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Energy saving projects (EnSPs) — Guidelines for economic and financial evaluation

Projets d'économies d'énergie — Lignes directrices pour l'évaluation économique et financière

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 301, *Energy management and energy savings*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

A complete assessment of an investment in an energy saving project (EnSP) requires analysis of all costs and benefits over the lifetime of the investment. This assessment can be used to prioritize the EnSPs. However, it is important to consider the aim and scope at the outset because this will prescribe the course to be followed. The basic criterion for evaluating an investment decision in an EnSP is that the benefits resulting from the EnSP should be greater than the costs incurred within a defined time period for the return on the investment.

This document provides guidance on a methodological framework for the calculation, evaluation and reporting of economic status by defining economic indicators to facilitate the selection of energy performance improvement actions (EPIAs), EnSPs or opportunities. It provides examples and concepts to demonstrate the financial value of the activities related to energy savings to ensure the business connection to the organization.

This document is intended to help EnSP investment evaluators to determine an appropriate approach or type of analysis at an appropriate level of detail and to assist energy savings evaluators in completing consistent analyses using documented assumptions and reasoning. This document includes analytical techniques that are commonly required for an economic evaluation of an EnSP.

Where possible, the financial evaluation of an EnSP should follow the approved method of the organization making the investment, and the detailed approach outlined in this document should be adjusted based on guidance from the organization.

The aim of an economic and financial evaluation is to provide the information needed to make a judgement or a decision in relation to EnSPs.

The perspective of analysis is important, as it often dictates the approach to be used. Also, the ultimate use of the results of an analysis will influence the level of detail required. The decision-making criteria of the potential investor should also be considered.

This analysis approach provides a significantly better evaluation of the long-term implications of an investment than methods that focus on first cost or short-term results. In this document, evaluation methods can be applied to virtually any public or private business sector investment decision as well as EnSPs decisions. Such decisions include the evaluation of alternative solutions with different initial costs, operating and maintenance costs, and the evaluation of investments to improve energy performance.

The process approach and steps used for EnSPs economic and financial evaluation, which are used throughout this document, are illustrated in Figure 1.

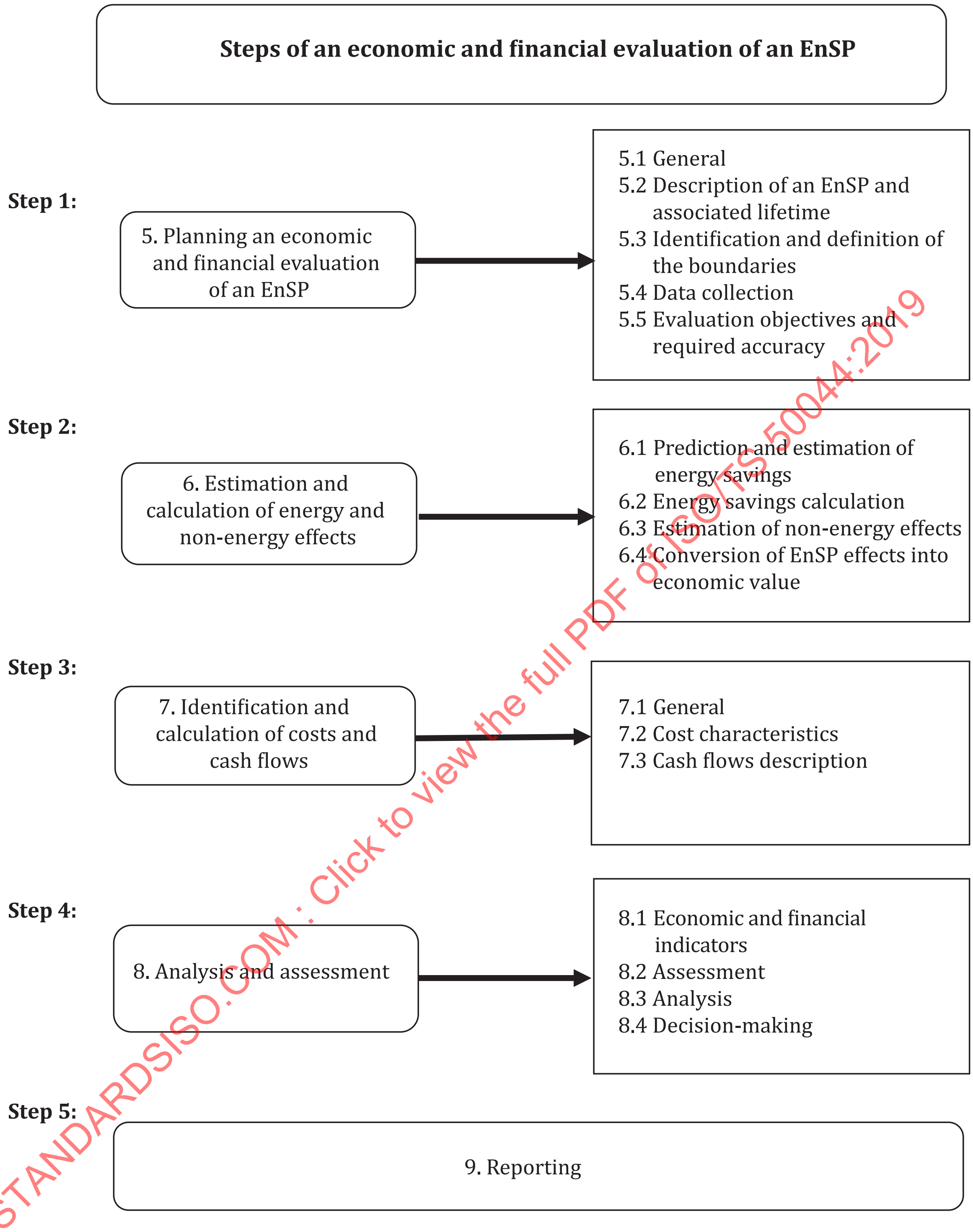


Figure 1 — Economic and financial evaluation approach

This document includes:

a) terms and definitions;

b) the types of costs that should be taken into account for the calculation of the economic and financial evaluation of EnSPs;

c) the data needed for the determination and calculation of costs related to the EnSP under consideration;

d) the calculation and assessment of economic and financial indicators (EFIs);

e) a general framework and rules for the economic priorities of EnSPs;

f) the principle of reporting and expression of results for the economic and financial evaluations of EnSPs.

This document provides indicators for the financial evaluation of all types of EnSPs. Those indicators include the internal rate of return (IRR), net present value (NPV), payback period (PP) and life cycle cost analysis (LCCA).

This document can be used by any organization during the important phases of an energy management system, such as energy review, design, procurement and management review, to prioritize and record energy performance opportunities accurately, consistent with ISO 50001.

This document also can be used by any stakeholder (e.g. policy makers, decision-makers, organizations, NGOs) that aims to quantify the cost of EnSPs over a specific period. Annex A provides guidance on the steps for an energy savings calculation. Annexes B to F provide an overview of the economic and financial evaluations with practical examples.

Energy saving projects (EnSPs) — Guidelines for economic and financial evaluation

1 Scope

This document gives guidelines for how to compare and prioritize energy saving projects (EnSPs) before implementation, using economic and financial evaluation. It includes a common set of principles.

This document is applicable to all EnSPs and energy performance improvement actions (EPIAs) that are developed by stakeholders and organizations for improving energy performance, irrespective of the type and size of an organization and its energy use and consumption.

The methodology for quantification methods for predicted energy savings and measurement and verification (M&V) of the energy savings are not in the scope of this document.

NOTE The methodology for the estimation of the energy savings is critical when determining cost savings.

The methodology of the scenario generation (building) for future energy saving measures and actions is not covered by this document.

General rules and methodologies within this document can be used either independently or in conjunction with other standards and protocols.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
annual cost
sum of running costs and periodic costs or replacement costs paid on the year *n*

Note 1 to entry: The running cost is the money that needs to be spent regularly to run an *energy saving project* (3.11) or an *energy performance improvement action* (3.10), e.g. cost of maintenance, labour costs.

3.2
capital cost
initial construction costs and costs of initial adaptation where these are treated as capital *expenditure* (3.3)

[SOURCE: ISO 15686-5:2017, 3.1.2, modified — Note 1 to entry has been deleted.]

3.3
expenditure
money used to purchase, install and commission a capital asset

[SOURCE: ISO 15663-1:2000, 2.1.6, modified — "capital" has been deleted from the term.]

3.4
cash flow
CF
movement of money into (cash inflow) or out of (cash outflow) a business, *project* (3.24) or financial product

Note 1 to entry: Cash flow is usually measured for a specified period.

3.5
discount rate
factor or rate reflecting the time value of money that is used to convert *cash flows* (3.4) occurring at different times to a common time

[SOURCE: ISO 15686-5:2017, 3.3.1]

3.6
direct cost
expense that can be traced directly to an *energy saving project* (3.11)

3.7
energy
electricity, fuels, steam, heat, compressed air and other similar media

Note 1 to entry: For the purposes of this document, energy refers to the various forms of energy, including renewable, which can be purchased, stored, treated, used in an equipment or in a process, and recovered.

