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General methods for predicting energy savings

Méthodes générales d'estimation des économies d'énergie

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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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

This document specifies general methods for the calculation of predicted energy savings (PrES). It also provides a process that should result in PrES satisfactory for the relevant stakeholders. It is meant to be used after the opportunities for energy performance improvements have been identified, but prior to the implementation of energy performance improvement actions (EPIAs). It is, therefore, meant to be used when selecting or specifying the EPIAs or the action plan, programme or policy to be subsequently implemented, as represented in Figure 1.

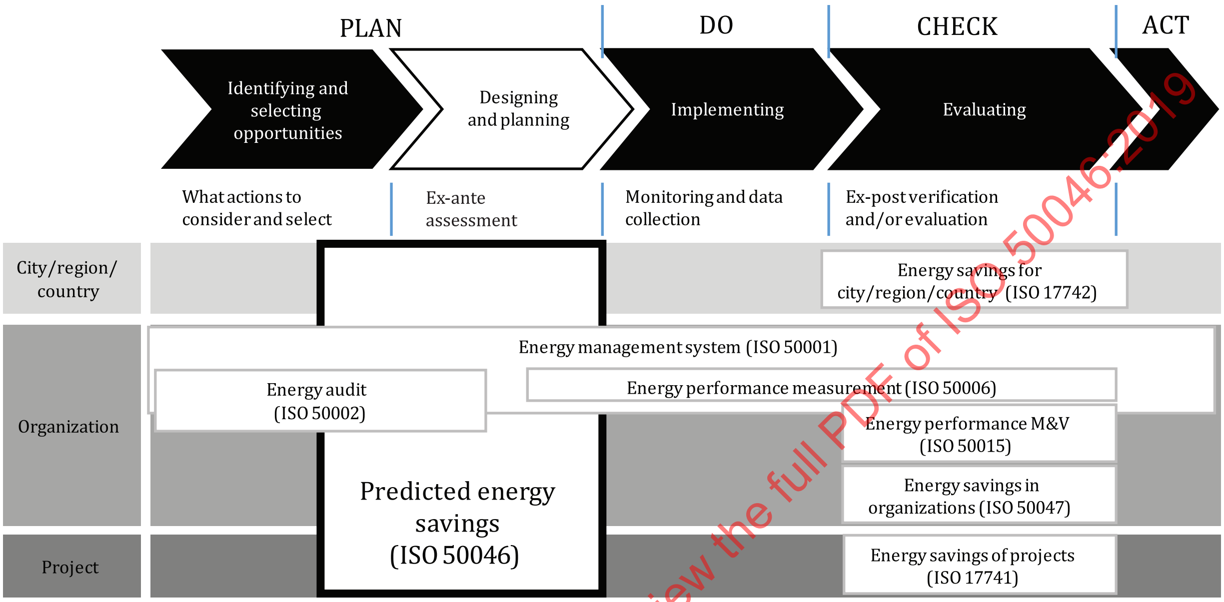


Figure 1 — The place of this document in a continual improvement process

The calculation of PrES can be undertaken on its own, or as part of a more comprehensive evaluation cycle. In the latter case, complementary guidance can be found in other documents, as illustrated in Figure 1.

This document builds on the general principles outlined in ISO 17743, which provides a methodological framework applicable to the calculation of and reporting on energy savings.

ISO 17742 deals with energy savings at the level of countries, regions or cities, distinguishing indicator-based and measure-based calculation methods.

ISO 50047 deals with energy savings in organizations. It uses an organization-based approach (a form of top-down approach), and an EPIA-based approach (sometimes referred to as being a “bottom-up” approach).

ISO 17741 deals with general technical rules for the measurement, calculation and verification of energy savings of projects.

This document uses the distinction between measure-based methods and indicator-based (or total-consumption-based) methods. Instead of distinguishing between the scopes of geographical entities, operational entities and physical systems, it makes a distinction between the levels of aggregation of energy savings: either unit level (action or project) or aggregated level (action plan, programme or policy).

This document provides a process for increasing the transparency of data and calculations used to predict energy savings. Examples of the use of PrES include:

— for selecting among energy savings opportunities;

— for investment decisions;

— for accounting or crediting energy savings (e.g. energy savings certificates[14]).

It provides methods that can be used, for example, in the context of energy audits, energy savings obligations, energy efficiency portfolio standards[14], voluntary agreements or energy performance contracting.

Irrespective of the methods chosen, validation and documentation of the calculation of PrES add value by increasing their credibility and reliability.

Following a bottom-up approach (measure-based methods, see ISO 17742), this document starts with the calculation of the PrES at the level of an EPIA or a group of EPIAs to be jointly implemented at the same site or by the same organization or energy end-user. These unitary PrES might then be aggregated to calculate the PrES of an action plan, programme or policy under consideration, taking into account causality issues wherever applicable.

For the calculation of the PrES of an EPIA, this document presents three different methods, classified as empirical estimation, statistical modelling and engineering modelling. These methods can be applied to different types of situations. The two general situations considered are (see 4.2):

— when users want to determine PrES according to the specific context in which the EPIA will be implemented;

— when users want to determine reference values of PrES for given types of EPIA.

Clause 4 of this document explains the objectives, context and principles of calculation of PrES. Clause 5 describes the preparation of the calculation process (preliminary step). Clause 6 describes the calculation process at the level of an EPIA. Clause 7 describes the additional steps needed for aggregating the PrES of an action plan, policy or programme. Clause 8 provides guidance on quality and uncertainty analysis. Clauses 4, 5, 6 and 8 are common to both aggregation levels (EPIA level and aggregated level).

General methods for predicting energy savings

1 Scope

This document specifies general methods for the calculation of predicted energy savings (PrES), using measure-based calculation methods, also known as bottom-up or energy performance improvement actions (EPIAs)-based methods (see ISO 17742). Indicator-based methods (see ISO 17742) and total-consumption-based methods (see ISO 50047) are not included in the scope of this document.

This document provides general principles for categorizing and choosing the method, taking account of the context, targeted accuracy and resources available for calculating the PrES. It also provides guidance on the conditions for ensuring the quality of the PrES, their documentation and validation.

It is applicable to calculation of PrES for any:

— type of EPIA;

— end-use sector;

— energy end-use;

— level of aggregation of energy savings;

— stakeholder.

NOTE 1 Stakeholders can include private or public organizations, energy auditors, energy services companies, energy and equipment suppliers, policy makers, etc.

This document considers PrES from:

— an EPIA; and/or

— an action plan, programme or policy (aggregated energy savings).

NOTE 2 An action plan, programme or policy can be implemented at different scales (organization, city, region, country).

This document describes how to calculate PrES over a prediction period. It can be used to calculate PrES in terms of primary energy or final (or delivered) energy (as defined in ISO 50047 and ISO/IEC 13273-1).

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
baseline period
defined period of time used to compare *energy performance* (3.10) with the *prediction period* (3.19)

[SOURCE: ISO 50006:2014, 3.2, modified — “prediction period” has replaced “reporting period”.]

3.2
boundary
physical or virtual limit around *energy using systems* (3.15) or facilities which are related to (an) *EPIA(s)* (3.11)

[SOURCE: ISO 17741:2016, 3.2, modified — Notes 1 and 2 to entry have been removed.]

3.3
context-specific data
data relating to a specific situation

EXAMPLE Electricity consumption for lighting in a particular office building, number of cars manufactured on a particular production line.

Note 1 to entry: *Reference data* (3.21) can be used when context-specific data are not available

3.4
empirical estimation
calculation method based on empirical expertise, experiments, tests or previous analyses

Note 1 to entry: Empirical expertise and experiments can be based on expert knowledge and practical experience using measurements and/or information from similar previously implemented *EPIAs* (3.11), previous benchmarking studies, manufacturers' data, and/or proven references (e.g. scientific literature).

3.5
energy
electricity, fuels, steam, heat, compressed air and other similar media

[SOURCE: ISO 50001:2018, 3.5.1, modified — Note 1 to entry has been removed.]

3.6
energy baseline
EnB
quantitative reference(s) providing a basis for comparison of *energy performance* (3.10)

Note 1 to entry: An EnB is based on data from a specified period of time and/or conditions, as defined by the organization, city, region or country.

Note 2 to entry: An EnB can be normalized using variables that affect *energy use* (3.14) and/or consumption, e.g. production level, degree days (outdoor temperature), etc.

[SOURCE: ISO 50001:2018, 3.4.7, modified — “city, region or country” has been added at the end of Note 1 to entry; Notes 2, 3 and 4 to entry have been removed; a new Note 2 to entry has been added.]

3.7
energy consumption
quantity of *energy* (3.5) applied

[SOURCE: ISO 50001:2018, 3.5.2]

3.8
energy efficiency
ratio or other quantitative relationship between an output of performance, service, goods, commodities or energy, and an input of *energy* (3.5)

EXAMPLE Conversion efficiency, energy required/energy consumed.

Note 1 to entry: Both input and output should be clearly specified in terms of quantity and quality and be measurable.

[SOURCE: ISO 50001:2018, 3.5.3]

3.9
energy end-user
individual or a group of individuals or organization with responsibility for operating an *energy using system* (3.15)

Note 1 to entry: The energy end-user may differ from the customer who might purchase the *energy* (3.5) but does not necessarily use it.

[SOURCE: ISO 17743:2016, 3.5]

3.10
energy performance
measurable result(s) related to *energy efficiency* (3.8), *energy use* (3.14) and *energy consumption* (3.7)

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

3.11
energy performance improvement action
EPIA
action or measure or group of actions or group of measures implemented or planned intended to achieve *energy performance* (3.10) improvement through technological, managerial or operational, behavioural, economic, or other changes

Note 1 to entry: In other documents (e.g. ISO 17742), "elementary unit of action" is used instead of EPIA.

Note 2 to entry: EPIAs can have other purposes than saving *energy* (3.5), for example, to reduce peak loads.

Note 3 to entry: EPIAs can be tailored (relating to a specific situation) or pre-specified (relating to a general context).

[SOURCE: ISO 50015:2014, 3.5, modified — "within an organization" has been deleted from the definition; Notes 1, 2 and 3 to entry have been added.]

3.12
energy performance indicator
EnPI
measure or unit of *energy performance* (3.10)

Note 1 to entry: EnPIs can be expressed by using a simple metric, ratio or a model, depending on the nature of the activities being measured.

Note 2 to entry: For additional information on EnPIs, see ISO 50006.

[SOURCE: ISO 50001:2018, 3.4.4, modified — "as defined by the organization" has been deleted from the definition.]

3.13
energy savings
reduction of *energy consumption* (3.7) compared to an *EnB* (3.6)

Note 1 to entry: Energy savings can be actual (realized) or expected (predicted).

[SOURCE: ISO 17743:2016, 3.8, modified — Note 2 to entry has been deleted.]

3.14
energy use
application of *energy* (3.5)

EXAMPLE Ventilation, lighting, heating, cooling, transportation, data storage, production process.

Note 1 to entry: Energy use is sometimes referred to as “energy end-use”.

[SOURCE: ISO 50001:2018, 3.5.4]

3.15
energy using system
physical items with defined system *boundaries* (3.2), using *energy* (3.5)

EXAMPLE Facility, building, part of a building, machine, equipment, product, etc.

[SOURCE: ISO/IEC 13273-1:2015, 3.1.9]

3.16
measure-based method
determination of *energy savings* (3.13) from *EPIA(s)* (3.11)

Note 1 to entry: When calculating aggregated *PrES* (3.18) (for cities/regions/countries), the process starts with calculating *unitary PrES* (3.22) at the EPIA level.

[SOURCE: ISO 17742:2015, 2.29, modified — “energy performance improvement action(s)” has replaced “end-user actions using unitary energy savings and elementary units of action”; Note 1 to entry has been replaced; the example has been removed.]

3.17
operating conditions
description of the conditions under which *energy using systems* (3.15) are operated

EXAMPLE Temperature setpoint, volume of production, types of products, driving style, weather conditions, etc.

3.18
predicted energy savings
PrES
energy savings (3.13) calculated prior to the implementation of *EPIA(s)* (3.11)

Note 1 to entry: PrES are also known as expected or ex-ante energy savings.

3.19
prediction period
defined period of time over which the *PrES* (3.18) are calculated

3.20
calculation assumptions
conditions chosen for calculating *PrES* (3.18) in order to make the *EnB* (3.6) and the predicted *energy consumption* (3.7) comparable

3.21
reference data
data relating to a general context

Note 1 to entry: When available, *context-specific data* (3.3) are preferred.

