



SmarterEPC

D4.1 The EPC and SRI on-site audit procedure (version 1)



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Document Information

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Acronyms

Acronyms	Description
EPC	Energy Performance Certificate
SRI	Smart Readiness Indicator
EPBD	Energy Performance of Buildings Directive

EXECUTIVE SUMMARY

This **first iteration of Deliverable D4.1** outlines the blueprint of the joint EPC and SRI on-site audit procedure. It reports the quality assurance mechanism used to refine it, involving external certified EPC assessors. Relying on the validation from market actors, SmarterEPC's approach ensures that the proposed audit procedure is both rooted in professional practice and applicable in real operational contexts.

To achieve this, the consortium executed a structured evaluation methodology:

- **Open call recruitment:** An open call was launched to recruit independent, professional energy and BACS assessors from across the targeted EU Member States.
- **Strict selection criteria:** Applicants were strictly vetted based on pre-defined selection criteria to ensure a high level of technical competency. These criteria emphasized explicit expertise in building automation, energy auditing, or existing national EPC frameworks.
- **Paid assessment consultation:** The selected experts were compensated for their evaluation work. They provided detailed feedback, identified operational bottlenecks in data collection, and validated whether the drafted instructions were clear and practical for field engineers.

The integration of these assessors' reviews has ensured that the current framework is robust, highly replicable, and well-tailored to the capacities of real-world professionals. **The most updated version of the drafted procedure is available in Annex 2.** The specific revisions incorporated from the expert consultation phase will be detailed further in the second version of Deliverable D4.1, to be released at the end of the project.

To further strengthen the review process, **additional unpaid external experts and active members of our network** were invited to assess the documents and provide constructive feedback.

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Introduction

The [SmarterEPC project](#) (Project No. 101121034), funded under the LIFE-2022-CET sub-programme, aims to enhance the audit process and issuance of Energy Performance Certificates (EPCs), Smart Readiness Indicators (SRIs) and related EPBD policy instruments (HVAC inspections, Renovation Passports) across the EU Member States.

This report represents the initial delivery (Version 1) of **Deliverable D4.1: The EPC and SRI on-site audit procedure**, a core outcome of Work Package 4 (WP4).

The objective of the SmarterEPC project is to help bridge the gap between building EPCs and the relatively new SRI. It accomplishes this by creating a series of innovative documents and tools that pave the way to the integration of the SRI scheme into EPCs.

A major barrier to the deployment of these schemes is the lack of a standardized approach for concurrent, cost-effective on-site EPC & SRI data collection. In response, Task 4.1 focuses on adapting well-established building energy audit standards (such as the **EN 16247 series**) to establish a singular, harmonized field procedure. This procedure enables accredited experts to assess both energy performance and building intelligence during a single site visit.

Deliverable D4.1 is structured in a **two-step delivery**. Version 1 (V1) focuses on the foundational programmatic steps of the procedure's framework creation. It shares the initial draft of the joint audit procedure and chronicles the comprehensive peer-review process, involving external certified EPC assessors, designed to validate the technical applicability of the document by market actors.

Scheduled for delivery at the end of the project lifetime (Q4 2026), the second release of D4.1 (V2) will present the updated version of the joint audit procedure document. This V2 will incorporate feedback from ongoing field testing within the project's large-scale demonstration campaign, which targets at least **200 EPCs and 1,000 SRIs** across a stratified sample of the European building stock.

On this basis, the sister project OpenBEP4EU will take this activity further at CEN level via a follow-up dedicated task.

1. Context and EPBD requirements

The EPBD (Energy Performance of Buildings Directive) requires the production of disclosure tools to inform building owners about the relevant energy performance properties of their buildings. This information shall allow them to make informed decisions in the management of their buildings, taking duly into account energy-related features.

Currently, there is experience about:

- **EPCs** (Energy Performance Certificates), that should valorise the energy performance of a building (either calculated or measured), when renting or selling building units. This should orient the market towards high-performance buildings.
- **IR** (Inspection report from regular inspection of heating systems, ventilation systems and air-conditioning systems according to EPBD Art. 23), that should introduce energy cost evaluations when taking system maintenance decisions.

Recast EPBD IV is adding new disclosure tools:

- **RP** (Building Renovation Passport), to introduce energy properties of the building in the context of long-term step-by-step renovation (staged deep renovation) with the decarbonisation objectives, including financial issues (investment, energy costs, subsidies).
- **SRI** (Smart Readiness Indicator), to display the level of smart-ready services, capacity control and automation of the building in relation to 3 key functionalities: optimise energy efficiency, adapt operation to the needs of the occupant, and adapt to signals from the grid.

Experience in the past showed the low quality of EPCs and inspection reports. Several root causes have been identified in:

- Few resources available versus the time required for an adequate on-site inspection;
- EPCs were not issued by experts (as required by the EPBD) and no adequate quality control was in place;
- Poor understanding of the field situation and difficulties in identifying the required input data for systems (example: COP of a heat pump) and building elements (example: U value of a wall);
- Lack of documentation about materials incorporated in the building and technical systems;
- Inaccurate estimation of shadings and possible microclimate.

The SmarterEPC onsite audit procedure tackles these issues by proposing:

- a guidance and procedure to conduct on-site work;
- information on the data to be collected and how to find it;
- to facilitate and help increase the efficiency of the on-site data collection.

2. Development steps of the procedure

2.1. Overview of the development process

A summary of the development steps of the on-site audit procedure is illustrated in Figure 1.

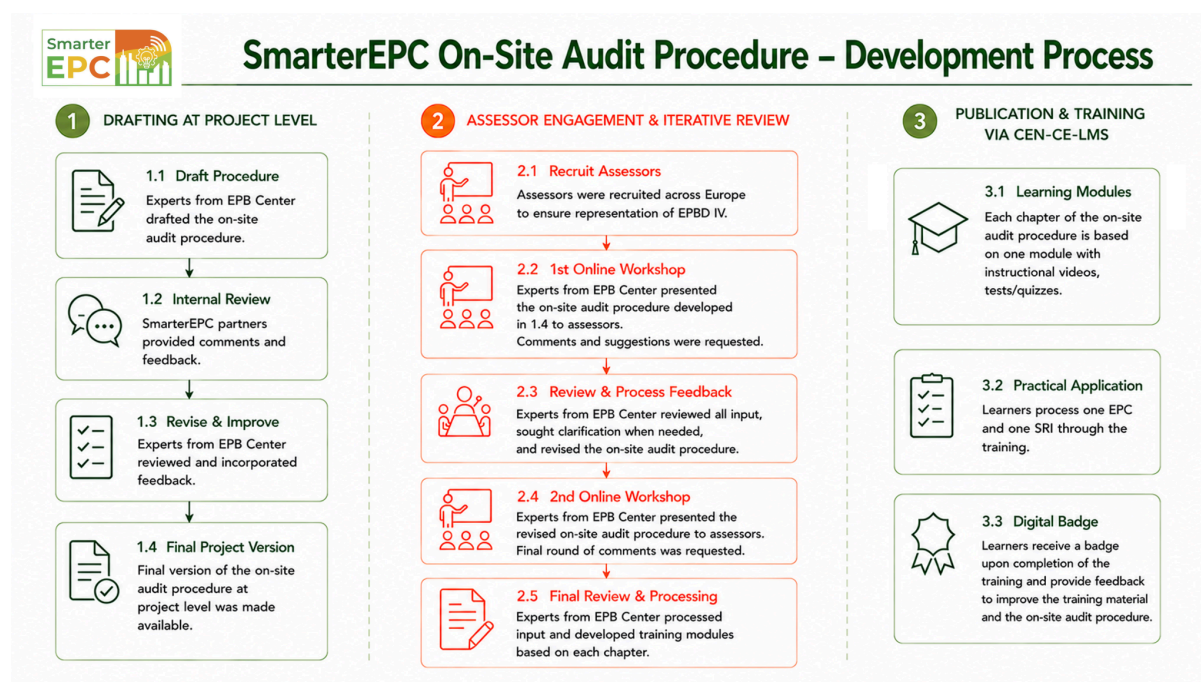


Figure 1. Development steps of SmarterEPC integrated EPC+SRI on-site audit procedure

The development of the integrated EPC+SRI on-site audit procedure followed an iterative and participatory approach involving both project partners and external market experts. The process was designed to ensure that the resulting procedure is technically robust, practically applicable, and aligned with the evolving European policy framework, particularly the revised Energy Performance of Buildings Directive (EPBD IV).

2.2. Drafting at project level

The first phase consisted of the development of a preliminary version of the integrated EPC+SRI on-site audit procedure by experts from the EPB Center. The EPBC team prepared an initial draft covering the assessment methodology, data collection requirements, evaluation procedures, and reporting structure for the integrated EPC and SRI assessments. This preliminary version underwent an internal review process involving all project partners, who provided comments, suggestions, and technical recommendations based on their respective areas of expertise. The feedback received was subsequently reviewed and incorporated, resulting in a consolidated project-level version of the On-Site Audit Procedure that served as the basis for the external validation activities.

2.3. Assessor engagement & iterative review

In parallel with the internal development activities, experienced external assessors were recruited according to the criteria and procedures described in Annex 1. Particular attention was given to ensuring a balanced geographical representation across European countries, thereby reflecting the diversity of national contexts and supporting alignment with the implementation objectives of the revised EPBD.

Prior to the validation activities, the selected assessors participated in a preparatory online workshop organized by EPB Center. During this session, participants were introduced to the SmarterEPC project objectives, the current and expected developments at the European level regarding the EPBD, EPCs, and the SRI framework, as well as the overall timeline of the validation process and the expected contributions from the assessors.

The assessor engagement was conducted over two rounds of validation, where contributors participated in an iterative review process. More details about each round of validation are provided in sequence:

First round of external validation

Following the preparatory activities, the consolidated project-level version of the On-Site Audit Procedure was presented to the external assessors during the first online workshop. The objective of this session was to collect practical and market-oriented feedback from professionals with direct experience in energy performance assessment and building auditing activities.

Assessors were invited to review the proposed procedure and provide comments, suggestions, and recommendations regarding its applicability, completeness, clarity, and feasibility in real-world assessment scenarios. Following the workshop, participants were given additional time to submit further observations and written feedback.

All comments received during this first consultation round were systematically reviewed by EPB Center. Where necessary, additional exchanges were organized to ensure a correct interpretation of the feedback and to support the revision process.

Second round of external validation

The revised version of the On-Site Audit Procedure was subsequently presented to the external assessors during a second online workshop. This second consultation round aimed to validate the modifications introduced following the first review cycle and to provide assessors with an opportunity to submit final observations and recommendations.

As in the previous stage, participants were invited to provide comments within a defined review period. The project team then analyzed and processed all submitted feedback,

incorporating the final recommendations deemed relevant for the improvement of the procedure.

This iterative validation process ensured that the resulting On-Site Audit Procedure benefited from both the technical expertise available within the consortium and the practical experience of market actors operating across different European contexts.

2.4. Publication & Training via CEN-CE-LMS

Following the completion of the two external consultation rounds, EPB Center finalized a first version of the integrated EPC+SRI On-Site Audit Procedure. The resulting document represents a consensus-based methodology developed through a collaborative process involving project partners and experienced assessors from across Europe.

To facilitate knowledge transfer, capacity building, and future uptake, the procedure was transformed into a structured online training programme hosted on the CEN-CE Learning Management System (CEN-CE-LMS) platform. In this framework, each chapter of the On-Site Audit Procedure was translated into an individual learning module comprising explanatory materials, instructional videos, and knowledge assessment exercises.

The training programme guides learners through the practical application of the methodology and includes hands-on exercises requiring participants to perform one EPC assessment and one SRI assessment using the developed procedure. Upon successful completion of the learning activities, participants receive a digital badge confirming their participation in the training programme. Although this badge does not constitute an accredited professional certification, it serves as evidence that the participant has completed the SmarterEPC training pathway.

In addition, the online learning environment incorporates mechanisms for collecting user feedback. This information will be used to support the continuous improvement of both the training materials and the integrated EPC+SRI On-Site Audit Procedure throughout the remaining duration of the project and beyond.

2.5. Testing of the procedure within SmarterEPC demonstration activities

The demonstration activities conducted within the SmarterEPC project will provide an opportunity to validate the applicability of the integrated EPC+SRI on-site audit procedure and assess the effectiveness of the associated training programme under real-world conditions. Participants will provide feedback on the clarity of the training materials, the completeness of the procedure, the usability of the assessment workflow, and the consistency of the generated outputs. The next version of this deliverable (Deliverable D4.1

V2) will, therefore, report on the outcomes of the demonstration and training activities, after processing the collected feedback.

Deliverable D4.1 V2 will include more details on the practical implementation of the integrated EPC+SRI on-site audit procedure, the performance of the training programme, and the lessons learned from its application across different European contexts and building typologies.

3. Structure of the procedure

Annex 2 presents the current version of the EPC and SRI on-site audit procedure, which will be further refined and enriched by the feedback derived from the project's ongoing demonstration activities. In this section, the underlying structure of the procedure is presented

3.1. Overview

The integrated EPC+SRI on-site audit procedure was designed to provide assessors with a structured, transparent, and reproducible methodology for collecting the information required to perform both EPC and SRI assessments. The procedure follows the practical workflow typically adopted by building assessors and aims to optimize the collection of information while minimizing the need for repeated site visits.

As illustrated in Figure 2, the data collection procedure and processing was organized into three main phases: **preliminary office work**, **on-site inspection activities**, and **final office work**. Naturally, the work starts by contacting the owner or building manager responsible for the building in question. The structure shown in Figure 2 reflects the chronological sequence of activities performed during a real assessment process, beginning with the collection and analysis of available documentation, continuing with the verification and completion of information during the site visit, and concluding with the preparation of the final input dataset required for EPC and SRI calculations.

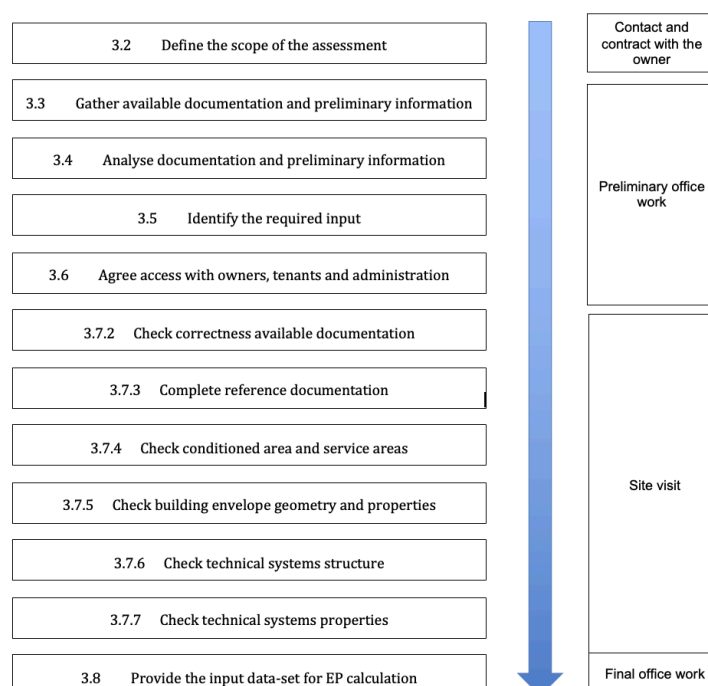


Figure 2. Workflow extracted from the integrated on-site audit procedure

The following items describe the purpose and rationale of each step of the integrated EPC+SRI on-site audit procedure.

3.2. Define the scope of the assessment

The preparation of a disclosure document (such as EPC and/or SRI) is originated by a request by the owner or building manager. Assuming that a request has been accepted and an agreement has been settled, the procedure begins by defining the scope of the assessment and identifying the information required to perform the evaluation.

The scope of the assessment must include the type of disclosure instrument to be produced (e.g., EPC, SRI, Renovation Passport or Inspection Report) and the building object to be assessed. This phase establishes the applicable regulatory framework, clarifies the objectives of the assessment, and determines whether the evaluation will be carried out at the level of a building unit or the entire building. A clear definition of the scope is essential to identify the information requirements, plan the subsequent data collection activities, and ensure that the assessment methodology is appropriate for the intended use.

3.3. Preliminary Office Work

Gather available documentation and preliminary information

Subsequently, available documentation and preliminary information are collected and analyzed to establish an initial understanding of the building characteristics and technical systems. This may include previous EPCs and disclosure documents, architectural drawings, technical system documentation, operation and maintenance records, inspection reports, and construction records. The purpose of this step is to establish an initial understanding of the building characteristics, identify the boundaries of the assessment, and support the planning of the on-site inspection activities. When documentation is incomplete or unavailable, additional sources, such as publicly available geospatial information, may be consulted to obtain a preliminary characterization of the building and its surroundings.

Analyse documentation and preliminary information

The documentation collected in the previous step is reviewed to obtain an initial understanding of the building and to prepare the on-site inspection. This analysis aims to identify the building geometry, the use of spaces, the available technical systems, and their areas of service. It also allows the assessor to identify missing or uncertain information that will need to be verified during the site visit and to plan the field activities accordingly. The outcome of this step provides the basis for planning the on-site inspection activities and identifying the information that must be verified, completed, or collected during the field visit.

Identify the required input

This step involves preparing a preliminary list of parameters to be verified or collected during the site visit, as well as identifying the spaces and technical areas that will need to be accessed. The objective is to ensure that the on-site inspection is carried out efficiently and that all relevant information required for the subsequent calculations is collected. In cases where building characteristics are repetitive, such as identical apartments or similar technical systems, representative sampling approaches may be considered to optimize the data collection process.

A series of 36 thorough checklists and reporting templates were provided in the integrated EPC+SRI on-site audit procedure (Section 17) to assist the on-site data-collection process. An example is provided in Figure 3.

Assessor company logo and header	
Building name/reference	
Contact information (owner/administration)	Name Phone/mail
ITEM	CHECK
The assessed object is identified	☐ Done ☐ YES ☐ NO ☐ Admin data checklist completed
The purpose of the assessment is defined	☐ EPC ☐ RP ☐ SRI ☐ IR
The contract for the assessment is signed	☐ Done ☐ Reference/date _____
The calculation method and calculation tool are defined	Method: _____ Tool: _____
Asking for available documentation	☐ YES ☐ NO ☐ Documents checklist completed ☐ Asked on _____ From _____ ☐ Received on _____
Documentation has been reviewed	☐ Done on _____
The input needs are identified	☐ Done on _____ ☐ YES ☐ NO ☐ Site visit checklist <u>have</u> been prepared
Access for the on-site visit has been agreed	☐ Done ☐ List of tenants is available
On site visit	☐ Done, Starting date ____/____/____ Ending date ____/____/____
Input data package is complete and archived	☐ Done on _____ ☐ Where archived _____
Energy performance calculation done	☐ Done on _____
Disclosure tool has been delivered to owner	☐ Done on _____
Date _____	Signature _____

Figure 3. Snapshot from the series of checklists available in the integrated EPC+SRI on-site audit procedure

Agree access with owners, tenants and administration

Prior to the on-site inspection, the assessor shall coordinate with the building owner, occupants, and/or building administration to arrange access to all relevant spaces required for the assessment. This includes confirming access to private areas, common spaces, and technical rooms, as well as validating the preliminary list of spaces identified during the preparation phase. Where possible, operation and maintenance personnel should be available during the site visit to support the identification of technical systems and provide additional information regarding the operation and specific characteristics of the building installations.

3.4. Site visit

Check the correctness of the available documentation

The first activity during the site visit consists of verifying the accuracy and completeness of the documentation collected during the preparatory phase. Building characteristics, space uses, technical systems, and geometrical information are compared against the actual conditions observed on-site. Any discrepancies identified are documented and the available records are updated to reflect the current state of the building. This verification step is essential to ensure that the subsequent assessment is based on reliable and representative information.

Complete reference documentation

Following the verification of the existing information, the assessor completes the reference documentation required for the assessment. This includes preparing or updating building plans, identifying conditioned spaces and service areas, documenting the location and configuration of technical systems, and collecting any additional information necessary to support the EPC and SRI calculations. The objective of this step is to establish a sufficiently detailed and consistent documentation basis for the remainder of the assessment process.

Check the conditioned area and service areas

The on-site inspection is carried out based on the preliminary analysis and the checklist prepared during the planning phase. The checklist identifies the information to be verified, completed, or collected during the visit, ensuring that all data required for the EPC and SRI assessments are systematically addressed. The assessor identifies and confirms the actual conditioned spaces within the assessed object, taking into account any modifications that may have occurred since the original documentation was produced. The use of spaces is verified and classified according to the applicable calculation methodology, while adjacent environments and their thermal conditions are identified. In parallel, the service areas associated with each technical system are verified to ensure a correct representation of the building operation and energy flows.

Check building envelope geometry and properties

The geometry and physical properties of the building envelope are inspected and documented to support the energy performance calculations. This activity includes confirming the dimensions and configuration of the envelope, as well as collecting information on construction elements, thermal properties, openings, shading elements, and any relevant features affecting the building's energy performance. Where documentary evidence is unavailable, observations made during the site visit are used to establish the required input data.

Check technical systems properties

The final stage of the on-site inspection focuses on the identification and characterization of the building technical systems relevant for EPC and SRI assessments. The assessor first determines the overall system structure, including the distinction between centralized, individual, and localized systems, as well as the extent of their service areas. Subsequently, the relevant characteristics of each system, including equipment specifications, control strategies, and operational features, are collected and documented to support the subsequent energy performance and smart readiness evaluations.

3.5. Final Office Work

Provide the input dataset for EP calculation

Following the completion of the on-site inspection, all collected information, observations, measurements, and supporting documentation are consolidated into a structured and traceable digital folder. The objective of this step is to ensure the consistency, reproducibility, and verifiability of the EPC and SRI assessments by maintaining a clear link between the input parameters used in the calculations and their underlying evidence sources. A suggestion for the structure and index of the digital folder is provided in Chapter 15 of the integrated EPC+SRI on-site audit procedure.

In summary, it is recommended that the documentation is organized according to a predefined structure comprising, among others, building plans and façade drawings, geometrical data, building envelope characteristics, service area layouts, technical systems diagrams, operational information, and the properties of individual systems and subsystems.

In addition, the assessment dossier should contain supporting evidence collected during the site visit, including notes, photographs, technical documentation, and records of the inspection activities. This structured approach ensures that the source of each input parameter can be readily traced and verified, thereby facilitating quality assurance, future updates, and potential auditing activities.

4. Training programme

To facilitate the adoption and practical implementation of the integrated EPC+SRI on-site audit procedure, a dedicated training programme was developed based on a modular approach. The training was designed to provide assessors with both the theoretical knowledge and practical competencies required to perform integrated EPC and SRI assessments.

The training programme follows a one chapter—one module principle, where each chapter of the procedure corresponds to a dedicated training module. For each training module, Unique Learning Outcomes (ULOs) were defined and mirror the objectives and key concepts of the corresponding chapter. This approach ensures that the procedure is covered systematically. Moreover, the training programme was organized into two complementary components: mandatory core modules and optional complementary modules.

4.1. Mandatory Core Modules

The mandatory modules constitute the core of the training programme and directly reflect the content of the integrated EPC+SRI on-site audit procedure. These modules are considered essential for all participants and cover the complete assessment workflow, from preparation and on-site inspection activities to data processing and reporting.

Each mandatory module includes a knowledge assessment component, typically in the form of quizzes or tests, designed to verify participants' understanding of the training material and reinforce key concepts. Successful completion of the mandatory modules and associated assessments forms the basis for documenting participation in the training programme.

4.2. Optional Complementary Modules

In addition to the core training modules, a series of optional complementary modules are provided to broaden participants' understanding of the wider technical, regulatory, and methodological context of integrated EPC and SRI assessments.

These complementary modules cover, among others:

- ➔ relevant outcomes from other SmarterEPC work packages and deliverables;
- ➔ the revised Energy Performance of Buildings Directive (EPBD IV) and related European guidance documents;
- ➔ additional technical and methodological topics relevant to building energy performance assessment.

The complementary modules are intended to enrich the learning experience and support continuous professional development, but they are not mandatory for completion of the training programme.

