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# Introducing a new perspective for the economic evaluation of industrial energy efficiency technologies: An empirical analysis in Italy

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ABSTRACT

An empirical analysis involving 130 Italian industrial firms showed that the economic viability of investments in energy efficiency technologies is mostly evaluated through indicators such as Pay-Back Time (PBT) and Internal Rate of Return (IRR), whose acceptability thresholds are affected by decision makers' risk propensity and other contingencies, such as the firm's financial health.

Our analysis suggests that these evaluation approaches hinder the adoption of several energy efficiency technologies, such as combined heat and power (CHP) plants, electric motors, variable speed drives (VSD), uninterruptible power supply (UPS), which are in fact economically viable if analyzed from a life cycle cost perspective, but appear to be unsustainable if analyzed through PBT or IRR indicators.

This paper addresses this issue by introducing a new evaluation perspective for investments in industrial energy efficiency technologies. Inspired by the life cycle economic assessment methodology for energy production plants – the so-called Levelized Cost Of Electricity (LCOE) – our indicator, called Levelized Energy Efficiency Cost (LEEC), correlates the energy savings that can be achieved through the implementation of an energy efficiency technology and the total costs incurred throughout the entire life cycle of the technology, e.g., initial investments, Operation & Maintenance (O&M), disposal costs. Accordingly, a technology can be considered as economically viable if the LEEC is lower than the energy price incurred by the firm, because in this case the economic benefits resulting from the energy saving due to the adoption of the technology is higher than the cost paid to obtain and operate it during its entire life cycle.

The application of such methodology in different Italian energy-intensive industrial sectors (e.g., automotive, cement, iron & steel and pulp & paper) shows that most of the considered technologies are economically viable, from the life cycle perspective on which this methodology is grounded. Therefore we suggest that the LEEC is a clear and simple tool for companies' decision makers to evaluate energy efficiency projects, to be used in combination with more traditional PBT or IRR indicators to gain a better understanding of the real economic viability of energy efficiency technologies.



## Introduction

In recent years, energy efficiency has become a hot topic in national and international policy discussion, being recognized as one of the most important factors for environmental and economic sustainable growth [23,39]. The industrial sector represents one of the greatest potential sources of energy efficiency. For instance, in Italy the industrial sector accounts for 24% of the national energy consumption [15], and its weight is similar to other European countries such as France (18%), Germany (25%) and UK (19%).

The European Union, through the well-known "20-20-20 package" [19], settled a non-binding target of 20% improvement in energy efficiency of the EU compared to projections for 2020, and recently approved the Energy Efficiency Directive – 2012/27/EU [63], which indicates to Member States how to achieve the 20% target on energy efficiency by 2020. Each Member State shall set its own non-binding national energy efficiency target, subsequently monitored by the European Commission. If necessary, the Commission will intervene with binding measures and adjustments for those nations that fall short of meeting their performance targets. Member States have brought into force the laws, regulations and administrative provisions necessary to comply with this Directive before 5 June 2014. Among the others, the Directive requires industrial and other large enterprises to conduct energy audits. Recently, a new framework in order to achieve a more competitive, secure and sustainable energy system and to meet EU 2050 greenhouse gas reductions target [20] has been

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agreed upon by EU countries, which includes new targets amending the former ones: a 40% cut in greenhouse gas emissions compared to 1990 levels, at least a 27% share of renewable energy consumption and at least 27% energy savings compared with the business-as-usual scenario and policy objectives for the period between 2020 and 2030 [21].

The Italian National Energy Strategy prioritizes energy efficiency as a cornerstone for a secure energy supply, for reducing energy costs for citizens and businesses, and for ensuring environmental protection through greenhouse gas reductions [39]. Among the current energy efficiency incentives available in Italy, the White Certificates scheme[1] is the most relevant for the industrial sector. Also thanks to a proactive legislation, important results have been already achieved in Italy, which ranks second worldwide among the most efficient countries [1].

However, much remains to be done, not only at Italian level, but also at the European one. Indeed, there are several barriers to energy efficiency, one being the proper economic evaluation of investments in energy efficiency technologies. Starting from an empirical analysis of Italian industrial companies, the aim of this paper is to analyze the decision making process for investments in industrial energy efficiency technologies, with a focus on the economic evaluation methods currently used and their drawbacks. The analysis focuses on the Italian market for energy efficiency because it is a relatively well-developed one and may be considered as a reference point for less-developed countries [1]. In this paper, a new indicator – the so-called Levelized Energy Efficiency Cost – is proposed and applied in different industrial fields and for different technologies that can be used in industrial processes. The energy consumption of industrial processes represents the highest part (around 90%) of the overall energy consumption in the Italian industrial sectors, with the remaining part due to the energy needs of industrial buildings.

