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Financial Indicators Within Energy Efficiency Evaluation[1]

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Abstract

The purpose of this paper is to present a (brief) literature review regarding the economic indicators – financial ratios – in the context of financial evaluation of energy efficiency projects, and in that manner to attempt to answer a research question which reflects upon the standard and non-standard methods of financial analysis within energy efficiency domain. The answers are given through desk research and literature review. A handful of frequently used measures of financial viability of energy efficiency improvements were found and presented; most of them tend to include the time-value of money into the equation, hence discount rates are particularly important for the analyses.

Keywords: Financial evaluation, energy efficiency, indicators, ratio analysis

JEL Classification: C49, Q40, Q51

1. Introduction

Energy efficiency is a hot topic not only in the era of global climate changes, but also within the perspective of never-ending cost-reduction efforts. Models and methods of estimating financial viability and long-term effects of energy efficiency improvement measures need to be (re)examined and reviewed in order to provide better information support for the policy makers and other stakeholders. The purpose of this paper is to present a concise literature review regarding measures of financial evaluation of energy efficiency developments, within the project titled "Methodological Framework for Efficient Energy Management by Intelligent Data Analytics" (supported by Croatian Science Foundation under Grant No. IP-2016-06-8350, http://www.efos.unios.hr/merida/en/).

Although energy efficiency has undoubtedly beneficial long-term effects (observable in our lifetime or not), accurately measuring and valuing it is within the domain of predicting the unpredictable, namely forecasting distant future and "measuring" (i.e. anticipating) variables with wide range of possible values. This is especially the case when making investment decisions – whether to invest or not into energy efficiency improvements, and what amount. Nonetheless, when past investments are reevaluated unmeasurable values also need to be conjectured and an answer needs to be given regarding what would have happened if investor had not financed energy efficiency improvements (Sajter (2017, p. 298)). However, when the researcher overcomes these obstacles s/he is found in the field of more or less "classic" investment decision making process. This paper aims to recast essential financial ratios which are used in this environment, with references to indicators which are often used in estimating profitability of investing in energy efficiency improvement measures.

This paper is organized as follows. The first chapter – introduction – reflects upon the importance of topic, states its purpose, and links it to a wider context. Second chapter provides background to the underlying key concepts of

[1] This work has been fully supported by Croatian Science Foundation under Grant No. IP-2016-06-8350 „*Methodological Framework for Efficient Energy Management by Intelligent Data Analytics*" (MERIDA). http://www.efos.unios.hr/merida/en/

economic indicators and financial ratios. The third is central to this paper, as it exhibits most often-used measures of financial viability of energy efficiency improvements. Final chapter concludes.

2. Economic indicators and financial ratios

Although it may sound somewhat politically incorrect, the quote "*statistics are like bikinis – what they reveal is interesting, but what they conceal is vital*" (Levenstein, 1951) may be ascribed not only to statistics, but also to economic indicators and financial ratios. Indicators and ratios also represent important insights into specific economic activities, but at the same time they are inevitably obscuring reality through simplifications and generalizations of underlying methodology. Nevertheless, when constructing financial indicators in evaluating energy efficiency improvements and/or projects there should be a distinct and precise demarcation between fundamental terms and concepts.

Economic indicators are statistics used in an attempt to determine the state of future economic activity (Encyclopedia Britannica, 2019). As such, they are also particularly relevant to energy efficiency evaluation. Some of the most influential economic indicators are employment, consumer prices, industrial production, retail sales, etc. Among them is the price of money – interest rate: an especially significant indicator which shows the cost of borrowing (Frumkin (2015, pp. 148–154), Temple, (2003, pp. 133–136)). By plotting various maturities together the yield curve is constructed; a range of returns on government securities from short- to long-term maturities. The yield curve influences the cost of capital for individuals, companies and the government, and is also among the most important indicators for the overall economy (Baumohl, 2013, pp. 349–354). It strongly affects the discount rate which is crucial in measuring financial viability of energy efficiency improvements. One should bear in mind that the term 'discount rate' sometimes specifically refers to primary credit from the central bank, i.e. short-term borrowing by commercial banks from the central bank (Frumkin (2015, p. 150), Tainer (2006, p. 241)). Interest rates are common economic indicators (The Economist, 2007, pp. 176–179), and they are the underlying basis ("wholesale" rates) for the calculation of the discount rates ("retail" rates), which are the interest rate used in discounted cash flow analysis to establish the present value of future cash flows from an investment in an energy-efficiency related or non-related project.

