side, many costs can be reduced beyond the energy costs. Once these aspects have been assessed in monetary terms, classic financial assessment methods (Net Present Value, Internal Rate of Return) can be applied to evaluate the profitability of an investment project. Risk impacts which cannot be translated into financial terms can be analyzed in qualitative terms, using risk management analytical tools.

Financial assessment of investment projects is often a difficult task. This does not apply only to energy-efficiency investments. However, very often figures exist and can be used. For instance, the process planning department usually has the related information, or is capable of computing it. The systematic analysis proposed in this paper enables identification of NEBs induced by an energy-efficiency project, translation of them into strategic terms, and in the end, into financial terms.

Conclusion

The conceptual framework described in this paper enables accounting for, in a systematic way, the most important aspects impacted by an energy efficiency investment. This analysis takes into account not only the energy impacts but also the operational and strategic impacts, i.e. the non-energy benefits impacts, of the projects analyzed. This broader approach enables emphasizing—and communicating—the strategic impacts of many energy-efficiency investments. Therefore it should raise more interest from businesses' upper management and, in turn, increase the number of energy-efficiency investments chosen.

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