[SOURCE: ISO 50001:2018, 3.5.1]

3.8
energy consumption
quantity of *energy* (3.7) applied

[SOURCE: ISO 50001:2018, 3.5.2]

3.9
energy performance
measurable result(s) related to energy efficiency, energy use and *energy consumption* (3.8)

[SOURCE: ISO 50001:2018, 3.4.3, modified — Notes 1 and 2 have been deleted.]

3.10
energy performance improvement action
EPIA
action or measure or group of actions or measures implemented or planned within an organization intended to achieve *energy performance* (3.9) improvement through technological, managerial, behavioural, economical, or other changes

[SOURCE: ISO 50015:2014, 3.5, modified — "or operational" has been deleted.]

3.11
energy saving project
EnSP
activity that is intended to contribute to a measurable reduction in *energy consumption* (3.8)

Note 1 to entry: An EnSP can also be intended to contribute to a reduction in greenhouse gas emissions.

Note 2 to entry: An EnSP includes at least one *energy performance improvement action* (3.10).

3.12
energy savings
reduction of *energy consumption* (3.8) following the implementation of an *energy performance improvement action* (3.10)

[SOURCE: ISO/IEC 13273-1:2015, 3.3.9]

3.13
hurdle rate
minimum rate of return on a *project* (3.24) or investment required by a manager or investor

3.14
indirect cost
expense that cannot be traced directly to an *energy saving project* (3.11)

3.15
inflation
sustained increase in the general price level

Note 1 to entry: Inflation can be measured monthly, quarterly or annually against a known index.

[SOURCE: ISO 15686-5:2017, 3.3.3, modified — "deflation" has been deleted.]

3.16
internal rate of return
IRR
discount rate (3.5) that gives a *net present value* (3.22) equal to zero

Note 1 to entry: IRR is also known as the discounted *cash flow* (3.4) rate of return.

Note 2 to entry: In the context of savings and loans, IRR is also known as the economic rate of return.

[SOURCE: ISO 26382:2010, 3.8]

3.17
interactive effect
significant *energy* (3.7) result occurring beyond the project boundary as a consequence of action(s) within the project boundary

Note 1 to entry: Correctly identifying and accounting for consequential effects mitigates the *risk* (3.27) of double counting when the results of various *energy performance improvement actions* (3.10) are combined.

Note 2 to entry: The consequential effect is limited to the boundaries of the authority of the management of the energy-using system.

EXAMPLE Changing the lighting system to be more efficient will have a consequential effect on the HVAC system. If the measurement boundary is the lighting system only, the consequential effect on the HVAC system should be described.

[SOURCE: ISO 17741:2016, 3.13, modified — Notes 1 and 2 have been replaced and the example has been slightly amended.]

3.18
life cycle cost
LCC
discounted cumulative total of all costs incurred by an *energy performance improvement action (EPIA)* (3.10) over its life cycle

Note 1 to entry: For an *energy saving project* (3.11), the discounted life cycle cost is the sum of all discounted costs of the constituent EPIAs, taking into consideration their respective lifetimes.

[SOURCE: ISO 15663-3:2001, 2.1.9, modified — "an energy performance improvement action" has replaced "a specified function or item of equipment" and Note 1 to entry has been added.]

3.19
life cycle cost analysis
LCCA
methodology for the systematic economic evaluation of *life cycle costs* (3.18) over a period of analysis, as defined in the agreed scope

3.20
maintenance cost
total of necessarily incurred labour, material and other related costs incurred to retain equipment, a process or its parts in a state in which it can perform its required functions in an *energy saving project (EnSP)* (3.11)

Note 1 to entry: Maintenance includes conducting corrective, responsive and preventative maintenance on EnSPs, or their parts, and includes all associated management, cleaning, servicing, repairing and replacing of parts, where needed, to allow the EnSP and its parts to be used for its intended purposes.

[SOURCE: ISO 15686-5:2017, 3.1.9, modified — In the definition, “equipment, a process” has replaced “a building”. In the note, “ENSPs” has replaced “constructed assets” and “repainting” has been deleted.]

3.21
minimum attractive rate of return
MARR
hurdle rate (3.13) for a *project* (3.24) within an organization

Note 1 to entry: MARR is used to determine the *net present value* (3.22).

Note 2 to entry: In capital budgeting, the *discount rate* (3.5) used is known the hurdle rate and is usually equal to the incremental cost of capital.

3.22
net present value
NPV
sum of the discounted future *cash flows* (3.4)

Note 1 to entry: NPV converts future cash flows using a given *discount rate* (3.5).

[SOURCE: ISO 15686-5:2017, 3.2.2, modified — Notes 1 and 2 to entry have replaced the Note 1 to entry.]

3.23
new project
project involving an energy using system that has not been installed or commissioned, such that the project cannot be considered and treated as a retrofit

[SOURCE: ISO 17741:2016, 3.16, Note 4 to entry]

3.24
project
unique process consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements including constraints of time, cost and resources

Note 1 to entry: An individual project may form part of a larger project structure and may consist of two or more *energy performance improvement actions* (3.10).

Note 2 to entry: The complexity of the interactions among project activities is not necessarily related to the project size.

Note 3 to entry: *Energy savings* (3.12) is the quantitative result as the project activities bring about reduction in the *energy consumption* (3.8) of energy-using systems within the project boundary.

Note 4 to entry: Retrofit project is a project conducted on an already existing energy-using system.

[SOURCE: ISO 17741:2016, 3.16, modified — Note 4 to entry has been deleted and Note 5 to entry renumbered accordingly.]

3.25
payback period
PP
period after which the initial capital invested has been paid back by the accumulated net revenue earned

[SOURCE: ISO 26382:2010, 3.13, modified — Note 1 to entry has been deleted.]

3.26
present value
PV
present worth
value of the *project* (3.24) *cash flow* (3.4) excluding the initial investment outlay

[SOURCE: ISO 15663-2:2001, 2.1.2, modified — “present worth” has been added as the admitted term.]

3.27
risk
effect of uncertainty on objectives

Note 1 to entry: An effect is a deviation from the expected. It can be positive, negative or both, and can address, create or result in opportunities and threats.

Note 2 to entry: Objectives can have different aspects and categories, and can be applied at different levels.

Note 3 to entry: Risk is usually expressed in terms of risk sources, potential events, their consequences and their likelihood.

[SOURCE: ISO 31000:2018, 3.1]

3.28
sensitivity analysis
test of the outcome of an analysis by altering one or more parameters from initial value(s)

[SOURCE: ISO 15686-5:2017, 3.2.5]

3.29
useful life
estimation of the median number of years of equipment life and accordingly the life of the *project* (3.24)

4 Symbols and abbreviated terms

For the purposes of this document, the following symbols, abbreviated terms and units apply.

Symbol/term	Description	Typical unit
A_n	annual investment (fixed and variable)	$
A_s	uniform annual saving	
A_t	net cash flow	$
$A_{t,i}$	annual costs, including variable and fixed annual costs and working capital cost	$
C_d	cost (or net proceeds) of disposal	$
C_e	cost of energy savings	$/kWh, $/MJ
C_i	initial cost of the system	$
C_m	cost of maintenance and repair	$
NOTE For simplicity, the financial unit of currency in this document is shown using a $ symbol. In practice, it will normally be in the local currency of the country where the EnSP is taking place.		

Symbol/term	Description	Typical unit
C_t	cash outflow (at the beginning of and during the project; this can include an initial investment)	$
DPP	discounted payback period	years
E_c	annual energy consumption	kWh, MJ
E_p	energy price	$
i	interest rate	%
IRR	internal rate of return	%
LCC	life cycle cost	$
n	lifetime of the system	years
NPV	net present value	$
PI	profitability index	—
PP	payback period	years
PV	present value	$
r	discount rate	%
R_t	cash inflow	$
SPP	simple payback period	years
t	time	years
NOTE For simplicity, the financial unit of currency in this document is shown using a $ symbol. In practice, it will normally be in the local currency of the country where the EnSP is taking place.		

5 Planning an economic and financial evaluation of an EnSP

5.1 General

When planning and describing an EnSP, the costs and cash flows involved should be considered. As for any other investment, an EnSP should normally show a return on invested capital more than the hurdle rate.

NOTE The organization takes the decision as to whether the project return needs to exceed the hurdle rate. An EnSP can be done as part of the social licence to operate.

To be able to take a decision about the course of action on the recommendations of an energy audit, management needs to calculate all the costs associated with the project and determine the potential returns of the proposal.

This, however, is not quite as simple as it might first appear. Savings from EnSPs often decrease with time and EnSPs can require more maintenance, with higher associated costs, as they get older.

If an EnSP is self-financed or implemented using borrowed money, the opportunity cost of money or interest payments will apply. Both inflation and tax will influence the value of any future energy savings that can be achieved. It is therefore important that the economic and financial evaluation process allows for all these factors, with the aim of determining which EnSPs should be undertaken and of optimizing the benefits achieved. Consequently, a number of accounting and financial evaluation techniques have been developed to help decision-makers.

The detail of the financial evaluation should be proportionate to the size of the investment. Organizations may consider the level of detailed financial analysis in relation to the magnitude of the benefits and associated costs.