Investing in energy efficiency improvements is a subcategory of a general investment decision making process with certain specifics (Sajter, 2017). After choosing the appropriate discount rate (which in itself is a complex issue), the rate is then embedded into different measures which can be helpful in calculating the return on investment.

There are many measures used to devise return on investment. Some of them are (Bragg, 2007, p. 123) net worth, book value per share, return on assets employed, return on operating assets, return on equity percentage, return on common equity, financial leverage index, equity growth rate, earnings per share, economic value added, relative value of growth, dividend yield ratio, etc. Short list would always include net present value and internal rate of return (Walsh, 2006, pp. 241–257) On the other hand, some of these investment measures are not applicable for the energy efficiency valuation, and here the aim is to present the ratios which are specifically used for that purpose.

On the other hand, ratios are – simplified – tools for measuring value (Bull, 2008), or tools for turning the data into information (Rist & Pizzica, 2015). The category of return on investment contains, as presented above, a handful of ratios, but from these a subset is deduced to value energy efficiency improvements. The list of ratios used to measure financial viability of energy efficiency improvements is lengthy, so the next chapter will present only the most common ones.

Therefore, certain economic indicators are key ingredients in building ratios which are used for the energy-efficiency valuation, and caution is advised in designation and differentiation of the indicators, ratios and other economic measures.

3. Measures of financial viability of energy efficiency improvements

Frequently used measures of financial viability (cost-effectiveness) of energy efficiency improvements include (the list could always be expanded):

1. simple payback period,

2. discounted payback period,

3. net present value,
4. internal rate of return,
5. modified internal rate of return,
6. benefit-to-cost ratio,
7. total life-cycle cost,
8. revenue requirements, and
9. levelized cost of energy.

They are briefly presented in the following paragraphs; sources are Ruegg and Marshall (1990:3-104), Short, Packey and Holt (1995:39-73), and Goswami (2007:3.4-3.8).

Simple payback period (SPB) is the time required for net revenues associated with an investment to return the cost of the investment, computed without accounting for the time value of money. This evaluation method measures the elapsed time between the time of an initial investment and the point in time at which accumulated savings or benefits are sufficient to offset the initial investment. It can be represented by the following equation:

$$SPB = \min(n) \vee \sum\nolimits_{t=0}^{n} (B_t - C_t) \geq I_0 \tag{1}$$

where n is year (or other period) in which payback occurs, B_t are benefits in the period t (energy savings), C_t are costs in period t, and I_0 are the total initial investment costs.

UNIDO survey of industrial firms investing in energy efficiency projects found that most firms use simple payback time method when assessing financial viability of energy efficiency projects, where SPB averaged 23 months (UNIDO, 2012, pp. 77–78). It trades time-value-of-money for simplicity and promptness. On the other hand, SPB ignores returns after payback. It shouldn't be used when choosing among mutually exclusive alternatives because the values of differing investment sizes are not considered, or when the issues of financing are involved.

Discounted payback period (DPB) is the time required for net revenues associated with an investment to return the cost of the investment, computed with accounting for the time value of money. DPB measures the time between the time of an initial investment and time at which accumulated discounted savings or benefits are sufficient to counterbalance the initial investment, but – unlike SPB – it sets the discount rate to a non-zero value:

$$DPB = \min(n) \vee \sum_{t=0}^{n} \frac{B_t - C_t}{(1+d)^t} \geq I_0 \tag{2}$$

where n is year (period) in which payback occurs, B_t are benefits in the period t (energy savings), C_t are costs in period t, d is the discount rate, and I_0 are the initial total investment costs.

DPB is often used as a supplementary measure when project life (duration) is uncertain. It is used to identify feasible projects when the investor's time horizon is constrained, to indicate how long capital is at risk. It is a rough guide for accept/reject decisions, but because it indicates the time at which the investment breaks even it is not a reliable guide for choosing the most profitable investment alternative, because savings and/or benefits after the payback time could be significant (as it ignores returns after payback, similar to SPB).