4.3. Learning assessment and continuous improvement

The training programme incorporates several mechanisms to assess learning outcomes and support continuous improvement. Knowledge quizzes are included within the mandatory modules to evaluate participants' understanding of the training content. In addition, participants are invited to complete a final survey upon completion of the training programme. This survey serves both as a feedback mechanism and as a means of documenting participation in the training activities.

The collected feedback will be used to continuously improve the training materials, refine the educational approach, and support future updates of the integrated EPC+SRI on-site audit procedure.

4.4. Integration with Existing European Training Initiatives

To promote alignment with existing European initiatives, the integrated EPC+SRI on-site audit procedure also incorporates selected external educational resources. In particular, participants may be provided access to relevant modules from established training schemes, such as the CEN-CE educational programme based on the European set of Energy Performance of Buildings (EPB) standards. This approach supports the development of a broader and more comprehensive skill set while strengthening the connection between the SmarterEPC methodology and existing European professional training frameworks.

Conclusions and next steps

The development of the SmarterEPC joint EPC and SRI on-site audit procedure represents a **strategic effort to unify EPC and SRI assessment frameworks into an actionable, market-ready procedure**, preparing for a broad European transformation in building performance certification. The work detailed in this deliverable brings the two schemes closer and creates tight links between energy and smartness assessment.

The work implemented in SmarterEPC develops, validates, and delivers a comprehensive joint EPC and SRI audit procedure, building on established building audit frameworks, in particular the EN 16247 energy audit standards. This methodology is designed as a **precursor to a standardized procedure** and will serve as a reference document to initiate CEN workshop processes, supporting the development and adaptation of standards for on-site EPC and SRI audits.

Version 1 of the procedure, enriched by the insights of selected expert assessors, is currently undergoing **intensive validation during our large-scale demonstration activities**. The lessons learned from these practical applications will be compiled dynamically, culminating in the publication of the next version of the procedure in the second version of this deliverable (to be released at the end of the project lifetime). Close collaboration with sister projects such as OpenBEP4EU and SRI platform working groups will ensure the efficient post-project exploitation of SmarterEPC project outcomes.

Annex 1: Recruitment of external, certified assessors

To ensure market relevance and practical applicability, SmarterEPC engaged certified building performance assessors in review tasks, spanning over about a year of project. These paid assessors, were recruited from more than 10 EU countries. Their participation in demonstration activities enable the project's methodologies and tools to be reviewed, tested, and validated in real operational contexts, reflecting the needs and constraints of the sector.

Description of the tasks to be performed

The consortium defined specifications of the tasks to be implemented. Each assessor was expected to execute the following exercises:

- Read, analyse, and review/comment assigned project documents, for instance the **EPC and SRI on-site audit procedure**,
- Actively attend a couple of 120-minute online interactive workshops,
- Participate in the virtual training programme,
- Conduct fieldwork assessments using the SmarterEPC Hub and the integrated digital building performance assessment and rating tools (optional),
- Provide structured feedback (e.g., questionnaire-based and open-ended evaluations).

Three key activities were listed in more detail:

Task 1 (Mandatory) - Enriching the energy audit standards for EPC, SRI, HVAC inspections & Renovation Passports assessments

- Review and provide feedback on a draft procedure (circa 100 pages, see Annex 2) for on-site EPC, SRI, HVAC, and Renovation Passports audits, developed by EPB Center's experts
- Feedback interventions will take place from July to September 2025, via [CEN-CE Learning Management System](#)
 - Recording from the preparatory online workshop (EU level, English), explaining the document and the follow-up review procedure
 - **Round 1** of comments from paid assessors during July (feedback process output as tracked changes and comments on the draft procedure)
 - **Online workshop 1** (EU level, English) on 29, 30, or 31 July (based on availability)
 - **Round 2** of comments from paid assessors during August 2025
 - **Online workshop 2** (EU level, English) on 1, 8 or 9 September (based on availability)
 - **Round 3** of comments, closing mid-September

Task 2 (Mandatory) - Review of the training programme for assessors

- Assessors are expected to be the first participants in the pilot phase of the virtual training program (both content and process)
- Evaluation of training material on EPCs, SRI, HVAC inspection, Renovation Passport, and data acquisition. Draft training materials will be available in [CEN-CE Learning Management System](#) by the end of October 2025
- Participation in the virtual training programme (asynchronous self-paced and a couple of interactive live online meetings) via the Moodle-based virtual training centre in November - December 2025

Task 3 (optional) - Demonstrating the SmarterEPC approach

- Conduct testing of the SmarterEPC Hub (EPC + SRI assessment) with real-world building data
- Assess functionality, usability, and data acquisition processes
- Testing to take place asynchronously in the period November 2025 - January 2026

The required qualifications of the assessors to be recruited were:

- Certified (at national level) EPC assessors and/or energy auditors with minimum 3 years' experience
- Experience in smart building technology is a plus
- Basic proficiency in English
- Access to BIM or DBL data, preferably for some assessors testing advanced functionalities (optional)
- Availability on the defined periods for feedback and testing

Benefits for assessors were also listed to increase their interest in participating in these activities:

- Stay ahead of national EPC, SRI, HVAC inspections and Renovation Passports updates, especially for the evolution of the EPC frameworks and voluntary/mandatory SRI introduction in 2027 (EPBD IV implementation by EU's Member States 29 May 2026)
- Gain hands-on experience with next-generation building performance assessment and rating (e.g., EPC, SRI) digital tools and formal recognition of attained knowledge
- Provide insights from the practical reality and shape European building performance policy instruments
- Payment for participation in methodology review, digital tool testing, virtual training programme, and overall feedback provision
- Elevated professional visibility across the project's communication channels (website, newsletter, social media, and public events).

Recruitment process

The [call for assessors](#) was implemented online with the EU Survey tool.

SmarterEPC - Work on a new 'Energy Audit Standard' - Recruitment of Paid Assessors

Fields marked with * are mandatory.

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The **SmarterEPC** project, funded under the LIFE-2022-CET sub-programme, aims to enhance the audit process and issuance of Energy Performance Certificates (EPCs), Smart Readiness Indicators (SRIs) and related EPBD policy instruments (HVAC inspections, Renovation Passports) across the EU Member States.

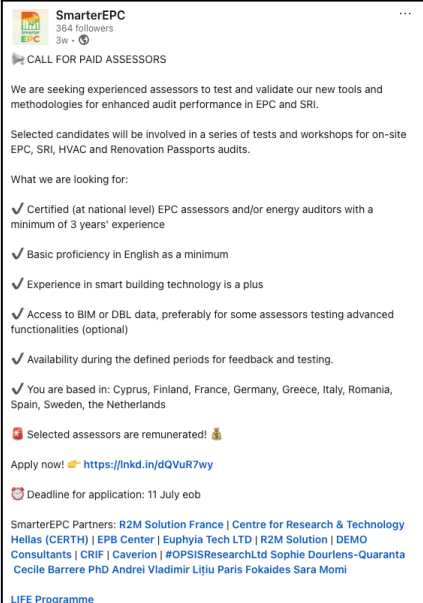
The SmarterEPC consortium partners are: R2M Solution France (coordinator), Centre for Research & Technology Hellas (CERTH), EPB Center, Euphyllia Tech LTD, R2M Solution Italy, DEMO Consultants, CRIF, Caverion, and OPSIS Research Ltd.

As part of this effort, **SmarterEPC team seeks to engage professional building performance assessors to contribute to demonstration activities and review and validate project methodologies and tools.**
This form outlines the role, expectations, and contractual arrangements for the recruitment of paid assessors.

Candidates are invited to go through the information and submit their application directly by submitting this form filled out.

Figure 4. Online form to recruit external assessors to review the draft procedure

It was promoted by the project's social media channels, supported by each partner through their social media and their direct contacts in the building sector.



SmarterEPC 364 followers · 3w ·

CALL FOR PAID ASSESSORS

We are seeking experienced assessors to test and validate our new tools and methodologies for enhanced audit performance in EPC and SRI.

Selected candidates will be involved in a series of tests and workshops for on-site EPC, SRI, HVAC and Renovation Passports audits.

What we are looking for:

- ✓ Certified (at national level) EPC assessors and/or energy auditors with a minimum of 3 years' experience
- ✓ Basic proficiency in English as a minimum
- ✓ Experience in smart building technology is a plus
- ✓ Access to BIM or DBL data, preferably for some assessors testing advanced functionalities (optional)
- ✓ Availability during the defined periods for feedback and testing.
- ✓ You are based in: Cyprus, Finland, France, Germany, Greece, Italy, Romania, Spain, Sweden, the Netherlands

Selected assessors are remunerated! 🤝

Apply now! ➡ <https://lnkd.in/dQVuR7wy>

Deadline for application: 11 July eob

SmarterEPC Partners: R2M Solution France | Centre for Research & Technology Hellas (CERTH) | EPB Center | Euphyllia Tech LTD | R2M Solution | DEMO Consultants | CRIF | Caverion | #OPSISResearchLtd Sophie Dourlens-Quaranta Cecile Barrere PhD Andrei Vladimir Lițiu Paris Fokaides Sara Momi

LIFE Programme



SmarterEPC

CALL FOR ASSESSORS

Interested in contributing to the integration of EPC & SRI?

Apply to join the team now!

Your expertise is **PAID!**

Co-funded by the European Union

Figure 5. Post and visual promoting the recruitment process

61 applications were received, exceeding the number targeted by the consortium (50). The number of applicants per country is presented in the next table.

Table 1. Number of applications received, and their country of origin

Country	Number of applications
Belgium	2
Croatia	1
Cyprus	3
Finland	16
France	4
Germany	8
Greece	4
Italy	8
Latvia	1
Romania	2
Slovakia	2
Slovenia	1
Spain	2
Sweden	6
The Netherlands	1
TOTAL	61

An eligibility check was conducted by the coordinator R2MF. 24 applications were considered not eligible, due to one of the following reasons:

- The applicant declared not to be available during the periods indicated in the task description
- The applicant declared not to be a certified building assessor
- The price proposed by the applicant exceeded the budget.

Concerning the 37 eligible applications, their evaluation was assigned to each partner according to their geographical proximity. Due to the lack of eligible applications from the Netherlands, applications from Germany were assigned to DEMO. Given its EU-level scope, EPBC was assigned the evaluation of the countries outside the geographical scope of the consortium.

Table 2. Evaluation of eligible applications

Partner	Number of applications evaluated	Corresponding countries
1-R2MF	1	France
2-CERTH	2	Greece

3-EPBC	9	Belgium, Slovakia, Slovenia, Spain, Sweden
4-EUP	3	Cyprus
5-R2MI and 7-CRIF	7	Italy
6-DEMO	4	Germany
8-CAV	9	Finland
9-OPS	2	Romania
TOTAL	37	12

Each partner evaluated the applications they were assigned according to the best value for money principle. For each application, a price score ranging from 0 to 4 and a technical score ranging from 0 to 6 were calculated, and summed into a total score ranging from 0 to 10.

The price score was calculated by each partner as follows: the maximum score (4) was given to the cheapest offer of their pool (considering the total price for the mandatory tasks 1 and 2). The price score of the other offers was calculated as the quotient between their price and the cheapest price, multiplied by 4.

The technical score was assessed by each partner based on the following aspects:

- Number of years of experience, including in smart building technologies
- Level in English
- Access to BIM or DBL data
- Willingness to participate in optional services

As a result, 23 applicants were selected. Some of the applications selected by EPBC from various countries were assigned, in terms of contractualisation and budget covering, to R2MF and OPS to balance the budget spent by all partners at this stage of the demonstration activities.

List of assessors selected

To ensure compliance with the General Data Protection Regulation (GDPR) and to preserve the confidentiality of individual contractual arrangements, the names of the external assessors and the details of their contractual arrangements are not disclosed in this deliverable. However, all relevant supporting documentation is securely retained by the consortium and can be made available for verification by the Project Officer, the European Commission, and authorised auditing bodies upon request.

#	Position	Country	Partner in charge
1	Project leader	France	1-R2MF
2	Chief Executive Officer	Spain	1-R2MF

#	Position	Country	Partner in charge
3	Energy Performance Certifier, Registered Energy Auditor	Slovakia	1-R2MF
4	RURAL AND SURVEYING ENGINEER	Greece	2-CERTH
5	Senior Project Manager, Scientific consultant	Greece	2-CERTH
6	Energy strategist and energy expert	Sweden	3-EPBC
7	Team Lead, Senior Project Manager	Belgium	3-EPBC
8	Project Mechanical Engineer	Cyprus	4-EUP
9	Mechanical Engineer	Cyprus	4-EUP
10	Energy Engineer/Consultant	Cyprus	4-EUP
11	Freelance Engineer and Construction Engineer	Italy	5-R2MI
12	Energy Efficiency Building Designer	Italy	5-R2MI
13	Accredited Energy Auditor & Consulting DGNB Auditor	Germany	6-DEMO
14	Project Lead	Germany	6-DEMO
15	EPC Assessor/Expert & Researcher	Germany	6-DEMO
16	Consultant	Italy	7-CRIF
17	Libero Professionista	Italy	7-CRIF
18	Consultant	Italy	7-CRIF
19	Energy and lifecycle consultant	Finland	8-CAV
20	Design Manager, HVAC and energy planning	Finland	8-CAV
21	ASSOC PROF	Romania	9-OPS
22	CEO, owner and Energy Auditor for buildings	Romania	9-OPS
23	Energy Auditor	Slovakia	9-OPS

Enriching the energy audits standards (task 1)

The work aiming to enrich the energy audit standard focuses on the review of the initial version of the joint on-site audit procedure by external auditors.

The workflow of Task 1 is detailed in **Figure 6**. It consists mostly in a preparatory online meeting with selected professionals followed by 2 rounds of comments leading to the version shown in Annex 2.

Enriching energy audits standards: integrated BP assessments



Figure 6. Task 1 - Timeline and key workshops

Task 1 closed at the end of 2025 and paid assessors were paid for the work done during December 2025 and January 2026.

Task 1 consultation specifically supported the identification of operational bottlenecks in field data collection, ensuring instructions were clear for field engineers, and verifying the feasibility of the procedure in real-world scenarios. The final polished feedback and concrete procedure updates are slated to be dynamically compiled during ongoing large-scale field

testing and will be fully published in **Deliverable D4.1 V2** at the end of the project timeline (December 2026).

Review of the training programme for assessors (task 2)

Not started, will be developed in **Deliverable D4.1 V2**.

Annex 2: EPC and SRI on-site audit procedure (DRAFT, June 2026)

See next pages.



Smarter EPC – Project

WP 4 – Task 4.1

The EPC and SRI on-site audit procedure (DRAFT)

Date of report: 2025-10-20

Prepared by: Laurent Socal
Jana Bendzalova

Distribution: For second review by auditors

More info: www.epb.center

Contact www.epb.center/contact

Information to the reader

This draft version is issued following processing of the 1st comments by the contracted assessors.

The pink boxes like this one

Sample editing remark

are editing remarks and notes that are used by the authors. They will be deleted when their contents or remarks will be transposed into the text.

This revision of the document has been drafted considering the 1st round of comments received.

Now the text is complete.

The text is still somewhat unbalanced with more focus on heating and domestic hot water. Suggestions and integrations on cooling, ventilation, lighting and other topics are welcome.

Comments should focus on topics such as:

- if the procedure is appropriate and applicable in practice;
- if the checklist are useful
- coordination of the checklists, that should be a modular system to adapt to system complexity. The best use would be developing an app based on the checklists to guide the data collection. The app could have the flexibility to extend automatically (e.g. number of service areas or of pipes) and to synchronise the photographic documentation.
- checklist on ventilation: it's quite difficult to cover all possible configuration with a structured questionnaire. It might be more productive to assess and validate the functional diagram of the ventilation system instead of trying to fill-in complex questionnaires. The checklist could be kept simple and tailored on the case of common VMC systems
- what is missing
- what is not relevant
- any editorial suggestions

This text in red on a yellow background is only for the purpose of illustrating the expected feed-back. It will be deleted in subsequent versions.

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1 Introduction

1.1 Context

Illustrate the EPBD IV directive and the new indicators and documents: EPC, RP, SRI

Until now documents have not been supported by a sufficient on-site inspection

Low cost = no resources for an adequate inspection

On-site work can be longer than calculation time.

The purpose of this guide is to inform the assessor □ but also keep in mind the point of view of national authorities': they may refer to this guide (or to a future standard) to ask for a decent on-site inspection before calculating an EPC or preparing a RP

1.1.1 EPBD requirements

The EPBD (Energy Performance of Buildings Directive) requires the production of disclosure tools to inform the owners about the relevant energy performance properties of their buildings. This information shall allow owners to make informed decisions in the management of their buildings, taking duly into account energy related features.

Currently there is experience about:

- EPCs (Energy Performance Certificates), that should valorise the energy performance of a building (either calculated or measured) , when renting or selling building units. This should orient the market towards high performance buildings.
- IR (Inspection report from regular inspection of heating systems, ventilation systems and air-conditioning systems according to EPBD Art. 23), that should introduce energy cost evaluations when taking system maintenance decisions.

Recast EPBD IV is adding new disclosure tools:

- RP (Building Renovation Passport), to introduce energy properties of the building in the context of long-term step-by-step renovation (staged deep renovation) with the decarbonisation objectives, including financial issues (investment, energy costs, subsidies).
- SRI (Smart Readiness Indicator), to display the level of smart-ready services, capacity control and automation of the building in relation to 3 key functionalities: optimise energy efficiency, adapt operation to the needs of the occupant, adapt to signals from the grid.

Experience in the past showed the low quality of EPCs and inspection reports.

Several root causes have been identified in:

- little resources available versus time required for an adequate on-site inspection;
- EPCs were not issued by experts (as required by the EPBD) and no adequate quality control was in place;

- poor understanding of the field situation and difficulties to identify the required input data for systems (example: COP of a heat pump) and building elements (example: U value of a wall);
- lack of documentation about materials incorporated in the building and technical systems;
- inaccurate estimation of shadings and possible micro climate.

This document tries to tackle these issues by proposing:

- a guidance and procedure to conduct on-site work;
- information on the data to be collected and how to find them;

to facilitate and help increase the efficiency of the on-site data collection.

Of course, this can support the process but still adequate assessor expertise and resources (adequate time and tools) are required to provide a sufficient quality input to the calculation model. No procedure can replace expertise.

It has to be noted that this procedure covers the assessment of the input data to the energy performance calculation, **not the calculation itself**. It is strongly recommended that the same person performs the data collection and the calculation for a number of reasons.

- It is not possible to perform calculations on objects that you do not know. The on-site inspection gives you a feeling of the real consistency and state of the building. This is especially true for RP preparation.
- It's not possible to collect the right data without having a direct experience of which are the needs and issues of performing the calculation (that is, inputting the right data into the calculation tool/software).
- Having been on-site, one has a clear idea of the building and systems and can go much faster and safer through all calculation options (also non-numeric options).
- During on-site inspection, contact and discussion with tenants provides useful information that is not easy to transmit.

1.1.2 Energy performance calculation methods in the EU

The on-site audit is primarily finalised to collect the input data to an energy performance calculation. The consequence is that the data to be collected strictly depend on the calculation method, namely on its input data set.

Additional information is required to generate credible recommendations (e.g feasibility and costs of ECMs and renovations). This type of info allows a more flexible format.

Unfortunately, the current EPBD IV does not require a unique energy performance calculation method. The Annex I to the EPBD about calculation methods only requires that:

- the calculation method “takes into account” a given set of influencing factors (e.g. insulation, systems)
- the calculation method be described in terms of a few main EN-EPBD standards, (EN) ISO 52000-1, (EN) ISO 52003-1, (EN) ISO 52010-1, (EN) ISO 52016-1, (EN) ISO 52018-1, (EN) ISO 52120-1, EN 16798-1 and EN 17423 or superseeding documents.

At the time of the issuance of the first EPBD in 2002 (Directive 2002/91/EC) there were already established national methods. The EU could not impose a unique energy performance calculation method, but it tried to encourage alignment by financing (mandating) CEN to prepare a set of comprehensive EN-EPB standards so that MS could progressively adopt them. The current relevant EN-EPB standards for the calculation and data collection by assessors are summarised in the following table

Table 1 – Information on the main EN-EPB standards considered in this document

Standard #	Contents	Notes
EN ISO 52000-1:2017	The “overarching standard”. General provisions for the overall calculation, electricity balance and interaction with the grid, final weighting (e.g. primary energy, CO ₂ emission, costs)	Little input required but potential high impact of custom options like k_{exp} value.
EN ISO 52016:2017	The standard about the building envelope. Allows the calculation of energy needs for heating and cooling, either with a monthly or hourly method with the nearly identical input data-set. Complemented by several EN-ISO standards about specific topics and building elements (e.g. EN ISO 6946:2017, EN ISO 13370:2017)	Input intensive, mostly through the connected standards. National methods fairly aligned.
EN 15316:2017 series of standards	Provides a calculation method of heating and domestic hot water systems	Several different national methods, still under development for heat pumps.
EN 16798-1	Default operating conditions, thermal comfort, IEQ,	This standard is under revision.
EN 16798-3:2017 to EN 16798-7 series of standards	Provides a calculation method of ventilation systems	Open to custom national methods for air flows in buildings.
EN 16798-9:2017 to EN 16798-15 series of standards	Provides a calculation method for cooling systems	Most of the contents will be transferred to EN 15316 series of standards
EN 15193:2017	Provides a calculation method of lighting systems	Basically a monthly method.
EN 15378-3	Defines criteria for the measured energy performance for heating and domestic hot water	Useful to process measured energy data
EN 15378-1	Defines an inspection procedure for heating systems according to EPBD II	To be updated according to new inspection requirements of EPBD IV
EN 16798-17	Defines an inspection procedure for ventilation systems according to EPBD II	To be updated according to new inspection requirements of EPBD IV
EN ISO 52120-1	Defines the functions of building automation and their levels.	SRI uses the same functions and levels, plus some additional function

Table 2 – Standards relevant for public authorities

Standard #	Contents	Notes
EN ISO 52010-1	Pre-processing of climate data	

Standard #	Contents	Notes
EN ISO 52018-1	Energy performance of buildings — Indicators for partial EPB requirements related to thermal energy balance and fabric features — Part 1: Overview of options	
EN 17423	Primary energy factors	

A comprehensive overview of the structure of EN-EPB standards is given in figure 1.