5.2 Description of an EnSP and associated lifetime

The following elements should be considered when carrying out an economic and financial evaluation of an EnSP:

— the aim of the evaluation;

— the required accuracy of the evaluation results;

— the availability of data related to energy consumption within the selected boundary;

— the capital budget for the implementation of the EnSP;

— the types of costs related to the EnSP, including non-energy costs;

— the current situation of energy consumption and relevant variables;

— the future situation of energy consumption and costs;

— uncertainty and risks associated with costs and savings from the EnSP;

— EFIs for the evaluation of the EnSP;

— whether a full financial evaluation is justified given the required investment in the project.

5.3 Identification and definition of the boundaries

5.3.1 General

An EnSP boundary should be selected to ensure that interactions and all activities related to an EnSP are included or calculated as interactive effects.

The EnSP boundary may include the facilities, systems, processes and equipment affected by the EnSP or EPIA(s) implemented within the project. The EnSP boundary should include measurements or calculations required to determine the interactive effects of the implementation of the project.

The project boundary can be drawn around an individual EPIA(s) or EnSP, if it is considered that there will be no interactive effects with other facilities, systems or equipment.

NOTE Examples of boundaries:

a) a university campus;

b) the engineering department within the university;

c) all the lighting systems in the university campus.

5.3.2 Examples of EnSP boundaries

According to the type of action, an EnSP or EPIA can take various forms, including:

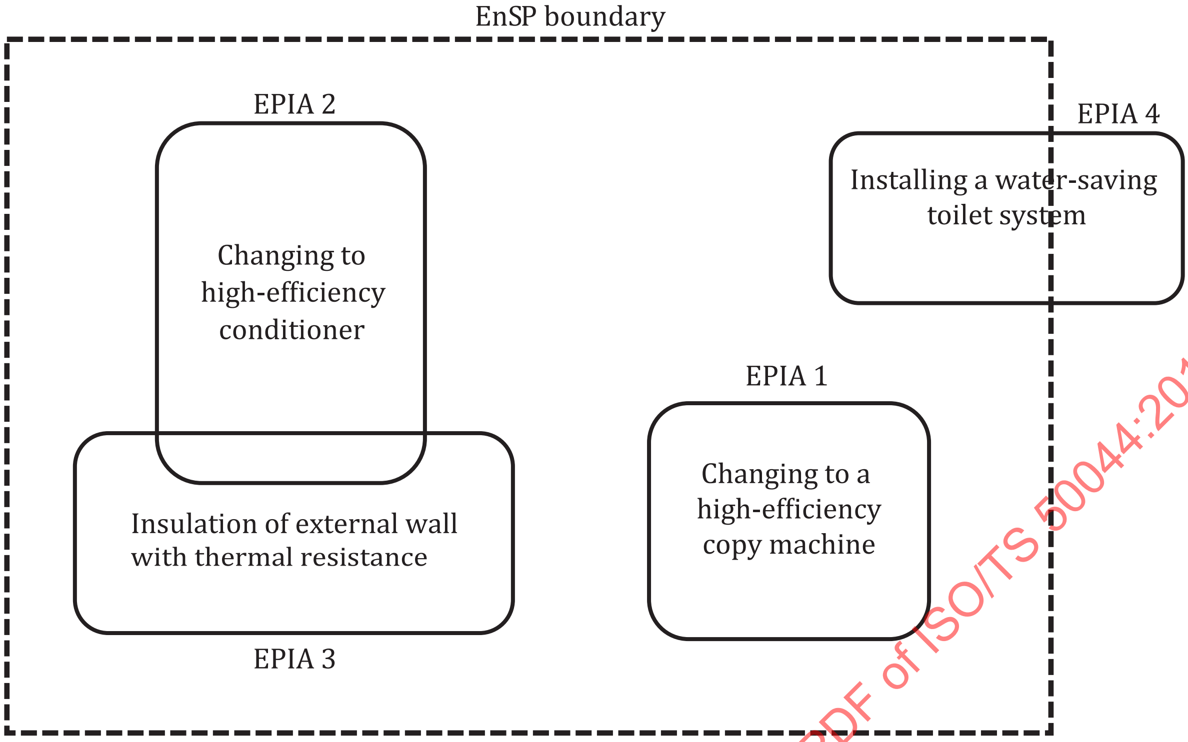
a) organizational culture, e.g. changing the behaviour of staff in an organization by training;

b) replacement of old technologies with new technologies or adding a new part to improve the operation of equipment;

c) application of renewable energy resources, e.g. using a photovoltaic panel to reduce the fuel consumption of a generating system;

d) use of procured services for improving energy performance, e.g. personnel training, energy audits, consultants for repairing and maintaining facilities and equipment.

An EnSP can include one or more EPIAs, as shown in Figure 2 and Table 1.



NOTE Installing a water savings toilet system does not save energy within the boundary of an EnSP. It can save energy outside the boundary depending on how the water is made available within the EnSP boundary.

Figure 2 — Example of EPIAs in an EnSP boundary

Table 1 — Example of EPIAs in an EnSP boundary

No.	EPIA	Inside or outside EnSP boundary?
EPIA 1	Installation of a new packaging machinery	Inside
EPIA 2	Replacement of motors with variable speed drives (VSDs) on the mixing and kneading machines	Inside
EPIA 3	Replacement of fluorescent lights with LEDs in the factory and adjacent offices	Crosses boundary (part inside, part outside)
EPIA 4	Staff training on new machinery	Inside
EPIA 5	Adding PV panels to the warehouse roof	Outside (even though some of the electricity generated can be used inside the factory)
EPIA 6	A new heat recovery unit in the wash room (where baking trays and mixing bowls are washed overnight)	Inside
EPIA 7	New air conditioning units in the sales department	Outside
EPIA 8	Changing the baking ovens from gas to electricity	Inside

5.4 Data collection

The collection and quantification of data necessary for the economic and financial evaluation of an EnSP need a data collection plan that includes sources, collection and measurement methods.

The collection of data for evaluation with enough accuracy depends on availability, reliability and related costs. In order to ensure the best quality and accuracy possible for the data, according to the quantification objectives and the resources available, a data collection plan should be defined. The plan should specify the data necessary to calculate the economic indicators and should state how and at what frequency the data should be collected and retained.

When data are not available, or the nature of the project is such that data cannot be measured, the estimation method should be used.

5.5 Evaluation objectives and required accuracy

Before undertaking an economic and financial evaluation, the organization should consider the required level of accuracy, based on the objective and methods of estimation. In many cases, a rough (approximate) estimate of the financial analysis may be undertaken or a published benchmark used to determine whether to undertake a subsequent detailed estimation. This initial estimation may not need to consider all the relevant variables, but should instead consider only those with the most significant effects. It may also rely on existing sources of data, such as meter readings, utility energy bills or annual production volumes.

In some cases, it is possible to use estimations and assumptions that reduce the amount of detail needed and permit the use of averages rather than detailed annual calculations.

For a final investment decision, more accurate data may need to be collected, e.g. by installing monitoring equipment, such as energy sub-meters, or by collecting other potentially relevant data, such as the number of people using a facility or the daily volume of production in an industrial facility.

Accuracy improves over the development stages of an EnSP. EFIs should be recalculated after each stage to make decisions on moving the EnSP forward.

6 Estimation and calculation of energy and non-energy effects

6.1 Prediction and estimation of energy savings

The first action for estimating energy savings for an EnSP is to select the appropriate savings estimation approach, considering the appropriate level of precision to conform to policy requirements.

The methodology for predicting energy savings for each type of EnSP or EPIA is given in ISO 50046.

6.2 Energy savings calculation

The calculation of predicted energy savings should be in accordance with ISO 50046. For an example of detailed calculations, see ISO 50046:2019, Annex E. The following points are important for an economic evaluation.

Depending on the EnSP complexity, measurement data accuracy level and availability of data, the calculation should be supported by measured data for baseline and post-installation conditions.

Energy savings calculations for an EnSP or EPIA vary widely in complexity and accuracy because these projects have not been implemented. To select the appropriate energy savings calculation, several factors should be considered, including accuracy, sensitivity, uncertainty and data requirements.

The prediction of energy savings should be carried out with levels of accuracy and cost appropriate to the objectives. Care should be taken since predictions with a higher accuracy involve a higher cost.

Converting from predicted energy savings into reduction energy costs is recommended and can be calculated by multiplying the energy consumption by the unit energy price for each source of energy. It should be noted that calculating the reduction of energy consisting of multiple EPIAs requires compensation for the interactive effects for predicted energy savings.

NOTE 1 For more information on general technical rules for the measurement, calculation and verification of energy savings in retrofit projects or new projects, see ISO 17741.

NOTE 2 Additional information on the steps for calculating energy savings is provided in Annex A.

6.3 Estimation of non-energy effects

The impact of EnSP measures is routinely calculated in terms of energy, and often emission savings, but an EnSP can also generate non-energy benefits. These include indirect benefits such as operation and maintenance savings, climate change mitigation, enterprise productivity, energy prices, increased occupant comfort or productivity, reduction in downtime, increase in throughput, reduced sensitivity to the quality of inputs, improved reparability, resilience to floods, temperature extremes, earthquakes, and power outages. Occasionally EnSPs have adverse effects on other parameters and, if present, these should also be calculated.

Identifying and quantifying the non-energy benefits of an EnSP in terms of cost reduction, value generation and risk mitigation, and the inclusion of these into investment assessments, can contribute significantly to raising the priorities of EnSP investments.