EXAMPLE National statistics about the average heat transfer coefficient of walls according to the year of construction, annual lighting hours based on similar facilities.

3.22
unitary predicted energy savings
unitary PrES
PrES (3.18) calculated for a unit being a single *EPIA* (3.11) or a group of EPIAs implemented at the same site or by the same organization or *energy end-user* (3.9)

3.23
validation
review, agreement and approval of proposed choices or decisions, by the stakeholders

4 Objectives, context and principles of calculation of PrES

4.1 Clarifying the objectives

The choice of a calculation method depends substantially on the context and objectives of the calculation of PrES. Before calculating PrES, objectives should be specified as described in 5.4. Examples of some objectives are:

— arriving at preliminary stage investment decisions (rough estimate to identify EPIA opportunities);

— ranking EPIAs while developing an action plan;

— taking final investment decisions (a detailed or comprehensive estimate is required);

— performance monitoring of an energy management system or an energy performance contract (for further comparison between predicted and actual energy savings).

Benefits, risks, costs or other factors that influence the accuracy, timeliness or cost in calculating the PrES should be considered in making a decision.

Specifying the objectives is important in determining the applicable clauses of this document:

— objective = to determine PrES at the level of an EPIA → Clause 7 does not apply;

— objective = to determine aggregated PrES → all clauses apply.

Annex A provides more details about the main criteria to take into account while using this document.

4.2 Analysing the context

When calculating PrES, two general situations can be considered:

a) in which data are based on a specific context (context-specific data);

b) in which data are based on a general context and independent of a specific context (reference data).

Both situations can co-exist, as they are not mutually exclusive. As far as possible, the use of context-specific data is recommended as it results in higher accuracy. Reference data may be considered when:

— the specific context is not known in advance; or

— many EPIAs are being assessed, which makes it very difficult or costly to collect context-specific data for each EPIA.

The choice between context-specific data and reference data also depends on the calculation objectives (as shown in Figure 2, see also the examples in Table A.1).

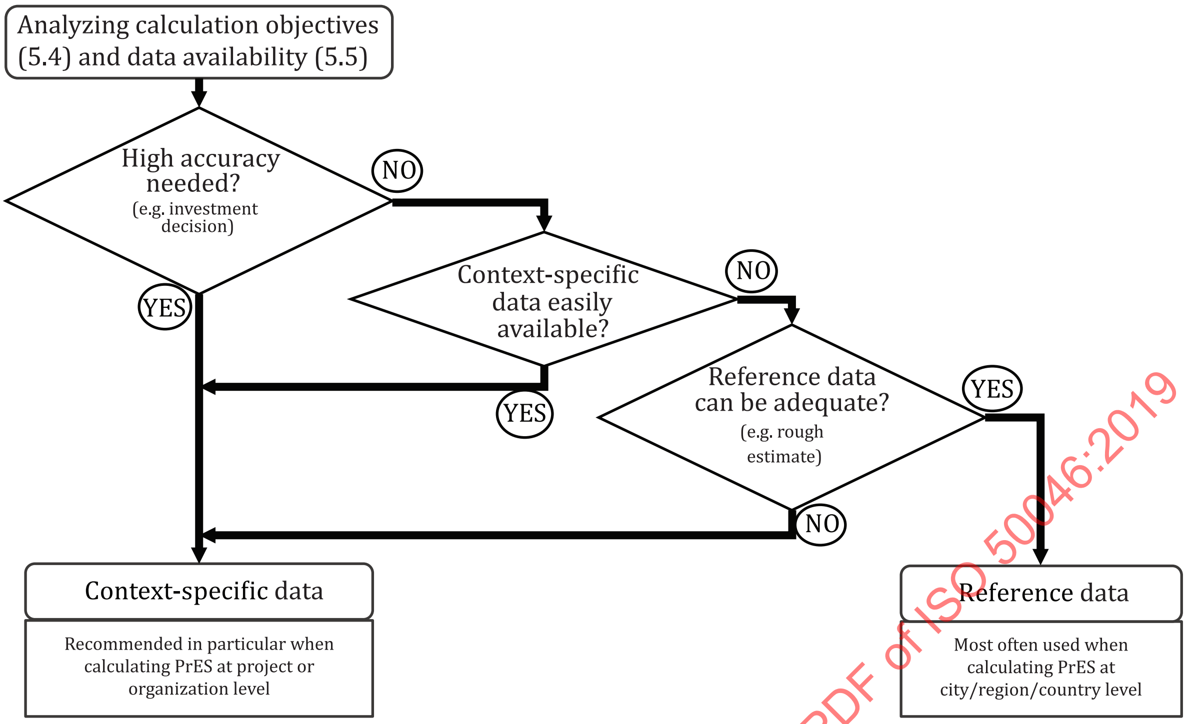


Figure 2 — Indicative decision path for choosing between context-specific and reference data

The following examples describe situations in which context-specific data, reference data or a combination of both are required:

- context-specific data:
  - contract or agreement between a service provider and a customer;
  - recommendations of an energy audit;
  - assessment of PrES while preparing a project;
- reference data:
  - accounting or crediting of energy savings for an energy efficiency obligation scheme or energy efficiency portfolio standards[14];
  - impact assessment of a future energy efficiency policy or programme;
- combined situations:
  - the energy savings of the same EPIA considered by a company can be calculated with context-specific data through an energy audit to ascertain the particular energy performance improvement it can bring to the company, and with reference data to ascertain the energy savings that could be credited if the EPIA were reported for an energy efficiency obligation scheme having its own rules for calculation of PrES.

In some cases, the PrES can be determined while comparing alternative potential EPIAs. For example, in determining which change(s) or new installation of lighting to designate as the EPIA, an organization might predict the energy savings of several candidate EPIAs. The PrES of the selected EPIA will have already been determined.

4.3 Principles

4.3.1 General

The general principles (detailed in 4.3.2 to 4.3.5) provide the basis for the calculation of PrES. The overall aim of the calculation methods is to provide reliable results in order to give confidence to the stakeholders when making a particular decision or pursuing a particular course of action.

The principles to ensure the quality of the PrES are:

— initial planning (simultaneous design of the EPIAs and their calculation);

— appropriate level of accuracy;

— transparency and reproducibility (of the calculation methods and of the PrES);

— reliability and validation.

4.3.2 Initial planning

Initial planning helps to ensure the feasibility of calculation.

Planning the calculation process simultaneously with the design of EPIA(s) makes it possible to account for the available resources and time (in particular the budget and the timing of the decision to be made, and the resources and time required for different calculation methods). Analysis of data availability and quality is particularly important while preparing for the calculation process (see Clause 5 for more details).

4.3.3 Appropriate level of accuracy

An appropriate level of accuracy should be selected depending on the objectives of the calculations. Accuracy of the PrES is considered to be appropriate when the stakeholders have confidence in using it. It does not always need to be the highest possible level. Assumptions that make the calculations simpler and that are consistent with the calculation objectives may be used if agreed to by the stakeholders[10].

The requirement about accuracy might differ greatly, for example, between the case of an approximate estimation to evaluate whether to implement a low-investment EPIA and the case of a detailed estimation to evaluate a high-investment EPIA. The costs of calculating PrES might thus differ greatly, mainly due to differences in the resources needed to collect additional data and/or to perform additional analyses (see the example in Annex E).

More details about accuracy and uncertainty are provided in Clause 8.

4.3.4 Transparency and reproducibility

To ensure transparency and reproducibility, this document identifies the information to be documented at each step of the calculation process. Documentation is the key to ensuring that the PrES can be understood and used in a correct manner. Transparency should make it possible for external experts to reproduce the calculations and results. See Annex B for an overview of documentation guidance, Annex C for an example of documentation template and Annex D for an example of using this template.

4.3.5 Reliability and validation

Reliability of the results can depend on several criteria, including:

— the choice of the calculation method;

— the availability and quality of the data to be used;

— the expertise and experience of the team applying the method;

— the accuracy of the PrES (combination of the method, the expertise and the means used).

Limitations of data are a frequent problem faced in calculating PrES, particularly while using advanced methods or modelling. Likewise, many of the methodological choices made while calculating PrES can raise questions leading to a decrease in the confidence of the stakeholders in the PrES.

The validation process is the key to ensuring reliability of PrES. The validation aspects are therefore highlighted at each step of the calculation process. See Annex B for an overview.

The validation process should be adapted according to the context and the calculation objectives. For simple cases, the validation process might be carried out in a single meeting. In complex cases, the validation process might require iterations and different steps.

Irrespective of the case, the validation should include an agreement by the stakeholders. The validation can also include (according to the calculation objectives and context):

— comparison of the PrES with values obtained by another calculation method;

— using a recognized and proven reference or data source;

— verification by a third party.

EXAMPLE In the case of building insulation, the energy performance improvement can be assessed as a change in the thermal performance of the building envelope. The result can be compared with the result of a building simulation, using recognized and proven reference values available in technical guides, or with feedback of a third party based on experience of wall insulation using similar insulation material and characteristics.

In this document, the distinction is made between a check and validation. A check does not necessarily imply an agreement that the proposition is correct, while validation means that the persons/organizations are endorsing the related decisions.

5 Preparation and selection of the calculation method

5.1 General

The calculation of PrES is an iterative process that is used to meet the calculation objectives. The iterations needed are a function of the complexity of the considered EPIAs. Figure 3 shows this iterative process for a general case.

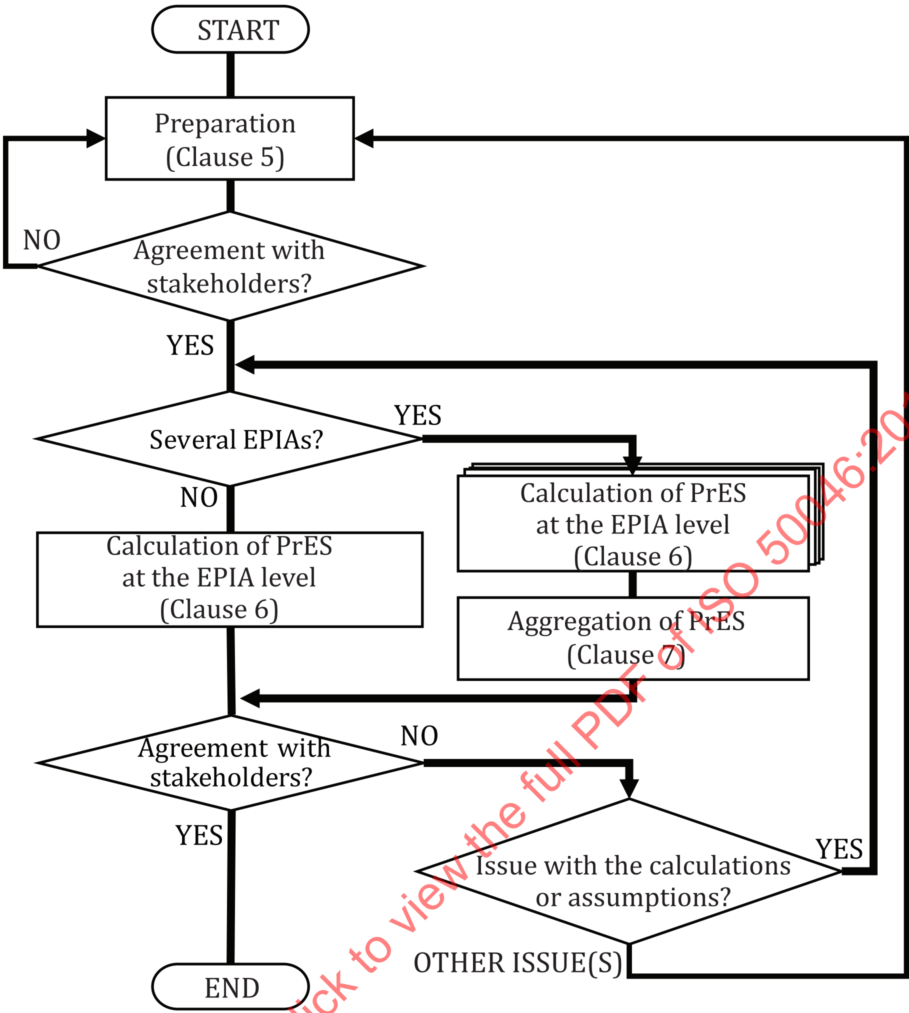


Figure 3 — View of the iterative process to calculate PrES

A similar iterative process can be used while designing or specifying an EPIA.