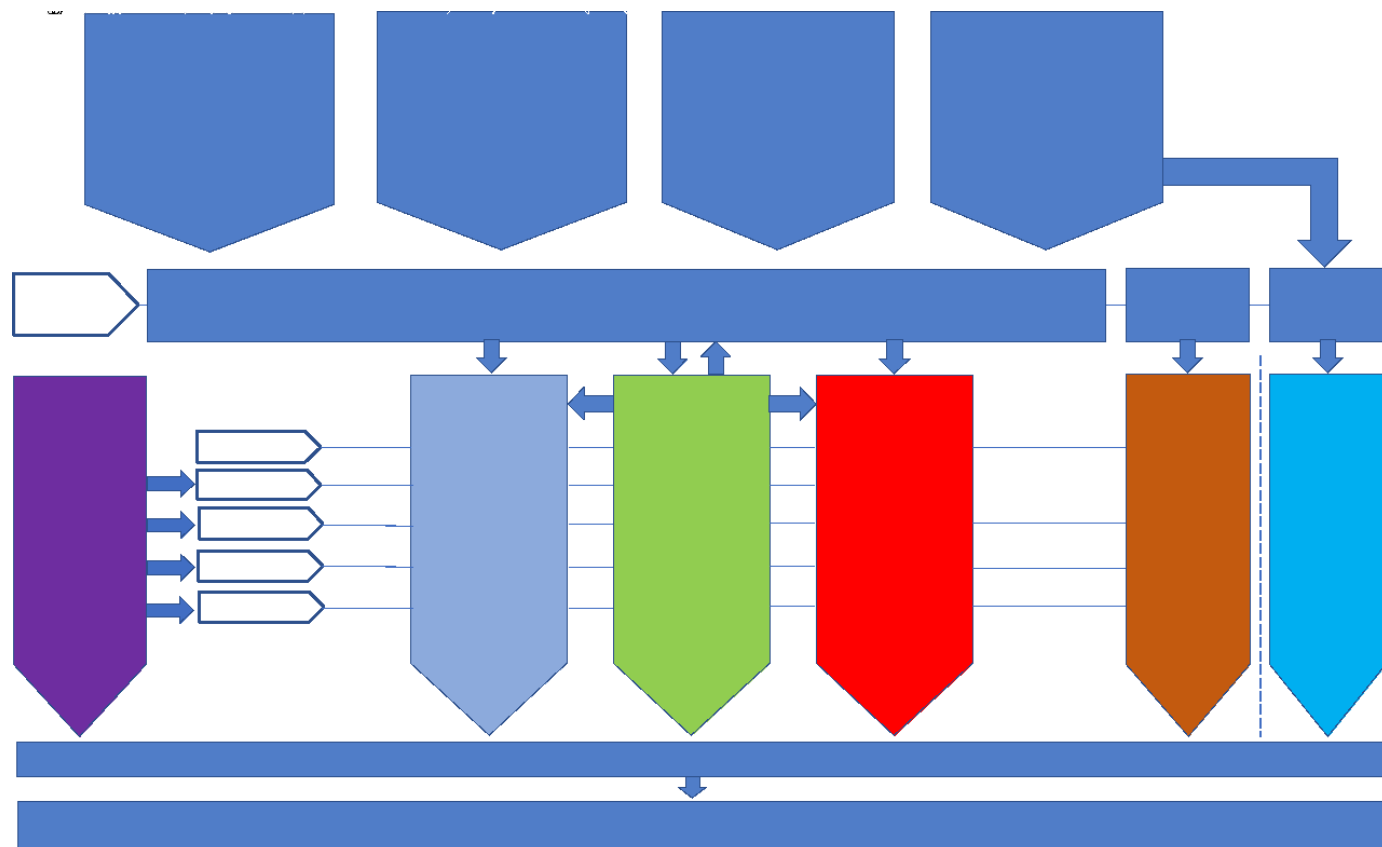


Figure 1 – Overview of EN-EPB standards

More info can be found on EPB-Center website, <https://epb.center/epb-standards/overview-epb-standards/>

Despite the flexibility of the EN-EPB standards in allowing custom MS options, the calculation methodologies, the level of details of the input (e.g. layers versus U-values of opaque elements) and the software tools used by assessors still strongly differ on a national or even regional or local basis.

This document focuses on the methodology based on EN-EPB standards, in line with the EPBD requirements, which shows clearly that they should be the aim or common frame for all national methods.

Some facts shall be noted.

- There is a good uniformity in the methods about the calculation of the building envelope (heating and cooling needs calculation). The thermal protection of the building envelope was historically the first concern. The first release of the standard EN 832 *“Thermal performance of buildings – Calculation of energy use for heating – Residential buildings”* was published in 1998. It was replaced in 2008 by EN ISO 13790 (escalating as worldwide standard) and then in 2017 by EN ISO 52016, which includes both a

monthly and an hourly method with consistent input for the description of the building. EN ISO 52016 is one of the “overarching standards” mentioned by EPBD, against which the national methods should be evaluated.

NOTE: Some differences between MS calculation methods are expected about the evaluation of thermal bridges, which can be quite relevant in insulated existing and even new buildings.

- There is not yet such convergence on technical systems standards (i.e. heating, domestic hot water, cooling, ventilation, lighting), with huge differences across MSs. Some national methods are based on simple tabular efficiencies whilst others perform detailed calculation on systems operating conditions.
- There are emerging concerns and topics, like heat pumps and interactions with the grid, which require additional standardisation work.
- There is a huge production of EN standards and EU regulations to rate products “as such”, linked to ERP and ECOLABELING directives. Unfortunately, the related product standards provide little if any information for the evaluation of the performance of products in the specific operating conditions of actual buildings, thus leading to the development of local calculation methods.

It is expected that the proposed procedures and checklist will be suitable for most MSs for the building envelope, whereas significant customisation may be required for technical systems description.

The standardisation of an input data frame, like an XML file, is not yet viable and therefore will not be attempted in this document given the differentiation in the required data input. For the time being, this can be only a long-term objective and yet another reason to push the adoption of the same energy performance calculation methods across EU.

Rather, most common approaches will be adopted (allowed EN-EPB methods representative of most national methods) and a common rationale for the inspection of technical systems will be provided.

1.1.3 New Regulatory provisions of Recast EPBD IV

The Recast EPBD IV introduces new elements (link https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401275) related to data collection, which energy assessors must take into account. The specific implementation will depend on how each Member State transposes the Directive into national legislation also because these new elements are partly mandatory and partly voluntary.

1.1.4 Guidance documents by the commission

The European Commission recently issued a set of so called “Guidance documents” on new or substantially modified provisions of the recast Energy Performance of Buildings Directive (EU) 2024/1275 including the Energy performance certificates (Articles 19-21, Annex V) and independent control systems (Annex VI)

(link:

https://energy.ec.europa.eu/document/download/ccef4a7a-6985-484d-aaef-a7d3a830fb0e_en?filename=Energy%20performance%20certificates%20%28Articles%2019-21%2C%20Annex%20V%29%20and%20independent%20control%20systems%20%28Article%2027%2C%20Annex%20VI%29%20-%20annex%203.pdf

) **bibliography reference**

The main contents of the guidance documents that impact the data collection process are summarised in the next clauses.

- Clause 3.1: EPC shall be “affordable” but also “high quality”

These are conflicting requirements. The compromise is making the production of an EPC and/or any other disclosure tool as efficient as possible. Efficiency in the process may arise from:

- assessor expertise;
- streamlined procedures (addressed in this document);
- making collected information reusable for multiple purpose (addressed in this document) or when updating the disclosure documents.
- Clause 3.2: possibility of “virtual visits”

Virtual visits means observing the assessed object (building and systems) through a visual communication device instead of being directly on-site. As an example, the assessor could have a videocall with the tenant in which the tenant shows to the assessor the required details on the phone.

To rely on a mere “virtual visit” is deemed by most interviewed experts as a severe risk for the quality of assessments. It is well known that in the past a lot of low quality EPCs have been issued without any site visit by the assessor.

Virtual visits shall not allow any short-cut on the expected outcome (contents and quality) of the assessment. The result of the inspection must be the same, irrespective of the assessment method. There is no need to provide special criteria for virtual assessments.

“Virtual” assessments are considered in this text as a preparation or complement to an on-site visit.

- a first virtual visit of the building through web-based street views may be very useful in preparation of the actual on-site visit for a first impression on the context;
- during on-site inspections, otherwise inaccessible parts of the building may be inspected by means of a virtual visit (e.g. inspecting a roof with a camera held by a drone);
- after an on-site visit, a video phone call with a tenant may quickly solve a specific doubt.

In short: in this document virtual visits are considered only a possible additional helpful integration of a regular on-site visit

- Clause 4 – recommendations in the EPC

The guidance document introduces a lot of mandatory requirements for recommendations. This implies that data and/or information shall be collected to provide recommendations on the following topics.

- Energy performance improvement: this is the original intent and an obligatory content already in current EPCs as well
- Improve GHG emissions: fairly connected with the original intent of recommendation, just slightly different metrics and critical role of the selection of the energy carrier.
- Improve IEQ (Indoor Environment Quality): this expands considerably the scope of recommendations and may conflict with energy and emission criteria.
- Estimate energy savings and GHG reduction following implementation of recommendations: this means repeating the energy performance calculation simulating the recommendations (which should not be new).
- Consider measures in case of major renovation or building element renovation: the important point is identifying building elements and/or technical systems in need of renovation for other reasons than energy or GHG (e.g. ageing, structural, functionality, safety). The additional cost of energy/GHG efficient solutions will be reduced. Also, if such an opportunity is missed, it takes a long time (decades) before it returns.

— System remaining lifespan. It is a trigger for the previously listed type of recommendations.

— Optimal temperature operation of systems: see next item, clause 4.4.

— Clause 4.4: Assessing more efficient temperature settings

This is one of the refrains in the EPBD IV. The objective is making the existing high temperature systems running on boilers as far as possible suitable for heat pumps.

The guidance document is limited to heating and applies a data intensive method. Providing recommendations on this topic requires a specific expertise on technical systems design and operation, as well as a clear understanding of building use.

It should be noted that insulating an existing building:

— reduces the required operating temperatures to medium or even low temperature levels without any replacement of distribution networks and heating terminals;

— immediately reduces the energy use, even of the boiler.

The logical conclusion is simple: first insulate buildings, then try to replace boilers by heat pumps. There are tons of additional reasons for that:

— reduced capital cost of the heat pump of smaller size;

— reduced grid **power** (kW) and energy (kWh) demand;

— reduced refrigerant gas concerns;

— reduced noise concerns

— reduced additional space required

— ... and more.

The concept of cascading effect shall be clearly in mind when providing recommendations on existing buildings in staged renovation (step-by-step) in order to avoid a lock-in effect and insulating first is clearly in line with the “efficiency first” principle.

This also means that the main concern to assess if the operating temperature can be reduced will be “is insulation of the building envelope easy, difficult or limited in possibility?”

For cooling systems, the question is much more complex and involves e.g. the evaluation if dehumidification is required and, if yes, if the cooling generation can be split according to temperature levels. The guidance document doesn’t provide any advice on that.

— Clause 4.5: Remaining life-span of systems

If it is short, the recommendation shall propose the replacement with technical systems suitable for 2030 and 2050 objectives.

Any proposed replacement should be compatible with 2030 objectives.

A short life-span means that a replacement or renovation is likely to be forced in the near future. In such a context, the adoption of energy/GHG efficient solutions is a mere additional cost, not the whole cost of the renovation. If such an opportunity is missed, it will take a long time (decades) before it returns, so not before 2050.

— Clause 5.2: Simplified update procedures.

The guidance document content suggests a theoretical understanding of the EPC generation process by the authors. In practice, everything in an EPC is based on an energy performance calculation that is

performed with a professional and/or officially authorised software (i.e. not a generic “tool”). As a minimum, an excel spreadsheet is used.

The critical point for the update procedure is therefore to archive:

- the source calculation file so that it can be reopened and modified, instead of repeating (mostly duplicating) the whole data collection process;
- the supporting documentation following on-site visit, to check if anything has changed.

The point here is not the procedure, which is obvious, it's about commercial practice concerning the disclosure to the customer (the owner of the assessed object) of the source documentation and source files of the energy performance calculation underlying the EPC. Usually, professionals only provide the required **output** to the customer, that is the EPC official format. There is no systematic obligation to provide source information (the **input** data) to the customer, which is considered professional value.

- Clause 7.1: mandatory elements of the certificate.

Listing mandatory elements in the certificate according to the EPBD IV, implies that the related data must be collected during the inspection:

- capacity to react to external signals: needs a detailed inspection/knowledge of the system controls;
- capable of low temperature operation: see comments to previous clause 4.4.

- Clause 7.1: voluntary elements of the certificate

Listing optional elements imply that related data must be collected during the inspection if the MS requires the information in the national EPC template. The following elements are listed.

- Size of generators and systems
- IEQ sensors and controls. Note: this can be very impacting.
- Charging points for vehicles
- Energy storage devices, type and size (kWh)
- Energy metering and monitoring
- Possible connection to district heating/cooling

- Clause 8.1.3 Validity checks on input data

The on-site visit report shall provide a sound documentation of the input data. Suggestions are provided in this document on this topic

1.1.5 On-site checks complemented by virtual means and visual check

Harmonise/coordinate with the text on clause 3.2 of the guidance document in the previous clause.

As previously stated, an on-site visit is deemed necessary to guarantee a minimum quality and reliability of the disclosure documents (EPC, RP and SRI). One of the reasons of the poor quality of EPCs is precisely the lack of an on-site visit and the interviewed experts confirm that. Unfortunately, the recast EPBD IV mentions the possibility (“*may*”) of replacing the on-site visit for “*affordability*” reasons. A critical analysis is required to justify an approach consistent with EPBD IV objectives. The following documents mention on site visits:

- Article 12(4) of the Recast EPBD requires that Renovation Passports are issued “*by a qualified or certified expert, following an on-site visit.*”

For the RP, the on-site visit by the assessor is clearly mandatory.

- Article 19(4) of the EPBD IV requires Member States to ensure that Energy Performance Certificates (EPCs) are issued *“by independent experts on the basis of an on-site visit, which may be carried out, where appropriate, by virtual means with visual checks”*.

To interpret correctly the exception to the basic requirement of the on-site visit, it shall be noted that Article 19(4) starts with *“Member States shall ensure the quality, reliability and affordability of energy performance certificates”*. This clearly states that quality, reliability, and affordability of the EPC are paramount. Any following provision of article 19 shall be interpreted according to this criterion. Therefore, the wording *“where appropriate”* shall be understood as:

- the replacement of the on-site visit by a virtual visit may be appropriate to improve affordability;
- but this shall not compromise quality and reliability.

It shall also be noted that article 19(4) states that *“MS shall take measures to ensure that energy performance certificates are affordable and shall consider whether to provide financial support for vulnerable households”*: the necessary cost of the EPC shall be supported anyway, no compromise is mentioned on quality and reliability.

- The guidance document issued by the Commission states that physical on-site visits are preferred. The criteria and conditions under which virtual checks may substitute on-site visits should be defined at the national level.

Clause 3.2 confirms the analysis of Article 19(4) of the EPBD IV. Virtual visits are acceptable only if the same level of quality of an on-site visit can be achieved.

Based on the above, it can be safely stated that the results obtained using virtual means must be in the same level of quality as on-site visits. This

A virtual visit could also be used to confirm the validity of data obtained through other means (e.g. plans, drawings, technical specifications). Access should include all relevant parts of the building or building unit, including for instance the cellar, the heating system, the roof, the garden or yard, and at least one flat, as well as a clear view of details of the windows/doors.

1.1.6 Independent Control System

The independent energy expert should be aware that the public authority will be obliged to monitor the quality of the energy performance certificates, renovation passports, smart readiness indicators and reports on the inspection of heating systems, ventilation systems and air-conditioning systems.

Therefore, input data must be justified and documented, as they may be subject to verification by public authorities.

Recast EPBD IV Article 27 requires Member States to establish an independent control system for energy performance certificates in accordance with Annex VI, and the independent control systems for renovation passports, smart readiness indicator and reports on the inspection of heating systems, ventilation systems and air-conditioning systems.

Member States shall provide a clear definition of what is a valid energy performance certificate. The definition shall ensure:

- validity check of the input data (including on-site checks) of the building used to issue the energy performance certificate and the results stated in the certificate;
- the validity of calculations

- a maximum deviation for the energy performance of a building, preferably expressed by the numeric indicator of primary energy use (kWh/(m².y));
- a minimum number of elements differing from default or standard values. To ensure that an EPC is tailored on the assessed building, Member States should ensure that a minimum number of building envelope and system characteristics used in a calculation be different from default or standard values.

Member States may include additional elements in the definition of a valid energy performance certificate, such as maximum deviation for specific input parameters.

Validity of Calculations

To ensure that an EPC is representative of its building, the building model and its characteristics require a minimum level of detail. The calculation tool which is in line with the calculation methodology specified by the relevant Member State must be used, Member States must ensure that the definition of a valid EPC includes information on which variables must be filled in and with a value different from default or standard.

Validity of Input Data

The validity of the input data shall be verified with information provided by the independent expert.

The validity of the input data shall be verified by on-site visits by control authority, which may be carried out by virtual means, where appropriate in at least 10 % of the energy performance certificates that are part of the random sampling.

The Commission recommends that the validity check is linked at least to those elements that are considered part of the minimum assessment or that are considered the most important contributors to the performance of a building (e.g. insulation values and performance of technical building systems).

Maximum Deviation from Energy performance of a building

Member States must set the maximum deviation of the “assessor value” from the “control value”. This assesses how far a given EPC can be from its control value before it cannot be considered a valid EPC.

1.2 Scope and contents of the document

What is the document about

This document defines procedures for on-site collection of the information required to prepare the disclosure tools defined by the EPBD, namely EPC, SRI, RP and system inspection.

This consists in the collection the following data required by the above-mentioned disclosure tools:

- building geometry, building elements properties and systems and components properties to feed the energy performance calculation, which is the basis for EPC and RP;
- data on the age and cost of energy, building constructions and systems, required for a RP;
- status of relevant systems and input data for the calculations according to EN 15378-2 for system inspections

This document covers:

- the overall procedure: organisation and execution of the on-site visit;
- technical aspects: what to look at and how;
- deliverables, how to record and present the data for further processing (input to software);
- tools (checklists and sample data collection templates).

For control functionalities relevant for SRI, reference will be made to specific documents.

Input data are tightly connected to the calculation method they feed. This document is based on EN EPB standards. However, the procedure and the concepts should be valid for any EU national application of the EPBD. Some difference may be found in the details of the actual input data required by national calculation method and inspection schemes.

The overall procedure is intended to be transposed into CEN standardisation proposal (as an EN-EPB standard), together with the list of deliverables.

Technical aspects and tools will be proposed as an accompanying technical report (CEN-TR), according to the requirements for EN-EPB standards.

1.3 Intended audience

The intended primary audience of this document are the assessors of disclosure tools.

Public authorities may also be interested in that they could refer to it to specify or verify requirements to the data collection functional to produce an EPC, RP, IR or SRI.

A CEN standardisation proposal will be prepared, to include the essential requirements outlined in this document. This document should be mentioned in the bibliography of such a standard as a background information (like the accompanying technical report to EN EPB standards).

1.4 Conventions and acronyms

1.4.1 Formatting

There might be a special format for advice and warnings in the text

1.4.2 Acronyms

The acronyms in the following table are used in this document.

Table 3 – Acronyms in this document

Acronym	Meaning
ECM	Energy conservation measure
EP	Energy performance
EPB	Energy performance of buildings
EPBD	Energy Performance of Buildings Directive
EPBD IV	Energy Performance of Buildings Directive (Directive EU/2024/1275)
EED	Energy Efficiency Directive (Directive EU/2023/1791)
EN-EPB	CEN standards about energy performance of buildings
EPC	Energy performance certificate
RP	Renovation passport
SRI	Smart Readiness Indicator
IR	Inspection report
LCA	Life-cycle costs analysis

AA	Air to air type heat pump
AW	Air to water type heat pump
WW	Water to water type heat pump
WA	Water to air type heat pump
MS	Member State
O&M	Operation and maintenance
PV	Photovoltaic
AHU	Air handling unit

1.4.3 Symbols

When necessary, this document uses as far as possible symbols and subscripts of the relevant EN-EPB standards. Additional symbols and subscripts may be used for special purpose.

The following symbols are used in this document

List to be prepared, probably none needed

2 Executive summary

To be written at the end...

3 Data collection general procedure

Planning / contractual phase

Start-up meeting

Document collection

Site visit

Who has to provide the data

Output documents

Use the model of EN 16247-1 with due simplifications

Add a chart and an indicative timeline

3.1 Introduction

This document provides concepts and guidelines that should be valid for any assessed object. The amount of actual work for the assessment and data collection will depend on the size complexity, and intended use of the building and technical systems.

The main procedure is given for the most common case of the collection of data for an energy performance calculation which is the basis of an EPC and RP.

SRI is based on qualitative information about the control options. Most of these options are relevant also for EP calculation. Additional information will be provided to embed SRI data assessment into EPC data assessment.

System inspection may require specific measurements and observations on systems, like a flue gas analysis. Additional information will be provided for these assessments.

3.2 Set the objectives and planning

The preparation of a disclosure document (such as EPC, SRI, RP and IR) is originated by a request by the user. This document does not cover the contractual and economic aspects of providing disclosure instruments. Therefore, it is assumed that a request by the owner has been accepted and an agreement has been settled.

The scope of work shall be clear:

- which disclosure document is required (EPC, SRI, RP, IR) and its purpose (selling, renting, new, renovated building, ...);
- which is the assessed object.

The disclosure tools and the context in which they are required (i.e. their purpose) are clearly set by the national regulation. If required on a voluntary basis, the reason of the request shall be stated in the agreement with the customer.

NOTE energy audit according to EED requires a different approach than energy performance disclosure tools according to EPBD, e.g. actual operating conditions are used for energy audit instead of standard operating conditions for EPC.

The possible assessed object is also defined by the regulation. The assessed object for an EPC can be:

- a building unit;
- an entire building.

Where EPCs are normally referred to building units (like in Italy), there are still cases where the EPC shall be issued for the entire building and the energy performance calculation has to be performed for the whole building, like:

- documentation to support an incentive application concerning the whole building;
- Energy performance contracting or loans concerning the whole building;
- RP, which is necessarily linked to the whole building.

It should be considered that where the EPC are referred to building units, it is much more effective to prepare all the EPCs simultaneously for the whole building block, especially in case of centralised technical systems.

3.3 Gathering preliminary information

Based on the type of building to be assessed, the expected relevant and useful documentation should be asked to the owner for collection and submission to the assessor.

The following documents should be required and/or sought.

- Previous EPCs or disclosure documents.
- Architectural plans.
- Functional diagrams of technical systems.
- Design documentation and records.

- Fuel delivery or fuel metering records
- Contracts, invoices or other evidence on actual construction works, materials and building elements,
- Operation and maintenance records.
- Electrical installation inspection reports
- Reports from professional inspections and professional tests of the heating system
- List of owner(s), tenant(s) and administration with their contacts.

The previous EPCs may be used to check administrative data and overall results, such as floor area, heated volume and other geometrical indicators. The subject of evaluation should be consistent with the previous certificate, considering any known modification of the building (extensions, superstructures) and the actual state of building and building elements.

Architectural plans shall be used to identify the boundary of the assessed object and any partition into spaces with different use category, thermal zones and/or service areas.

Functional diagrams are used to understand the organisation of technical services. The service area of each technical system should be identified in the architectural plans.

If architectural plans and/or functional diagrams are not found, the assessor will have to build a schematic plan of the building and/or functional diagram from scratch. They have to allow the geometrical and technical description of the building with sufficient precision for EPC purpose. Not all details are needed but at least the following has to be identified:

- the geometrical scheme with the dimensions of the building envelope and of any relevant internal partition;
- any division of the building into spaces with different use category (e.g. office, residential);
- which spaces are served by each existing technical system (service areas).

Fuel delivery records, metering records, design records and maintenance records are optional but very useful to check if the calculated energy performance is consistent. There are often unknown properties of building elements and abnormal results compared to operation records can detect wrong assumptions.

The as-built design documentation and records or delivery notes and invoices with product data declaration are fundamental to identify the insulation layer or windows properties of recent buildings.

If nothing is available, have a look at google maps to have a first understanding of the assessed object. It is also useful to understand possible shadings of neighbouring buildings.

The list of contacts of owners, tenants and administration is intended to support organisation of site visits (agree access to the building).

3.4 Analyse the preliminary information

The objective is to identify:

- the geometry of the boundaries of the conditioned space;
- the use of the building, as space categories;
- which services are available,
- the type and consistency of systems.

- centralised versus autonomous systems,
 - service areas of each system,
- and to plan the field work.

3.5 Identify the input needed

You need to have a first idea of how the calculation will be organised and of the required input to be checked on site (but then add details as you discover new things on site).

Prepare

- a list of items to check (help with checklists in **clause 17**)
- a list of rooms/spaces in the building to be accessed to collect the required information

Some properties of the building units may be repetitive (e.g. identical apartments in a building block). Sampling may be considered in this case.

3.6 Agree access with owner and tenants

Access must be agreed with the owner and/or tenant(s).

Confirm the list of rooms and spaces to be accessed with the owner and/or tenants and/or building administration.

Access to private parts of the building shall be arranged with the respective occupants and tenants.

Access to common parts (e.g boiler room, mechanical rooms, common staircase, and corridors) shall be agreed with the administration of the building.

The operation and maintenance staff should be available when visiting the mechanical rooms to help identify the technical systems and reporting any special feature of the installation.

3.7 On-site work

3.7.1 Introduction

On-site work consists of the following activities.

- Checking and validating the existing documentation.
- Completing the reference documentation.
- Checking building plans and the use of the building.
- Checking building envelope properties.
- Checking technical installation structure (general organisation of systems, e.g. centralised/individual, available/not available services).
- Checking technical installation properties (data on equipment and components).

3.7.2 Checking documentation

The first step is confirming any previously collected documentation.

Red markings and notes should be applied to document any found discrepancy and, most important, state the actual situation.