Net present value (NPV) is the value in the base year (usually the present) of all cash flows associated with a project. NPV is the common profitability measure. When used in energy efficiency evaluation it compares present value benefits of mutually exclusive, alternative investments i:

$$NPV_i = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+d)^t} \tag{3}$$

where B_t are benefits in the period *t* (energy savings), C_t are costs in period *t* associated with investment *i*, and *d* is the discount rate. When considering energy efficiency projects analysis of future cash flows consists primarily in estimating avoided energy-related costs. An investment in energy efficiency project would be considered profitable if the costs were counterbalanced with savings due to decreased energy expenditures. In energy efficiency evaluation there is a common[2] practice to use higher discount rates.

Dixit & Pindyck (2012, p. ix) state that "*the traditional 'net present value' rule, which is taught to virtually every business school student and student od economics, can give very wrong answers*" because it ignores irreversibility (i.e. irrevocability) and the option of delaying an investment. When investing in energy-efficient buildings (or in energy efficiency measures) the invested resources are typically irrevocable for long periods of time, as one usually cannot reallocate invested resources (while relocation is possible, divestment often isn't). Following this reasoning, Verbruggen et al. (2011) introduced the concept of "energy performance endowment" of a building, where endowment encompasses "*orientation, compactness, availability of passive construction parts (e.g. a cellar for cool storage), insulation and air tightness, shading blades, heat distribution equipment, coolers, sensors, meters, etc*." A new building could be equipped with an excellent, mediocre or poor energy endowment. Energy efficiency projects are financially easy to bear in excellently endowed buildings. These buildings have a low level of irrevocability, i.e. they are flexible. Verbruggen (2012) expands on this notion and considers that the financial appraisal of efficiency investments should be embedded in a framework made up by three dimensions: future time, doubt (i.e. uncertainty) and irrevocability.

Internal rate of return (IRR) is the discount rate required to equate the net present value of a cash flow stream to zero. The IRR is the discount rate *d* (the rate of return on the investment) for which the NPV is zero. It is compared to the investor's minimum acceptable rate of return to determine if the investment is desirable[3]:

$$0 = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+IRR_i)^t} \tag{4}$$

where B_t are benefits in the period *t* (energy savings), C_t are costs in period *t* associated with investment *i*, and IRR_i is the internal rate of return (the discount rate) for each comparable investment *i*. However, IRR is not recommended when deciding among mutually exclusive alternatives because the sizes of opposing investments are not considered. The investment project is usually assessed by comparing the IRR of with a "hurdle rate" that represents the opportunity cost of capital. Also, IRR method assumes reinvestment at the same (IRR) rate[4].

Modified internal rate of return (MIRR), or overall rate of return (ORR) is the discount rate required to equate the future value of all returns to the present value of all investments, with a specific reinvestment interest rate. MIRR is calculated by assuming that all cash inflows received before the end of the analysis period are reinvested at the discount rate (IRR) until the end of the analysis period. The final amount (future value) at the end of the analysis is then discounted back to the base year by using modified IRR. It is calculated as:

$$0 = \sum_{t=0}^{n} \frac{B_t}{(1+IRR_i)^t} - \sum_{t=0}^{n} \frac{C_t(1+IRR_i)^n}{(1+MIRR_i)^t} \tag{5}$$

[2] "(…) *consumers use high discount rates in evaluating the costs and benefits of energy efficiency*" (Howarth & Sanstad, 1995, p. 108).
[3] E.g. Alcorta (2014).
[4] Internal rates of return vary considerably across sectors and types of investments. For energy efficiency projects with a three-year lifespan and no resale value, UNIDO (2012, p. 78) estimated mean internal rate of return at 25%, 37% for 4 years, 43% for 5 years and 50% for 10 years.

where $MIRR_i$ is the overall rate of return on a given investment alternative i, B_t are benefits in the period t (energy savings), C_t are costs in period t associated investment i, r is the reinvestment rate at which net returns can be reinvested (usually set equal to the discount rate), n is the length of the study period, and I_t are the investment costs.