This clause describes the key aspects that should be considered while preparing for the calculation of PrES and choosing the calculation method (as presented in Figure 4). This applies to the calculation of PrES in both cases: at the level of an EPIA and for aggregated PrES from an action plan, programme or policy. The calculation process at the EPIA level is described in Figure 6 of Clause 6. The next steps while aggregating PrES are presented in Figure 8 of Clause 7.

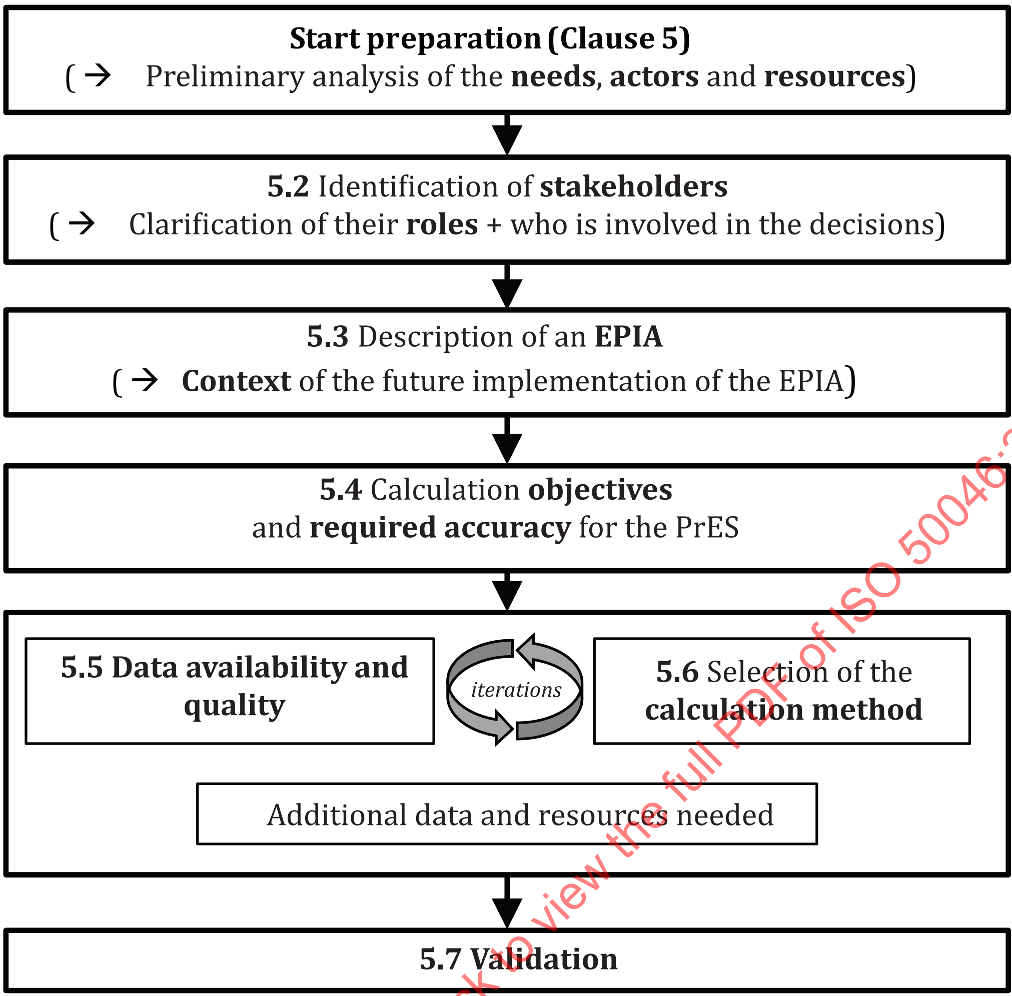


Figure 4 — Overview of the preparation process

NOTE Iterations can be needed when there are disagreements among stakeholders or while selecting the calculation method if no solution can be found to meet the data requirements.

5.2 Identification of the stakeholders

Preparation starts with the identification of stakeholders involved in the EPIAs under evaluation and of their role, priorities, objectives and constraints.

EXAMPLE Stakeholders can be investors, providers or installers of EPIAs, regulatory bodies, public agencies, energy companies, energy auditors, energy end-users, customers or beneficiaries of EPIAs, or services aiming at saving energy.

The clarification of the role of each stakeholder is important for the success of the calculation process. Different stakeholders might be involved in data collection. It is important to clarify which stakeholders need to give their assent to the methodological choices and decisions to be taken (see Figures 3 and 4), and which stakeholders need to take part in the validation of the PrES (see 5.7). In a simple case, the agreement can be between a service provider and its customer, whereas validation can be done by the customer.

The stakeholders can decide what should be reported. Reporting is based on the documentation of the PrES and calculation method.

5.3 Description of an EPIA

5.3.1 General

Description of an EPIA includes explanations of:

— the energy-using system(s) targeted by the EPIA;

— how the EPIA is expected to improve the energy performance of this energy-using system.

EXAMPLE 1 Energy performance improvement in the case of building insulation is linked to a change of the thermal performance of the building envelope. The related energy performance improvement is therefore specific to the characteristics of the EPIA (types of materials, thickness, etc.), which achieves an increase in the energy efficiency of the building.

EXAMPLE 2 Installation of sensors and controls can avoid lights remaining on when no one is present in a room. In this case, the energy performance improvement is directly the difference in the energy consumption.

EXAMPLE 3 In the case of an eco-driving programme for cars, the energy performance improvement will be a change in an EnPI: the lower specific energy consumption expressed in litres/km travelled.

The description of an EPIA also specifies the implementation and operating conditions. This includes:

— a description of the system and environment in which an EPIA will be implemented;

— the planned operating conditions of the energy using system and the EPIA;

— whether requirements apply concerning the EPIA implementation (e.g. minimum energy performance requirements defined in a regulation).

5.3.2 General types of EPIA

When calculating PrES, it can be convenient to distinguish two general types of EPIA:

— pre-specified EPIA: description of the EPIA mainly based on reference data (see 4.2 and the example in Annex D);

— tailored EPIA: description of the EPIA mainly based on context-specific data (see 4.2 and the example in Annex E).

5.3.3 Boundaries of the EPIA and PrES

As an EPIA can affect an energy using system other than the targeted one(s), the boundaries used for calculating the PrES (PrES boundaries) might need to be expanded from the corresponding EPIA boundaries.

PrES boundaries should encompass all energy-using systems affected by the EPIA, unless the choice to neglect or exclude an energy-using system from the PrES boundaries can be justified and agreed upon by designated stakeholders (and the agreement recorded).

Definition of the PrES boundaries should be based on the analysis of the calculation objectives and data availability (see 5.5). A literature review might be helpful in identifying the most appropriate boundaries.

Analysis of the PrES boundaries should also include a review of the possible interactive effects between energy-using systems that might be indirectly impacted by implementing the EPIA but were not explicitly targeted by the EPIA. Accounting for interactive effects can arise in projects installing a large number of, or types of, EPIAs (see 7.3). If careful definition of the boundaries of the EPIA and the

PrES does not satisfactorily account for interactive effects, this should be documented along with any additional data or analyses used to account for their effect.

EXAMPLE Energy consumption for air conditioning might be indirectly affected by changing to a more efficient lighting system that produces less heat.

5.3.4 Key questions about the planned implementation of EPIAs

The preparation of the calculation process includes an analysis of the context of the EPIA's planned implementation (and potentially of the related programme or policy).

— What are the main objectives of deploying the EPIA?

EXAMPLE 1 Reducing energy bills, increasing comfort, improving competitiveness, meeting energy savings or environmental targets.

— Who will be involved in the implementation of the EPIA?

EXAMPLE 2 For the installation of an energy-efficient boiler: this might include the installer, the building operator, the customer, the energy auditor advising on the new boiler, a public agency providing information on or grants for the replacement, or a third party providing a financing solution for this EPIA.

— What are the expected costs and benefits of implementing the EPIA?

Consider which costs and benefits to include (e.g. easily quantifiable elements like equipment costs and non-financial benefits like comfort). Also consider which entity incurs the costs or receives the benefits and in which timeframe.

— Will the EPIA be implemented within a particular action plan, programme or policy?

EXAMPLE 3 Action plan of an organization, energy efficiency obligation scheme or energy efficiency portfolio standards, subsidy scheme, energy audit programme.

— Is the implementation of the EPIA expected to encourage actions with effects beyond its direct savings?

EXAMPLE 4 Implementation of the EPIA might demonstrate its effects to others resulting in its adoption by them.

5.4 Calculation objectives and required accuracy

The analysis in 5.3.4 makes it possible to specify the calculation objectives (see 4.3.3), taking into account the following three key questions.

— What will the calculation result be used for? (See 4.1.)

— To whom will the results of PrES be communicated?

EXAMPLE 1 Energy end-users, site owners, energy managers, investors/financiers, contracting stakeholders, regulatory bodies or public authorities.

— Do legal or other requirements apply to the calculation and/or the reporting of the PrES?

EXAMPLE 2 It can be necessary to use data from regulations on energy performance of products or buildings, or to apply the rules of an energy efficiency obligation scheme or energy efficiency portfolio standards.

The accuracy targeted for the PrES can then be defined taking into account the calculation objectives, based on these questions.

5.5 Data availability and quality

The preparation of the calculation process includes:

— a review of the data sources about the planned EPIAs and how they are expected to affect the energy consumption;

— a review of the available data sources about similar previously implemented EPIAs (in particular, the calculation model or formula, and reference values);

— a review of the possible means of collecting additional data;

— a review of the quality of each data source.

Examples of data sources: energy bills, device invoices, energy audits, surveys, expert estimates, information from similar EPIAs previously implemented, manufacturers' data, national (or other) statistics, standards.

Data availability can be classified into the following three categories[10]:

a) data already available and/or routinely provided,

b) data that could be collected by available means and with available expertise (for data collection and analysis),

c) data that would require additional resources for collection and/or expertise.

These categories can be used to identify the resources needed for data collection according to data needs and collection options. The assessment of the resources needed includes an analysis of the needs for verification and analysis of the data quality necessary to achieve the accuracy targeted. Data quality and any issues should be documented. Third party verification should be considered based on agreement with the stakeholders.

NOTE More information about data, in particular for buildings, can be found in ISO/TS 50008.

5.6 Selection of the calculation method

5.6.1 General types and choice of the calculation method

In general terms, PrES reflect the difference between an EnB and a predicted energy consumption [see 5.6.4 and Formula (1)]. A calculation method consists of three main components, which can be used to determine the EnB (see 6.3) and the predicted energy consumption (see 6.4). This subclause deals with the selection of these components, while their implementation is presented in Clause 6. The main components are given in Table 1.

Table 1 — Main components of a calculation method

Components of the calculation method	Possible alternatives
Type of data analysis (see 5.6.2)	Empirical estimation, statistical modelling, engineering modelling
Data collection techniques and sources (see 5.6.3)	Measurements, metering, monitoring of selected variables, sampling, literature review, benchmarking, design data, etc.
Type of calculation formula or model (see 5.6.4)	See Formulae (1) to (4) (in 5.6.4)

5.6.2 Type of data analysis

The calculation method is described according to the type of knowledge or expertise used to analyse the data[10][11]. The different options for measure-based methods can be summarized in three types of data analysis, as given in Table 2.

Table 2 — General types of data analysis

Type of data analysis	Examples
Empirical estimation	Expert knowledge and/or use of previous analyses (benchmarking, laboratory testing, etc.)
Statistical modelling	Regression models, randomized treatment/control models, conditional demand models
Physics-based (or engineering) modelling	Algorithms or simulations using thermodynamics, heat transfer, electrical engineering, etc.

These three types of data analysis may be combined for the calculation of PrES (e.g. for bottom-up stock modelling). The determination of the EnB is described in 6.3.

Choice of the method (or combination of methods) to be used should be based on:

— analysis of the calculation objectives (see 5.4) and the accuracy required;

— whether data to determine EnB are available or not (see, for example, the case of new energy using systems or devices);

— data availability (taking into account their reliability) (see 5.5);

— feasibility and costs of additional data collection that might be needed;

— available resources (e.g. personnel, devices, software, financial resources) and time needed to implement the method (or combination of methods);

— expertise of the personnel.