3.7.3 Completing documentation

Following documentation check, the basic documentation check shall be completed so that at least the following documents are available:

- Overall plan of the building, with indication of:
- the conditioned area;
- the use of internal spaces (by space categories, e.g. residential, office, commercial);
- the service area served by each technical system;
- the position of technical systems equipment and layout of main distribution lines
- Facades schematics, with windows, doors and relevant obstacles for shadings (e.g. balconies)
- Design specification, purchase invoices, contracts with product data declaration (e.g. insulation layers, windows properties)
- Basic functional diagram of technical systems
- In case of costs estimation, the energy bills and energy contracts may be needed (for more see Chapter 13)

These documents shall be enough detailed to support the further collection of input data required for the energy performance calculation.

3.7.4 Checking the conditioned area and the use of building

Collect thermal zone related input data. Check if there are several space categories in the assessed object. If so, classify the internal space of the assessed object according to the space categories defined in your energy performance calculation procedure. The classification will depend on your national calculation procedure. The space categories are defined in EN ISO 52000-1, table B.XX.

Check and record also the type of spaces in contact with the assessed object (adjacent building and/or building units), distinguishing between heated and unheated environments and heated environments with different indoor temperature (storage, staircases).

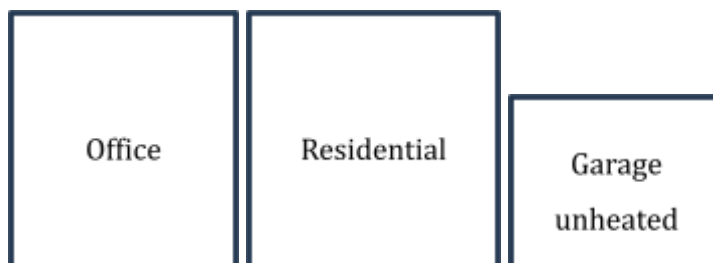


Figure 2 – Sample plan with conditioned area and space category

Check which spaces are actually conditioned compared to the documentation. With time, modifications such as closing a balcony occur.

3.7.5 Checking building envelope properties

The building envelope geometry and the properties of building elements shall be recorded.

See clause 5 for more details.

3.7.6 Checking technical installation structure

Before collecting data on equipment and components, determine the structure of technical systems.

Start checking for each service independently, if the systems are:

- centralised, that is serving an entire building or a group of building units;
- individual, that is dedicated to a part of the building (usually a single building unit);
- localised, that is serving only a limited part of a building unit (e.g. a stove in the living room)
- derived from a centralised system, when the assessed object is a single building unit (or, at least, not the entire part of the building served by that technical system).

This may happen independently for each service: the heating service may be centralised whilst domestic hot water is produced individually for a residential building block.

Also consider that some systems may provide several functions, such as combined space heating and domestic hot water preparation.

For each technical system, locate on the plan:

- the position of the generator and of other main equipment (e.g. storage vessel, mechanical rooms with pumps);
- the serviced area (this may require the assistance of O&M staff for complicated systems);
- the routing of the connections (distribution subsystems).

3.7.7 Checking technical installation properties

Collect the required input data for the calculation following the relevant clauses:

- Clause 6 for the space heating system
- Clause 7 for the domestic hot water service
- Clause 8 for the space cooling system
- Clause 9 for the ventilation system
- Clause 10 for the lighting system
- Clause 11 for the PV system
- Clause 12 for the battery storage system
- Clause 14 for additional specific inspections for SRI, if this indicator is required

Complete the list at the end of the process

3.8 Provide data-set to be used in the EP calculation

Following the field work, collect the notes and observations and assemble into a structured folder so that the source information of the input data can be readily retrieved and checked. A suggestion for a structure and index is given in **clause 15**.

The suggested structure should follow the same index as before:

- Plans
- Facades drawings
- Building geometry notes
- Building envelope elements technical properties notes
- Plans of service areas
- Technical systems functional diagrams
- Data per technical system and subsystems

3.9 Additional information

The EPBD IV requires for additional mandatory information in the EPC. It is therefore not enough to collect the data input for the energy performance calculation. According to the “guidance document on EPC” by the EU Commission, the following additional information is mandatory:

- capacity to react to external signals and/or to adapt to signals from the grid;
- capacity of low temperature operation.

Also the recommendations shall consider additional elements such as

- improving GHG and IEQ;
- system remaining lifespan;
- optimal temperature operation of systems.

This means that it is not enough to describe the building and systems “as they are” but there are additional properties to assess.

Any recommendation should be “feasible”. This means that during the on-site inspection there should be an eye on the practicality of the actions that could be recommended.

EXAMPLE You may recommend to replace an old boiler by a heat pump in an old building. However, if the required flow temperature is too high, the heat pump will simply lock out. Also, if you do not insulate the building (i.e. reduce the load), obtaining a sufficient power grid connection (enough kilowatts) can be challenging if not impossible and the space required for the generator might not be available.

The capacity to react to external signals depends not only on the current status of controls. There might be available options to acquire external signals that have not been used.

Recommending better operating conditions requires a deeper knowledge of systems and the verification that the proposed modifications are feasible and do not conflict with comfort and reliability of service.

NOTE The EPBD requires to assess the capacity of all systems to operate at better operating conditions. This is very often oversimplified as “capacity to operate at a lower temperature”, even in the guidance document by the commission (there is an evident bias on heating systems).

Actually, a “better operating condition” could be:

- a higher operating temperature for cooling systems
- a lower outdoor air flow rate for mechanical ventilation systems
- a higher DT operation for heating systems with condensing boilers
- a lower flow rate at low loads for heat pump heating and cooling circuits
- ... and more

Examples of “better operating conditions” that can be applied in real environments:

— Night Setback for Heating Systems:

Reducing the setpoint temperature during unoccupied night hours (e.g., from 21 °C to 17 °C) in office buildings can significantly lower energy use without impacting daytime comfort.

— Adaptive Control of Shading Devices

Automated adjustment of external shading (blinds, louvers) based on solar radiation and indoor temperature can significantly reduce cooling loads and improve thermal comfort, particularly in buildings with large glazed surfaces.

— Heating-cooling interlock

To ensure that one system is disabled before the other starts with improved seasonal changeover control.

— Night cooling

Using outside air to reduce indoor temperatures and lower daytime cooling loads.

3.10 Who is responsible for each information

Define the responsibility for the correctness of the information collected.

Part of the information may be under the responsibility of the owner.

The assessor is overall responsible for the correctness of the input data.

For:

- unknown layers and properties of building elements
- outdated equipment not covered by default values in the calculation
- equipment whose manufacturer data is not available for any reason

the assessor shall make an educated expert guess. When relevant, the rationale of the guess should be documented.

A good rule of thumb is that unknown properties should be considered worse on the safe side.

A systematic bias can lead to unacceptable deviations. For energy performance calculation purpose any evaluation should be fair

If available, the source can be statistical tables with properties of buildings depending on construction year. When using this source of information:

- It shall be verified that the building complies with all boundary conditions stated in the tables
- If the building has been renovated
- that the proposed value is still plausible.

If the assessor decides to acquire data via a virtual inspection, this does not allow any reduction in the required accuracy.

3.11 Special issues depending on application

3.11.1 EPC

The national regulatory requirements and rules have to be followed that may differ from the rules in EN EPB standards. This may apply in particular to:

- dimensions (internal, overall internal, external);
- definition of reference floor area (e.g. spaces included, excluded, spaces below low ceilings);
- missing system consideration (assumed system, no system);
- national standard climate conditions;
- standard use patterns;
- building categories to be considered;
- services to be considered (e.g. external lighting, people transport);
- shading from neighbour buildings

3.11.2 RP

According to EPBD: Renovation passport means a tailored roadmap for the deep renovation of a specific building in a maximum number of steps that will significantly improve its energy performance.

Deep renovation means a renovation which is in line with the 'energy efficiency first' principle, which focuses on essential building elements and which transforms a building or building unit before 1 January 2030, into a nearly zero-energy building and from 1 January 2030, into a zero-emission building.

The renovation passport shall include the estimated energy savings and the estimated savings on the energy bill, clearly indicating the assumptions on energy costs used for the calculation;

The RP has a broader scope than the EPC, because it has to specify and evaluate the energy and the cost efficiency of step-by step renovations and upgrades the building towards to reach nearly-zero energy building or zero-emission level from 2030. This implies:

- reaching an energy performance level
- complying with additional qualitative requirements (e.g. no on-site fossil fuel use, demand flexibility)
- identify appropriate timing of individual renovation steps

The data for energy performance calculation has to be collected as for an EPC (you still need to calculate the energy performance of the building and then of the proposed renovated status after each step).

Additional data is required on:

- ageing of building structures and remaining lifespan,
- need for renovation due to other reason than energy performance (e.g. degradation of aesthetics, exposed concrete reinforcement, seismic stability, planned change in use category);
- remaining life span of technical systems equipment and components;
- possibility of renovation (e.g. ease of addition of external insulation, space for additional equipment, suitability to heat pump installation)
- renovation steps already envisaged by the owner
- cost for renovation steps (investment, energy costs, operational costs, other costs if relevant).

3.11.3 SRI

SRI focuses on control features. The considered control options for SRI (functionality levels) are similar but not 1 to 1 equal to those required for EP calculation with EN and/or national standards.

There is no complex calculation to obtain the SRI, the only data required is the functionality level of each control function. It is recommended to use the checklist given in clause 17 during the field work.

For each function, check for which parts of the building the selected functionality level is valid. For each function, check which is the criterion for the split (area / flow rate/ power).

Each function is assessed against 7 impact criteria that reflect the benefits of smart technologies:

- Energy efficiency
- Energy flexibility and storage
- Comfort
- Convenience
- Health, well-being, and accessibility
- Maintenance and fault prediction
- Information to occupants

The complete list of functions is given in **clause 17.22.**

3.11.4 System inspection

Little or no calculation is required after the on-site visit.

The inspection may require some measurements on the system, such as:

- flue gas analysis for combustion generators;
- flow rate and pressure measurement for ventilation systems.

Be sure to agree with the tenant or the administrator the possibility of the measurements and any required assistance by operation and maintenance staff.

4 General information on the building

4.1 Administrative information

General information on the building includes all the geometrical, geographic, and administrative information that identifies the assessed object, its location and overall size. Most of this information should be collected at the beginning of the process, before the field work phase.

First, the assessed object shall be defined, either building or building unit.

Typical administrative information includes:

- Address
- Cadastral information
- Ownership information, list of owners and tenants if relevant
- Building administration identification and contact
- Operation and maintenance staff identification and contact
- Permit for use for identification of dedicated use
- Property status and documents of any legalization in case of deviation from the initial permit
- Space category identification of the assessed object (can be multiple, but should be based on legal basis, e.g. permit for use). Different use (e.g. residential building used as office) should be neglected.
- Purpose of energy performance assessment (EPC, RP, IR)

Normally it is not the task of the EPC assessor to evaluate urban regulation conformity... This might be required by national regulations but it is not required by EPBD

4.2 History of the building

Year of construction can be a clue for the type of construction (materials and layers of walls) and also for known issues. Local professional associations may have guides, records or memories of local techniques in the different ages.

Ask the owner and tenants for history of the building and known issues.

Collect data about:

- past renovation actions (e.g. what has been done, design specifications, as built documentation)
- plans for future renovation.

4.3 Comparison with measured energy use

In principle, measured energy use data is not strictly required for an EPC. However, it is strongly recommended to compare the calculated energy use with the actual measured energy use. The energy performance calculation results shall be consistent with the measured energy use.

To allow a formal comparison, the measured energy must be normalized to a standard climate and standard use or the calculation must be repeated with actual operation conditions (tailored energy performance). Given the context, it is recommended to prepare a design energy signature for heating and/or cooling so that it can

be checked against a measured energy signature. This procedure avoids the need for climate correction thus reducing the uncertainty. EN 15378-3 provides methods for both, normalisation to standard conditions and for energy signature.

In this context, the purpose is not to formally validate the calculation model (for e.g. energy performance contracting) but to identify any major issue in the assumptions made by assessor when describing the building envelope and/or the technical systems (e.g. presence and status of an assumed insulation layer).

It is normal that there can be a deviation between a calculation in standard conditions and actual measured energy performance under actual conditions. However, any significant deviation should be explained.

5 Building envelope data collection

5.1 Introduction

The input data on the building envelope include the following.

- The geometry: plan, size, use of spaces, areas of components and elements.
- The properties of building elements and building components (opaque elements, elements in contact with the ground, windows, thermal bridges)
- The impact of surroundings (e.g. shadings).

NOTE1 a **building element** is a major part of a building, e.g. wall, floor or roof

NOTE 2 a **building component** is building element or a part of it

There is no standard or theoretical procedure that can give a precise answer on the layers and U values of an existing wall. Tables and national publications may describe typical construction techniques used in the past for typified industrial constructions but this is no final answer about the actual material layers within a wall for all cases. Recent design information may be more reliable. The real construction information (e.g. delivery contracts, invoices) should be always used instead of default values for recently constructed buildings. Experience and expertise are needed in any case to correctly identify the layers of materials within a wall.

If there is an insulation layer, the highest concern shall be:

- identify correctly the material and thickness of the insulating layer;
- estimate correctly the thermal properties of the insulating layer:
 - using design lambda values instead of declared values, consider deterioration by age or by humidity (EN ISO 10456),
 - consider the deterioration of the insulation layer by thermal bridges, e.g. beams in roof insulation layer or the supporting structure of wall cladding in the wall insulation layer (by incorporating linear or point thermal bridges into a equivalent thermal conductivity of the quasi-homogeneous layer according to methods in the EN ISO 6946 or ISO 10211).
- identify thermal bridges related to the overall building envelope.

Describing the building envelope is a geometry intensive task. You need to be very ordered in describing the building. It's easy to get lost or to forget some measurements.

The climatic data and standard use (indoor temperature, intermittent heating, temperature setbacks) for energy needs for space heating and cooling calculation for EPC are usually set at the national level. For RP the climate data and standard use may be the same as for EPC (at least for achieved energy class for each step)

and/or tailored to building actual climate location and use. This should be defined in national legislation implementing RP.

The results of the building envelope calculation are the energy needs for space heating and cooling and possibly for (de-) humidification of a building. Additionally, the calculation can provide the internal temperatures for IEQ evaluation. The complete calculation may include the influence of technical buildings systems and of control aspects.

The resulting design load (losses under design conditions) can be used to check the appropriate sizing of the equipment and can provide default values for system components.

NOTE The data input about the building envelope for energy performance calculation is largely in excess of what is needed for a heat load calculation (sizing). Professional tools normally provide both information with the same input.

The calculation method and the input data for the calculation of the building envelope are clear in the definitions and quite homogeneous among countries. EN ISO 52016 (or the former EN ISO 13790) is the main standard for the calculation of energy needs for space heating and cooling. There are many inputs from and many interactions with several other EPB standards. National documents may provide input data and detailed calculation procedures not provided by this standard may be needed.

The evaluation of input data for the building envelope (U-value, thickness, lambda of layers) is significantly depending on the experience of the assessor, with less explicit information available than for technical systems.

The rule should be that a less precise approach (default values) should lead to a less favourable result.

Add some notes on physics behind

As an introduction, there should be guidance on

- the typical values of lambda of materials □ importance of the precision in the identification of the insulating layers
- the typical values of U values □ importance of insulation
- the consideration of thermal bridges □ default values if the structure is not known vs exact values
- the effect of gains □ the importance to input correctly shadings

The assessor conducts an on-site inspection to collect data on the building envelope elements and components, which include the walls, roof, floors, windows and doors and thermal bridges The goal is:

- to understand how heat losses and gains, air, and moisture move through the structures, which directly affects energy consumption for heating, cooling, and ventilation;
- identify the structure of elements and components (e.g. opaque elements layers, windows components) for proper estimation of their properties and input to the calculation.

For typified constructions, the input to the calculation can be a default U values.

Calculated U-values are mostly depending on the thickness and conductivity of the insulating layer which is usually not visible.

Usually the inputs are the properties of each layer or component of a building element:

- lambda value of materials (design value for operating conditions, not a declared values under standard testing conditions), considering linear or point thermal bridges in the layer (e.g. beams in insulation) by a quasi-homogeneous layer according to methods in the EN ISO 6946 or ISO 10211.
- Thickness of layer or element
- State (e.g. significant degradation by age or by humidity, etc.). EN ISO 6946 provides formulas for deterioration based on the state
- The area of each building envelope element with different thermal properties that enclose thermally conditioned spaces through which thermal energy is transferred, to or from the external environment (based on national definition) shall be determined. The value depends on whether internal, overall internal or external dimensions are being used in the local context.

Additionally, the assessor shall collect the data for the calculation of the reference floor area for energy performance indicators expressed per m² and for requirements and/or comparison against benchmarks (based on national definition).

5.2 Key steps of data collection

1. Visual inspection, geometry and measurements

- Collect data on geometry (plans, design drawings) or measure and note the basic geometry for basic geometry characteristics calculation (reference floor area and volume, areas of elements),
- note the tilt angle of elements and the bay dimensions if relevant
- prepare a schematic plan of floors and facades and put measurements on them
- Identify construction materials of elements (e.g., type of windows, materials of walls, roof, etc.), record insulation types, thickness, of layers and installation quality.
- Measure and determine the dimensions of walls, roofs, floors, windows, and doors for each type of the building envelope element with different properties or on different thermal indoor and outdoor conditions or thermal zones.

NOTE usually you will not calculate areas of building elements right on-site. In most cases you record the dimensions of each element and then the area is determined manually or inside the calculation tool. Use of a software tool in which the geometry of the whole house of building can be modelled (whether or not in combination with EP calculations) can avoid forgetting parts of the building envelop. The photographic documentation with reference objects e.g. ruler in the picture could be useful. The issue is not forgetting to assess useful information when on-site.

- Determine the tilt angle, per external building element (from horizontal, measured upwards facing)
- Determine the orientation angle per external building element, (expressed as the geographical azimuth angle of the horizontal projection of the inclined surface normal; convention: angle from South, eastwards positive, westwards negative), satellite mapping tools could be useful for orientation angle
- Determine for each building envelope element the type of shading (overhang, fins, horizon angle).
- Determine the internal effective heat capacity based on construction type (very light, light, medium, heavy, very heavy), if using the simplified method for heat capacity

2. Opaque elements:

- Check the types of opaque elements (e.g. different materials or different thickness of construction),
- Estimate the layers of each type of opaque element of the building envelope
- Estimate the thickness and properties of materials of each layer for calculation of thermal transmittance of each element of the building envelope (U-values)

3. Ground Floor and Basement

- Check the type of ground floor (slab-on ground floor, suspended floor, heated basement)
- Estimate the layers of each envelope element
- Estimate the thickness and properties of materials of each layer for calculation of thermal resistance and transmittance

4. Window and Door Evaluation (transparent elements):

- Identify materials of windows/doors components for estimation of thermal properties (e.g., single-, double-, or triple-glazed, properties of glazing, frame, and distance profiles, double windows ...).
- identify the size of windows, tilt angle and orientation angle per windows and doors
- identify the windows shading types and colours
- Classify windows according to type and size. Note the number of each type of windows with the same properties (size, properties of glazing and distance profiles and shading type) so that you need to describe each type once and indicate their position on floor plans and facades schemes. Use „self-speaking codes“ to facilitate communication (e.g. W120x140 to indicate a window 120 x 140 cm with basic shading.
- Assess potential for thermal bridging, check the mounting position of the frame in the wall to evaluate the thermal bridges between the frame and the wall (see details in [clause xxx](#)).
Be precise: inspect number and type of joints and gaskets of opening elements for air tightness and check the mounting position of the frame in the wall to evaluate thermal bridges.

5. Airtightness and Ventilation:

- Assess airtightness, inspect number and type of joints and gaskets of opening elements, look for unintentional gaps. (?? How will this be part of the calculation – This may rise a warning)

6. Use of Tools and Technology

Usually, time and budget for an EPC do not allow using all these instruments. Laser meters are common practice, but not the rest.

- Use laser measurement devices, image capture and processing technologies for building geometry.
- Detect insulation gaps, use the moisture meters and thermal cameras if relevant,
- Use Blower door test results (if available) to measure airtightness if relevant (e.g. if there is a national requirements) (and if there is an entry for that in the calculation method).

7. Documentation and Photographic Evidence:

- Record observations in standardized forms or software.

- Take photos for reference and reporting. Insert them in the folder structure mentioned in clause 3.

This data shall be fit to input into the energy performance calculation tool or software.

Use of software to estimate the building's energy performance, propose retrofit measures, and support compliance with energy codes and requirements.

This shall be mentioned at the beginning, asking for a suitable software (authorised, certified, it depends on the country) and then the data shall be collected to be suitable for input into that software.

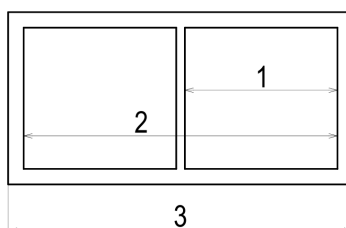
5.3 Geometry

It is the base for building envelope calculation and reference floor area calculation for indicators expressed per square meter (e.g. kWh/m²).

Information on geometry is also used for systems (length of distribution pipes according to the probable layout)

There are three dimension conventions commonly in use and defined in EN EPB standards:

- internal dimensions, measured between the finished internal faces of each room in a building (excluding the thickness of internal partitions); dimension measured from wall to wall and floor to ceiling inside a room of a building
- overall internal dimensions, measured between the finished internal faces of the external elements of the building (including the thickness of internal partitions, excluding the thickness of the external elements); dimension measured on the interior of a building, ignoring internal partitions
- external dimensions - dimension measured on the exterior of a building, measured between the finished external faces of the external elements of the building.



(Add sample intermediate dimensions. They differ for internal and overall internal)

Figure 3 – Type of dimensions

KEY

- 1 - (Net) internal dimensions
- 2 - Overall internal dimensions
- 3 - External dimensions

Special situations, out of these three types of dimensions specified in the EN EPB standards, may be defined at the national level or can be allowed by software, e.g. intermediate dimensions (the construction axis). Intermediate dimensions are usually required for borders between the zones, between building units, etc. In such case the use of default values may not fit exactly with these dimensions, however in case of using intermediate dimensions just for borders between units or zones has usually a limited impact.

All dimensions can be collected, but internal dimensions require knowing and recording the internal layout of all rooms, which is time consuming and not recommended unless necessary.

Any of these dimension systems may be used for the calculation of energy needs, provided that the system chosen is used consistently for all parts of the building construction and thermal bridges evaluation.

Remember that:

- the adopted values of thermal bridges shall be consistent with the chosen dimension system (for the correctness of transmission losses calculation).
- the reference area for the energy performance is identified by the national regulation together with special cases and exceptions for e.g. small unheated areas, low height rooms, slope roofs, staircase across floors, small protrusions, walls between units.
- all area and volume dependent parameters (e.g. internal gains, minimum air exchange rate) are always referred to a specific type of dimensions (e.g. net or gross surface and volume) and conversions may be needed to apply the correct reference. This should have been taken into account when defining national default values or using other than national software.

A reference plan for the geometry of the building shall be prepared. The floor plans shall identify at least

- the orientation of the building (where is the North)
- the reference contour line of the conditioned area and any thermal zones
- the different types of opaque elements
- the relevant objects such as doors and windows in the wall and their size and position (axis, elevation).