Like the IRR, the modified internal rate of return expresses economic performance in terms of an annual rate of return over the analysis period. On the other hand, it requires as an input a defined reinvestment rate which makes it possible to express net cash flows (excluding investment costs) in terms of their future value at the end of the analysis period. The MIRR rate of return is often recommended as a complement to the IRR analysis because it avoids some of the limitations of the IRR.

Benefit-to-cost ratio or savings-to-investment ratio (BCR, B/C, SIR) is the ratio of the sum of all discounted benefits (net savings) accrued from an investment to the sum of all associated discounted costs.

This method divides benefits by costs, and when used in energy efficiency evaluation benefits are regarded as energy cost savings. Therefore, the numerator of the ratio is usually composed as energy savings (net of maintenance and repair costs), and the denominator as the sum of investment and replacement costs (less salvage value). BCR takes into account time value of money, and is based on discounted cash flows. Generally, it takes the following form:

$$BCR_i = \frac{\sum_{t=0}^{n} \frac{S_t}{(1+d)^t}}{\sum_{t=0}^{n} \frac{I_t}{(1+d)^t}} \tag{6}$$

where t counts the number of periods, BCR_i are ratios for energy efficiency investment alternatives i, S_t are the savings (excluding those investment costs in the denominator), d is the discount rate or opportunity cost of capital which is used to bring future costs back to their present value, and I_t are the investment costs.

Benefit-to-cost ratio delivers a dimensionless number, unlike some other methods that provide a performance measure in dollars. The higher the ratio, the more dollar savings realized per dollar of investment. For a project to be acceptable, the ratio must have a value of 1 or greater. Among mutually exclusive projects the project with the highest ratio should be chosen. The disadvantages of the BCR are that it is especially sensitive to the choice of the discount rate, and can provide incorrect analysis if the size or scale of the various projects being compared is large. It is frequently used in projects that involve the public interest, when evaluating investments from a societal perspective.

Total life-cycle costs (TLCC) are the costs incurred through the ownership of an asset over the asset's life span or the period of interest to the investor. TLCC analysis considers all significant costs over the life of the project, which are then discounted to a base year using present value analysis.

The TLCC method sums for each investment alternative the costs of acquisition, maintenance, repair, replacement, energy, and any other monetary costs (minus any income amounts, such as salvage value) that are affected by the investment decision. The timing of costs is considered for all amounts.

The investment alternatives should include a base-case of not making the energy efficiency investment for comparison purpose, and at least one case of an investment in a specific efficiency system. The equation is:

$$TLCC_i = \sum_{t=0}^{n} \frac{I_i + C_i + M_i + R_i - S_i}{(1+d)^t} \tag{7}$$

where $TLCC_i$ is the life-cycle cost of alternative i, I_i is the investment cost of alternative i, C_i is energy cost associated with alternative i, M_i is the nonfuel operating and maintenance cost of i, R_i is the repair and replacement costs of i, S_i is the resale value less disposal cost associated with alternative i, and d is the discount rate.

TLCC is generally not recommended for energy efficiency evaluation when deciding on investments because it provides no frame of reference for what are acceptable and unacceptable costs, and it does not address benefits and returns. As such it should be used for ranking or selecting among mutually exclusive alternatives that provide equal benefits and returns.

Revenue requirements (RR); the amount of money that must be collected from customers to compensate for all expenditures (including taxes) associated with an investment. The general decision rule is to choose the alternative for which the present value of the multiperiod investment revenue requirement is the lowest. RR is not recommended for economic evaluation when deciding whether to accept or reject an investment because it provides no reference for what are acceptable or unacceptable costs, and benefits and returns are not addressed.

The equation for RR is the same as the before-tax TLCC.

Levelized cost of energy (LCOE) is the cost per unit of energy that, if held constant through the analysis period, would provide the same net present revenue value as the net present value cost of the system.

The LCOE considers all the costs associated with an investment alternative and takes into account the time value of money. The LCOE is the cost that, if assigned to every unit of energy produced (or saved) over the analysis period, will equal the total life-cycle cost (TLCC). It usually considers taxes, but disregards financing costs.