The specification of a calculation method is based on the research of available references for similar EPIAs, providing a basis for possible EnBs, calculation formulae/models, data collection techniques, data sources, experience feedback, etc. (see, for example, References [10], [11], [12] and [13]).

5.6.3 Data collection techniques and sources

The calculation method includes specification of data collection techniques (see the examples in Table 1) and data sources in order to meet the data needs (based on the preliminary analysis described in 5.5).

It is important to take into account the calculation objectives and available resources in order to ensure the best possible quality of data. Data collection techniques and sources are chosen on the basis of their reliability and cost. In cases of missing data, the assumptions made should be documented in the calculation method.

5.6.4 Type of calculation formula or model

5.6.4.1 General formula

Calculation of the PrES is specific to each type of EPIA and energy using system. It starts from the general formula, i.e. Formula (1):

$$\text{PrES} = \text{energy baseline} - \text{predicted energy consumption} \quad (1)$$

The same boundaries are used while determining the EnB and the predicted energy consumption. If this is not possible, the justifications for the differences should be included in the documentation. EnB and the predicted energy consumption shall be made comparable by ensuring that the operating conditions are equivalent (see Figure 5). This should be taken into account while specifying the calculation assumptions (see 6.5.1).

Formula (2) can be used as an adaptation of Formula (1).

$$\text{Pr ES} = \text{energy baseline} \times \text{predicted energy savings ratio} \tag{2}$$

with

$$\text{predicted energy savings ratio} = 1 - \left(\frac{\text{predicted energy consumption}}{\text{energy baseline}} \right) \tag{3}$$

While determining an EnB or predicted energy consumption, two cases can occur (see ISO 17742):

— type I for cases in which energy consumption data are available or can be collected, and can be used to determine EnB or predicted energy consumption without any revision;

— type II for all other cases, where energy consumption will be determined from a combination of variables (see Formula (4) and Figure 5).

These types are not mutually exclusive. In practice, situations involving a combination of both types can be encountered.

NOTE Type I for predicted energy consumption usually means that energy consumption data are available from similar EPIAs previously implemented in similar conditions.

Wherever possible, actual energy consumption data should be obtained, as it usually incorporates all the technical and usage characteristics of the specific EPIA being assessed and is the soundest basis for determining an EnB. Wherever this is not possible, an effort should be made to create these characteristics so as to calculate the energy consumption that best represents the baseline energy consumption that would have occurred. Credibility can be increased if:

— the EnB is calibrated with data from actual energy consumption and the results of the calibration documented; or

— the inputs and model development are documented and compared to historical norms, if they are available; or

— the model used is fully disclosed to stakeholders who agree to its use, and the calculation method is documented.

5.6.4.2 Type I calculation

The EnB or predicted energy consumption for type I can be determined using empirical estimation. The EnB or predicted energy consumption is then directly determined based on energy consumption data, for example, from previous monitoring of the energy using systems where the EPIA is planned to be implemented. In that case, the calculation formula used will be either Formula (1) or Formulae (2) and (3).

EXAMPLE 1 [For Formula (1)]: An old refrigerator is replaced by a new more energy efficient one, and the data on annual energy consumption is available from the manufacturers for both, because data were measured for both models within the same test (operating) condition, and this condition is considered as the average condition. The manufacturers' data on the old refrigerator might not reflect age-related reduction in energy performance.

EXAMPLE 2 [For Formula (3)]: A pilot project on eco-driving found that it was possible to reduce the EnB of the participating drivers by 10 % on an average. The predicted energy savings ratio can, therefore, be estimated at 10 % when the same eco-driving approach is used.

5.6.4.3 Type II calculation

The EnB for type II can be determined using statistical or engineering modelling, or a combination of both. In this case, the adaptation of Formula (1) is given by Formula (4).

$$\mathrm{PrES} = f\left(X_1;X_2;\ldots;X_i;\ldots;X_n\right) - g\left(X_1;X_2;\ldots;X_i;\ldots;X_n\right) \quad (4)$$

where

$f()$ is the function used to represent the EnB;

$g()$ is the function used to represent the predicted energy consumption;

X is a variable affecting the energy consumption;

i is the index for the variables.

The documentation of the calculation formula or model should explain the variables taken into account.

Figure 5 shows a way of using Formula (4) for determining the EnB and the predicted energy consumption.

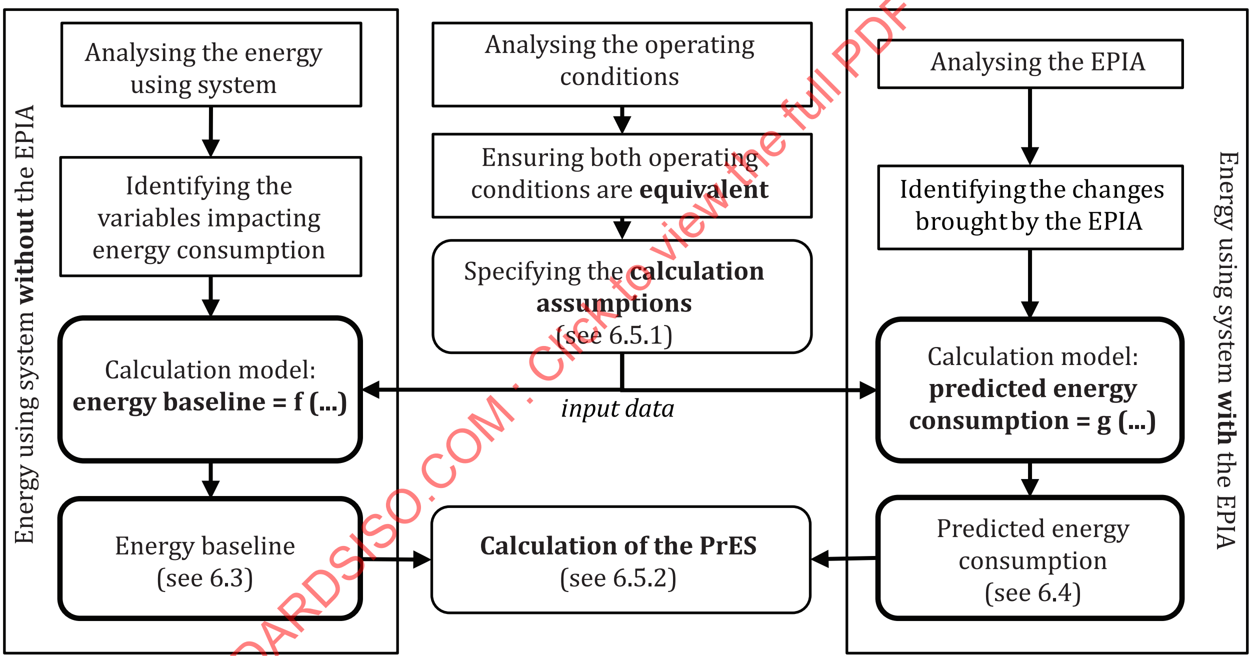


Figure 5 — Type II calculation

Examples of using Formula (4) are provided in Annex D, showing a case where the form of the functions $f()$ and $g()$ is the same, and Annex E, showing a case where the forms of the functions $f()$ and $g()$ are different.

The choice of the values to be used in the formulae is further explained in 6.3 to 6.6.

5.7 Validation

The acceptability and usefulness of the PrES will be increased if the key data available (see 5.5), the possible options of calculation methods (see 5.6) the main data needs (applicable to different options) are documented and validated.

Validation of the description of an EPIA should include an agreement by the stakeholders on:

— technical specifications of the EPIA and its implementation and operating conditions;

— PrES boundaries;

— selection of the variables.

The related information should be documented.

Validation should also include a review of literature to check that the technical characteristics of the EPIA, the range of operating conditions, the boundaries and the selected variables are consistent with those encountered in similar situations. Where there are differences between the proposed description of EPIA and other specifications encountered in the literature, a justification should be included in the documentation of the calculation method.

Stakeholders should understand and agree with the calculation of the PrES based on the determination of the following:

— planning of the calculation process (where checks and/or validations are needed, and the due date by which calculation needs to be completed);

— roles of each stakeholder (in particular, for data collection and validation);

— objectives of calculating PrES and the targeted accuracy;

— analysis of the data quality;

— choices of possible additional data collection;

— choices of the calculation method, calculation formula, and data collection techniques and sources;

— resources committed and cost of calculation of the PrES.

In some cases, validation might be obtained by confirming that written requirements (e.g. laws, codes or regulations) have been followed.

NOTE Higher accuracy usually results in higher costs. Stakeholders can agree on the appropriate accuracy by taking into account the calculation objectives and the resources available.

The following information will typically be included in the documentation to enable third-party reproducibility:

— the references used to select the variables, and to specify the formula or model;

— the data needed, and the corresponding data sources used;

— the frequency of data collection (e.g. per month, per year) and dates;

— the validation process (e.g. model calibration, statistical analysis, benchmarking).

Validation also includes a check to compare the specified calculation method with calculation methods used in similar situations and for which documentation is available. In case of differences, justification should be documented in the calculation method.

Many references are available on methodologies and methods for calculating energy savings. Sources are also available to provide case studies or other forms of experience feedback and sharing. Examples of sources can be found in References [10] to [13].

When decisions from the preparation require significant discussions, these discussions should be documented.

6 Calculation process for an EPIA

6.1 General

This clause:

— describes the calculation process at the level of an EPIA or a group of EPIAs that are implemented at the same site or by the same organization or energy end-user;

— highlights the important steps for successful calculation;

— emphasizes the key points to obtain results that are validated and give confidence to the stakeholders.

6.2 Overall calculation process

Irrespective of the calculation method used, the calculation of PrES aims at calculating the difference between the EnB and the predicted energy consumption. Figure 6 shows the overall calculation process, highlighting the key steps of the process and their aim. This process can be iterative.

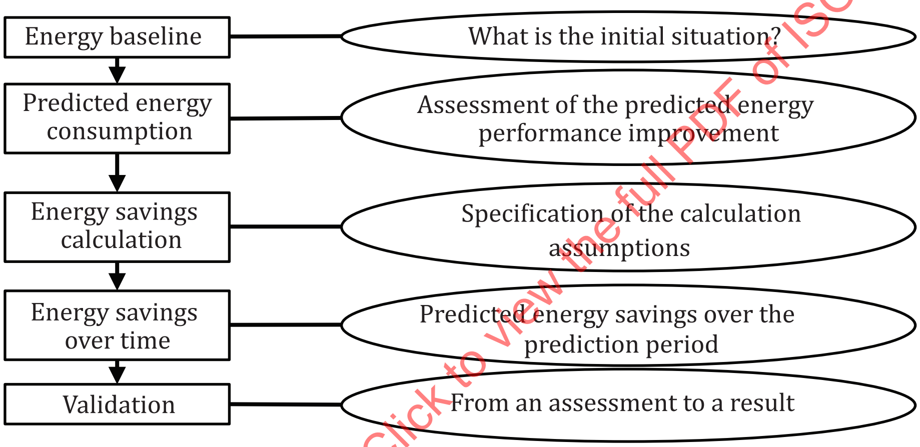


Figure 6 — Overview of the calculation process

6.3 Determination of the EnB

6.3.1 General

Taking into account the data availability and reliability (see 5.5), the EnB is determined according to the following steps:

— choosing the type of EnB according to the calculation objectives (see 6.3.2);

— determining the baseline period (specifying the dates and duration of the baseline period; see 6.3.3);

— collecting the data needed;

— determining and validating the EnB (see 6.3.4).

Complementary guidance about the determination of an EnB can be found in ISO 50006.

6.3.2 Types of EnB

Four types of EnBs with their purpose are shown in Table 3. These four types result from a combination of two situations and two types of comparison:

— types of comparison (see ISO 17743):

  — before/after (time-related);

  — without/with (case-related);

— types of situation (see 4.2):

  — context-specific (see the examples in Annex E);

  — general context (use of reference data) (see an example in Annex D).

Selecting the type of EnB to be used takes into account the analysis of the calculation objectives, and the requirements that can apply to the EPIAs (e.g. if the EPIAs or groups of EPIAs are to be accounted for a utility programme, an energy efficiency obligation scheme or energy efficiency portfolio standards).

How the EPIA is implemented or the PrES used can make the choice between the two types of comparisons obvious, as these are not equally applicable. If the two are equally applicable, the stakeholders can be consulted.

For projects, the most common type of EnB is “context-specific before”.