EnSP evaluators should use established methodologies to measure, quantify, verify, monetize and report non-energy benefits. The non-energy effects of an EPIA or EnSP can be positive (e.g. improved productivity, air quality, health) or negative (e.g. reduced lifetime, increased maintenance, performance degradation of non-energy performance). Organizations should assess the positive and negative effects of the EPIAs and ensure that investments directly identifiable and necessary to realize those impacts are included in the financial analysis.

6.4 Conversion of EnSP effects into economic value

6.4.1 General

The essence of an economic and financial evaluation is the identification of all expenditures and revenues over the lifetime of an EnSP, with a view to assessing the ability of an EnSP to achieve financial sustainability and a satisfactory rate of return. The evaluation is usually done at constant market prices and in a cash flow statement format. It is the difference between all revenues and expenditures at the time and place where they are incurred.

6.4.2 Revenues

The cash flow statement sets out the revenues to be derived from an EnSP. These revenues can take several forms. The easiest to identify are the energy savings and non-energy savings from the EnSP. Revenue valuation is then simply a matter of estimating the monetary value of these savings and non-energy savings.

6.4.3 Estimation of external costs and benefits

An economic evaluation of an EnSP typically focuses on measuring the benefits and costs of the EnSP to the direct users of the infrastructure or asset in question. However, an EnSP can also result in benefits to or costs borne by other users, usually referred to as “external costs” or “externalities”.

The estimation of external costs and benefits are not part of the financial analysis of an EnSP, but the imposition of a price (e.g. carbon price) associated with an external cost can be considered in the sensitivity analysis.

7 Identification and calculation of costs and cash flows

7.1 General

An economic and financial evaluation of an EnSP or EPIA involves three elements:

a) the identification and estimation of costs related to the investment (financial approach);

b) the identification and estimation of all the benefits to be obtained from the investment (economic approach);

c) a comparison of the expensed costs with the energy savings benefits and non-energy benefits to determine the appropriateness of the investment (evaluation and analysis).

7.2 Cost characteristics

7.2.1 General

The main objectives of implementing the economic and financial evaluation for an EnSP can be categorized as follows:

a) collect and calculate the related costs and cash flows of equipment and installations;

b) assess and calculate both direct and indirect costs, e.g. working capital, general and start-up expenses, manufacturing costs;

c) calculate the price of the energy utility as a function of the location: it is assumed that the EnSP is working under the expected utility prices (e.g. fuel and electricity prices) applicable to the location of the EnSP during the project evaluation period, and under the present condition of utility prices, including inflation, especially regarding energy based on the location.

An analysis of the results will provide a proper insight into the appropriateness of the EnSP and an economic prospective point of view. The nature of any energy supply contracts should be considered when determining the potential energy cost savings. Any so-called “take or pay” contracts are especially important as energy savings may not result in any energy cost savings.

In order to analyse an EnSP based on economic and financial considerations, all costs should be defined and calculated.

When appraising the potential costs involved in an EnSP, it is important to specify the type of cost, including fixed, variable and total costs. The determination and calculation of type and portion of each cost help evaluators to select appropriate indicators for the economic evaluation of an EnSP and help stakeholders to make decisions.

There are two types of costs in a typical EnSP:

— variable costs;

— fixed costs.

The total investment of any project is therefore the sum of the fixed and variable costs.

The example given in Annex B illustrates how both fixed and variable costs can be combined to make the total operating cost.

7.2.2 Variable cost

The costs associated with the EnSP operation and the energy consumption reduction should be calculated. In a general categorization, these costs are known as “variable costs” and contain two subgroups called “general expenses” and “manufacturing costs”.

Variable costs should be assessed on an annual basis as a minimum. The best source of information for estimating variable costs is use of past utility bills, market trends for energy sources and applicable data from similar projects. However, inflation and geographical location should be taken into account while estimating the variable costs.

Variable costs may include:

a) direct and indirect labour costs;

b) raw materials;

c) utilities, including water and energy;

d) repairs and maintenance;

e) depreciation (in some conditions).

7.2.3 Fixed costs

Fixed costs can be divided into the following two groups.

a) Direct costs: Some costs are directly associated with the type of equipment and the way it performs in the EnSP. Costs that are mainly spent on purchasing the necessary equipment and its installation are direct costs. Expenses related to the foundation, the site preparation and the measurement instruments are subsidiaries of this cost and are required for the preparation of each EnSP.

b) Indirect costs: Costs that are not directly associated with EnSP operations but should be added to the fixed expenses overhead of the industrial plant are indirect costs. This group includes engineering supervisions and construction expenses. In addition to these costs, contingency costs should be taken into account, particularly during the construction and preparation of the different project phases. These costs can also be considered as indirect costs.

The different subgroups of direct and indirect costs are shown in Figure 3. In an economic and financial evaluation of an EnSP, the information given in the figure is considered by both investors and evaluators.

7.2.4 Total capital investment

Prior to the implementation of an EnSP, there are multiple expenses that should be specified in order to purchase and implement the machinery, equipment and services related to the EnSP. Generally, the required capital to prepare and procure the required equipment is called the "fixed capital cost". Similarly, the required capital used in the units is called the "working capital" (e.g. a permanent increase in stocks). The sum of the fixed cost and the working costs is commonly called the "total capital investment".

Figure 3 presents the methodology and typical groups of direct and indirect costs, which are used to calculate the total capital investment.

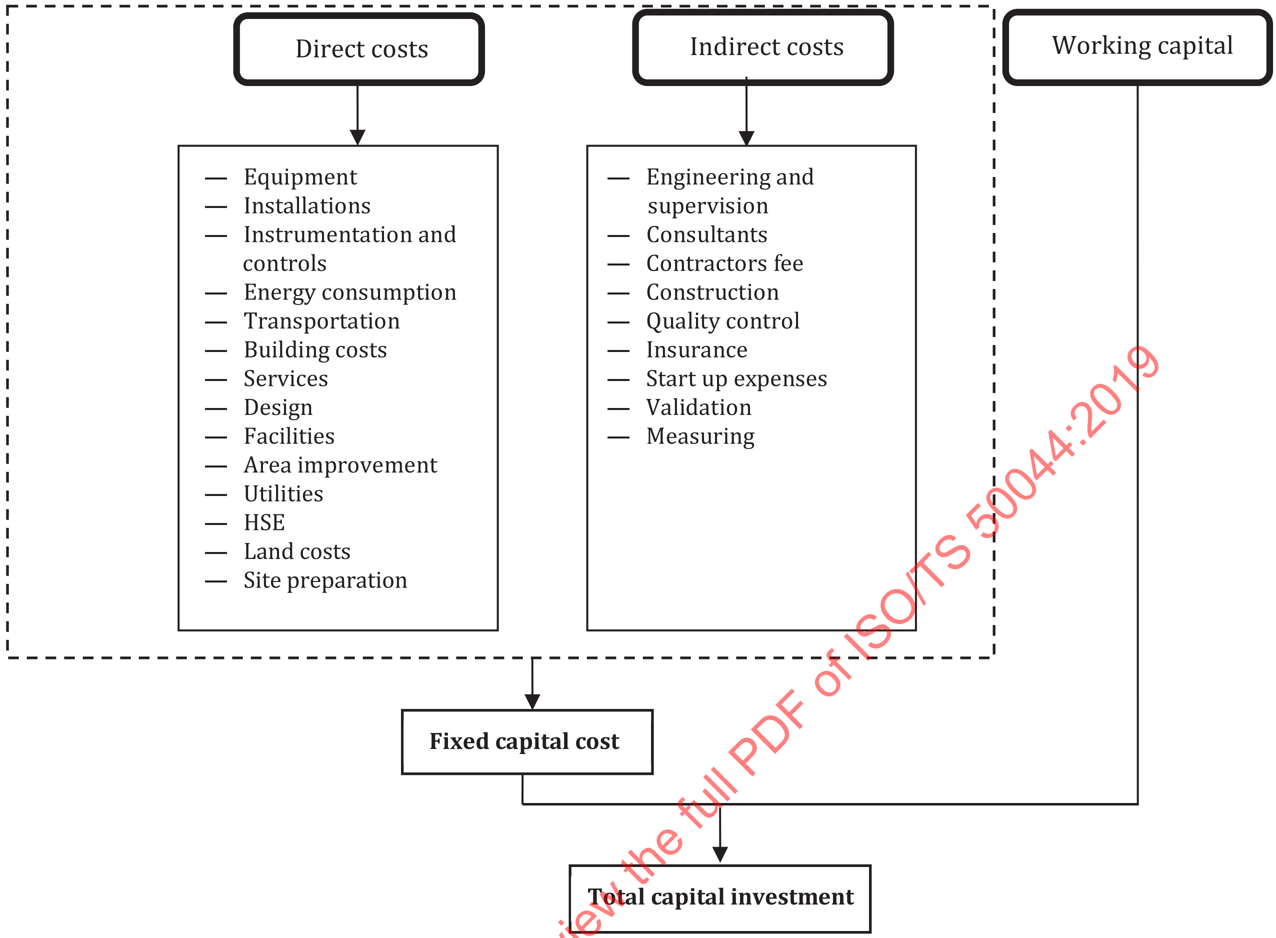


Figure 3 — Methodology by which the total capital investment is calculated

7.3 Cash flows description

7.3.1 General

The revenues and annual expenses associated with an EnSP during the lifetime of investment are represented as cash flows. EnSP evaluators can increase the timing of cash flows and apply the time value of costs using cash flow diagrams.