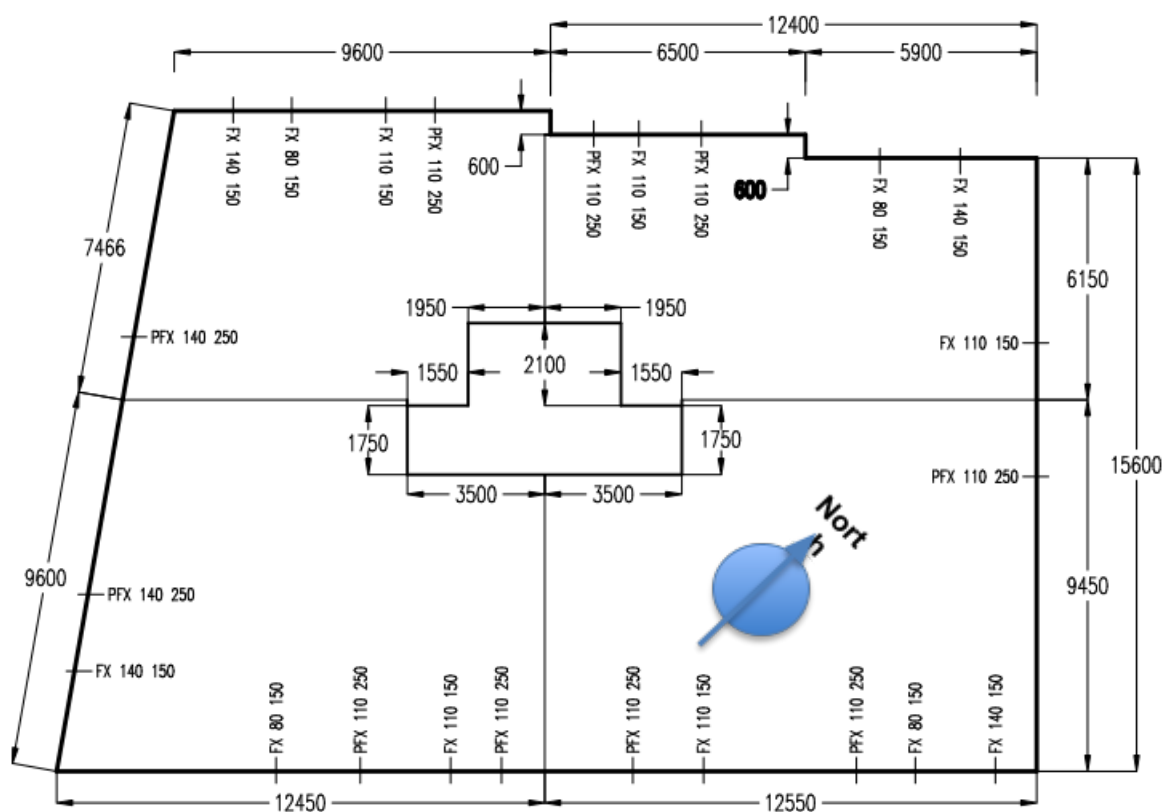


Figure 4 – Sample schematics of a floor with 4 thermal zones (4 building units)

This example has been prepared with a CAD to explain the concept of “reference line” but it could be a hand-made sketch or a set of notes over a layout plan.

(Windows position is indicated by codes such as FX for windows and PFX for glazed doors.)

If a mere Excel tool is used for the calculation, the schematic plan is the minimum required basis to document the correct acquisition of the geometry of the building.

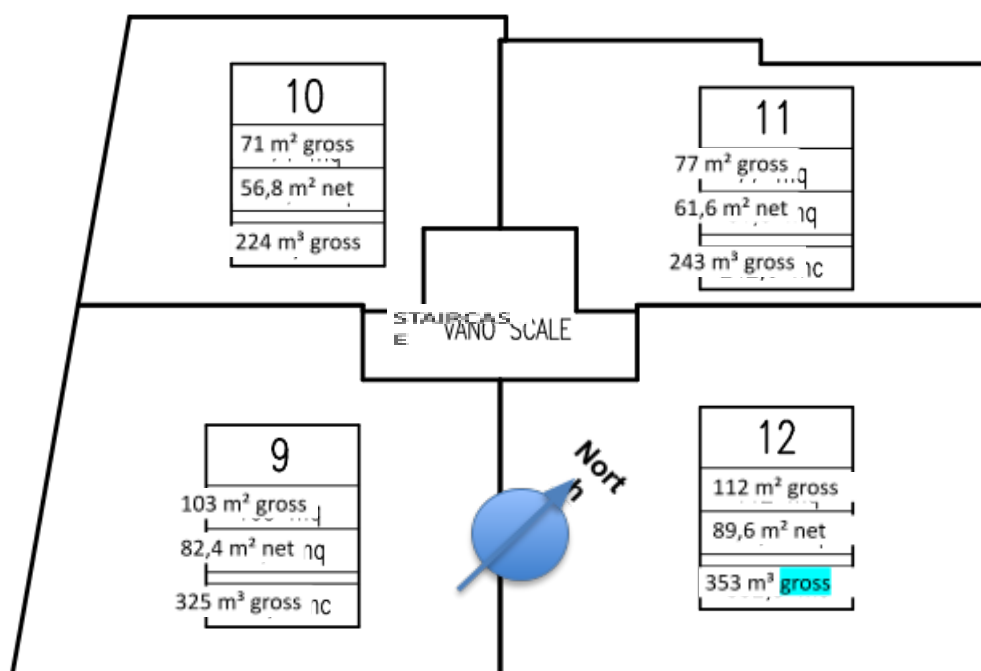


Figure 5 – Sample schematics of a floor with thermal zones net floor area, gross floor area and gross volume of each thermal zone (one per building unit in this example)

The position of windows and doors, as well as of obstructions such as balconies and perpendicular walls can be best represented in a schematic of each façade.

If a graphic software tool (2D, 2D input recreating 3D or directly 3D) is used to input the geometry of the building, the schematic plan is needed to acquire on-site and document the field work.

The schematics should also be produced by any graphic software tool and should be printed (at least in pdf) for quality check of the input, documentation and further reference. If this feature is not available.

Depending on your national or regional setting, you may need to use the internal, overall internal or external dimensions. The reference contour will then follow the external or internal face of the external walls. The reference line for internal walls separating thermal zones is the middle for external and overall internal dimensions. If net internal dimensions are used, then both faces of each internal wall shall be drawn.

Add a plan with the main contour for the three cases.

Figure 6 – Sample schematics for net internal dimensions

Figure 7 – Sample schematics for overall internal dimensions

Figure 8 – Sample schematics for external dimensions

If not evident, it is also important to identify the relative position of floor plans so that exposed floors and ceilings can be identified.

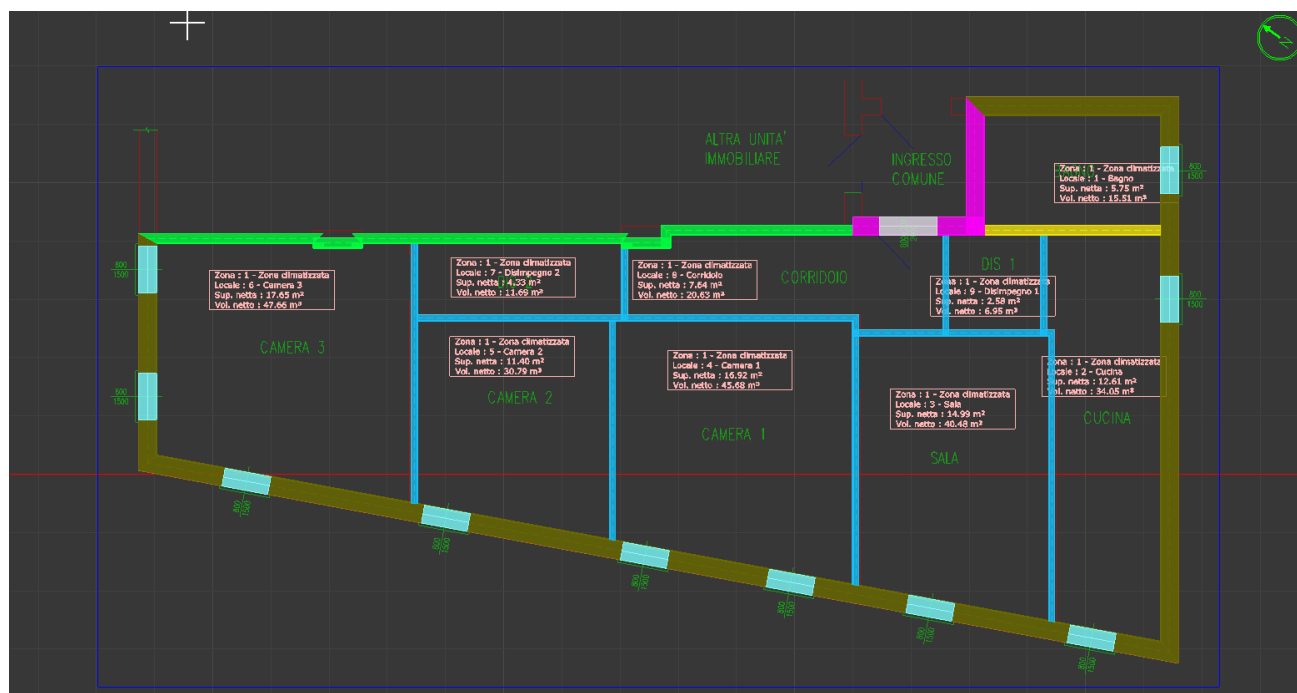


Figure 9 – Sample schematics produced by a software tool

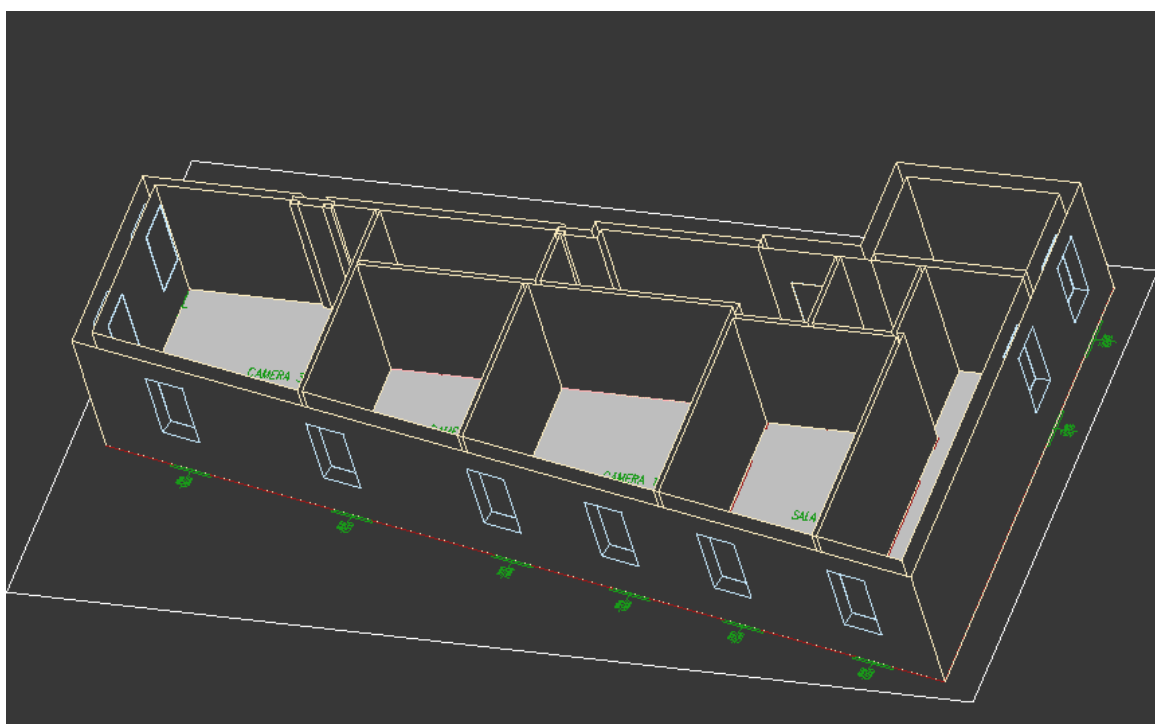


Figure 10 – Sample 3D views generated by a 2D input.
 This view confirms the correct position of windows and of the internal partitions

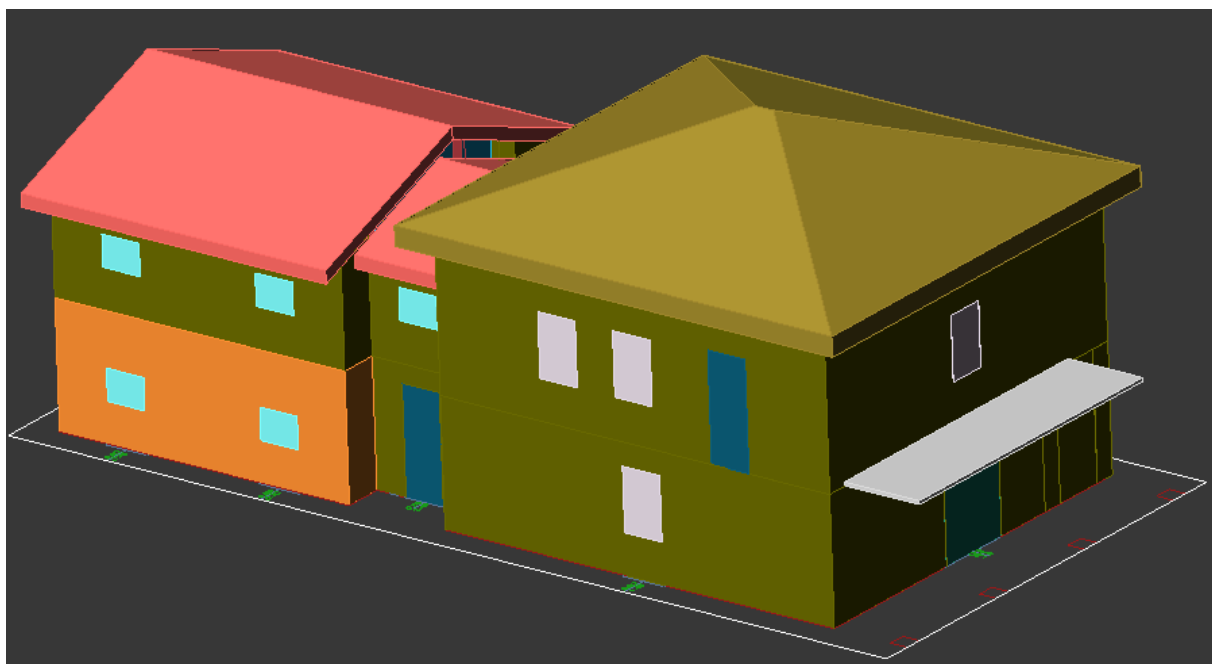


Figure 11 – Sample 3D views generated by a 2D input.

This view confirms that the two floors were correctly aligned.

The orange part on the ground floor on the left is an unheated garage. This has to be recorded.

If construction drawings to scale are available, contours and objects can be highlighted on the drawings.

When collecting and inputting data into your calculation tool, proceed with an evident order (e.g. clockwise around the building), to reduce the risk of forgetting any element and facilitate any verification of the completeness of data collection.

Inspect and document also the surrounding for shadings from obstacles or reflection from other buildings.

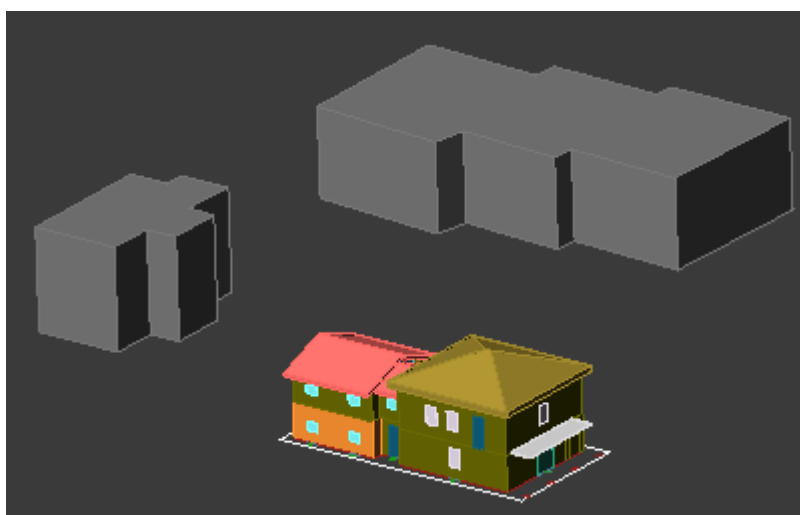


Figure 12 – Sample view of neighbouring buildings to determine shading by the horizon

The geometrical input data for building elements are listed as part of the thermophysical parameters in EN ISO 52016-1 chapter 6.3.4. They are:

- Area, per construction element; in case of protruded components also the projected area

- Tilt angle, per external building element (from horizontal, measured upwards facing)
- Orientation angle per external building element, (expressed as the geographical azimuth angle of the horizontal projection of the inclined surface normal; convention: angle from South, eastwards positive, westwards negative)

5.4 Technical properties of building elements and components

5.4.1 General

Thermophysical parameters of the building components and building elements needed for the calculation of energy needs for space heating and cooling are defined in EN ISO 52016-1.

The input data list can differ for hourly and monthly calculation. The monthly calculation may require dynamic parameters.

The technical input data may be related to:

- thermal zones;
- building elements;
- thermal resistance/thermal transmittance, per opaque building element
- effective thermal resistance, per building element in thermal contact with the ground, including slab-on-ground floors, suspended floors and basements
- thermal transmittance, per window, window with closed shutter, doors
- thermal transmittance, per curtain wall
- transmittance of solar radiation
- thermal bridges, both related to the whole building and considered in building element (e.g. thermal bridge between the spacers and seals around the edges of the glass unit)
- external solar shading.

5.4.2 Opaque elements

The data collected during inspection must allow calculation of thermal resistance (R) and thermal transmittance (U-values) of opaque elements or components. Calculation procedures are given in EN ISO 6946 which provides the method of calculation of the thermal transmittance of building elements in contact with the external air. Information shall be collected during inspection on:

- Homogeneity of building component, element or layer under consideration. Components may consist of thermally homogenous or inhomogeneous layers. They may contain air layers, metal fasteners which must be noted during inspection and considered. Corrections may be needed to the thermal transmittance. The approximate method is provided in Annex F of EN ISO 6946 for correction to the thermal transmittance for:
 - the air voids in insulation (gaps, cavities in insulation),
 - mechanical fasteners penetrating an insulation layer (collect additional data on the lambda of the fastener, number of fasteners per m², length of fastener that penetrates the insulation layer)

- precipitation on inverted roofs.
- data on dimensions of layers or components, should be acquired from the design of building elements, by measurement or by estimation. Dimensional data are needed on individual materials in homogeneous and inhomogeneous layers of a building element
- The layers, thickness and type of materials of original structure and position and thickness of an additional insulating layer.
- It may be important to distinguish between an old original thermal insulation layer degraded by age and a new additional insulation layer with better thermal insulation properties
- The tilt angle of element
- The colour of the element (for solar gains via opaque elements evaluation)
- The type of space under the roof (unheated, heated, ventilated).
- Design thermal conductivity (λ) in $W/(m \cdot K)$ of layer material. It is important to use design thermal values (design thermal conductivity or design thermal resistance)¹ not a declared value of the product.
- The design value includes possible degrading effects from ageing, moisture, and/or convection. In contrast to the declared value which is the expected value of a thermal property of a building material or product assessed from measured data at reference conditions of temperature and humidity. Recalculation is possible using EN ISO 10456. According to definition in EN ISO 6946 the *design thermal conductivity is value of thermal conductivity of a building material or product under specific external and internal conditions which can be considered as typical of the performance of that material or product when incorporated in a building component.*
- Non-standard conditions of materials have to be noted (e.g. high humidity)
- The environments on both sides of the component, that can be:
 - internal and external environments,
 - two internal environments (internal partition),
 - internal environment and an unheated space. In some cases unheated space can be treated as a thermal resistance.
- Direction of heat flow (horizontal, upwards, or downwards heat flow) that has impact on external surface resistance R_{se} and internal surface resistance R_{si}

Data needed for transmission heat transfer coefficients (EN ISO 13798) are:

- thermal transmittance of building envelope element (U-value)
- area of building envelope element
- point/linear thermal transmittance of thermal bridges
- number/length of point/linear thermal bridges
- indoor environment temperature in the building under consideration (usually set at the national level)
- indoor environment temperature in adjacent unconditioned space

¹ EN ISO 6946

- indoor environment temperature in the adjacent building
- external temperature
- Class for the solar absorption coefficient of the external surface, per opaque element depending on colour (light colour, intermediate colour, dark colour)

Layers cannot be observed directly unless there are open spots due to damages or in the cellar or under-roof space. Pay a visit to the underroof and to the cellar.

Measurements of U-values is not viable and is time consuming. Make assumptions based on type of building, the construction type, year of construction and thickness of walls is not preferred but could be an exceptional solution especially for typified constructions.

5.4.3 Ground Floor and Basement

Calculation procedures for thermal transmittance via the ground are given in EN ISO 13370 - Thermal performance of buildings — Heat transfer via the ground — Calculation methods. This standard deals with elements in thermal contact with the ground and provides methods which take account of the three-dimensional nature of the heat flow in the ground below buildings.

For floors and basement walls in contact with the ground, the large thermal inertia of the ground and the periodic heat flows related to the annual cycle of internal and external temperatures are taken into account. The steady-state heat flow is a good approximation to the average heat flow over the heating season.

The data collection depends on the type of ground floor. Check firstly the type of ground floor or basement. The possible types are:

- Slab-on ground: this is a floor construction laying directly on the ground.
- Suspended floor: this is a construction in which the lowest floor is held above the ground, resulting in an air void between the floor and the ground.
This air void, also called underfloor space or crawl space, may be ventilated or unventilated. It does not form part of the habitable space.
- Heated basement: this is a usable part of a building that is situated partly or entirely below ground level and is part of the heated space: it is heated to a desired temperature set-point.
A usable space below ground level which is not kept to a desired set-point is not a heated basement but just an unheated space. A floor over an unheated basement is a building element towards an unheated space.

Geometrical characteristics to be collected:

- Area of floor
- Exposed perimeter
- Thickness of the external walls (above the ground for a slab on ground and of the walls under the ground for a heated basement). The thickness of the walls of the building at ground level is required, including all layers
- Suspended floors: Height of the upper surface of the floor above external ground level
- Basement: depth of basement floor below ground level

- Check if a slab-on-ground floor has edge insulation, placed either horizontally or vertically along the perimeter of the floor. It is counted when the width or depth of the edge insulation, is small compared to the width of the building. (Annex D EN ISO 13370). The data to be collected for slab-on-ground floor:
- the thickness of the edge insulation (or foundation)
- the width of horizontal edge insulation or the depth of vertical edge insulation (or foundation) below ground level
- Check the depth of the underfloor space below ground level for suspended floors. Check if the underfloor space extends to an average depth of more than 0,5 m below ground level, because then the different formulas are used for calculation of the thermal transmittance for heat flow through the ground.
- Unheated basement ventilated from the outside:
 - Additional geometrical data needed for unheated basement ventilated from the outside: the height of the basement walls above ground level, the air volume (net volume) of the basement.

For exposed perimeter (the total length of external wall dividing the heated building indoor environment from the external environment or from an unheated space) check and note:

- The total perimeter of the building and the total ground-floor area,
- The length of the wall between the heated building indoor environment and the external environment. The length of the wall between the heated building and the unheated space (e.g. garages). The perimeter includes the lengths of external walls separating the heated space from the external or unheated environment and excludes the lengths of walls separating the part under consideration from other heated parts.

Thermal characteristics to be collected:

- Thermal resistance, R , of the floor slab on ground, including all layers. Hard core below the slab is assumed to have the same thermal conductivity as the ground and should not be included.
- Thermal transmittance of elements (U -values of floor and walls in contact with ground in case of basement)
- Thermal resistance of walls of the basement, including all layers
- The total thermal resistance of the suspended part of the floor (between the internal environment and the underfloor space),
- Type of junctions for linear thermal transmittance associated with wall/floor junction thermal bridges
- Length of linear thermal bridges
- Check existence of edge insulation. It is treated as a linear thermal transmittance, which has a negative value. Low-density foundations, of thermal conductivity less than that of the soil, are treated as vertical edge insulation
- The thermal resistance of the horizontal or vertical edge insulation (or foundation);

- Check the ventilation below suspended floors of the underfloor space or unheated basement (ventilated or unventilated underfloor space, natural or mechanical ventilation, unheated basement ventilated from the outside);
- Ventilation rate V , in m^3/s for mechanically ventilated floors (if known)
- For naturally ventilated suspended floors the input data to be collected are: the area of ventilation opening per perimeter length, in m^2/m (inputs on the design wind speed at 10 m height, in m/s and the wind shielding factor are defined in EN ISO 13370).
- Additional data needed for unheated basement ventilated from the outside: the thermal transmittance of the floor between the internal environment and the basement, the thermal transmittance and area of the walls of the basement above ground level, the ventilation rate n of the basement (or default value of $n = 0,3$ air changes per hour may be used)

The thermal resistance of materials used below ground level should reflect the moisture and temperature conditions of the application (potential correction of design λ values of materials according to EN 10456).