Table 3 — Types of EnB

Type of energy baseline	Purpose	Examples (for the EnB in the case of a replacement of a refrigerator)
“Context-specific before”	To represent the actual situation before the implementation of the EPIAs	Metered energy consumption of the refrigerator to be replaced
“Context-specific without”	To represent what would be the situation without implementation of the EPIAs, at the same time horizon as when the EPIA would be implemented	Energy consumption of the new refrigerator that a given household was planning to buy, before being offered a grant for another refrigerator with a higher energy efficiency
“Reference before”	To represent a reference situation before the implementation of the EPIAs	Average energy consumption of the stock of refrigerators for the area considered
“Reference without”	To represent a reference situation without the implementation of the EPIAs	Minimum energy performance requirements set by legal or other requirements, or market average

“Context-specific without” is mostly used when considering EPIAs to be implemented for a new building or plant, and when it is therefore not possible to have data about the situation before the EPIAs are implemented but data specific to the planned new building or plant are available (e.g. size of the building, number of occupants). When using a “context-specific without” baseline, the situations to be compared should be clearly stated, and their choice and definition should be explained. For example, in the case of a new building, the “context-specific without” EnB can be calculated based on the minimum requirements of the current building code for the same building size and functions as for the new building that is planned to be built. The method should also explain which characteristics were taken into account to ensure that both buildings are comparable.

When average characteristics are used as a reference, the representativeness of the average is a key criterion for the analysis of data quality. This analysis takes into account the extent to which the conditions of the EPIAs for which the PrES are being calculated are similar to the conditions for which the reference values have been determined. In cases where the scatter around the average value is not symmetrical, using average values might not be appropriate.

6.3.3 Baseline period

The specification of the baseline period includes the duration of the baseline period, mentioning the starting and ending dates.

EXAMPLE 1 Baseline periods: One year from 1 January to 31 December, one heating season from 1 October to 31 March, or one working week from Monday to Friday.

The baseline period is distinct from the data collection period that represents the number of operating cycles and corresponding dates of the data set used to determine the EnB.

EXAMPLE 2 Data collection period: When determining the EnB of a camping site, the data collection period can be three summers (each from 15 June to 15 September).

Different choices of the baseline period can be made using the same collected data set:

— the baseline period can be specified using several, but not all, operating cycles included in the data set, selecting the most representative operating cycles;

— the baseline period can be specified to be equivalent to the data collection period;

— the baseline period can be specified to be equivalent to one operating cycle, using average values from the data collection period.

The operating cycles in the data collection period should be chosen to be representative of the typical operating conditions. The duration of the baseline period should be chosen to be long enough to capture operating conditions representative of a normal or planned activity, taking into account the variability in operating patterns. The most common duration for the baseline period is a year (12 months), in particular for energy end-uses where the energy consumption is weather-sensitive. The starting and ending dates are chosen in order to be consistent with the dates of the data collection (e.g. metering dates).

In addition to the variations observed within one cycle (e.g. due to seasonality), there might also be variations from one cycle to the other (e.g. due to a difference in the heating degree days from one year to the other). It may then be necessary to include several cycles in the data collection period to determine the EnB, in order to avoid the EnB being biased by unusual conditions.

In some situations, it is possible that data collection occurs over a shorter time frame than the baseline period. For example, when building lighting schedules do not change throughout the year. A few months, or even weeks, of data can be adequate to calculate a full year of baseline lighting energy consumption. Another example is when modelling that normalizes for different operating conditions can reduce the required length of the baseline measurement period.

The rationale for the choice of data collection period(s) compared to the baseline should be documented and reviewed with the stakeholders.

NOTE 1 When sufficient data are available, the minimum number of operating cycles to determine the EnB can make it possible to identify trends in energy consumption.

NOTE 2 When energy consumption before the EPIA significantly increases or decreases (e.g. due to other EPIAs or to variations in energy prices or economic cycles), using average values may not be appropriate. In these cases, the determination of the EnB will take into account an analysis of the trends observed.

6.3.4 Determination and validation of the EnB

Irrespective of the type of calculation formula (described in 5.6.4) and EnB (see 6.3.2), determination of the EnB should include a description of the baseline period operating conditions. These operating conditions are the values of the variables that are the cause of the energy consumed within the PrES boundaries over the baseline period. Unless the calculation objectives justify a different choice, the baseline period operating conditions should be chosen to represent the typical operating conditions, i.e. the most frequent or normal operating conditions. In cases where different operating conditions are used, explanations for this choice should be documented.

NOTE 1 The typical operating conditions will generally be different from design specifications (e.g. average load curve versus nominal power rating of a motor).

Examples of baseline period operating conditions:

— for an industrial process: types of products and related production volumes;

— for buildings: occupancy rate, setpoint temperature, weather conditions;

— for transport: distance travelled, weight carried.

The baseline period operating conditions might then be changed while calculating the PrES (see 6.5.1), in order to make the EnB and the predicted energy consumption comparable.

When it is not possible to collect sufficient data to detect possible trends in past energy consumption, the corresponding explanations should be documented in the calculation method.

Data related to unusual conditions (e.g. energy consumption during refurbishment works) should be excluded from the determination of the EnB, unless its use can be justified. Such data should be documented.

NOTE 2 The data used to determine the EnB can require updating during the calculation process. For example, when the decision to implement an EPIA has been postponed. Likewise, reference values (stock or market average) can require updating if the same calculation method is used repeatedly over time (e.g. the stock or market average might need to be updated each year or every three years, when used as reference values for energy efficiency obligation schemes or energy efficiency portfolio standards).

NOTE 3 In the case of implementing the EPIA prior to the failure of the existing equipment, the organization can choose a baseline with two parts: the first part would predict energy consumption of the existing operational equipment for the period up to the end of its remaining expected lifetime; and the second part would predict energy consumption using the difference in efficiency between the EPIA and the equipment that would have been replaced by the user when the existing equipment failed. The period for the second part will be the expected useful life of the EPIA shortened by the remaining useful life of the existing equipment.

Validation of the EnB should include an agreement by the stakeholders about the choice of the type of EnB, and the values to be used (for the energy consumption and/or for the selected variables). Validation of the EnB can also include a check through a comparison with similar data (benchmarking) or by using two distinct calculation methods.

6.4 Determination of predicted energy consumption

The predicted energy consumption is determined by analysing the changes brought about by the EPIA.

Assessment of the improvement in energy performance should include analysis of the data available to document the expected impact of an EPIA to be implemented. This expected impact might be a reduction in the energy consumption or an improvement in the energy performance of the energy using system.

This assessment can lead to definition of a calculation model for the predicted energy consumption.

Assessment of the improvement in energy performance is combined with the specification of the predicted operating conditions (see Figure 5 and 6.5.1) to determine the predicted energy consumption (see 6.5).

In addition, it should include explanations about conditions of validity, as shown in Table 4.

Table 4 — Conditions of validity according to the type of assessment

Type of assessment	Conditions of validity
Specific to a given context (given characteristics of the EPIA, given conditions of implementation)	Values can be used when planning the same type of EPIA in a similar context
Average value to be used to calculate the energy savings of a large number of EPIAs	Values cannot be used for a specific context, and representativeness of the average value should be checked
Based on operating conditions set in a regulation or specifications (e.g. manufacturers' data)	This choice should be mentioned in the documentation, and the assessment verifies whether the predicted operating conditions are similar to the pre-specified operating conditions (see 6.5.1)

Validation should include an agreement by the stakeholders on the predicted energy consumption. The related information should be included in the documentation. Validation of the improvement in energy performance (or the predicted energy consumption) might also include a check by comparing with similar data (benchmarking) or by using two distinct calculation methods. The explanation of this assessment is an essential part of the calculation process.

6.5 Calculation of the PrES

6.5.1 Specifying the calculation assumptions

The conditions used to determine the EnB (see 6.3) and the predicted energy consumption (see 6.4) need to be consistent, so that both situations are comparable.

Predicted operating conditions can be estimated by making the following assumptions:

— no change as compared to the baseline period;

— planned changes;

— extrapolation of previous trends.

EXAMPLE 1 Examples of predicted operating conditions:

— weather conditions as set in building codes;

— a planned increase in the volume of production;

— a planned change in assembly plant operations based on new controls;

— statistical extrapolation of distances travelled based on previous trends.

The conditions chosen for calculating the PrES are specified as calculation assumptions. There is no automatic best option when choosing the calculation assumptions (see below). The choice is made according to the calculation objectives. Under these circumstances, stakeholder input can be an important consideration to achieve useful outcomes.

Considering the use of predicted estimates, three choices of operating conditions are possible (see ISO 17743:2016, 4.6.1):

— if baseline period operating conditions (as described in 6.3.4) are chosen as the basis to calculate the PrES, then the predicted energy consumption is calculated to be consistent with the baseline period operating conditions;

— if predicted operating conditions are chosen as the basis for the calculation of the PrES, then the EnB is calculated to be consistent with the predicted operating conditions;

— if operating conditions based on a regulation or specifications are chosen as a basis for the calculation of the PrES, then both the EnB and the predicted energy consumption need to be calculated to be consistent with these pre-specified operating conditions.

Another particular case is when past experience has proven that the method chosen does not capture all the effects on energy consumption after the installation of an EPIA. For example, a rebound effect might occur (e.g. a higher setpoint temperature for a dwelling after the insulation of the building envelope). In such a case, past experience can be used to derive the operating conditions for determining the predicted energy consumption and a detailed explanation should be provided.

The choice of operating conditions to make the EnB and the predicted energy consumption comparable can be more complex if the EPIA can be deployed in a manner that makes the baseline conditions less applicable.

EXAMPLE 2 Example of a complex case: an action plan to install LED lights in residences considers how the hours/year of use, and therefore the PrES, can change with the scale of deployment of the EPIA, as earlier adoptions might be in rooms with longer duration of use (kitchens, family or common rooms) and later adoptions might occur in rooms with shorter duration of use (bedrooms or storage spaces).

6.5.2 Calculation

PrES is calculated by using Formula (1), (2) or (4) (see 5.6.4), based on the EnB (see 6.3), the predicted energy consumption (see 6.4) and the calculation assumptions (see 6.5.1).

6.5.3 Documentation and validation

Validation of the PrES should include an agreement by the stakeholders on the choice of the calculation assumptions. The related information should be documented.

Validation of the PrES can include a check by comparing the value obtained with similar data (benchmarking) or with the result obtained for the same EPIA with another calculation method.

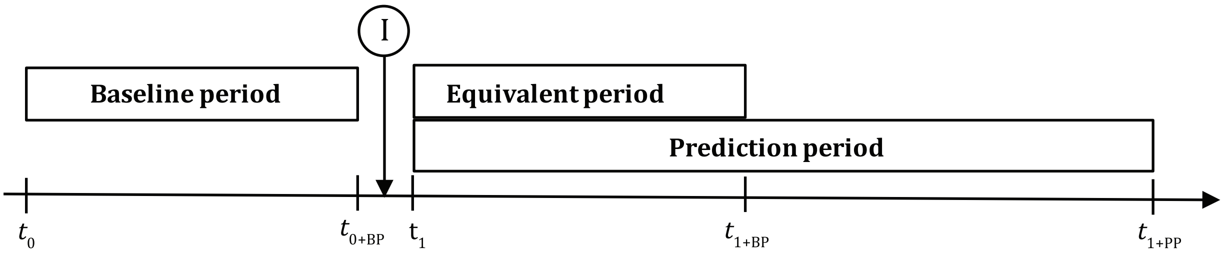
6.6 PrES over the prediction period

The PrES should be first calculated for a period equivalent to the baseline period.

EXAMPLE 1 Example of an equivalent period: if the duration of the baseline period is one year, then the PrES are first calculated for a duration of one year after the implementation of the EPIA.

In many cases, the EPIAs are expected to have a lifetime longer than the duration of the baseline period. According to the calculation objectives, the calculation of the PrES might then be extended over a given duration, the prediction period. This is done according to the choice of the type of baseline. For a case-related (or without/with) comparison, the same period (duration and dates) is used to compare EnB and predicted energy consumption. For a time-related comparison (before/after comparison), the PrES are first calculated as the difference between the baseline period and the equivalent period (see Figure 7). Then, the PrES are extrapolated for the whole prediction period.

EXAMPLE 2 In a simple case, the extrapolation can be a multiplication of the PrES for the first year by the number of years included in the prediction period.