Depending on the location of the EnSP, tax cash flows, depreciation, inflation and the interest rate, the cash flows of an EnSP are represented as one of the following types:

a) single sum cash flows;

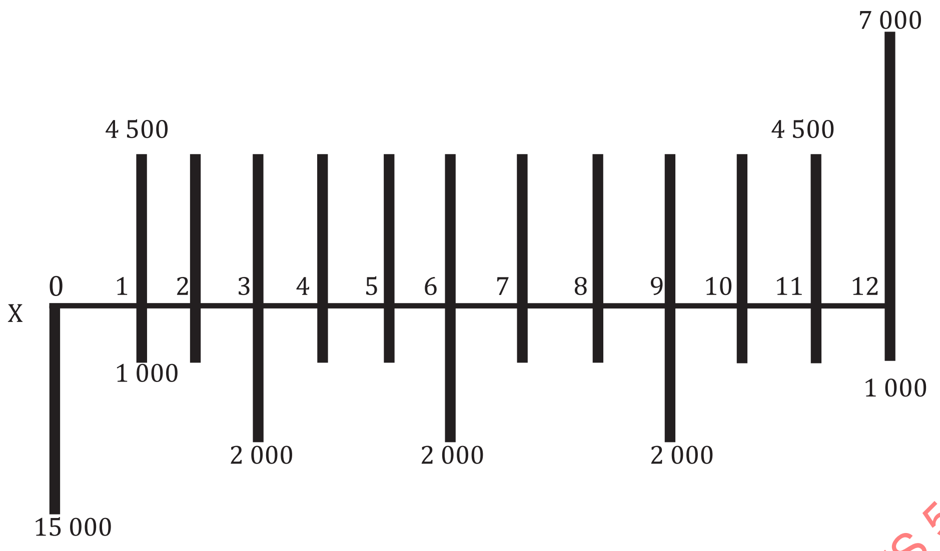
b) series cash flows:

1) uniform series cash flows;

2) gradient and equivalence series cash flows;

3) series cash flows with time value of money factors.

Figure 4 presents a typical cash flow diagram with detailed cash flows.



Key

X year

NOTE

— The EnsP initial cost (cash outflow) is $ 15 000.

— The EnSP has $ 1 000 annual maintenance costs (cash outflow).

— The EnSP saves $ 4 500 annually in fuel costs (cash inflow).

— The EnSP has $ 1 000 more in replacement maintenance at the end of every 3 years (cash outflow).

— The EnSP has a $ 2 500 higher salvage value at the end of 12 years.

Figure 4 — Typical cash flow diagram of an EnSP

7.3.2 Accounting for future cash flows

All the calculations in this document should be done using inflation-adjusted currency values. The adjustment should be performed using accepted, specified and appropriate indices of inflation compiled by a government agency or other sources determined to be reliable.

7.3.3 Rates of time preference or comparison

All rates of time comparisons should be adjusted for inflation, including discount rate, MARR, IRR, etc.

7.3.4 Choosing a rate of time preference or comparison

All rates should be based on objectives, data from past experience, market interest rates or rates of return at a regional or national level. They should also be based on the long-term average economic performance, unless special circumstances render such long-term data unreliable or not predictive of future performance. They should not be based on the organization’s internal history or preferences.

The discount rate may be adjusted for risk, but it should not be more than seven percentage points higher than the long-term average rate of interest on ten-year government bonds of the appropriate government(s).

The use of a minimum attractive rate of return (MARR) that is equal to the discount rate should be considered. The MARR should be chosen based on measured rates of return on investments of comparable organizations. It may be based on observed long-term stock dividends and share appreciation or other similar market data.

8 Analysis and assessment

8.1 Economic and financial indicators

8.1.1 General

From an economic perspective, it is assumed that a project is undertaken if the total benefits exceed the cost. For EnSPs, cost benefit analysis needs to consider the concept of time value of money, i.e. the cash inflow and outflows cannot be simply added or subtracted. This analysis is used to prioritize identified EPIAs.

The economic indicators that should be presented for the evaluation of an EnSP are:

a) present value (PV);

b) net present value (NPV);

c) internal rate of return (IRR);

d) payback period (PP);

e) life cycle cost analysis (LCCA);

f) profitability index (PI).

An organization should examine the relevant indicators if the project is a retrofit or new project type or when an action plan for the EnSP is defined to replace equipment, a system, facility or process. For an analysis of a retrofit project, the existing energy performance of the organization should be compared with the new proposed situation using the appropriate energy performance indicators.

An organization should use EFIs to evaluate whether an EnSP should be implemented. If two or more EnSPs are available, and available capital is limited, EFIs should be used to rank the projects to take investment decisions. Financial investment decisions should also consider estimation uncertainty and risk.

All indicators require an interest rate to calculate their value. In the case of some indicators such as PV, NPV and LCCA, a hurdle rate is chosen by the organization based on its cost of capital and the risk involved in the EnSP.

The following conventions are used to arrive at the cash flows.

At any given point in time (t = 0, 1, 2... n), there can exist both revenue (positive) cash inflows, R_t, and cash outflows, C_t.

The net cash flow, A_t, is defined by Formula (1):

$$A_t = R_t - C_t \tag{1}$$

where

R_t is the cash inflow over time;

C_t is the cash outflow (at the beginning of and during the project; this can include an initial investment).

8.1.2 Present value

The concept of present value, PV, as a measure of investment worth can be generalized as shown by Formula (2):

$$\mathrm{PV} = \sum_{t=1}^{n} A_{\mathrm{t}}(P\,|\,F,i,t) \tag{2}$$

where

A_{t}	is the net cash flow;
$(P\,|\,F,i,t)$	is the present value factor and is read “to find P given F at i % for n years”;
i	is the interest rate, in %;
P	is the amount of money at the beginning of the nth year;
F	is the future amount of money at the end of the nth year;
t	is time;
n	is the lifetime of the system, in years.

The time value of money factor is summarized in Table 2.

Table 2 — Time value of money factor

Symbol	Factor	To find	Given
$(P\,|\,F,i,t)$	$(1+i)^{-t}$	P	F
$(F\,|\,P,i,t)$	$(1+i)^{t}$	F	P
$(P\,|\,A_{\mathrm{t}},i,t)$	$\dfrac{(1+i)^t-1}{i(1+i)t}$	P	A
$(A_{\mathrm{t}}\,|\,P,i,t)$	$\dfrac{i(1+i)^t}{(1+i)^t-1}$	A	P
$(F\,|\,A_{\mathrm{t}},i,t)$	$\dfrac{(1+i)^t-1}{i}$	F	A
$(A_{\mathrm{t}}\,|\,F,i,t)$	$\dfrac{i}{(1+i)^t-1}$	A	F

8.1.3 Net present value

If an organization has a time preference that can be expressed by a discount rate (r), it is indifferent about receiving an amount of “X” from the beginning of an investment or an amount of X · (1 + r)^n in “n” years since the investment started. Using this difference, an organization can convert all current and future expenditures and receivables to the present situation and count them together. This is known as the net present value, NPV, of the EnSP, which is defined by Formula (3):

$$\mathrm{NPV} = \sum_{t=0}^{n} \frac{R_{\mathrm{t}} - C_{\mathrm{t}}}{(1+r)^t} \tag{3}$$

where

R_t is the cash inflow over time;

C_t is the cash outflow (at the beginning of and during the project; this can include an initial investment);

r is the discount rate, in %;

t is time;

n is the lifetime of the system, in years.

NOTE For an example of an NPV calculation, see Annex D.

8.1.4 Internal rate of return

The IRR is the compound rate of interest that, when used to discount the costs and benefits over the period of analysis, makes costs equal to benefits when cash flows are reinvested at the project's IRR.

The IRR approach is designed to calculate a rate of return that is "internal" to the EnSP. That is:

— if IRR > MARR, the EnSP is attractive;

— if IRR < MARR, the EnSP is not attractive;

— if the IRR is very close or equal to the value of the MARR, then it is often helpful to evaluate the EnSP using another indicators.

Thus, if the MARR changes, new calculations are required.

NOTE 1 The value of IRR is typically determined through a trial and error process. An expression for the present value of an investment is written without specifying a value for the interest rate, i. Various values of i are substituted until a value of i is found that sets the NPV equal to zero. The value of i found in this way is the IRR.

While the flexibility of this approach is appealing, there are two major drawbacks. First, the iterations required using the trial and error approach can be time consuming. This factor is mitigated by the fact that most spreadsheets and financial calculators are pre-programmed to calculate an IRR value when given a cash flow series. The second, and more serious, drawback to the IRR approach is that some cash flow series have more than one value of the IRR (i.e. more than one value of i sets the NPV expression to zero). However, it can be shown that, if a cash flow series consists of an initial investment (cash outflow at $t = 0$) followed by a series of future cash flows (cash inflow or zero cash flows for all $t > 0$), then a unique IRR exists. If these conditions are not satisfied, a unique IRR is not guaranteed and caution should be exercised when making decisions based on the IRR.

NOTE 2 For examples of IRR calculations, see Annex E.