For thermal properties of opaque elements see also chapter 5.4.2.

Data to be collected on building boundary conditions:

- Note the type of ground. Default values for thermal properties of the different ground types are given in Table 9 in EN ISO 13370. If the ground type is unknown, values for sand or gravel should be used.
- Note the type of location in case of naturally ventilated suspended floors for the wind shielding factor estimation (sheltered-city centre, average-suburban, exposed-rural)
- Note if there are different temperatures in different rooms or spaces immediately above the floor. Use a spatial average by weighting the temperature of each space by the area of that space in contact with the ground for estimation of annual mean internal temperature or average temperatures for each month.

5.4.4 Windows

Calculation procedures for thermal transmittance for windows are given in EN ISO 10077-1 - Thermal performance of windows, doors and shutters — Calculation of thermal transmittance including the list of input data. Default values for glazing, frames and shutters or other windows elements can be used. In that case, not all of the input data listed below are required.

Thermal bridges in joint between the window or door frame and the building envelope are excluded from window properties (U-values), but are included in the thermal bridges (see [clause 5.4.5](#)).

The geometrical characteristics of the window or door to be collected and noted:

- Window or door dimensions (height, width, frame width and frame thickness).
- Window or door area estimated as an overall sum of the frame area, A_f , and the glazing area, A_g (or the panel area, A_p). The frame area and the glazed area are defined by the edge of the frame, i.e. sealing gaskets are ignored for the purposes of determination of the areas.
- Frame area. The frame area is the larger of the two projected areas seen from both sides
- Area of opaque panels within the window or door
- Total perimeter of the glazing or the opaque panel is the sum of the visible perimeter of the glass panes (or opaque panels)

- Total perimeter of the panel
- Total length of the glazing bar
- Positions of windows in external wall for thermal bridges calculation for window/wall junctions, window position in the wall (outer surface, centre, inner surface), proximity to other constructions, e.g. ceiling, corner. The positions of windows in the external wall should be taken into account when assessing the thermal bridges calculated using the finite element method or by the selecting an appropriate predefined thermal bridge type.
- The tilt angle of window

Check if there is any change in the wall layers below windows (window sill of a different construction than the wall e.g. smaller thickness or different material). This should be considered as a different type of wall (see **clause 5.4.2**)

A general rule for the geometrical characteristics of the window: If the area or perimeters are different on either side of the window, pane or panel, then the larger of the two shall be used.

The following thermal characteristics of the window/door components necessary for the calculation of the thermal transmittance of the window or door have to be identified.

- Type of window (single, double or coupled window). This is related to the whole window construction.
- Thickness of unventilated air spaces for coupled and double vertical windows
- Type of frame, thermal transmittance of frame (frame material wood, plastic, metallic with and without thermal barrier; metallic with pinpoint metallic connections or any combination of materials), Based on the type of the frame the data needed is:
 - PVC-hollow frame profiles: the number of hollow chambers,
 - wooden and metal-wood frames: thickness of frame, hardwood, softwood (the values correspond to a moisture content of 12 %).
 - Metal frames: metal frames without a thermal break; metal frames with thermal breaks
- Type of glazing, thermal transmittance of glazing (simple glazing, multiple glazing, double or triple glazing uncoated glass, emissivity of its surfaces, air- or gas-filled), double or triple glazing low-emissivity glass air- or gas-filled;
- Thermal transmittance of opaque panel
- Note the inclination, α , of the glazing to the horizontal such that $90^\circ \geq \alpha \geq 60^\circ$ (heat flow direction $\pm 30^\circ$ from the horizontal plane). Horizontal, or inclination α of the glazing to the horizontal such that $60^\circ > \alpha \geq 0^\circ$ (heat flow direction more than 30° from the horizontal plane). The design values should consider the actual inclination of the window in the determination of U_g for the calculation of the energy demand of the building. Declared values are calculated or measured for horizontal heat flow. Surface thermal resistances, (R_{si} , R_{se}) for vertical position are already included in the known U-value of glazing and frame provided by producer.
- Type and properties of the external shutter/blind, Additional thermal resistance due to the air layer enclosed between the shutter and the window and the closed shutter itself. Thermal transmission properties of the shutter/blind and on its air permeability. Type of unventilated air spaces for coupled and double vertical windows (thickness of air space, one side coated, both sides uncoated)

- Types of shutters/blinds and their respective roller shutter boxes and thermal values of the shutter boxes.
- Type of frame/glazing junction for linear thermal transmittance due to combined effect of panel, spacer and frame (the glass spacers at the edge of the glazing or glazing bars integrated in the glazing).
- Type of glazing bars for estimation of linear thermal transmittance due to combined effect of glazing bar and glazing, (Aluminium and steel spacers or thermally improved spacers)
- Note: The default thermal characteristics of the windows provided in EN ISO 10077-1:2017, Annex H, Tables H.1 to H.4 are calculated for windows: positioned vertically; of dimensions 1,23 m by 1,48 m; with frame area equal to 30 % and 20 % of the total window area; with glazing and frame types as follows:
 - glazing: $U_g \geq 2,1 \text{ W}/(\text{m}^2 \cdot \text{K})$: uncoated glass; $U_g \leq 2,0 \text{ W}/(\text{m}^2 \cdot \text{K})$: low emissivity glass;
 - frame: $U_f = 7,0 \text{ W}/(\text{m}^2 \cdot \text{K})$: metal without thermal break; $2,2 \text{ W}/(\text{m}^2 \cdot \text{K}) \leq U_f \leq 3,8 \text{ W}/(\text{m}^2 \cdot \text{K})$: metal, with thermal break; $U_f \leq 2,0 \text{ W}/(\text{m}^2 \cdot \text{K})$: wood or PVC;
 - with a single light.

Check the conditions for your default values. Values for windows of other sizes, positioned other than vertically, with other frame area fractions or with other frame/glazing permutations should be estimated using formulas in EN ISO 10077-1 (usually part of software tool).

Note 2: In some countries, minimum requirements for U-value for windows are set for a specific defined window dimension.

The thermal, solar and light characteristics of the glazing and solar and light characteristics of the solar protection devices for estimation of the total solar energy transmittance are treated in ISO 52022-1.

Next windows properties to be estimated and noted related to the solar properties of windows and doors and for characteristics of the solar protection devices are:

- The total solar energy transmittance at normal incidence. Informative default values can be used based on typical types of glazing:
 - Single glazing
 - Double glazing
 - Double glazing with selective low-emissivity coating
 - Triple glazing
 - Triple glazing with two selective low-emissivity coatings
 - Double window
- Type of solar protection devices: external, internal, integrated solar protection devices
- reduction factor, for typical types of blinds based on blind type:
 - White venetian blinds
 - White curtains
 - Coloured textiles
 - Aluminium-coated textiles
- Rules for operation of shutters and solar shading devices

- Manual operation
- Motorized operation with manual control
- Motorized operation with automatic control
- Combined light/blind/HVAC control
- the shading reduction factors for external obstacles for window

Data related to ventilation heat transfer coefficients are:

- Air tightness, air infiltration,
- air infiltration, from the exterior: air flow rate through heated or cooled space
- pre-heating or pre-cooling, heat recovery

5.4.5 Thermal bridges

Calculation can be based on several approaches:

- Detailed simulation, based on EN ISO 10211- Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations)
- Simplified calculation based on tabulated values in catalogues of default Linear thermal bridges (e.g. EN ISO 14683- Thermal bridges in building construction — Linear thermal transmittance — Simplified methods and default values) or in national publications.
- Simplified approach based on default delta U-value for deterioration of U-values, surcharges,
- incorporating linear or point thermal bridges into a quasi-homogeneous layer according to methods in the EN ISO 6946 or by the equivalent thermal conductivity of the quasi-homogeneous layer based on ISO 10211 (see also chapter 5.1).

Look at:

- Position of insulation in the walls and roofs
- Connection of walls to roof
- Positioning of windows related to insulation and connection between the frame and the main wall insulation
- Termination of wall insulation towards the ground floor
- any interruption or deviation of the insulating layer for example by the presence of structural elements such as balconies, slabs, pillars, or geometric discontinuities such as corners and edges.
- any sign of mould (corners, around openings, ...) that may indicate a thermal bridge and/or a too low air exchange rate. Possibly have a look with an IR camera if in winter.

Mention that how to consider thermal bridges depends on MS regulation. This can range from simple additional U values (e.g. SK) to simplified thermal bridges (e.g. according to EN 14683) to finite elements calculation according to EN ISO 10211 (e.g. IT).
--

If there are significant thermal bridges, then the thermal transmittances should be calculated in accordance with ISO 10211 or considered in simplified way based on EN ISO 14683.

Linear thermal bridges occur at the following locations in a building envelope demonstrated also in **Figure 13**:

- at junctions between external elements (corners of walls, wall to roof, wall to floor);
- at junctions of internal walls with external walls and roofs;
- at junctions of intermediate floors with external walls;
- at columns in external walls (if not allowed for in the U-value of the wall);
- around windows and doors.
- Balcony attachments
- Slab on internal or external walls

EN ISO 14683 provides default values of Ψ for a range of commonly occurring types of two-dimensional thermal bridge,

NOTE These default values of Ψ are based on two-dimensional numerical modelling in accordance with EN ISO 10211. They generally represent the maximum effects of thermal bridging. Default values are valid only for consideration of heat transfer, and not for consideration of critical surface temperature to avoid surface condensation.

Linear thermal transmittance values depend on the type of dimensions used (see example in **Figure 4**).

In **Figure 13**, the notations R, B, C, GF, IF, IW, P and W refer to the location of the thermal bridge roof, balcony, corner, ground, window, internal wall, ..).

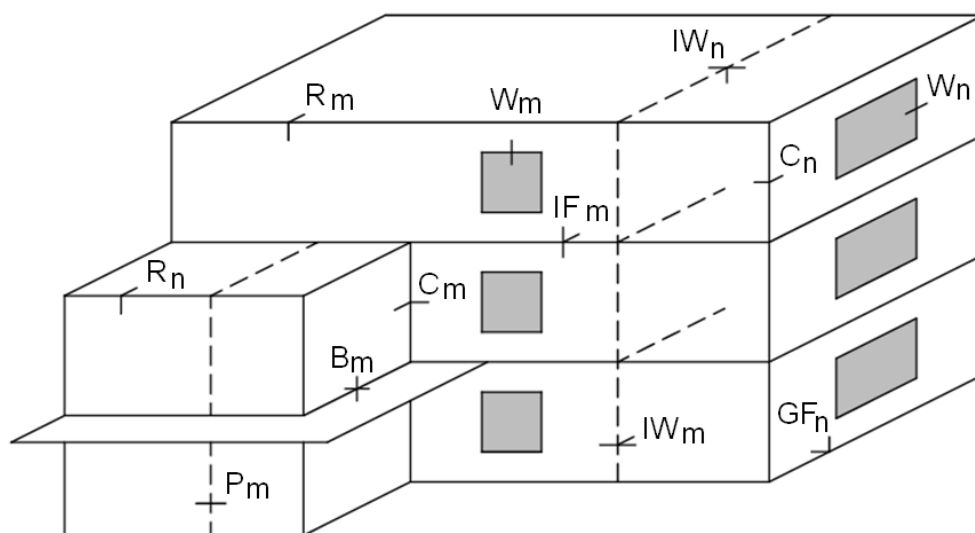


Figure 13 – Types of thermal bridges (based on EN ISO 10211)

Input data to be collected for detailed calculation (EN ISO 10211):

- Description of structure is recommended, building plans including dimensions and materials including any known alterations to the construction, physical measurements and details from inspection.
- Description of the geometrical model: 2-D or 3-D geometrical model with dimensions.
- Geometric characteristics to be collected and noted:
 - Area
 - Width of building component
 - Thickness of building component
 - Length
 - Volume
 - Characteristic dimension of floor on the ground

Thermal characteristics of building component to be collected for detailed calculation:

- Design thermal conductivities of materials. Table design values can be used, or have to be recalculated in line with ISO 10456 if based on declared data supplied by the manufacturer.
- The thermal conductivity of soil shall be as 2,0 W/(m·K) unless other values(s) are given.
- thermal resistance
- external and internal surface resistance
- thermal transmittance
- boundary temperatures

Thermal characteristics based on EN ISO 14683:

- thermal transmittance of element
- linear thermal transmittance of thermal bridge
- The point thermal transmittance of the point thermal bridge
- annual average ground heat transfer coefficient
- transmission heat transfer coefficient through unconditioned spaces

Default values of linear thermal transmittance Ψ for a range of commonly occurring types of two-dimensional thermal bridge are provided in **Annex C** in EN ISO 14683 and examples from EN ISO 14683 are presented in **Figure 14**.

Roof

Corner

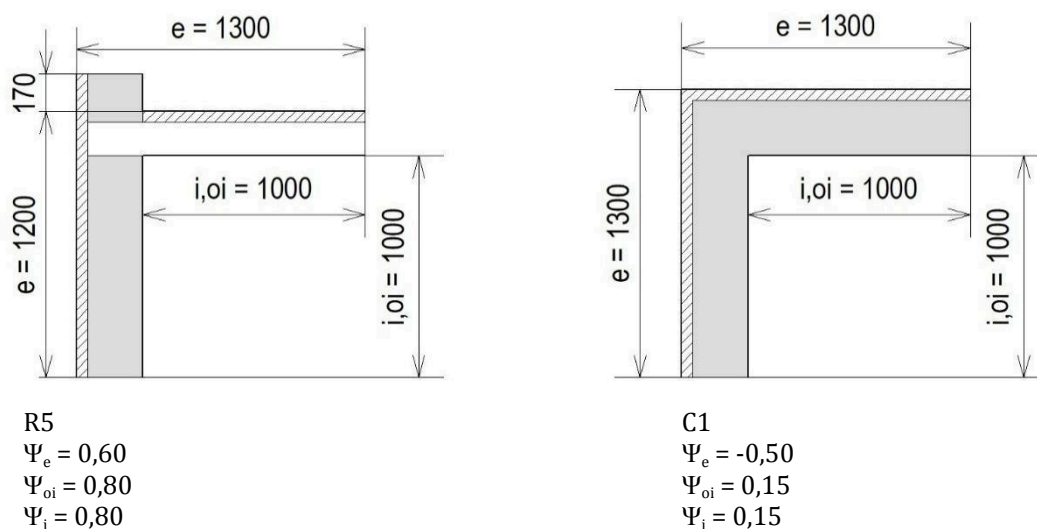


Figure 14 – Sample values of thermal bridges - Source: EN ISO 14683

This information is needed for proper selection of thermal bridge

- Type of dimensions (internal, overall internal, external)
- Geometry of thermal bridge, position of principal thermal insulation

For each thermal bridge type and location of the principal insulating layer, Table C.2 in EN ISO 14683 gives an outline sketch of each detail and values of Ψ , rounded to the nearest 0,05 W/(m·K), based on the three systems of measuring building dimensions:

- Ψ_i based on internal dimensions;
- Ψ_{oi} based on overall internal dimensions;
- Ψ_e based on external dimensions.

In the case of external dimensions, the measurements are to the bottom of the floor slab, or to the bottom of the insulation (if below the floor slab).

The thermal bridges are grouped by type and with four locations of the principal insulating. The insulating layer can be located

- at the outside of construction
- in the middle of construction
- at the inside of construction, or
- all the way through

5.4.6 Shadings

Shading calculation is detailed in EN ISO 52016-1 Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent head loads — Part 1: Calculation procedures.

Actual hourly on/off pattern solar shading provisions over the year are in Annex G (Normative) Dynamic transparent building elements

Obstacles around the building have to be noted. Two types of shading objects are distinguished:

- Simple shaped obstacles for façade elements, such as (window) rebates, overhangs and side fins, or other geometrically similar shading objects, such as other building parts (e.g. walls) or balconies.
- Other obstacles, the shading object either the obstacle shading from ground or shading from sky (top down “overhang”).

Note (EN ISO 52016-1): The difference between obstacles and overhangs is that an obstacle ends at a certain height above the ground level, while an overhang starts at a certain height above the ground level.

Geometrical data to be collected on:

- Depth of a (simple) overhang (or similar shading object)
- Vertical distance between the edge of the façade element and a (simple) overhang (or similar shading object)
- Depth of a (simple) right/left side fin (or similar shading object)
- Horizontal distance between the edge of the façade element and a (simple) right/left side fin (or similar shading object)
- Height from ground level, per shading obstacle in a skyline segment
- Horizontal distance between the shaded surface k and the shading object (obstacle) in a skyline segment, per shading object, measured between their central points

Consider evergreen trees as well
MAKE a list of shading objects

5.5 Special features

5.5.1 EPC calculation

For recommendations for improvement of energy performance the following features have to be taken into account:

- Age, status based on maintenance and remaining lifespan of structures
- What can be insulated / replaced
- Check integration possibility of renewable energy sources on building envelope for heating, cooling or just for generating electricity.

5.5.2 RP specific

The objective of the RP is similar to the recommendations in the EPC but the aim is to propose the step-by step deep renovation in appropriate order based on the lifespan of building structures and systems and energy efficiency first principle to reach the level of “nearly zero-energy building” before 1 January 2030, and, a “zero emission building” from 1 January 2030.

The focus of RP is on the staged investment and renovation. The step-by-step renovation is often preferred due to the excessive one-time investment costs. The cost savings also have to be calculated and evaluated for each renovation step. The most cost-effective sequence of renovations that brings to a nearly -zero energy building or zero emission building shall be proposed that might be based on a global costs (net present value based on the LCA). It is therefore important to leverage any renovation of the building, even if not triggered by energy performance consideration.

Conservation state of structures (wooden frames..., windows, external finishings, ...) is relevant to identify those building elements that would undergo renovation anyhow.

Any planned renovations of the building, also for other purposes than energy efficiency, shall be identified (source is the owner), so that additional energy conservation measures can profit of basic work.

Prices of materials shall also be collected to provide reliable cost estimates. This is not an on-site activity but a follow-up in the office.

Current energy prices and the forecast for energy prices increase are also inputs for calculation of savings on the energy bill and cost effectiveness of renovation steps based on global costs calculation (see also chapter 13).

The renovation steps have to be discussed with owner and adapted to his preferences and financial capabilities.

5.5.3 SRI specific

SRI evaluates the presence and level of automatic control of solar shadings and window opening in coordination with HVAC operation.

The level of the function listed in **table 4** shall be determined.

Table 4 – SRI Functions related to building envelope

FUNCTIONALITY		LEVEL	
DE-1	Window solar shading control	☐ ____%	No sun shading or only manual operation
		☐ ____%	Motorized operation with manual control
		☐ ____%	Motorized operation with automatic control based on sensor data
		☐ ____%	Combined light/blind/HVAC control
		☐ ____%	Predictive blind control (e.g. based on weather forecast)
DE-2	Window open/closed control, combined with HVAC system	☐ ____%	Manual operation or only fixed windows
		☐ ____%	Open/closed detection to shut down heating or cooling systems
		☐ ____%	Level 1 + Automated mechanical window opening based on room sensor data
		☐ ____%	Level 2 + Centralized coordination of operable windows, e.g. to control free natural night cooling

DE-4	Reporting information regarding performance of dynamic building envelope systems	☐ ____% No reporting ☐ ____% Position of each product & fault detection ☐ ____% Position of each product, fault detection & predictive maintenance ☐ ____% Position of each product, fault detection, predictive maintenance, real-time sensor data (wind, lux, temperature...) ☐ ____% Position of each product, fault detection, predictive maintenance, real-time & historical sensor data (wind, lux, temperature...)
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5.5.4 Inspection specific

An inspection of the building envelope is recommended when inspecting a heating system if an improvement of the building envelope can ease system upgrade. As an example, a common issue will be replacing boilers with heat pumps in the existing buildings. A common prerequisite for this upgrade is insulating the building envelope.

It is also worth noting that insulating the building cuts energy use and emissions for heating anyway.

The building envelope properties also have an impact on HVAC systems sizing.

5.6 Practical tips and tricks

When available, emergency route plans are a good source of basic layout.

Have a draft layout before taking measurements.

Go round the clock in describing the building envelope. Capturing a comprehensive set of perimeter photographs of the building during the on-site inspection is recommended to support later calculations and verification.

Take also overall measurements to check the sum of parts of the building (internal or external dimensions)

If internal dimensions are needed, you may use coefficients to convert gross to net values:

- Multiply by 0,8 gross area to get net area (0.75 for small family houses)
- Multiply by 0,7 gross volume to get the net volume

These multiplication factors are sometimes provided in national calculation methods.

6 Heating system data collection

6.1 Introduction

6.1.1 General

The calculation and inspection of heating systems (and of most types of technical systems) is far from being standardised across Europe. There are several reasons for that.

- Heating systems configurations are very various, ranging from simple autonomous to complex centralised systems. Sometimes additional systems like fireplaces and stoves are available for some rooms.

- There are several technologies available for each heating sub-system.
- Calculation methods vary from simple tabulated methods to elaborate detailed methods.
- Operating conditions may be calculated or simply assumed.

It is also difficult to collect the data about technical systems because:

- not all devices are fully and correctly standardised and new types of devices are continuously being developed (e.g. new heat pump configurations);
- components and equipment are often old and there is no more documentation nor info from the original manufacturer;
- components may be concealed or inaccessible.

Also, systems may be not homogeneous (e.g. different types of heating terminals in a space heating system) and some kind of average values shall be figured out when dealing with practical cases if the calculation method has not enough flexibility to accommodate special configurations (e.g. systems zoning).

An additional difficulty is the high sensitivity to operating conditions of

- distribution losses;
- and the efficiency of heat pumps.

This requires the identification of operating conditions, that may not be easy if inspecting when the system is off.

Before inspecting in details any technical systems, its general structure (e.g. basic functional diagram) shall be assessed and verified. If no documentation is found, a minimum information set shall be assembled. Then, the inspection of technical system will usually follow the same order of the calculation chain, going from emitters to generation.

6.1.2 The structure of technical systems

Technical systems consist of the following functional elements, called sub-systems:

- **Generation** sub-system, which converts the delivered energy carriers into the desired energy type.

Example of generation sub-systems:

- A boiler converts chemical energy of the fuel into heat (heating generation).
- A heat pump uses electric energy to provide heat (heating generation) or heat extraction (cooling generation).
- A lamp converts electricity into a light flux (lighting generation).
- A fan converts electricity into an air flow (ventilation generation).

The generation sub-system may also consist of a direct connection when the delivered energy carrier is already the desired type of energy (example: district heating connection)

- **Storage** sub-system, which allows generation and use of energy at different time intervals.

Storage of heat is common for domestic hot water and is used also for heating and cooling.

Storage of electricity is becoming more frequent in connection with PV to increase the on-site match between production and use of electricity.

— **Distribution** sub-system, which allows to transport the desired energy flow from generation and/or storage to the location where it is needed use within the building.

The transport of heat may be based on water, air or refrigerant gas.

The distribution network may have a complex structure with several levels.

— **Emission** sub-system, which transfers the desired energy flow into the serviced space.

Examples of emission sub-systems:

— radiators, fan coils, embedded panels, unit heaters for space heating;

— fan coils, embedded panels for space cooling;

— air diffusers for ventilation.

— Emission **control** subsystem, that ensure that the desired service is provided when needed, where needed and in the amount needed.

Examples of emission control subsystems are:

— a room thermostat, controlling space heating and cooling;

— a CO₂ control controlling the amount of outdoor air, for ventilation.

When analysing technical systems, an evaluation shall be made for each relevant subsystem.

For a given service (i.e. H, W, C...) or installation configuration, a given subsystem may be not relevant like:

— storage for ventilation and lighting;

— distribution for a split room air conditioner.

In these cases, the evaluation of the given subsystem is skipped

6.1.3 Energy balance of a subsystem

For each subsystem, the basic energy balance used in EN-EPB standards is represented in the following **figure 15**.