Key

I implementation of the EPIA

t_0 start of the baseline period

t_{0+BP} end of the baseline period

t_1 start of the equivalent period (and of the prediction period)

t_{1+BP} end of the equivalent period

t_{1+PP} end of the prediction period

Figure 7 — Periods taken into account for a time-related comparison

This step of the calculation process is needed when the objective is to calculate cumulative energy savings over the lifetime of an EPIA, or to calculate the contribution of EPIAs for achievement of an energy savings target set for a given period. However, if the objective is to calculate only the first-year energy savings, this step is not needed.

EXAMPLE 3 Examples of a prediction period: Article 7 of the European Union Energy Efficiency Directive sets an energy savings target for the period 2014 to 2020. The member states were then asked to calculate the PrES of their energy efficiency policies over this period (2014 to 2020). In the United States, an energy efficiency portfolio or other reporting standards require the utilities to report the first-year energy savings, annual savings over the forecast horizon, life cycle savings, or future savings from past EPIA installations.

The prediction period cannot be longer than the EPIAs' lifetime unless there is a legal or other requirement to do so. Further, if energy savings are forecast to continue, the PrES should be explicit and underlying rationales or assumptions documented. In addition, the extrapolation of the PrES over time (if any) might also require retention rates, persistence rates and changes in operating conditions to be taken into account. Details about these aspects can be found in Annex F.

In addition, for longer prediction periods, care should be taken to consider whether assumptions of the baseline and/or EPIA remain unchanged. These assumptions should be reviewed with stakeholders and documented.

EXAMPLE 4 Example of a change in technical assumptions over time: LED lights (both the basic technology and LED's incorporation into lighting fixtures) have rapidly improved efficacy (lumens/Watt) in just a few years.

Validation of the PrES over the prediction period includes an agreement by the stakeholders on the duration of the prediction period, and on the assumptions about the changes that might occur during this period. The related information should be documented.

Validation can also include a check by comparing with similar data (benchmarking).

7 Aggregation of the PrES

7.1 General

This clause adds guidance to Clause 6 when the objective is to calculate the PrES of an action plan, programme or policy involving planned implementation of a number of EPIAs. This requires aggregating PrES of distinct EPIAs.

The first step of the calculation process is to ensure the consistency of the PrES to be aggregated (see 7.2). The second step is to aggregate the PrES over the EPIAs that are planned or foreseen in the action plan, programme or policy (see 7.3). Then, according to the context, a third step might be needed to assess the share of these total PrES that can be assumed to be the result of an action plan, programme or policy (see 7.4).

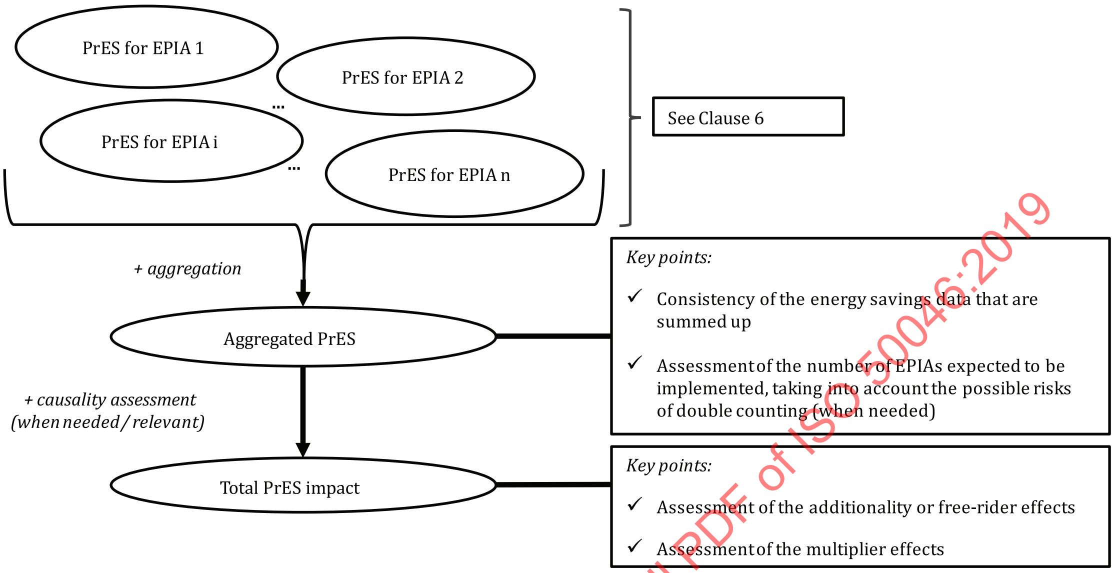


Figure 8 — Overview of the calculation process when aggregating PrES

7.2 Ensuring the consistency in aggregating PrES

Consistency can be enabled by:

— converting all the PrES into a common energy unit (GJ, toe, kWh, etc.);

— using the same basis (primary energy or final/delivered energy, as defined in ISO/IEC 13273-1);

— verifying that all the PrES are calculated for the same type of duration (e.g. one year, over the lifetime of the EPIA);

— explaining how consistency has been ensured while determining the EnB and while choosing the calculation assumptions for different EPIAs.

When factors are needed to convert all results into a common energy unit, the consistency of the values used for the conversion factors should be checked. Examples of conversion factors can be found in Reference [14].

When considering use of fuel, it should be documented if its energy content is expressed on a net calorific value (NCV) or gross calorific value (GCV) basis.

7.3 Aggregation of PrES

The aggregation can be done either by summing up the PrES of each EPIA, or by first summing the number of EPIAs per type of EPIA (having the same unitary PrES) and then summing the PrES over the different types of EPIAs [see, respectively, Formulae (5) and (6)] (see ISO 17742).

$$\text{Aggregated PrES} = \sum_{i=1}^{n} \left(\text{PrES of EPIA}_i\right) \tag{5}$$

where

i is the index for a single EPIA;

n is the number of EPIAs included;

or

$$\text{Aggregated PrES} = \sum_{j=1}^{m} \left(\text{number of EPIA}_j \times \text{PrES of EPIA}_j \right) \quad (6)$$

where

j is the index for the type j of EPIAs;

m is the number of distinct types of EPIAs.

Formula (5) is preferred when context-specific data are used to calculate PrES (e.g. calculating the PrES of an action plan of a company based on an energy audit).

Formula (6) is preferred when reference data are used to calculate energy savings (e.g. calculating the PrES of an energy efficiency obligation scheme).

NOTE 1 Action plans might occur over several time periods. So Formulae (5) and (6) might need to take into account the time periods in which the EPIAs were installed. This can be done by indexing the number of EPIAs installed in each time period and including an additional summation over the installation period.

The assessment of the number of EPIAs that will be implemented can be based on the assumptions presented in Table 5, according to the calculation objectives.

Table 5 — Assessment of the number of EPIAs according to different calculation objectives

Assumption	Calculation objectives
Planned number of EPIAs	Calculation done directly for the organization(s) or participant(s) who will pay for and/or implement the EPIAs → Assessment based on the number of EPIAs that these organizations or participants plan to implement. EXAMPLE 1 Action plan of a company.
Objectives of the programme or policy	Calculation done to assess the potential impact of a programme or policy → Assessment based on the number of EPIAs required to achieve the objectives of the programme or policy. EXAMPLE 2 Scenario to achieve objectives of climate change mitigation.
Estimated number of EPIAs	Calculation done to assess the potential impact of a programme or policy → Assessment based on the past experience of a similar programme or policy, or based on modelling. EXAMPLE 3 Modelling used for the impact assessment of a new policy.

Interactive effects between EPIAs or between EPIAs and other energy using equipment can occur in programmes. These should be accounted for by careful definition of boundaries (see 5.3.3). The data and analysis undertaken to account for them should be documented.

In cases where PrES are aggregated over several action plans, programmes or policies simultaneously, there might be a risk of double counting (i.e. counting several times the PrES of the same EPIA). In such cases, the assessment of the number of EPIAs includes explanations about how this risk has been avoided or taken into account.

NOTE 2 EPIAs might be implemented over different years and summed up for the same prediction period (according to the duration of the action plan/programme/policy), taking into account their implementation year.

An action plan/programme/policy might have a longer duration than the EPIA lifetime. The way to take into account the renewal (or not) of the EPIA over this period should be documented (see 6.6).

7.4 Assessing the causality between an action plan, programme or policy and the EPIAs

The calculation of PrES is not necessarily made directly for the organization(s) or person(s) paying for and/or implementing the EPIAs. The calculation of PrES might be done for an organization (e.g. a public agency or an energy company) in charge of a policy or programme (known as a facilitating measure in ISO 17742) that is aimed at triggering the implementation of EPIAs by other organizations or persons. In such cases, the calculation of PrES might need to assess the causality between this facilitating measure and the EPIAs to be implemented.

The assessment of the causality might consider:

— additionality: taking into account the extent of PrES that would have happened without the implementation of an action plan, programme or policy;

— free-rider effects: share of EPIAs that would be implemented (or partly implemented) in the absence of the facilitating measure;

— multiplier effects: share of EPIAs that would be implemented (or partly implemented) due to the facilitating measure beyond the scope of the facilitating measure.

These effects are particularly difficult to assess when calculating PrES, for EPIAs still to be implemented. Their assessment can be based on experience feedback from similar facilitating measures and/or modelling (e.g. by comparing different scenarios).

One possible approach to take into account causality in the calculation of PrES is to choose a type of EnB based on a case-related (without/with) comparison (see 6.3.2).

In order to differentiate between the aggregated PrES without causality assessment and the result with causality assessment, the aggregated PrES with causality assessment is also called the “total PrES impact”.

7.5 Documentation and validation

Documentation of the aggregated PrES can include:

— the conversion factors used (when needed);

— the references or sources where documentation about the PrES of the EPIAs or types of EPIAs included in the aggregated result can be found;

— the assumptions made to assess the number of EPIAs included in the aggregated result;

— whether the causality has been assessed (and if so, the related data, analysis and study results used or assumptions made).

Documentation of the aggregated PrES might include explanations about the provisions included in the design of the facilitating measure in order to avoid possible free-rider effects and/or to support or facilitate multiplier effects (in particular, in cases of facilitating measures aimed at market transformations).

Validation of the aggregated PrES should include an agreement by the stakeholders. It might also include a check by comparing different methods or sources based on experience feedback for the assessment of the number of EPIAs (wherever possible) and/or the causality, when needed (wherever possible).

8 Quality and uncertainty

8.1 General considerations

PrES as calculated are not always achieved in practice. Accuracy can be ensured by taking into account the quality of PrES, which can depend on several factors, including:

— quality of the implementation of the EPIAs;

— quality of the calculation and related data and assumptions.

8.2 Quality criteria for the EPIAs and their implementation

PrES assume the correct implementation of an EPIA, i.e. quality criteria for implementation. EPIA's quality and other criteria and requirements about their implementation should be documented. This can help to determine whether the EPIAs will be implemented as expected (e.g. to avoid defects in materials and workmanship) to provide the expected level of energy performance. These quality criteria or requirements are important to minimize the possible differences between the predicted operating conditions and the actual operating conditions after the implementation of the EPIAs.

EXAMPLE A requirement about the qualification or certification of a professional who will install the EPIA can help limit the risk of bad workmanship.

8.3 Quality criteria for calculation methods

The reliability of PrES can depend on several criteria, including:

— appropriateness of the calculation method (and of the related methodological choices);

— data quality;

— skills, experience and expertise of the evaluators or other persons processing the data, specifying and applying the calculation method.

Documentation of the calculation method should make it possible to review these elements, and in particular the data sources. This includes justification about data quality and sources, in particular the main data used.

Quality criteria or quality assurance guidelines can be specified for the calculation method and its implementation in order to ensure that the elements mentioned above are taken into account. Examples can be found in Reference [11].

8.4 Analysing the quality and/or assessing uncertainty of PrES

When performing the calculation of PrES, analysis of the quality and/or of the uncertainties should take into account:

— quality criteria and/or uncertainties of the data collected;

— quality criteria and/or uncertainties on data estimated for the EPIAs;

— uncertainties due to measurements and/or related quality criteria;

— uncertainties due to the omission of variables, and/or quality criteria to set thresholds for accepting to neglect secondary variables;

— uncertainties due to calculation models and/or related quality criteria;

— uncertainties due to human behaviours and/or related quality criteria;

— uncertainties introduced due to interactive effects between EPIAs (see 5.3.3);

— uncertainty due to a possible rebound effect (see 6.5.1).