8.1.5 Payback period

8.1.5.1 Simple payback period

The simple payback period, SPP, of an investment is calculated by Formula (4):

$$\mathrm{SPP} = \frac{C_i}{A_t} \tag{4}$$

C_i is the initial cost of the system;

A_t is the net cash flow.

NOTE It is apparent that this indicator ignores the time value of money concept because no time value of money factors are included in the determination of the payback period. This implicitly assumes that the applicable interest rate for converting future amounts to present amounts is zero.

8.1.5.2 Discounted payback period

The discounted payback period, DPP, indicator is used to calculate the length of time to recoup an investment based on the investment's discounted cash flows.

The DPP is calculated by Formula (5) when it is assumed that all cash flows are equal:

$$\mathrm{DPP} = \ln\left(\frac{1}{1-\left(\frac{C_\mathrm{i}\times r}{\mathrm{CF}}\right)}\right) \div \ln(1+r) \tag{5}$$

where

DPP is the discounted payback period, in years;

C_i is the initial cost of the system, in $;

r is the discount rate, in %;

CF is the cash flow (sum of the cash inflow and outflow), in $.

When cash flows are uneven, the DPP is calculated by Formula (6):

$$\mathrm{DPP} = (N-1) + \frac{C_\mathrm{i} - \mathrm{Cum\ PV(CF)}}{\mathrm{PV(CF)}} \tag{6}$$

where

N is the year in which the cumulative present value of cash flows from investment exceed the initial investment;

C_i is the initial cost of the system, in $;

Cum PV(CF) is the cumulative present value of the cash flows from investment at the end of the year (N – 1);

PV(CF) is the present value of the cash flow in year N.

NOTE For examples of payback period calculations, see Annex C.

8.1.6 Life cycle cost analysis

LCCA calculates the cost of a system or product over its entire life span, sometimes referred to as "cradle to grave." When conducting a life cycle cost analysis, all facets of an EnSP should be considered for their merit, especially when the purpose is to compare multiple EnSP options using the same method to find the overall best choice.

Life cycle cost, LCC, should be calculated for an EnSP using Formula (7):

$$\mathrm{LCC} = C_\mathrm{i} + \sum_i^n \frac{E_\mathrm{c}\times E_\mathrm{p}}{(1+r)^i} + \sum_i^n \frac{C_{\mathrm{m},i}}{(1+r)^{n+1-i}} + \sum_i^\mathrm{n} \frac{A_{\mathrm{n},i}}{(1+r)^{n+1-i}} + \frac{C_\mathrm{d}}{(1+r)^n} \tag{7}$$

where

C_i is the initial cost of the system, in $;

C_d is the cost (or net proceeds) of disposal;

E_c is the annual energy consumption;

E_p is the energy price;

C_m is the cost of maintenance and repair;

A_n is the annual investment (fixed and variable);

r is the discount rate, in %;

i is the interest rate, in %;

n is the lifetime of the system, in years.

While this method provides a definitive answer for the best choice based on the complete and repeating life cycle costs of the equipment, system, facility or process, LCCA results may be considered in the context of an organization's budget situation and the expected life of the plant, so as to balance the choice of EnSPs with the lowest LCCA costs against funding constraints.

For each EnSP, an LCCA study should include a consideration of costs for at least the following categories: design, initial construction, energy and utilities, operations and maintenance, repairs, replacement, and salvage. Other relevant costs may also be included. All identified costs are normalized to a point in time, often the present value, in which case the lowest present value of the costs indicates the preferred alternative in the LCCA. To use this method, a point in time should be identified when all systems are at the end of their life at the same time. The life spans of systems and equipment are determined based on equipment documentation and professional experience, and are influenced by usage patterns and maintenance. Where LCCA is used for an EnSP funded directly or indirectly by third parties, such as a government or utility companies (as part of a wider demand side management programme), this subjectivity is often removed by mandated tables that stipulate system life, maintenance cost assumptions per year, etc. The remaining variables are first cost and utility cost, which are easier to estimate. Assumptions about the project life cycle should be retained as documented information.

The LCCA approach can also be used with an additional summed term representing an implied (or actual) cost for externalities. This is most commonly done to include an assumed cost of carbon.

NOTE 1 For additional information, see IEC 60300-3-3 and ISO 15663 (all parts).

NOTE 2 For an example of a LCCA, see Annex F.

8.1.7 Profitability index

The profitability index, PI, is the ratio of the present value of a future cash inflow, at the required rate of return, to the initial cash outflow of an investment, as shown by Formula (8):

$$\mathrm{PI} = \frac{\sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\mathrm{PV}} \tag{8}$$

where

A_t is the net cash flow;

i is the interest rate, in %;

t is time;

PV is the present value of the EnSP, which is the initial investment.

NOTE This indicator is a modified form of NPV.

8.2 Assessment

8.2.1 General

After calculating the EFIs of an EnSP, an assessment is required for the selection and participation of each EnSP. The assessment presents the framework and defines the terms used in determining the economic and financial results after implementing an EnSP.

In the assessment stage, the EnSP evaluators specify the topics to be addressed in the assessment procedure for a specific EnSP. The process for creating the assessment procedure may be flexible, while adhering to the principals of accuracy, completeness, conservativeness, consistency, relevance and transparency.

8.2.2 Sensitivity analysis

The final ranking of alternatives significantly depends on the weights attached to the main criteria. Small changes in the relative weights significantly impact the final ranking. Since the relative weights are generally based on professional judgements, the stability of the ranking under the varying criteria weights should be tested.

Sensitivity analysis should be used when determining the impact of a particular variable. By creating a given set of scenarios, evaluators can determine how changes in one variable(s) will impact the objective of an EnSP or EPIA. Sensitivity analysis also indicates which variables have the greatest impact on a project, enabling evaluators to focus on the key variables.

The impact of assumptions should be investigated by changing the input into the economic evaluation. Investment and savings should be set at the limit of their accuracy and the economic evaluation recalculated at these limits.

This analysis is done if needed and according to the wishes of the organization or the stakeholder.

8.2.3 Uncertainty and risk assessment

8.2.3.1 General

As economic and financial evaluation requires assumptions about future behaviour, an iterative risk analysis can be used to progressively reduce uncertainty, but a residual risk always remains. Therefore, an economic and financial evaluation should include a consideration of uncertainty and risk assessment.

NOTE More detailed guidance on risk management can be found in ISO 31000, which provides a principles framework and a process for managing risk. ISO Guide 73 provides a vocabulary. IEC 31010 focuses on risk assessment concepts, processes and techniques.

8.2.3.2 Uncertainty and determination of the causes of risk

The uncertainty and the level of risk associated with an economic and financial evaluation can depend on the quality of available data, stability of the scope, pricing assumptions and methods of calculation.

In order to address uncertainty and reduce risks, the key issues and barriers to an economic and financial evaluation should be understood. Issues that should be considered include:

— confusion over the costs and energy price to be included/excluded (e.g. scope and/or elements of the EnSP);

— variety of indicators (e.g. NPV, PV, IRR, net savings);

— transparency and robustness of the underlying assumptions and methods of calculation;

— lack of information about detailed planning at the beginning of the EnSP;

— introduction of a new technology/products and prediction of the cycle of obsolescence;

— interface issues between capital costs and operating and maintenance costs up to the end of life;

— costly energy savings certification/education programmes;

— shortage of energy savings evaluators and professional education programmes.

Common misjudgements that can increase uncertainty of an economic and financial evaluation include:

— the use of optimistic estimates (in order to justify the project);

— the use of unattainable service lives;

— impractical maintenance programmes and replacement scheduling.

Judgements about future activities/occurrences that are outside the control of the person undertaking the economic and financial evaluation, but which can be considered within the scope of the analysis include:

— the likelihood that required maintenance levels can be achieved;

— future users' requirements (e.g. flexible space utilization, functional suitability);

— changing user behaviour (e.g. intensity of use, vandalism).

Other issues that can also cause uncertainty in the results of an economic and financial evaluation over long periods include:

— general inflation rates;

— fuel cost inflation, which can be higher or lower than general inflation;

— labour and material costs;

— exchange rates for imported goods or services;

— changes in taxation (including energy or carbon taxes);

— overhead/profit and on-cost allowances;

— changes in legislation (particularly with regard to health and safety and energy performance/ carbon emission targets).

Internal so-called "shadow pricing" of greenhouse gas emissions savings may be considered.

8.3 Analysis

8.3.1 Energy data quality

An analysis of energy data can be used to calculate an energy baseline that establishes the relationship between energy consumption and energy savings. For example, a manufacturing plant can calculate the energy baseline from energy consumption data and production data for a given time period.

Analysis can give many insights into the reasons for variations in energy consumption and energy efficiency. Graphs and statistics often raise questions that lead to further investigation, resulting in a more in-depth and accurate understanding of the energy consumption and energy savings opportunities that can exist within an organization.

The quality of data depends on the objectives of the EnSP, data sources, methods of data estimation, type and boundaries of the EnSP, type of equipment and facilities, and the kind of energy consumed.

NOTE For additional information related to energy savings calculation methods, see ISO 50046 and ISO 50047.

8.3.2 Social cost benefit analysis

8.3.2.1 General

Social cost benefit analysis (SCBA) is a methodology for evaluating investment EnSPs from the point of view of society.