Levelized cost of energy is the dollar value that must be received for each unit of energy produced to ensure that all costs are covered and a reasonable profit is realised. Profit is gained by discounting future revenues at a discount rate that equals the rate of return that might be obtained on other comparable investments.

In general form, LCOE is calculated as follows:

$$\sum_{t=1}^{n} LCOE \times \frac{Q_t}{(1+d)^t} = \sum_{t=1}^{n} \frac{C_t}{(1+d)^t} \vee \sum_{t=1}^{n} \frac{LCOE \times Q_t}{(1+d)^t} = TLCC \tag{8}$$

where t counts the number of periods, Q_t is the amount of energy production in period t, C_t is the cost incurred in period t, and d is the discount rate. LCOE is recommended in ranking alternatives given a limited budget because the measure will provide ordering of the alternatives. However, it is not recommended when selecting among mutually exclusive alternatives because differing investment sizes are not judged.

Having all the tools described above could make decision making confusing and even render subjects indecisive, therefore we need clear and simple pointers regarding what method to use for a typical decision in energy-efficiency context (Table 1.).

Table 1. Choosing between measures

Measure	Decide whether to accept or reject	Ranking between alternatives	Lease/buy: financing decision
SPB and DPB	Recommended only under limited circumstances	Not to be used	Not to be used
IRR	Recommended only under limited circumstances	Not to be used	Not to be used
MIRR	Use	Use	Recommended only if incremental benefits and costs are used
BCR	Use	Use	Recommended only if incremental benefits and costs are used
TLCC	Use if costs predominate	Not to be used	Use if costs predominate

Source: Ruegg and Marshall (1990,13)

The measures described above are some of the most frequently used in estimating financial effects of energy efficiency investments, and as such they should be regarded as foundations of financial analysis in this field. However, financial analysis ought to be expanded having in mind the idiosyncrasies of energy efficiency evaluation; impact of the weather and other externalities (rebound and spillover effects) should be included. Unfortunately, the absence of reliable data and/or other resources often do not permit these inclusions. Furthermore, Cooremans (2011) shows that, even though they are widely used, the impact of financial evaluation methods and financial factors on businesses investment choices is neither simple nor important as is often claimed, which could be explained by several factors:

1. quality of the calculations (practice often does not follow finance theory's advice; e.g. applying same discount rate to all companies' investment projects, regardless of their specific risk level),

2. influence of national and corporate cultures (e.g. German companies make less use of financial evaluation methods than their British counterparts; Carr & Tomkins (1996)),

3. importance of intuition and judgment as opposed to analysis (there are certain cognitive limitations and biases; quantitative foundations of decision making are supplemented by qualitative elements),

4. investment category, as it influences the financial criteria used (duration, capital budgeting tool, discount rate) and the procedure (type of analysis carried out), and

5. strategic factors (the hierarchic level at which a project is initiated, etc.).

These factors are particularly applicable in financial evaluation of energy efficiency projects.

4. Conclusion

The motivation for this paper came from the need to obtain a summarizing literature review regarding measures of financial evaluation of energy efficiency developments within the project funded by Croatian Science Foundation (Grant No. IP-2016-06-8350).

After a comprehensive research of the literature key measures of financial viability of energy efficiency improvements were found and presented. Most of them tend to include the time-value of money into the equation, hence discount rates are particularly important for the analyses. Frequently used measures of energy efficiency improvements include simple payback period, discounted payback period, net present value, internal rate of return, modified internal rate of return, benefit-to-cost ratio, total life-cycle cost, revenue requirements, and levelized cost of energy.

However, due to uncertainty of particular inputs in the measures the examination could be expanded with the risk analysis. Since uncertainty (which rests upon probability and its distributions) is a key component of risk, risk assessment techniques should also be considered since they can improve making a more informed decision regarding investing in energy efficiency. Another important hindrance for the energy efficiency analysis is the fact that standard measures only account for the effects which are expressible in monetary units, while the effects not measured in monetary units (such as preservation of the eco-system, etc.) are not expressed. Hence, possible future studies should also strive to examine and encompass risk-based analyses and non-monetary effects within the evaluation framework which would certainly help managers and policymakers (as well as other stakeholders) in making better decisions.

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