In addition to these quality criteria and/or sources of uncertainties, documentation of the PrES (see Annex B) should explain the key methodological choices (determination of the EnB, PrES boundaries, assumptions about the number of EPIAs). These choices do not create uncertainties by themselves, but it is always important to remember that energy savings are always relative to these choices.

According to the information available and the calculation objectives, the overall accuracy of the PrES might be assessed on a qualitative or quantitative basis. Quantitative assessment of uncertainty is to be preferred to qualitative assessment. Either approach should be fully documented.

Qualitative assessments can be carried out by checking quality criteria[11], comparison with other EPIAs or by use of expert estimates.

Quantitative assessments imply that an uncertainty analysis can be carried out by using statistical methods, sensitivity analysis or expert estimates.

The acceptable accuracy (assessed either qualitatively or quantitatively) should be set according to the calculation objectives (see 5.4), and agreed upon by the stakeholders.

Examples of methods to address uncertainties can be found in References [10], [11] and [12]. More details about guidelines on measurement and verification while assessing the uncertainty of a value based on past experience can be found in ISO 50047 and ISO 50015.

Annex A
(informative)

Overview of the main criteria to take into account when using this document

The scope of this document covers a wide range of situations. This annex provides guidance about the analysis of the context and objectives for calculating PrES (see 4.1 and 4.2 for more details) when making choices about the calculation method. It provides an overview of the main aspects to take into account, and where to find more details about them in this document.

When using this document, the first aspect to take into account is the scale to be considered (see Figure A.1). This specifies whether PrES will need to be aggregated. In cases where no aggregation of PrES is needed (a common case for projects), Clause 7 does not apply.

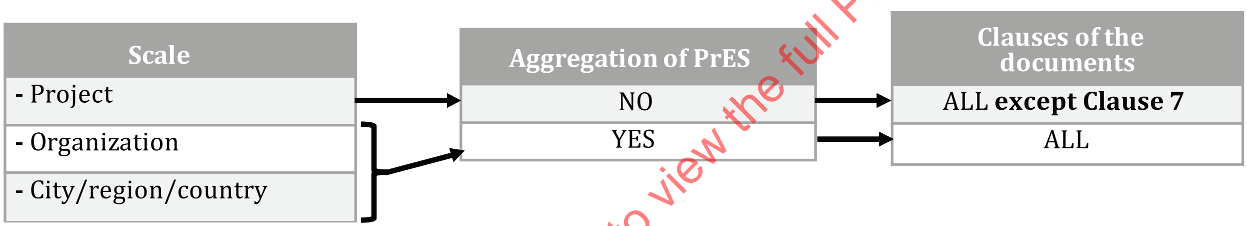


Figure A.1 — Types of scale and need to aggregate PrES

The second set of aspects to take into account are the general types of EPIA (see 5.3) and the types of data used. These aspects are linked. The data used in cases of pre-specified EPIAs are usually reference data, while the data used for tailored EPIAs are usually context-specific data. More details about how to choose between reference data and context-specific data are provided in Figure 2 (in 4.2).

The third set of aspects to be taken into account include the type of calculation in 5.6.4 (linked to the data available) for determining the EnB and predicted energy consumption. Type I calculation is commonly implemented by using empirical estimation. Type II is commonly implemented with statistical or physics-based modelling, and might combine different sources of data.

Table A.1 provides examples of situations and corresponding possible choices for the calculation method. Examples of energy efficiency obligation schemes and of optimization of an industrial process are further detailed, respectively, in Annexes D and E.

Table A.1 — Examples of situations and corresponding possible choices for the calculation method

Example	Scale	Aggregation of PrES	Type of EPIA	Type of data used	Data available for baseline	Type of calculation	Type of data analysis
Boiler replacement in a company	Project	No	Tailored	Context-specific data	Annual energy consumption	Type I	Empirical estimation
Grants for energy efficient vehicles	Region	Yes	Pre-specified	Reference data	Annual energy consumption	Type I	Statistical calculations
Action plan on street lighting	City	Yes	Tailored	Context-specific data	Power and number of lighting hours	Type II	Physics-based calculations
Action plan on lighting	Organization	Yes	Pre-specified	Reference data	Power and number of lighting hours	Type II	Physics-based calculations
Programme for boiler replacement in dwellings	Country	Yes	Pre-specified	Reference data	Data about the dwelling stock, etc.	Type II	Combinations of all options
Optimization of an industrial process	Project	No	Tailored	Context-specific data	Data about the industrial process	Type II	Combinations of statistical and physics-based modelling
Energy efficiency obligation scheme	Country	Yes	Pre-specified	Reference data	Various	Type II	Combinations of all options

Annex B
(informative)

Overview of the main issues subject to validation and/or documentation

Table B.1 — Overview of the main issues subject to validation and/or documentation

Steps of the calculation process	Issues subject to validation and/or documentation
5.1 General	Agreement on the planning for the calculation process (in particular when validations are needed).
5.2 Identification of the stakeholders	Agreement on and documentation of the roles of each stakeholder (in particular for the data collection and for the validations).
5.3 Description of an EPIA	Agreement on and documentation of: ✓ the technical characteristics of the EPIA and the selected variables; ✓ the PrES boundaries.
5.4 Calculation objectives and required accuracy	✓ Agreement and documentation of the calculation objectives. ✓ Agreement on the resources committed for the calculation process.
5.5 Data availability and quality	Agreement on: ✓ the analysis of the data quality; ✓ the decision about additional data collection.
5.6 Selection of the calculation method	Agreement on and documentation of: ✓ the chosen type(s) of data analysis; ✓ the data collection techniques and sources (and assumptions for missing data); ✓ the selected variables and calculation formula; ✓ the validation process (e.g. model calibration, benchmarking).
6.3 Determination of the EnB	Agreement on and documentation of: ✓ the choice of the type of EnB; ✓ the values used (for the energy consumption and/or for the selected variables).
6.4 Determination of predicted energy consumption	Agreement on and documentation of the determined reduction in energy consumption or improvement in the energy performance of the energy using system.
6.5 Calculation of the PrES	Agreement on and documentation of the calculation assumptions.
NOTE 1 "Agreement" here means an agreement by the stakeholders. NOTE 2 When possible, it is recommended to perform a check for each of the steps listed above, by making a comparison with data found in the literature for similar situations or obtained for the same situation with a different calculation method.	

Table B.1 *(continued)*

Steps of the calculation process	Issues subject to validation and/or documentation
6.6 PrES over the prediction period	Agreement on and documentation of: ✓ the duration of the prediction period; ✓ the assumptions about the changes that might occur over this period.
7 Aggregation of the PrES	Agreement on and documentation of: ✓ conversion factors (when needed); ✓ references or sources about the PrES aggregated; ✓ assumptions used to assess the number of EPIAs per type of EPIA; ✓ whether the causality has been assessed (and if so, the related assumptions).
8.4 Analysing the quality and/or assessing the uncertainty of PrES	✓ Agreement on the acceptable accuracy. ✓ Documentation about the sources of uncertainty taken into account. ✓ Documentation of the quality criteria used to specify the implementation of the EPIA and/or the calculation method.
NOTE 1 "Agreement" here means an agreement by the stakeholders. NOTE 2 When possible, it is recommended to perform a check for each of the steps listed above, by making a comparison with data found in the literature for similar situations or obtained for the same situation with a different calculation method.	

Annex C
(informative)

Example templates for documenting a calculation method and PrES

This annex provides examples of templates that can be used for documenting a calculation method and PrES.

Table C.1 gives an example of a template for documenting PrES at the EPIA level. According to the type of data collection technique used, additional information might be required.

EXAMPLE Explanations about the sampling method when using surveys.

Likewise, according to the type of calculation method used, additional information might be required:

— for estimations: explanations about the level of reliability of the data sources used;

— for statistical modelling: the statistical significance of the result, as well as the verification of the conditions where the statistical method can be used (e.g. review of the distribution of the errors);

— for physics-based (or engineering) modelling: explanations about the calibration of the calculation model.

Table C.2 gives an example of a template for documenting PrES at the action plan/programme/policy level by aggregating results from different EPIAs.

Table C.1 — Example of a template for documenting PrES at the EPIA level

EPIA	**Name of the EPIA**	(Making explicit the targeted energy-using system and the improvement brought by the EPIA, see 5.3.)
	PrES boundaries	(Including explanations about the possible technical interactions, see 5.3.)
	Implementing and operating conditions	(Including explanations about the baseline period and predicted operating conditions of the targeted energy using system, see 6.5.1, and references to requirements and/or quality criteria when relevant, see 8.1.)
Calcu-lation method	**Calculation objectives**	(What will the calculation result be used for? To whom will the energy savings data be communicated? What is the required accuracy for the PrES? See 5.4.)
	Calculation method	(Estimation/statistical modelling/engineering (physics-based) modelling, see 5.6.)
	Determination of the EnB	**Type of EnB**: ("context-specific before"/"context-specific without"/"reference before"/"reference without", see 6.3.2.) **Baseline period:** (including duration, dates and data set used, see 6.3.3) **Baseline period operating conditions:** (including assumptions about the representativeness of the EnB, see 6.3.4)
	Predicted energy consumption or description of the improvement in energy performance	(When using Type I calculation, providing the predicted energy consumption and the related data source or reference.) (When using Type II calculation, providing a description of the improvement in energy performance, i.e. data representing the improvement in energy performance, related data sources, and explanations when needed, see 6.4.)
	Calculation formula or model	(Making explicit the selected variables that are taken into account, and including references about the calculation formula or model which justify the use of that formula and variables, see 5.6.4.)
	Main data sources	(Mentioning the data collection technique and the collection dates, and highlighting the assumptions used in case of missing data, see 5.5 and 5.6.3.)
	Calculation assumptions	**Choice for the operating conditions:** (mentioning what operating conditions are used as basis for the calculation, see 6.3.4 and 6.5.1.)
	Prediction period	(Mentioning the duration considered for the calculation, and the related assumptions about the EPIA lifetime and possible changes over time, see 6.6.)
Energy savings	**Annual PrES**	(Making explicit the energy unit and the basis: primary or final energy.)
	PrES over the prediction period	(Making explicit the energy unit + primary or final energy + reminding the prediction period be taken into account.)
	Condition of validity	(Values specific to a given context/conditions for the representativeness of average values/other explanations, see 6.4.)
	Quality of the PrES	(Qualitative and/or quantitative assessment of the accuracy of the PrES, see 8.3.)
Validation process		(Stakeholders involved in the calculation process and the validation approach.)

Table C.2 — Example of template to document PrES at the action plan/programme/policy level (aggregating results from different EPIAs)

Framework	**Name of the framework**	(Name of the action plan, programme or policy.)
	Area covered	(In terms of geographical or organizational scope.)
	EPIAs covered	(List of the EPIAs covered by the framework and/or reference where the list can be found.)
	Complementary information	(Other explanations useful to the understanding of the PrES.)
Calculation method	**Calculation objectives**	(What will the calculation result be used for? To whom will the energy savings data be communicated? See 5.4.)
	Common energy unit used	(Mentioning the conversion factors or the reference used for conversion factors, when relevant, see 7.2.)
	General rules for the EnB	(Explanations about how the consistency between the EnBs used for the different EPIAs is ensured, for example, by using the same type of baseline or the same baseline period.)
	General rules for the calculation assumptions	(Explanations about how the consistency between the calculation assumptions used for the different EPIAs is ensured.)
	General rules for the prediction period	(Explanations about how the consistency between the prediction period used for the different EPIAs is ensured.)
	Other consistency issues	(Explanations about how other consistency issues are handled, when relevant.)
	Calculation methods used at the EPIA level	(References about the calculation methods or guidebooks or general guidelines used at the EPIA level.)
	Number of EPIAs	**Number of EPIAs (per type of EPIA):** **Assumptions used**: (assumptions about the expected number of EPIAs, mentioning how risks of double counting are handled, when relevant, see 7.3.)
	Causality	(Explanations about how the additionality, free-rider effects and/or spill-over effects are taken into account, when relevant, see 7.4.)
Energy savings	**Annual PrES**	(Making explicit the energy unit + primary or final energy + total PrES or total PrES impact.)
	PrES over the prediction period	(Making explicit the energy unit + primary or final energy + total PrES or total PrES impact + reminding the prediction period taken into account.)
	Overall accuracy	(Qualitative and/or quantitative assessment of the accuracy of the PrES, see 8.3.)
Validation process		(Stakeholders involved in the calculation process and the validation approach.)