Organizations may wish to consider the social costs and benefits that affect their objectives, such as the social licence to operate, or that are needed to satisfy their stakeholders. An SCBA can also be relevant to governments and local authorities for evaluating major energy-related investments.

An SCBA assesses the opportunities of an EnSP by considering the benefits compared to the costs, as well as other economic aspects such as:

a) social and environmental costs (externalities);

b) non-energy costs and benefits.

To perform an SCBA, it is necessary to use the cash flows of financial analysis and make a number of adjustments, such as the following.

— Corrections for external effects: It is possible that the implementation of an EnSP has external impacts that affect it positively or negatively. These external effects occur without monetary compensation and therefore they are not taken into account in the SCBA process. They are assessed and evaluated in the economic analysis.

— Non-energy costs and benefits: This includes all actions that can have economic side effects simultaneously with EnSPs. If the investment in an EnSP has additional effects, e.g. for productivity, these results should be considered in the evaluation.

8.3.2.2 Steps of SCBA

The SCBA process for an EnSP involves the steps presented in a) to g).

a) Transforming market prices into accounting prices: There are situations where market prices are set by governments and do not reflect the social opportunity costs of inputs and outputs. This stage should take into account, in particular, the following aspects:

   1) distortion of shadow prices (shadow wage);

2) fiscal corrections.

b) Distortion of shadow prices: In some EnSP investments, the labour factor has an essential contribution. Theoretically, wages reflect the social value of working time and effort, i.e. marginal value to society. In practice, there can be some distortions. Wages can be an indicator of the distorted social opportunity cost of labour because the labour market is imperfect or because there are macroeconomic imbalances (high and persistent unemployment). In the primary EnSP investment, a very careful analysis of the impact on employment should be made because:

1) it is important to check the loss of jobs in other sectors as a result of the EnSP; gross benefits of employment can overestimate the net impact;

2) there are situations in which an investment project can lead to the preservation of jobs that otherwise would have been lost.

c) Fiscal corrections: In the SCBA there are some items that can be regarded as transfers from one economic agent to another, without any economic impact. For example, a subsidy from the government for an investor is a pure transfer that does not create an economic value while being a benefit to the recipient. In order to correct these distortions, a set of rules should be applied, such as:

1) all input and output prices should not contain VAT and other indirect taxes;

NOTE Taxes are paid by consumers to the project, the project pays taxes to the government and the government redistributes the money to consumers in the form of public spending. The prices of inputs, including labour, include direct taxes, e.g. an employee receives a wage from which taxes are deducted and the tax is used by the government for public services.

2) subsidies granted by the government for the project developer are pure transfers and should not be taken into account when calculating income in the SCBA.

d) Valuation of non-economic impacts: At this stage, the assessment of relevant impacts of the project to society, and of the impacts that do not have an available market value, should be made. These potential impacts should be identified, evaluated and given a realistic monetary value. In environmental projects, non-economic impacts can be landscape and noise. For landscape, the impact assessment can be done using a model that provides estimates of the willingness to pay for certain characteristics of the area (i.e. a environmental landscape feature model). For noise, the assessment involves a sensitivity analysis for changes in real estate prices due to noise (i.e. a noise sensitivity index).

e) Including additional indirect effects: These indirect effects can be positive or negative depending on the distortion and elasticity of goods in the secondary market. The indirect effects should be taken into account in the analysis only when the size of the distortion is sufficiently relevant and measurable. In general, a good use of shadow prices and a good monetization of externalities are usually sufficient to account for indirect effects.

f) Updating the estimated costs and benefits: The costs and benefits that occur at different times of the investment should be updated. In the SCBA, the discount rate is called the “social discount rate”. This rate reflects the social vision of how future benefits and costs should be evaluated from the present. The social discount rate can be different from the financial discount rate when the stock market is inefficient.

g) Calculation of economic and financial performance indicators: In the SCBA, after correcting the distortion of prices/wages and choosing a social discount rate, it is necessary to calculate a series of EFIs. The indicators used in the SCBA are typically:

1) net present value (NPV), i.e. the difference between the discounted total social benefits and costs;

2) internal rate of return (IRR);

3) payback period (PP);

4) life cycle costs (LCC);

5) profitability index (PI).

8.4 Decision-making

8.4.1 General

A detailed investigation phase determines the feasibility of each EnSP and provides decision-makers with the information they need to make a final investment decision. Further analysis is often required before a decision is made on what EnSPs to implement. This can require an investment in equipment to improve measurement accuracy or in time spent collecting more data. Other factors that may be considered in this evaluation are:

a) shutdowns or downtime required to implement the change;

b) changes in production output;

c) changes in other process inputs, such as water or raw materials;

d) changes in maintenance costs;

e) hardware changes that make spare parts inventories obsolete;

f) costs of hardware or structural modifications required to match existing and new equipment;

g) business plans or forecasts that affect the lifetime or throughput of the process being changed;

h) costs of training or new skills that can be required;

i) a comprehensive and detailed analysis that builds confidence in the findings among the project team and senior management.

The EFIs calculated in accordance with 8.1 can be used to determine which EnSPs will provide the highest added value to the organization.

Depending on the values obtained by the EFIs, EnSPs can be approved or rejected.

8.4.2 Selection of an EnSP based on indicators

The selection of an EnSP based on EFIs can be made as follows.

a) Present value (PV) is an indicator that may not be used alone to justify the EnSP and may be used in conjunction with other indicators. If this indicator is used and if PV ≥ 0, then the investment is attractive. However, it is recommended to use NPV, see b).

b) Net present value (NPV) determines the current value of the discounted net cash flows from an investment based on the organization's required rate of return. It takes into account the equipment life, risk of the investment and when the energy savings will be delivered.

NOTE 1 NPV is simple to calculate using the NPV formula or a spreadsheet NPV function.

If the sum of the present value of the expected annual savings is greater than the initial investment, the NPV of the project will be positive and may be undertaken. The risk of the project is taken into account by selecting an appropriate discount (hurdle) rate for the investment.

As a general rule, an investment project with an economic rate of return lower than the discount rate or with a negative economic NPV should be rejected unless it has another strategic value to the business or meets other objectives of the organization.

The NPV may need to be supplemented by other approaches for long-term investments, such as an analysis of long-term cash flows, because the NPV of cash flows becomes very low beyond 10 to 20 years, depending on the discount rate. This can be problematic if a project does not earn money in its early years. Organizations may choose to use lower discount rates when determining NPVs for a long-term investment.

c) Internal rate of return (IRR) follows the same reasoning as NPV, see b). The main difference is that, rather than choosing a discount rate which is based on the risk of the project, this method relies on an iterative solution to determine which discount rate will cause the NPV of the project to equal zero. IRR is calculated by trial and error by varying the discount rate in the NPV formula until the NPV is equal to 0.

   If the IRR is unique and IRR ≥ MARR, then the investment is attractive.

   NOTE 2 Depending upon the cash flow, multiple IRRs can exist. If the cash flow consists of an initial investment (net negative cash flow) followed by future non-negative cash flows, then a unique IRR exists.

   If the EnSP has a single initial investment at $t = 0$ and savings that are represented as a single uniform series over the life of the project, then an alternate method can be used to calculate the IRR. The alternate method involves calculating the ratio C_i/A_s, where C_i represents the initial investment and A_s represents the uniform annual savings. The interest tables are then searched for a value of i % such that $(C_i \mid A_s, i, n) = C_i/A_s$. For projects with the cash flow pattern described above, the ratio of C_i/A_s is equal to the value of the payback period.

d) Payback period (PP), either simple payback period (SPP) or discounted payback period (DPP), is used for the comparison and prioritization of more than one EnSP. The EnSP that has the minimum payback period is attractive. When organizations use this indicator for only evaluating one EnSP, the attractive period of time to return investment should be defined.

   NOTE 3 In some documents, simple payback period can be useful to identify which EnSP is to be analysed more carefully.

e) Life cycle cost analysis (LCCA) is a method for assessing the total cost of facility ownership. It takes into account all the costs of acquiring, owning and disposing of an EnSP. LCCA is especially useful when project alternatives fulfilling the same performance requirements but differing with respect to initial costs and operating costs have to be compared in order to select the one that maximizes net savings. When comparing two EnSPs, the EnSP that has the lower life cycle cost is more attractive.

f) Profitability index (PI) is useful when comparing alternative EnSPs that have significantly different initial costs. It uses a present value calculation. If PI > 1, the NPV is positive and the EnSP is accepted. If PI = 1, the NPV is zero and the investment earns a rate of return equal to the discount rate. If PI < 1, the EnSP is rejected.

9 Reporting

The report of the economic and financial evaluation process for an EnSP should include:

a) the scope and boundary of the EnSP;

b) the type and any technical information related to the project;

c) the method used for the calculation of energy savings;

d) the currency and condition of the investment;

e) calculated EFIs;

f) the result of the assessment and analysis;

g) the relative proportions of the risks identified that can be attributed to the various factors in the evaluation;

h) the priority of project, if required;

i) a reference to this document, i.e. ISO/TS 50044.

Annex A
(informative)

Energy savings calculation steps

A.1 General

The process of establishing energy savings estimates can be divided into the steps presented in A.2 to A.7.