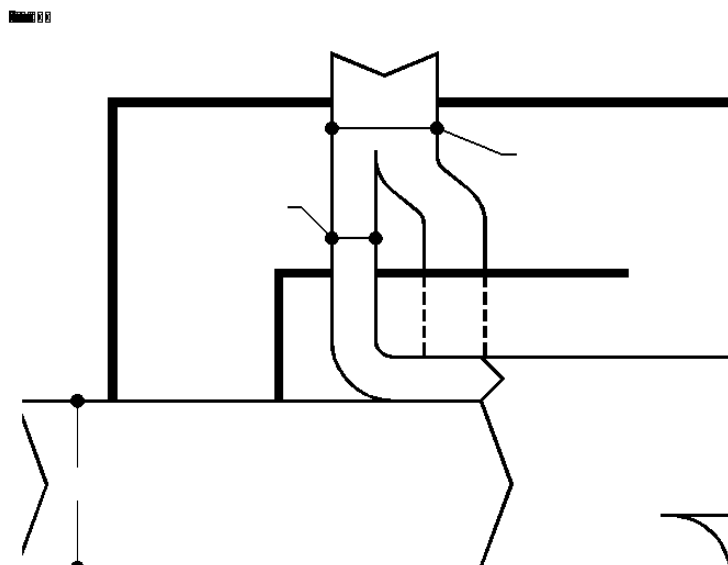


Figure 15 – Energy balance of a subsystem

KEY

- SUB sub-system Y for service X balance boundary
- SUB HRec sub-system Y heat recovery boundary
- $Q_{X;Y,out}$ sub-system Y heat output (= $Q_{X;Y+1}$, heat input of the next sub-system(s))
- $Q_{X;Y,in}$ sub-system Y energy carrier input
- $W_{X;Y,aux}$ sub-system Y auxiliary energy
- $Q_{X;Y,aux,rvd}$ sub-system Y auxiliary energy transferred into the sub-system
- $Q_{X;Y,ls}$ sub-system Y thermal loss
- $Q_{X;Y,rbl}$ sub-system Y recoverable heat for space heating
- $Q_{X;Y,ls,rbl}$ sub-system Y thermal loss (thermal part) recoverable for space heating
- $Q_{X;Y,aux,rbl}$ sub-system Y recoverable auxiliary energy
- $Q_{X;Y,ls,nrbl}$ sub-system Y thermal loss (thermal part) non recoverable
- $Q_{X;Y,aux,nrbl}$ sub-system Y non recoverable auxiliary energy

NOTE X = H (heating), C (cooling), W (domestic hot water), V (ventilation), ...

Y = em (emission & control), dis (distribution), gen (generation), sto (storage), ...

The starting point is always the required output $Q_{i,j,out}$.

Auxiliary energy, losses and also the main input are calculated by:

- either simple tabulated values (e.g. giving efficiencies, expenditure factors, loss factors, recovery factors found in a table according to a description of the subsystem), like

$$Q_{X;Y;ls} = Q_{X;Y;out} \cdot \frac{1-\eta_{X;Y}}{\eta_{X;Y}} \quad (1)$$

$$Q_{X;Y;ls;rbl} = Q_{X;Y;ls} \cdot k_{rbl} \quad (2)$$

...

— or detailed calculations, defined in specific standard modules.

The main equation to get the required input is then:

$$Q_{X;Y;in} = Q_{X;Y;out} + Q_{X;Y;ls} - W_{X;Y;ls;rvd} \quad (3)$$

Equation (3) applies to heating and domestic hot water. For cooling systems, the basic energy balance of a subsystem is slightly different because electric energy use is not recovered (i.e. contributing to satisfy the demand) but is an additional load. Equation (3) for the heating case becomes

$$Q_{C;Y;in} = Q_{C;Y;out} + Q_{C;Y;ls} + W_{C;Y;ls;rvd} \quad (4)$$

for the cooling case.

Some subsystems use different approaches, like heat pumps and air handling units.

In total, based on the required output, the following results are calculated:

- the required energy input, that will be the required output of the next subsystems in the row;
- the required auxiliary energy input;
- the recoverable heat, to be considered in the relevant thermal zone balance (but a subsystem may have several elements whose losses are in different thermal zones, like a distribution system spanning though the whole building).

This approach is used in most European calculation methodologies.

Sometimes, instead of considering explicitly the recoverable heat in the thermal energy balance, the recovered heat is calculated (by simple tabulated coefficients) and considered directly inside the same subsystem. The main equation is then:

$$Q_{X;Y;in} = Q_{X;Y;out} + Q_{X;Y;ls} - W_{X;Y;ls;rvd} - Q_{X;Y;ls;rvd} \quad (5)$$

This approach is often used for the heating systems in the monthly method, also to avoid iterations.

The required input and the data to be collected will highly depend on the calculation method in use in your country or region.

6.1.4 Subsystems of the space heating system

For the space heating system, all subsystems may be present.

Usually there is no storage sub-system with gas and oil boilers.

The heating system may serve several service areas, with different heat emitters, control type and temperature regime. Domestic hot water production may be also connected to the same heat generation subsystem.

6.1.5 Where to find the data on equipment and components

Not all the data of the equipment and system components can be found on-site. You can obviously see on-site the diameter of a pipe, the length of a pipe and the thickness of an insulation material. The nominal power of a

boiler is usually found on the nameplate. If you are looking for the declared COP and capacity of a heat pump in a given condition, this will be very seldom, if ever, found on site.

As a general rule for systems, always take note of the make and model of equipment and components and take a picture of the nameplate and of any relevant details: this will allow you to search the internet for the technical data sheet of the equipment or systems component.

This is a quite general advice.
Maybe move to some general section

6.1.6 Air based and VRV/VRF heating systems

Heating systems may range from ordinary water based systems, to split room air conditioner and VRV/VRF systems in heating mode.

Water based heating systems are completely covered by this clause 6.

Split systems and VRV/VRF systems are also covered by this clause, considering that distribution losses be already taken into account in the COP of the room air conditioner or VRV/VRF systems.

For air based heating systems, this clause 8 covers any water based generation part up to the heating coil of the air handling unit or any ducted fan coil.

6.2 General information on the heating system

6.2.1 Heating service areas and operating schedules

General information on the heating system includes the following.

- The list of service areas and their identification on a plan of the building

A “heating service area” is a set of spaces (usually rooms) served by the same branch of the heating system that share the same operating schedule.

- The location of boiler room(s) and mechanical room(s).

- The list of the heating systems serving that building, with the connected service areas.

This may range from one system for the whole building to several autonomous systems to a mixture of common and individual systems.

- The operating schedule of the heating systems (operation time and set temperatures of the service areas).

It is recommended to prepare a functional diagram of the heating system(s) in the building showing the connections between heating systems and service areas. An example of such a functional diagram of a heating is shown in **figure 16**.

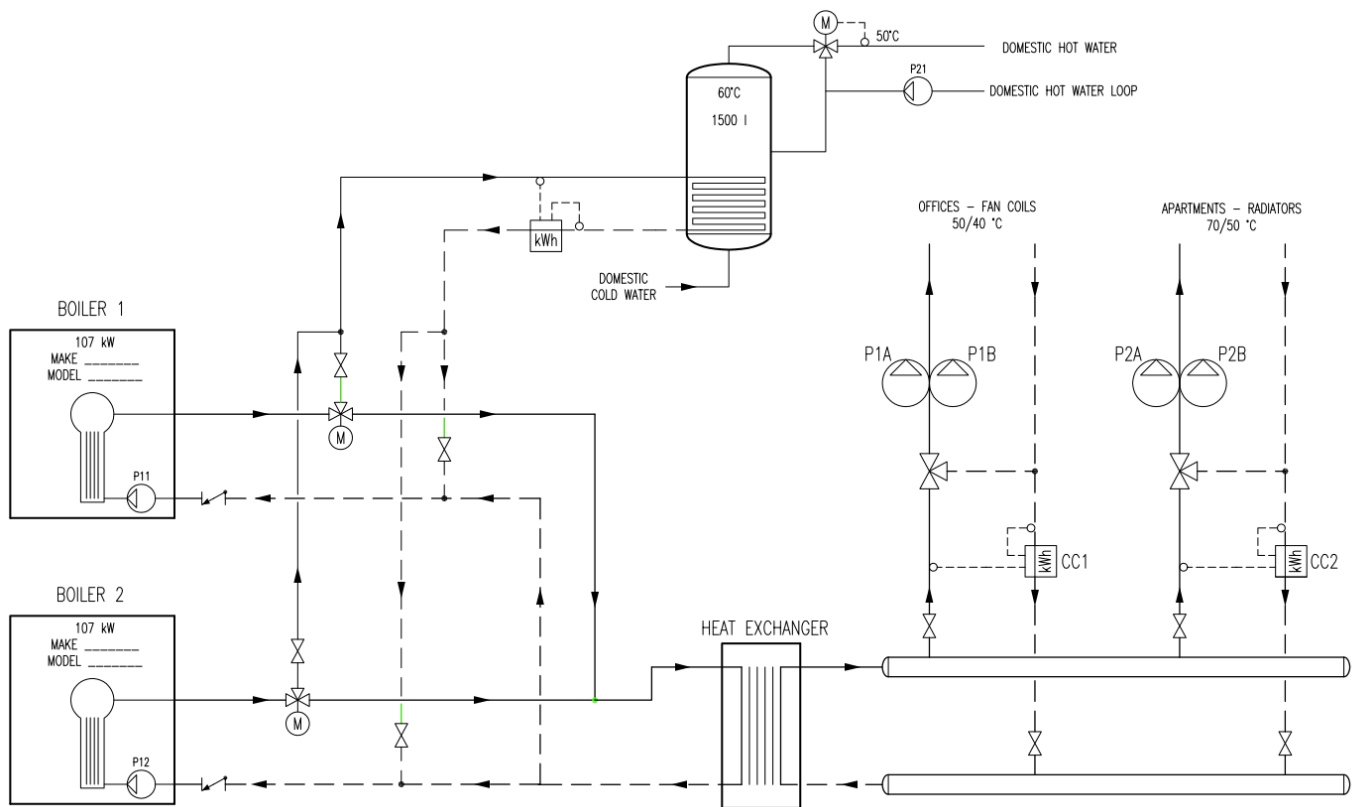


Figure 16 – Sample functional diagram of a heating system

The example in **figure 16** is not a complete functional diagram (example: all safety features are not indicated). It is limited to the information required for an energy performance assessment (e.g. how many boilers, make and model, which are the area served, is the heating system also providing domestic hot water, how is the heating system controlled). Actually, more information is needed (e.g. nameplate data of the pumps, time schedules) and can/should be annotated directly on the diagram.

NOTE The diagram shown has been extracted from a drawing. It can also be handwritten on a sheet of paper during the on-site data collection. There is no obligation of format in this task, the essential is transmitting a clear and understandable information for the purpose of performing an energy performance calculation.

The functional diagram should also highlight the connections between the heating system(s) and other technical systems such as:

- domestic hot water preparation using the heating generation system (shown in the example in **figure 16**);
- connection of AHU coils and/or duct heating coils to the heating system (not included in the example in **figure 16**).

6.2.2 Additional information

6.2.2.1 EPC

No additional info required.

6.2.2.2 RP

The possibility to extend the time operating schedule is relevant to reduce operating temperature.

6.2.2.3 SRI

The level of the functionalities about heating system monitoring and reporting listed in **table 5** shall be assessed.

Table 5 – SRI Functions related to heating system

FUNCTIONALITY		LEVEL	
H-3	Report information regarding heating system performance	☐ ____%	None
		☐ ____%	Central or remote reporting of current performance KPIs (e.g. temperatures, submetering energy usage)
		☐ ____%	Central or remote reporting of current performance KPIs and historical data
		☐ ____%	Central or remote reporting of performance evaluation including forecasting and/or benchmarking
		☐ ____%	Central or remote reporting of performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection
H-4	Flexibility and grid interaction	☐ ____%	No automatic control
		☐ ____%	Scheduled operation of heating system
		☐ ____%	Self-learning optimal control of heating system
		☐ ____%	Heating system capable of flexible control through grid signals (e.g. DSM)
		☐ ____%	Optimized control of heating system based on local predictions and grid signals (e.g. through model predictive control)

6.2.2.4 Inspection

No additional info required.

6.3 Heat emission**6.3.1 Introduction**

Emission losses are linked to the local overheating induced by the heating terminal. A heating terminal must be hotter than the environment, therefore the losses of the building envelope in the area around the heating terminals are higher than what is calculated assuming a uniform temperature equal to the standard set-point condition (e.g. the typical 19...21 °C indoor temperature, depending on the national definition of standard comfort in winter).

Examples:

- the wall behind a radiator will be overheated, leading to higher transmission losses than calculated under uniform indoor temperature assumptions

- stratification in high height rooms causes higher temperatures on the ceiling and upper part of the walls;
- part of the heat released by a panel embedded into a heat loss element will be directed outside;

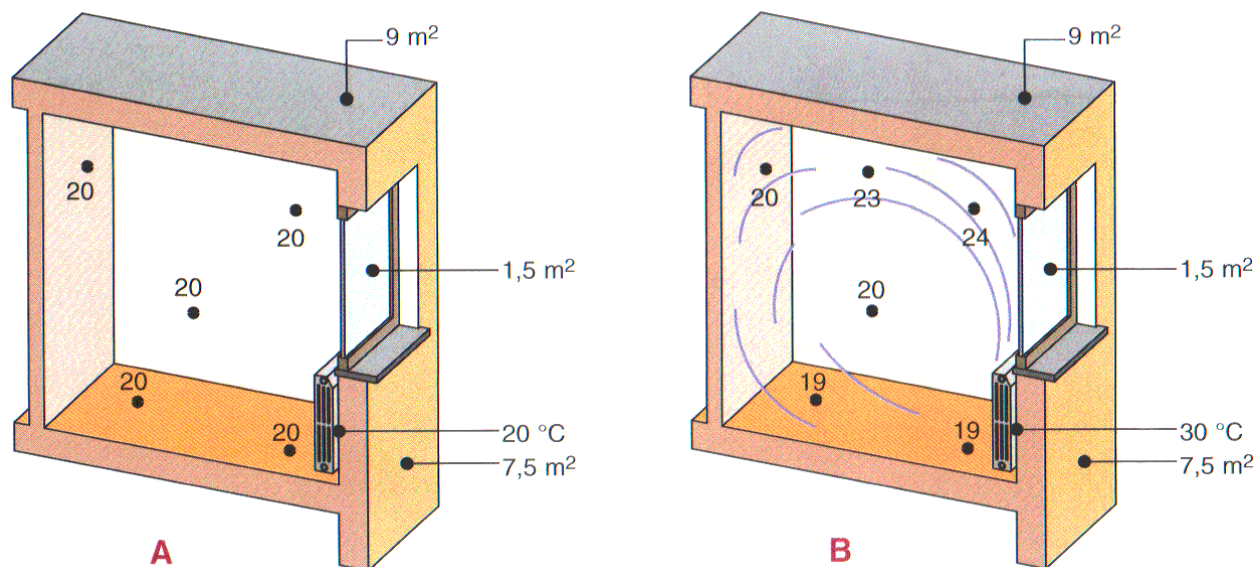


Figure 17 – Emission losses: A = ideal temperature distribution B = real temperature distribution

These effects can be exacerbated by wrong practices like crating a niche to install radiators below poorly insulated windows. The localized overheating occurs exactly near reduced walls and under the sill, which are the areas with lowest thermal resistance. Similarly, the share of heat emitted directly to the exterior by embedded panels is increased by the thermal bridge of uninsulated floor or ceiling junctions to the external walls.

NOTE Insulation of external walls also increases emission efficiency, reduces stratification and increases comfort.

6.3.2 What to look at

Most calculation methods, including EN 15316-2, are based on tabulated data depending on the properties of heating terminals. This is by far the most common method used. Some standards may provide only concepts on how to calculate emission losses in details. In the following, it is therefore assumed that a simplified tabular method is used.

It is therefore enough to identify qualitative properties of the heat emission system.

Sometimes the heat emission system is not uniform over a building. Different types of heating terminals may be installed due to different requirements in the various areas of the building or they may have been simply added when modifying the heating system.

The following list summarizes the aspects to be assessed, usually by visual inspection.

- Type of heat emitters, typical solutions are:
- radiators;
- embedded terminals (embedded in floor, ceiling or walls);
- fan-coils, wall mounted (exposed) or ducted
- unit heaters;

- air terminals, for air-based systems;
- direct electric heaters.
- Positioning of heat emitters, depending on emitter type
- Radiators can be installed on internal walls, external insulated walls, external non-insulated walls, ...
Positioning radiators on the external walls is preferred to reduce stratification.
- Embedded terminals can be embedded in heat loss elements or internal structures.
- Reduced insulation behind and around radiators:
- installation of radiators on poorly insulated structural elements (e.g., slab edges, window reveals);
- installation of radiators in front of windows without a reflective screen;
- installation of radiators below uninsulated window sill;
leading to additional localized heat loss
- Any obstruction to free air circulation around heating terminals, causing local overheating and capacity reduction.
- Insulation between embedded terminals and the installation structure: part of the heat will be emitted on the other side.
- Auxiliary energy use, for fan coils
- Hydraulic connection of the heating terminals (single pipe ring, double pipe)
- Height of the rooms, which influences stratification
- Size of emitters may be relevant if operating conditions shall be calculated, e.g. because you want to recommend the installation of a heat pump. In several MS there are databases of the nominal power of typical radiators or correlations that allow to estimate the nominal power of radiators based on size and type.

When looking at the hydraulic connection of emitters, you can often evaluate the insulation level of the distribution pipes.

6.3.3 Input data

6.3.3.1 Configuration data

Typically, the calculation of emission losses is based on tabulated values, so the assessment is related to the information needed to navigate in the default data tables. This information may require

- **Type** of heat emitters (see list in the previous clause)
- **Positioning** of heat emitters
- **Operating temperature regime:** high-temperature operation (e.g., 70/50 °C in design conditions), medium, or low-temperature systems, as this affects local overheating and losses.

- **Insulation level of the building element where they are mounted:** radiators are usually mounted on the external wall, which can be insulated or non-insulated. radiators.
- **Insulation level between heating terminal and the embedding structure:** panels are usually mounted on an insulating support to reduce emission on the other side.
- **Degree of enclosure or shielding:** Presence of radiator covers, recesses, or niches that alter heat emission and increases additional losses.
- **Mounting details and insulation backing:** Whether emitters are installed with reflective/insulating panels behind them or directly on uninsulated external walls.

6.3.3.2 Auxiliary energy

Additional information is the nominal power of auxiliaries (fan) of fan coils. Fan-coils can be often operated at several fan speeds. The highest in use should be identified and the rated power for that speed should be used. Alternatively, the auxiliary energy can be estimated as a fraction (typically 2...5%) of the required energy output. This might look negligible but if the conversion factor of electricity is around 2,0, this is a significant burden. In some national standards, the effect of the auxiliary energy use is taken into account as a reduction of emission efficiency.

6.3.3.3 Non homogeneous situations

Ideally a calculation method should be performed per homogeneous service areas. You need for this a software that supports zoning of heating system.

Several tools do not allow for this, so you might consider using a weighted average of the efficiencies for the various situations that you find in a building. The relevant weight should be specified in the national calculation method. Typical weights are

- the area served by the given configuration. It's probably the simplest and doesn't require any additional heat loss or energy use calculation.
- the heat load in the area served by the given configuration. Requires an additional calculation.
- the installed power of radiators, similar to heat load but checking what is installed:
- the energy need for the area. It is likely to be the most accurate but requires a calculation of heating needs for each area served by the given configuration.

Marginal different situations should be ignored. Example: in the bathroom, the floor heating may be insufficient to cover the design heat load. Therefore, a radiator (or a towel warmer) is added in the bathroom to assist the floor heating and it is connected in parallel with the floor heating loop in the same room.

6.3.4 Additional information

6.3.4.1 EPC

The type of heat emitters, their dimensions (i.e. nominal capacity) and the possibility to expand them might be relevant in connection with some recommendations. See next clause for more details if you plan to include e.g. the recommendation to install a heat pump in a radiator system. Take and archive pictures on the typical radiators.

6.3.4.2 RP

For the renovation passport, the type of heat emitters and the required operating temperature are an important information when recommending an upgrade to heat pumps, which require low flow temperature operation.

It is critical for existing buildings with radiators to assess the installed capacity of radiators. In many countries catalogues of typical radiators or correlations based on radiator type and size have been developed to identify the nominal capacity of installed radiators.

- Installed radiator capacity: Evaluating the size and nominal thermal output of radiators compared to room-specific heat loads. In many countries, catalogues or empirical correlations are available to estimate radiator capacity based on dimensions, fin types, and panel configurations. For large buildings, sampling a representative number of rooms can be used to extrapolate total capacity.

The assessment can be based on sampling of rooms for large buildings.

It is important also to assess the possibility to enlarge radiators for the purpose of correcting possible unbalances if the building is insulated (the relative effect of additional insulation on heat loads may vary significantly across rooms).

Consideration of Heat Emitters and Operating Temperature for Renovation Passports

For renovation roadmaps and passports, the type of heat emitters and their required operating temperature are critical factors when recommending an upgrade to low-temperature systems such as heat pumps. Many existing buildings with traditional radiators are designed for high flow temperatures (e.g., 70/50 °C), which can limit the efficiency of a heat pump retrofit.

Key assessment steps include:

- Adaptation to upgraded envelope: If the building undergoes insulation improvements, heat loads will decrease, potentially creating hydraulic or thermal imbalances across rooms. It may be necessary to enlarge or resize radiators in certain rooms to ensure uniform comfort levels and optimal operation with lower supply temperatures.
- Automation and control via thermostatic radiator valves (TRVs): Installing TRVs on radiators allows room-level temperature regulation and automated control of heat distribution, improving overall system efficiency. This is particularly important for buildings transitioning to low-temperature heating systems, as TRVs help maintain comfort, avoid overheating in well-insulated rooms, and enable zoning control without costly piping modifications.

Incorporating these considerations ensures that system upgrade recommendations in the renovation passport are both technically feasible and optimized for future energy performance improvements.

Agreed, to be merged into the text that already has the same considerations

For the RP, it is essential to check the achievable temperature level without and with additional insulation of the building.

6.3.4.3 SRI

Information on SRI functions are given in clause 6.4.4.3 about heat emission control.

6.3.4.4 Inspection

The type of heat emitters is needed to:

- estimate the system efficiency
- figure out the operating temperature level and assessing if it can be reduced.

In practice the evaluation follows the same method as the energy performance calculation.

See the previous **clause 6.2.3** for more details

6.4 Heat emission control

6.4.1 Introduction

The focus is on the control of the indoor temperature.

Room temperature control losses occur because to guarantee comfort (the set-point) in the less favoured room you must overheat (and thus increase losses) all other rooms. The amount of unnecessary heating depends on the type and quality of room temperature control.

Typically, the control losses are taken into account by a “control efficiency” or a “control expenditure factor” given as a tabulated value or sometimes calculated with some empirical correlation. The EN standard introduces the concept of “indoor temperature increase” $\Delta\theta_{inc}$ according to the emission and control type. Again, $\Delta\theta_{inc}$ can be given by tabulated values, sometimes tested values on products or empirical correlations.

Anyway, most calculation methods are tabulated efficiencies, expenditure factors or temperature increase, with possibly some empirical correction for special cases and the input data is a qualitative description of the type of heat emission control.

6.4.2 What to look at

The key is identifying how the indoor temperature is controlled during the heating season. This information consists of the following.

- Level of indoor temperature control.
- The worst situation is having no indoor temperature sensor and relying only on outdoor temperature sensors (feed-forward instead of feed-back). An example is a pure distribution flow temperature reset based on outdoor temperature. Such control type has been common in the past.
- If there are indoor temperature sensors, the next information is the level of spatial resolution of the temperature sensors and controls. The typical possible levels are:
 - by building unit or entire building (e.g. one thermostat per apartment in a representative room, acting on a zone valve);
 - by groups of homogeneous spaces (e.g. one thermostat in a representative room for day zone, one in the night zone, acting on zone valves);
 - room by room (e.g. room thermostats in each room)
 - on each heating terminal (e.g. thermostatic valves or thermostats on fan-coils)
- Type of control action (ON-OFF, PI, PID, ...), that can be:
 - ON-OFF, which is the basic control given by e.g. a simple mechanical thermostat
 - P control, which is provided by e.g. thermostatic valves;

- PI and PID control that can be provided by electronic controllers and electrically driven actuators (but be careful, electronic thermostat are often just on-off whilst an apparently simple thermostat and ON-OFF valve can support PID control by controlling e.g. the duty cycle of ON-OFF comand)
- Operation time control, that can be:
 - continuous operation, that is the systems is always operating unless turned off manually;
 - fixed time control, that is operating following a clock and/or calendar;
 - optimised time control, that is operation time is related to reaching comfort in a given time window during a day and/or a week;
- Set point temperature control, that can be
 - constant set-point, that is the systems is always operating with the same set point, like e.g. with manual thermostatic valves
 - Set-back control, where the set-point can be changed in connection with a time control.
- Additional functions.