Annex D
(informative)

Case example in the residential sector using reference data

This annex provides a case example of a calculation of PrES per unit of EPIA within the framework of the French White Certificates scheme.

The French White Certificates scheme[18][19] set an obligation for energy suppliers to achieve a certain amount of final energy savings. The achievements are monitored through the issuance of energy savings certificates. This annex takes this scheme as an example to illustrate the documentation of PrES per unit of EPIA, according to the templates of Annex C.

NOTE The scheme does not calculate PrES, but PrES per unit of EPIA. These ratios make it possible for the stakeholders to know in advance how many energy savings certificates they can get for a given type of EPIA. The number of EPIAs is not predicted by the public authority. It can be predicted by the stakeholders, when they prepare their programmes.

The example first presents the general rules of the scheme to aggregate PrES at the national level. Then the particular example of "insulation of loft or roof" is used to illustrate how PrES per unit of EPIA are calculated at the level of an EPIA, for the case of pre-specified actions.

Table D.1 — General rules of the French White Certificates scheme to aggregate energy savings at the national level

	Name of the framework	French White Certificates scheme *(in French: dispositif des Certificats d'Economies d'Energie, CEE)*
	Area covered	France (national)
Framework	**EPIAs covered**	109 eligible standardized (pre-specified) actions (as of March 2015), covering all sectors (residential, tertiary, industry, agriculture, transport).
	Complementary information	The calculation method is used to account for PrES of a very large number of actions. To minimize administration costs of the scheme, reference values determined by type of EPIA are used, based on the most recent and reliable data available at the national level.
	Calculation objectives	Aggregated energy savings at the national level are used for several purposes: — to account for the achievements of each energy supplier; — to monitor the overall achievements of the scheme compared to the overall target set for each period; — to report the achievements to the European Commission. Up to now (2019), most of the energy savings came from pre-specified EPIAs. Aggregated energy savings have thus been mostly based on PrES per unit of EPIA, multiplied by the number of EPIAs recorded when issuing certificates.
Calculation method	**Common energy unit used**	The energy savings are calculated in kWh of final energy cumulated over the lifetime of the EPIA.

Table D.1 *(continued)*

	General rules for the EnB	General rules were set to ensure the consistency of the EnB among the many types of EPIA. Two types of EnB were used: ✓ In case of EPIAs on the building envelope or on the heating system of a building, the EnB was based on the characteristics of the national building stock (type of baseline = “reference before”). ✓ For the other types of EPIAs, the EnB is based on the technical and economic state of the market for the product or service related to the EPIA, on the most recent date for which data are available (type of baseline = “reference without”).
	General rules for the calculation assumptions	The PrES per unit of EPIA are calculated taking into account pre-specified operating conditions (e.g. average heating degree days per climate zone, as set in the national building code).
	General rules for the prediction period	The energy savings are calculated for the predicted lifetime of the EPIA. This choice was made so that EPIA with a longer lifetime, often requiring higher investments, are not disadvantaged in the accounting system, compared to EPIA with a shorter lifetime. This would have been the case if only first-year energy savings would have been accounted for.
	Other consistency issues	No other consistency issue.
	Calculation methods used at the EPIA level	Calculation formula are specified for each type of EPIA (see example below). The most common calculation method is simplified engineering modelling.
	Number of EPIAs	Number of EPIAs (per type of EPIA): the number of EPIAs is not predicted beforehand. It is monitored when EPIAs are implemented. The scheme thus does not defined PrES, but PrES per unit of EPIA. These ratios make it possible for the stakeholders to know in advance how much energy savings certificates they can get for a given type of EPIA. The number of EPIAs is not predicted by the public authority. It can be predicted by the stakeholders, when they prepare their programmes. Rules to avoid double counting: The same EPIA might involve several stakeholders; however the energy savings certificates are issued only once. This is monitored by requiring the applicants for certificates to submit a form signed by the beneficiary where he/she states that he/she gave his/her agreement only to one organization to apply for certificates for the action he/she has benefited from. Random controls are also performed.
	Causality	Additionality is ensured by two main rules: 1) additionality in terms of level of energy performance: only actions that go further than the European and national regulations in force can be eligible; 2) active and encouraging role of the applicants for energy savings certificates (triggering effect): the applicants are required to show that they have played an active and encouraging role by describing how they play this role, by providing evidence that their contribution to trigger the EPIA was direct and made before the EPIA was started, and by providing a sworn declaration signed by the beneficiary of the EPIA confirming their role.
Energy savings	**Annual PrES**	See results presented in the French National Energy Efficiency Action Plans or in the French annual reports for the Energy Efficiency Directive[21].
	PrES over the prediction period	Same as above.

Table D.1 *(continued)*

	Overall accuracy	The quality of the PrES is based on using the most recent and reliable data available at the national level, and on the validation process (when monitoring the EPIAs and when specifying the EPIAs, see example below).
Validation process		Validation process when issuing energy savings certificates and aggregating energy savings at the national level. The aggregation of the energy savings is based on the data registered by PNCEE (National Centre for the Energy Savings Certificates).[a] PNCEE is in charge of the monitoring, verification and supervision of the energy savings certificates. The General Directorate for Energy and Climate is in charge of publishing and reporting the results of the scheme at the national and European level.
NOTE The information presented is in line with the rules applied in 2013, unless otherwise mentioned.		
[a] Public body attached to the General Directorate for Energy and Climate.		

The information given in Table D.2 is the information that was used for the first period of the scheme (2006 to 2009). It has been updated for the successive periods. This is an example of engineering modelling and uses Formula (4) with the same type function for $f()$ and $g()$ (see 5.6.4).

Table D.2 — Example of the documentation for the calculation of PrES per unit of EPIA, of a pre-specified EPIA eligible for the French White Certificates scheme

EPIA	**Name of the EPIA**	**Insulation of loft or roof for residential buildings**, with an additional thermal resistance equal or bigger than 5 m²·K/W and installed by a professional (official reference: formerly BAR-EN-01, now BAR-EN-101).
	PrES boundaries	The energy consumption taken into account within the EPIA boundaries is the heating consumption of the building. In terms of possible interactive effects, it is assumed that there is no other EPIA simultaneously implemented.
	Implementing and operating conditions	**Implementing conditions** The insulation materials are required to have a certification and the installation is required to be done by a professional. **Operating conditions** The indoor setpoint temperature is assumed to be 19 °C (as set in the building code). It is assumed that there is no other change to the building envelope than the insulation of roof or loft, and no change to the heating system.
Calcu-lation method	**Calculation objectives**	The calculation objective is to determine PrES per unit of EPIA. The main audience for these PrES per unit of EPIA is the stakeholders involved in the French White Certificates scheme, i.e. energy suppliers, but also other actors who could be applying for energy savings certificates (e.g. local authorities) and companies providing services to value the energy savings certificates. The information is important to all these stakeholders so that they can know in advance how many certificates they can get for the EPIAs they plan to implement or support, and therefore to develop their business models.
	Calculation method	Simplified engineering modelling.
	Determination of the EnB	**Type of EnB**: "reference before" Characteristic used to determine the EnB: — heat transfer coefficient of the roof or loft (U), before the action is implemented: U_{baseline} = 2 W/m²·K (see explanations below); — average efficiency of electric heating devices for the national building stock: η = 95 %; — average efficiency of boilers for the national building stock: η = 60 %.

Table D.2 *(continued)*

		The EnB is based on the assumption that half of the building stock would have no roof insulation (U = 3 W/m²·K) and the other half would have a weak insulation (U = 1 W/m²·K), meaning an average reference value of U = 2 W/m²·K. This was taken as a conservative assumption, as 62 % of the individual houses were built before 1975 (i.e. before the first building code that included energy efficiency requirements), and that 74 % of the households reporting to have made insulation actions were living in a dwelling with no insulation [survey carried out by the French Agency for the Environment and Energy Management (ADEME)]. **Baseline period**: one year (no particular date, as the operating conditions are specified according to the building code, and not according to a particular year or period: it is a calculated baseline period). **Baseline period operating conditions**: pre-specified operating conditions set in the building code (see the calculation assumptions below).
	Description of the improvement in energy performance	Energy performance improvement brought by the insulation material, through its additional thermal resistance (R). The change in the thermal performance of the building envelope is therefore calculated as a difference between the baseline heat transfer coefficient ($U_{baseline}$) and the predicted heat transfer coefficient ($U_{predicted}$): $\Delta U = U_{predicted} - U_{baseline}$ where ΔU is the difference in the heat transfer coefficient of the roof or loft (in W/m²·K); $U_{baseline}$ is 2 W/m²·K (see EnB above); $U_{predicted}$ is $\dfrac{1}{\dfrac{1}{U_{baseline}}+R}$; R 5 m²·K/W (minimum energy performance requirement for the EPIA). **Predicted operating conditions:** pre-specified operating conditions set in the building code (see the calculation assumptions below) + assumption that there is no other change to the building envelope than the insulation of roof or loft, and no change to the heating system.
	Calculation formula or model	[Type II calculation and Formula (4)] The PrES per unit of EPIA are calculated per surface of insulation material installed (kWh/m² of insulation material): $$\text{PrES per unit of EPIA} = \frac{\frac{\Delta U}{1\,000}\times(n_{HDD}\times 24)\times 0{,}5}{\eta}$$ where ΔU is the difference in the heat transfer coefficient of the roof or loft in W/m²·K (see energy performance improvement above) divided by 1 000 to convert W into kW, as the PrES per unit of EPIA are expressed in kWh/m²; n_{HDD} are the heating degree days (see calculation assumptions below, and multiplied by 24 to convert the day unit into an hour unit, as the PrES per unit of EPIA are expressed in kWh/m²); η is the average efficiency of the heating system (see EnB above).

Table D.2 *(continued)*

<table>
<tr><td></td><td></td><td>The value 0,5 is included as the coefficient to take into account intermittency and free heating (see calculation assumptions below).

The calculations are performed taking into account the following criteria:
— type of energy used for heating: heating fuel or electricity (influencing the average efficiency of the heating system; see EnB above);
— climate zone: the three official climate zones set in the building code (influencing the number of heating degree days; see calculation assumptions).</td></tr>
<tr><td></td><td>Main data sources</td><td>— national statistics for the average efficiency of heating systems;
— minimum energy performance requirements for the EPIA (additional thermal resistance);
— building code for the pre-specified operating conditions;
— conservative estimates for other values.</td></tr>
<tr><td></td><td>Calculation assumptions</td><td>Pre-specified average operating conditions set in the building code:
— indoor temperature of 19 °C;
— average heating degree days per climate zone:
<table>
<tr><th>Climate zone</th><th>Reference average annual heating degree days</th></tr>
<tr><td>H1</td><td>2 695</td></tr>
<tr><td>H2</td><td>2 205</td></tr>
<tr><td>H3</td><td>1 470</td></tr>
</table>
The choice of using these pre-specified operating conditions is made for the PrES per unit of EPIA to be representative of a typical year (in terms of heating degree days) and a typical behaviour (in terms of setpoint temperature).

A coefficient is applied to take into account the intermittency (not all rooms are heated or rooms are not heated all the time) and free heating (heat from the inhabitants, lighting, etc.). This coefficient has been set to 0,5 as a conservative assumption, and is applied to both, EnB and predicted energy consumption.</td></tr>
<tr><td></td><td>Prediction period</td><td>The PrES per unit of EPIA are calculated for the predicted lifetime of the EPIA: 35 years.</td></tr>
<tr><td>Energy savings</td><td>Annual PrES per unit of EPIA</td><td>The French scheme defines PrES per unit of EPIA, and not PrES. The number of units is not predicted before the EPIAs are implemented. The objective is to provide stakeholders with certainty about how many energy savings certificates they can get when implementing EPIAs.

The annual PrES per unit of EPIA are expressed in kWh/m² of insulation material installed, with a differentiation according to the energy type used for heating and to the climate zone.
<table>
<tr><th rowspan="2">Climate zone</th><th colspan="2">Type of final energy</th></tr>
<tr><th>Electricity</th><th>Heating fuels</th></tr>
<tr><td>H1</td><td>62</td><td>98</td></tr>
<tr><td>H2</td><td>51</td><td>80</td></tr>
<tr><td>H3</td><td>34</td><td>53</td></tr>
</table>
Example of annual PrES: an energy company plans to support the renovation of buildings that will imply the insulation of 10,000 m² of walls. These buildings are located in zone H1 and heated with electricity. For this case, PrES are then 620,000 kWh/year.</td></tr>
</table>