A.2 Step 1: Defining an EnSP

In order to select an appropriate savings estimation approach, an EnSP should be defined. Defining the EnSP includes identifying:

a) the existing equipment, its operation, age, performance characteristics and load profile;

b) the proposed measure and its impact on equipment performance, operation and/or load;

c) the equipment and load boundaries, which establish the scope of the equipment;

d) the major parameters on equipment performance and load;

e) the characteristics of equipment operation and load: constant or varying;

f) the project installation type (see A.5) and the load type (existing/new/added load).

A.3 Step 2: Selecting an appropriate estimating method

An energy savings estimation method should be selected for the EnSP based on the data quality.

A.4 Step 3: Establishing equipment useful life values

The equipment useful life values should be established to determine the EnSP baselines and cost effectiveness.

A.5 Step 4: Establishing an EnSP type

In order to properly determine the baseline parameters, an EnSP type should be established. There are four different EnSP types in the customized programme: replace on burnout, retrofit early retirement, retrofit add-on and new construction/new load, as explained in Table A.1.

Table A.1 — Project type summary descriptions

Project type	Project description
Replace on burnout	Existing equipment has less than one year of remaining useful life[a]
Retrofit early retirement	Existing equipment is fully functional and has more than one year of remaining useful life
Retrofit add-on	Control is added to existing fully functional equipment
New construction/new load	Installation of new equipment to service a new or added load

[a] The remaining useful life is the effective useful life minus the number of years since the equipment was installed (based on the fully commissioned date).

A.6 Step 5: Establishing an annual energy baseline

An annual energy baseline should be established based on the operation of existing equipment, but assuming minimum-standard efficiency equipment, which includes state-mandated codes, federal-mandated codes, industry-accepted performance standards or other baseline energy performance standards as determined by the organization.

A shorter period than a year can be appropriate when the operating and load profile of the equipment can be adequately represented.

A.7 Step 6: Calculating the energy savings

For the retrofit of existing equipment/systems capacity equipment when baseline or post-installation production levels are different (i.e. the equipment load is higher or lower), the annual energy savings are calculated by assuming the post-installation production.

Annex B
(informative)

Example of cost characteristics

The capital cost of a diesel generation set is $ 900 000, the annual output is 219 MWh and the maintenance cost is $ 30 000 per annum. The cost of producing each unit of electricity is 0,350 $/kWh. The life of the diesel generator is 5 years. The total cost is calculated as shown in Table B.1.

Table B.1 — Cost of a diesel generation set

Item	Type of cost	Calculation	Cost $
Capital cost of generator	Capital employed	—	900 000
Annual maintenance	Fixed	30 000 × 5 (years)	150 000
Fuel cost	Variable	219 000 × 0,350 × 5	383 250
Operating cost			533 250
Total cost			1 433 250

From the example, it can be seen that the fixed costs represent 28,13 % of the operating cost. In fact, the annual electricity output of 219 MWh assumes that the plant is operating with an average output of 26,32 KW based on 8 322 hours of operation during a year. If this output was increased to an average of 70 kW, the annual fuel cost would become $ 201 889 with the result that the fixed costs would drop to 12,83 % of the operating cost.

Thus, the average unit cost of production decreases as output increases.

Annex C
(informative)

Examples of payback period calculation

C.1 Simple payback period

C.1.1 General

The simple payback period is the simplest technique that can be used to appraise an EnSP. In theory, once the payback period has ended, all the project capital costs will have been recouped and any additional cost savings achieved can be seen as a clear profit. Obviously, the shorter the payback period, the more attractive the project becomes. The length of the maximum permissible payback period generally varies with the business culture concerned, the life cycle of the equipment and the strategic value of the project to the organization. In some organizations, a payback period of more than three years is acceptable.

C.1.2 Example

A new small cogeneration plant installation is expected to reduce a company's annual energy bill by $ 48 600. If the capital cost of the new boiler installation is $ 222 000 and the annual maintenance and operating costs are $ 4 200, the expected payback period, PP, for the project can be calculated using Formula (C.1):

$$\mathrm{PP} = \frac{C_\mathrm{i}}{A_\mathrm{t}} \tag{C.1}$$

PP = 222 000 / (48 600 – 4 200) = 5,0 years

where

C_i is the initial cost of the system;

A_t is the net cash flow.

C.2 Discounted payback period

C.2.1 General

The discounted payback period is used to evaluate the time period needed for an EnSP to bring in enough profit to recoup the initial investment.

C.2.2 Example

An initial investment of $ 50 000 is expected to generate $ 10 000 per year for 8 years. If the discount rate is 11 %, the discounted payback period of the investment is calculated using either a) or b).

a) Solution 1: The discounted payback period, DPP, is calculated using Formula (C.2):

$$\mathrm{DPP} = \ln\left(\frac{1}{1-(\frac{C_\mathrm{i} \times r}{\mathrm{CF}})}\right) \div \ln(1+r) \qquad \text{(C.2)}$$

where

C_i is the initial cost of the system ($ 50 000);

CF is the cash flow ($ 10 000);

r is the discount rate (11 %).

Therefore: DPP = 7,65 years

b) Solution 2: The discounted payback period is calculated using Formula (C.3):

$$\mathrm{DPP} = a + (b/c) \qquad \text{(C.3)}$$

where

a is the last period with a negative discounted cumulative cash flow;

b is the absolute value of the discounted cumulative cash flow at the end of period a;

c is the discounted cash flow during the period after period a.

NOTE c is the sum of the absolute value (modulus) of the discounted cash flow during period a and the cash flow in the period immediately after period a when the cumulative discounted cash flow becomes positive.

The data for a practical project are given in Table C.1.

Table C.1 — Data collection

Year n	**Cash flow** CF	**Present value factor** PV = $1/(1+r)^n$	**Discounted cash flow** (CF × PV)	**Cumulative discounted cash flow**
0	50 000	1	50 000	50 000
1	10 000	0,9	9 009,01	40 990,99
2	10 000	0,81	8 116,22	32 874,77
3	10 000	0,73	7 311,91	25 562,85
4	10 000	0,66	6 587,31	18 975,54
5	10 000	0,59	5 934,51	13 041,03
6	10 000	0,53	5 346,41	7 694,62
7	10 000	0,48	4 816,58	2 878,04
8	10 000	0,43	4 339,26	–1 461,23

The last period with a negative discounted cumulative cash flow (a) = 7.

The absolute value of the discounted cumulative cash flow at the end of the period a (b) = 2 878,04.

The discounted cash flow during the period after period a (c) = 2 878,04 + 1 461,23 = 4 339,26.

Therefore: DPP = a + (b/c) = 7 + (2 878,04 / 4 339,26) = 7,66 years

Annex D
(informative)

Example of net present value calculation

D.1 General

NPV is one of the preferred indicators for evaluating an EnSP. This indicator gives user a "yes" or "no" for the investment decision. It takes into account the equipment life, risk of the investment and when the energy savings will be delivered. It is simple to calculate using the NPV formula or a spreadsheet NPV function.

If the sum of the present values of the estimated energy savings is greater than the initial energy investment, the NPV of the EnSP will be positive and may be undertaken if it meets the business needs of the organization.

D.2 Example

There are two EnSPs with specified capital costs and net savings, as given in Table D.1. The annual discount rate for each EnSP is 8 %. The NPV indicator shows which projects should be accepted.

Table D.1 — EnSPs financial data

	EnSP 1	**EnSP 2**
Capital cost ($)	30 000	30 000
Year	**Net annual saving** ($)	**Net annual saving** ($)
1	+6 000	+6 600
2	+6 000	+6 600
3	+6 000	+6 300
4	+6 000	+6 300
5	+6 000	+6 000
6	+6 000	+6 000
7	+6 000	+5 700
8	+6 000	+5 700
9	+6 000	+5 400
10	+6 000	+5 400
Total net saving at end of year 10	+60 000	+60 000

The annual cash flows are multiplied by the annual discount factors with a discount rate of 8 % to determine the annual present values, as shown in Table D.2.

Table D.2 — NPV calculation

Year	Discount factor for 8 % (*a*)	EnSP 1		EnSP 2	
		Net annual saving ($) (*b*)	Present value ($) (*a* × *b*)	Net annual saving ($) (*c*)	Present value ($) (*a* × *c*)
0	1,000	−30 000	−30 000	−30 000	−30 000
1	0,926	+6 000	+5 556	+6 600	+6 111
2	0,857	+6 000	+5 142	+6 600	+5 656
3	0,794	+6 000	+4 765	+6 300	+5 002
4	0,735	+6 000	+4 410	+6 300	+4 630
5	0,681	+6 000	+4 086	+6 000	+4 086
6	0,630	+6 000	+3 780	+6 000	+3 780
7	0,583	+6 000	+3 498	+5 700	+3 323
8	0,540	+6 000	+3 240	+5 700	+3 078
9	0,500	+6 000	+3 000	+5 400	+2 700
10	0,463	+6 000	+2 778	+5 400	+2 500
		NPV 1 = +10 254		NPV 2 = +10 867	

NOTE The discount factor, DF, is based on an assumed discount rate, i.e. cost of capital, and can be determined using the formula:

$$DF = (1 + i/100)^{-n}$$

It can be seen that over a 10-year life span the NPV 1 for EnSP 1 is $ 10 254 while for EnSP 2 it is $ 10 867,80.

Therefore, EnSP 2 is the preferred project.