The paper is organized as follows. Section literature review contains a literature review on the main indicators used to evaluate the economic viability of energy efficiency technologies. Section empirical analysis presents an empirical analysis of the Italian industrial firms aimed at identifying the most common criteria used to evaluate investments in energy efficiency technologies. Section a new perspective for the evaluation of energy efficiency technologies introduces a new indicator, called Levelized Energy Efficiency Cost, to evaluate the economic viability of energy efficiency technologies and compare the economic viability of different energy efficiency technologies calculated with a traditional methodology (i.e. PBT) and with the LEEC indicator. Finally, concluding remarks are presented in Section conclusions.

## Literature review

This section contains an analysis of the literature on the main indicators used to evaluate the economic viability of energy efficiency technologies, in both industrial as well as other sectors, such as households, services and public sectors.

In particular, we conducted an extensive review of the relative literature, considering the leading journals on this topic (Applied Energy, Applied Thermal Engineering, Energy, Energy and Buildings, Energy Conversion and Management, Energy Procedia, Renewable and Sustainable Energy Reviews, Renewable Energy, Sustainable Energy Technologies and Assessments). In addition to this, we searched in Google Scholar publications with "energy efficiency", "energy efficiency technology", "economic evaluation" and "feasibility study" among the keywords. This has led to the identification of many additional papers and highly cited books and book chapters.

From the 63 publications identified and analyzed in our literature review, these indicators emerge as most commonly used to evaluate the economic viability of energy efficiency technologies:

- Net Present Value (NPV);
- Net Present Cost (NPC);
- Pay-Back Time (PBT);
- Internal Rate of Return (IRR).

The NPV indicators uses the discounted differential cash flows generated by the investment during its operation, applying a discount rate that measures the risk level of the investment [65]. In other words, the NPV compares the present values of the net cash inflow forecasted for the future, with the initial capex investment to determine the profitability of the investment or project [59].

The NPV is calculated as follows:

$$\mathrm{NPV} = \sum_{t=0}^{T} CF_t/(1+i)^t$$

$T$ = project duration in years,
$i$ = discount rate,
CF (Cash Flow) = expected net benefit at the end of the each year.

With reference to energy efficiency investments, the annual cash flow includes the costs of the preliminary activities (before the implementation of the energy efficiency technology, such as audit, design and planning), the cost of purchase and installation of the energy efficiency technology (net of funds eventually obtained through third party financing) and the annual cost of operation and maintenance of the energy efficiency technology (including the cost of debt due to third party financing and the repayment of the obtained funds) as cash outflows, and the monetary value of the annual energy savings as cash inflows. Incentives may also be considered as cash inflows [67]. Besides, T represents the expected useful life of the energy efficiency technology. According to this method, an investment is acceptable if the NPV is positive. Morrone et al. [41], Bartela et al. [4], Vahl et al. [66] have adopted, among the others, NPV as the indicator to evaluate the economic feasibility of energy efficiency investments. A first issue related to NPV calculation regards cash flow estimation, which is inherently uncertain. Second, companies have different ways of identifying the discount rate, although a common method entails using the expected return of other investment choices with a similar level of risk [77].

A similar tool for evaluating energy efficiency investments is the Net Present Cost (NPC), which represents the total discounted cost of an asset during its entire lifetime [50]. Such costs refer to the cash outflows mentioned above for the Net Present Value calculation. When comparing two or more alternative investments, the one with the smallest NPC is preferred. Ren and Gao [49], Tempesti and Fiaschi [62] and Díez et al. [13] have adopted, among the others, NPC as the indicator to evaluate the economic viability of energy efficiency investments.

The Pay-Back Time (PBT) of an investment is a measure of the time that is required to reach the point at which the sum of the differential cash inflows (discounted or not discounted) is equal to the sum of the differential cash outflows (again, discounted or not discounted). Both cash inflows and outflows are the same as the ones mentioned above for the NPV calculation. Differently from NPV, the PBT is more subjective in its application, as the decision-maker has to define a maximum acceptable time (generally called

[1] White Certificates, also known as "Energy Efficiency Certificates" (EEC), are tradable instruments giving proof of the achievement of end-use energy savings through energy efficiency improvement initiatives and projects. The white certificates scheme was introduced into the Italian legislation by the Ministerial Decrees of 20 July 2004.