The level of control is the fundamental information which is always required and relevant. It is refined by the type of control action.

Time control, set-back and optimisation functions are mostly relevant for highly intermittent occupation, like for offices and schools, whereas they have little impact on well-insulated and/or continuous operation buildings (e.g. residential, hospitals).

6.4.3 Input data

The input data is the type of control among the options considered in your national or regional calculation method. See previous **clause XXX** for general information, see your calculation method for the exact list of required details about level of control, type of control action and other relevant details for the calculation.

An additional input data can be the auxiliary energy used by controls. Usually, an average constant power is assumed.

6.4.4 Additional information

6.4.4.1 EPC

The feasibility of an upgrade of the control system is to be evaluated, especially if the current level is the lowest (no control, just outdoor temperature reset).

A very common solution on radiators is the installation of thermostatic valves. This has to be coordinated with the replacement of the circulation pump with a new one correctly sized and set.

6.4.4.2 RP

Nothing special here

6.4.4.3 SRI

For each function, the respective level shall be identified.

To evaluate the SRI you must identify the level of each function, that is the highest level for which the specified control properties are fully satisfied.

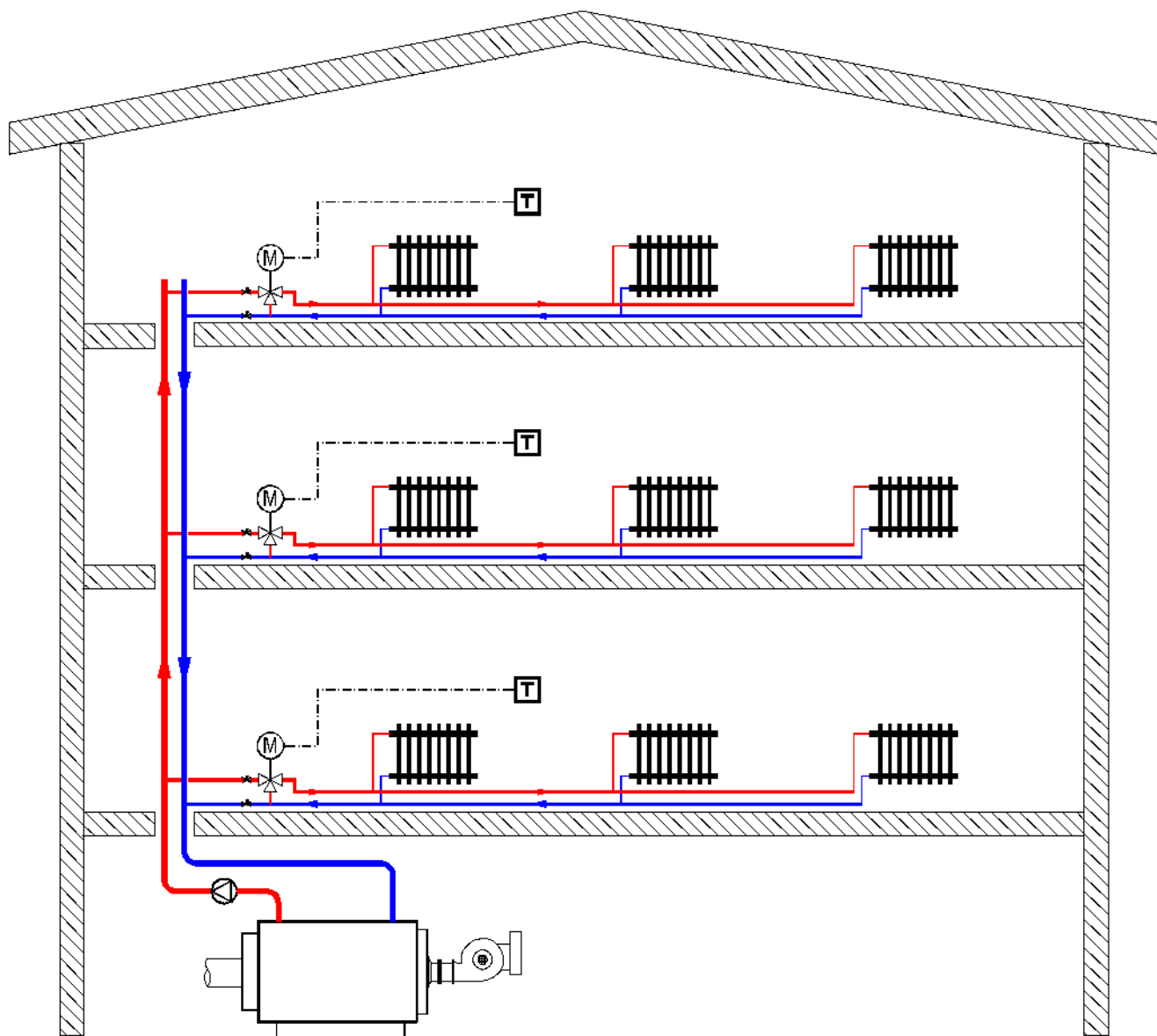
The following is an extract from the input sheet of the SRI calculation tool version 4.5.

Table 6 – SRI Functions related to heating emission

FUNCTIONALITY		LEVEL	
H-1a	Heat emission control	☐ ____%	No automatic control
		☐ ____%	Central automatic control
		☐ ____%	Advanced central automatic control
		☐ ____%	Advanced central automatic control with intermittent operation and/or room temperature feedback control

6.4.4.4 Inspection

The evaluation of the control sub-system



is performed exactly as for the energy performance calculation.

No additional procedure is required for the heating system inspection.

6.5 Distribution

6.5.1 Introduction

The distribution subsystem raises two concerns:

- the heat losses from the pipes and the other components of the distribution sub-system;
- the use of auxiliary energy for the pumps.

The amount of distribution losses is not only a question of the length and insulation level of the pipes, additional significant influencing factors are:

- the temperature regime of the distribution network;
- the type of hydraulic distribution circuit (2 way control valves versus by-pass control valves, see below);
- the time operating schedule;
- the possible recovery of losses.

Distribution losses are addressed in very different ways in the national methods. There are two main alternatives.

- Detailed calculation methods, which apply heat transmission physics to each homogeneous segment of the distribution network.
- Simplified calculation methods, based on tabulated distribution efficiencies or expenditure factors or loss factors.

Generally speaking:

- Simplified calculation methods are obviously much faster but their validity is limited by boundary conditions;
- Detailed calculation methods are more flexible, they can adapt to virtually any situation, but are at higher risk of mistakes.

When both are available in your national context (e.g. in Italy, see UNI-TS 1300-2) then:

- If your system matches **all** boundary conditions (be careful, there might be hidden boundary conditions), then use the simplified method. This will simplify both the data collection process and the calculation process. In this case, going the detailed method would be a waste of effort and will not add to accuracy.
- If your system does not match **all** boundary condition, then use the detailed method. Using the simplified method is at risk of huge mistakes.

Example of hidden boundary condition: a tabulated method states an efficiency of 92% for a two pipes, zone distribution system. It looks like losses are only 8%. The value looks wrong. Actually the value is correct if you consider that:

- only non-recovered losses are accounted. Recovered losses are still heat going into the heated space. So actual losses are much higher than 8% but most of them are recovered.
- the network is operated at variable temperature, according to external temperature (outdoor temperature reset).

If your system:

- either has long pipe runs outside the main insulation layer of the heated space
- or is operated at constant high temperature because it is also serving heat exchangers to provide instantaneous domestic hot water in dwellings (constant high temperature operation 24/24 7/7)

then you are outside the boundary conditions and using 92% efficiency will be a big mistake.

This shall be clearly understood during the site visit: if you are planning to use a simplified method for the distribution efficiency, then check carefully if your sub-system fulfils all boundary conditions and assumptions underlying the tabulated values.

EN 15316-3 only defines the detailed method. The simplified method consists of applying the detailed method with a simplified input, that is estimating the length of pipes based on the building size.

Auxiliary energy use for the space heating distribution depends mostly on

- flow rate and required head;
- type of pumps: electronic versus normal;
- type of flow control: constant versus variable.

Modern electronic pumps are by far more effective (they use much less power) than old pumps, especially small size ones.

In most EU calculation methods, the input data is the rated power of the pump, which is then corrected according to the control options. EN 15316-3 uses head and flow rate in the design condition, which may be complicated to estimate on site.

Provide rule of thumb to estimate flow rate and head loss...

It must be noted that a common mistake is a bad commissioning of circulating pump, resulting in useless auxiliary energy use and can even cause installation malfunctioning.

6.5.2 What to look at

The following are the attention points for the heating distribution network.

- Identify the type of distribution system.
- Horizontal distribution versus vertical distribution versus special cases.

Horizontal distribution means that there are a few main vertical shafts, then the distribution on each floor is independent and derived from the shafts and/or collectors.

Vertical distribution (old systems) means that there are a number of vertical shafts serving 1 or 2 radiators per floor.

Special cases are Tichelmann distribution layout and more.

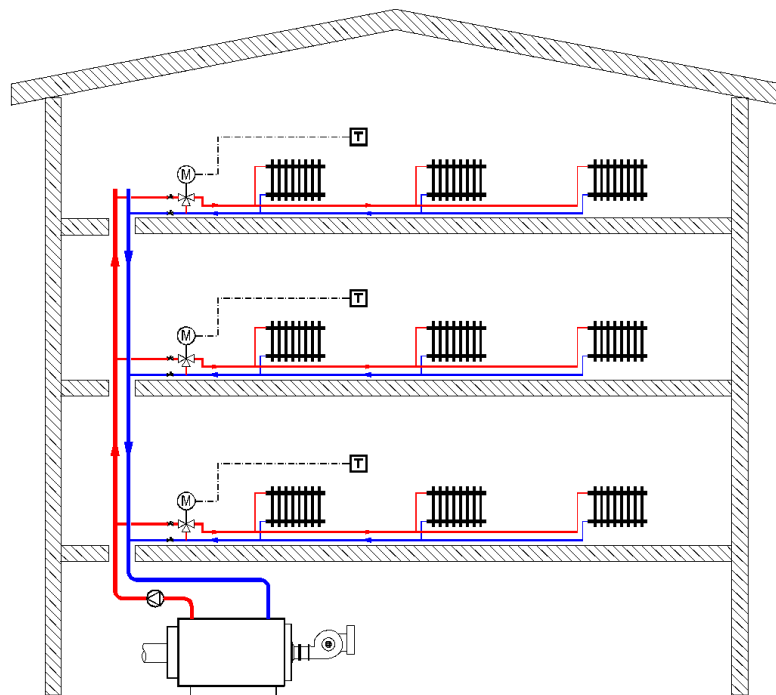


Figure 18 – Horizontal distribution

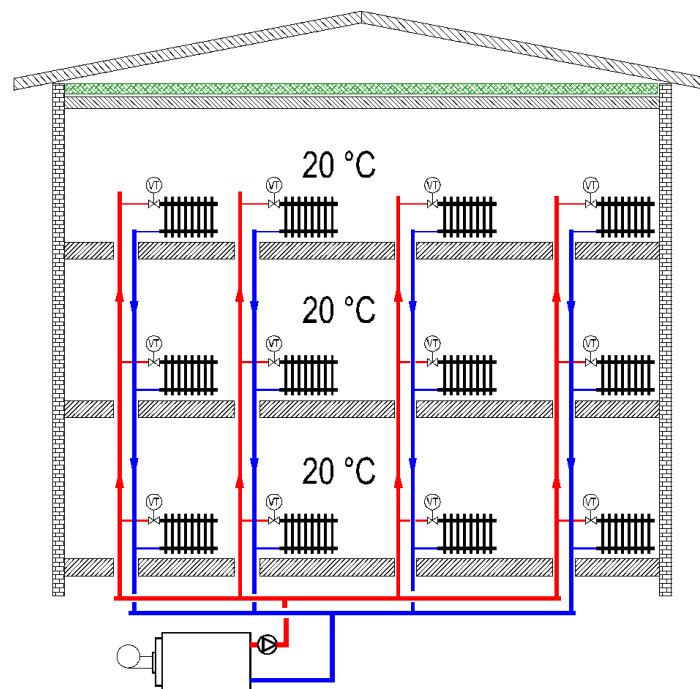


Figure 19 – Vertical distribution

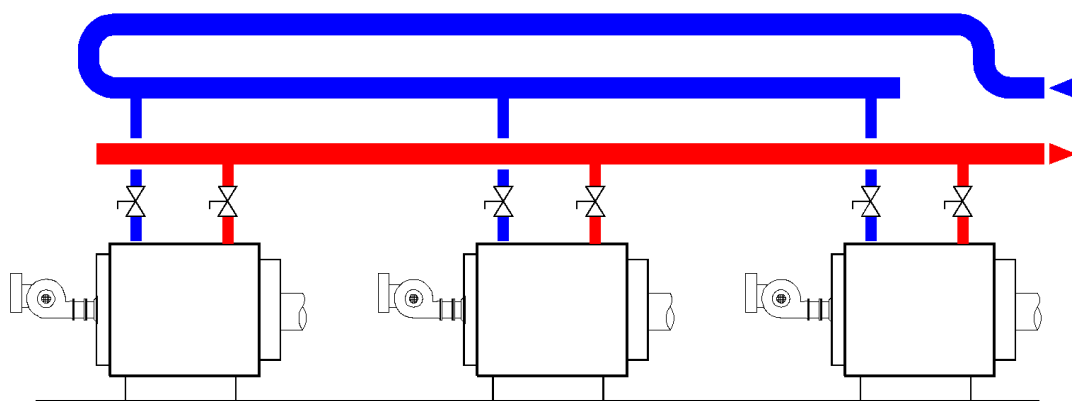


Figure 20 – Tichelman connection

— Double pipe versus single pipe systems

Double pipe is the common system when all radiators are connected in parallel.

Single pipe means that radiators are connected in series.

Single pipe systems are more difficult to balance and generally require higher flow temperatures, which can be an issue for heat pumps.

This distinction usually applies to the connection to the individual terminals.

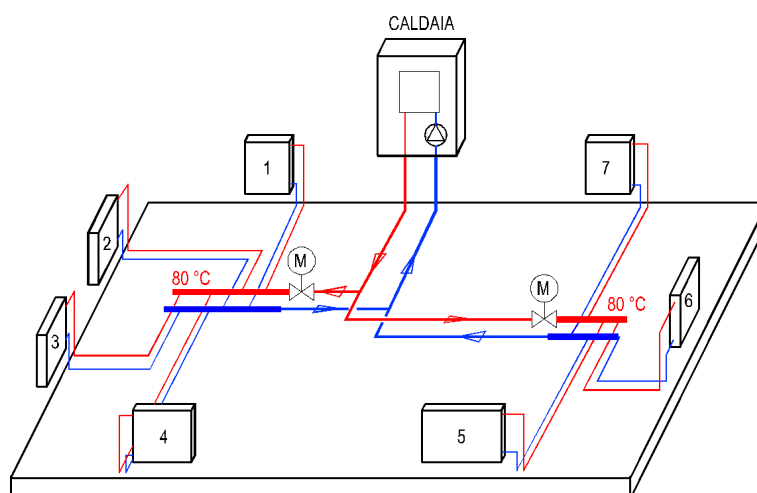


Figure 21 – Double pipe connection

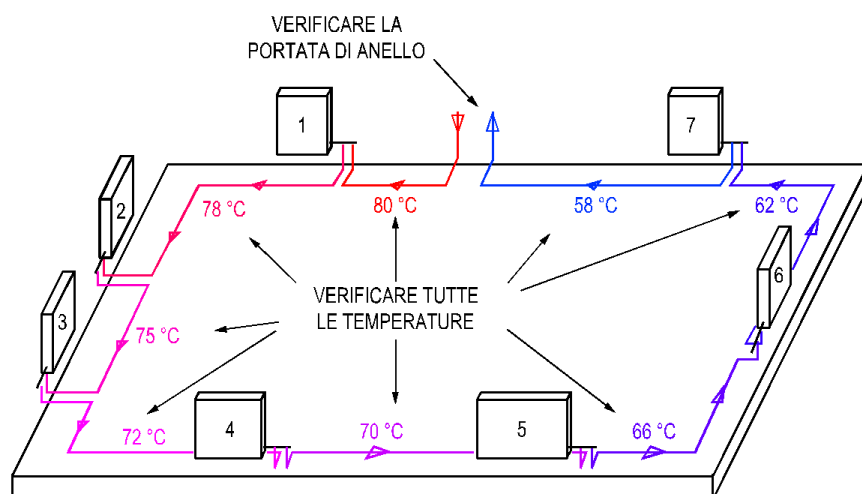


Figure 22 – Single pipe connection

- Layout of the distribution system
- Location of headers and zone collectors

If the detailed method is used, locating the zone distribution collectors allows to estimate the length of the main pipes and of the connections to the heating terminals.

Collectors are usually accessible for maintenance. For embedded emitters, control valves, balancing devices and sometimes local pump are installed on the collector or within the collector niche.

- Identify possible runs

For horizontal distribution type, the pipes are usually running from the main headers in the boiler room to zone collectors and from zone collectors to heating terminals. For very large systems there may be sub headers in local mechanical rooms.

For vertical distribution types, the main distribution line acts as a collector running along the perimeter of the building (some connections maybe also inside the building, for central rooms) and feeds all the raisers. Heating terminals are connected to the raisers, usually one or two per floor. The collectors runs are usually in the basement and are usually exposed. The flow collectors to the raisers may be in the cellar in the olds systems designed for natural circulation.

If the system is in operation, concealed runs can be confirmed by an IR camera.

- Functional diagram of the distribution system

The functional diagram shall have enough details to identify the following features

- Type of emission control of each circuit
 - Direct circuit with 2 way valve
 - Mixing type circuit, with 3 way mixing valve adjusting supply temperature
 - By pass type circuit, with 3 way mixing valve adjusting flow rate

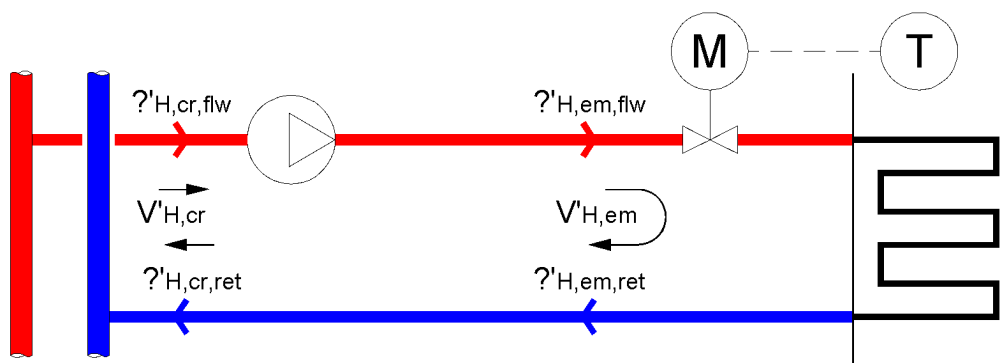


Figure 23 – Direct circuit, no mixing valve

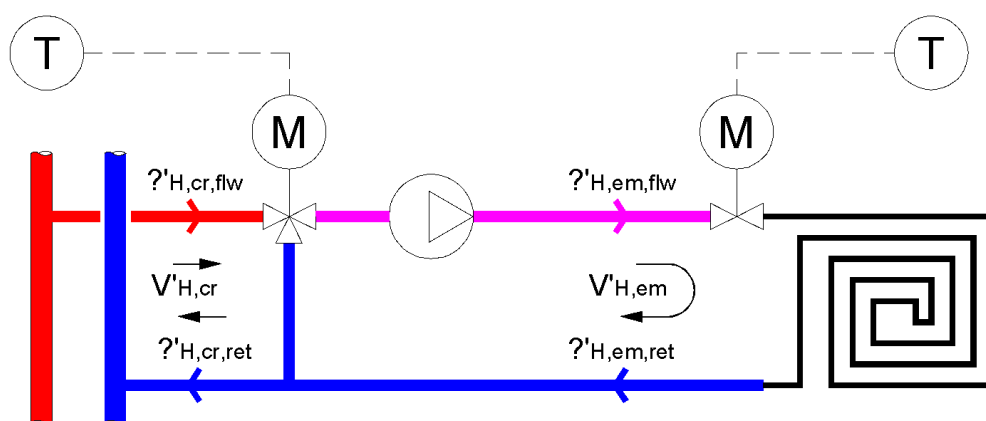


Figure 24 – Mixing type circuit (the pump is after the 3 way valve)

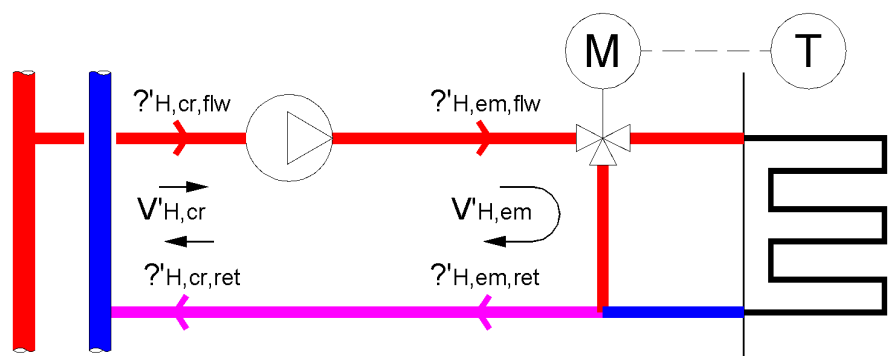


Figure 25 – By pass type circuit (the pump is before the 3 way valve)

- Parallel versus series distribution to heating terminals (double pipe versus single pipe)
- On-off versus modulating control valves
- Common loops
- Connection of generators
 - Parallel connection versus series connection of generators

Parallel connection of generators is the most common. Series connection is used for e.g. hybrid systems with heat pump and boiler.

— Independent flow / direct connection

The direct connection of the generator to the distribution headers forces the circulation of the same flow rate in the distribution and in the generator.

When this is not possible (due to e.g. generator requirements on minimum flow rate), a disconnection header is used to allow different flow rates. Detailed calculation methods take this into account because this can significantly influence flow and return temperature to the generator, which respectively determine the efficiency of heat pumps (flow temperature from the heat pump) and condensing boilers (return temperature to the boiler).

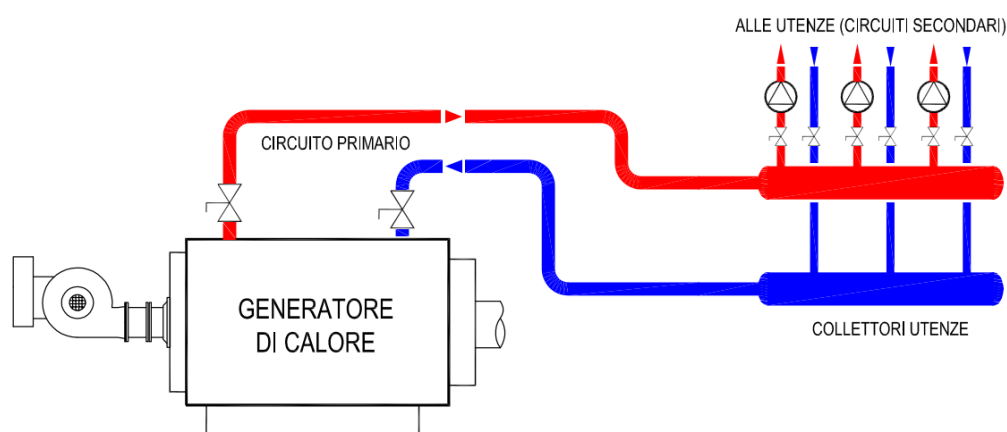


Figure 26 – Direct connection

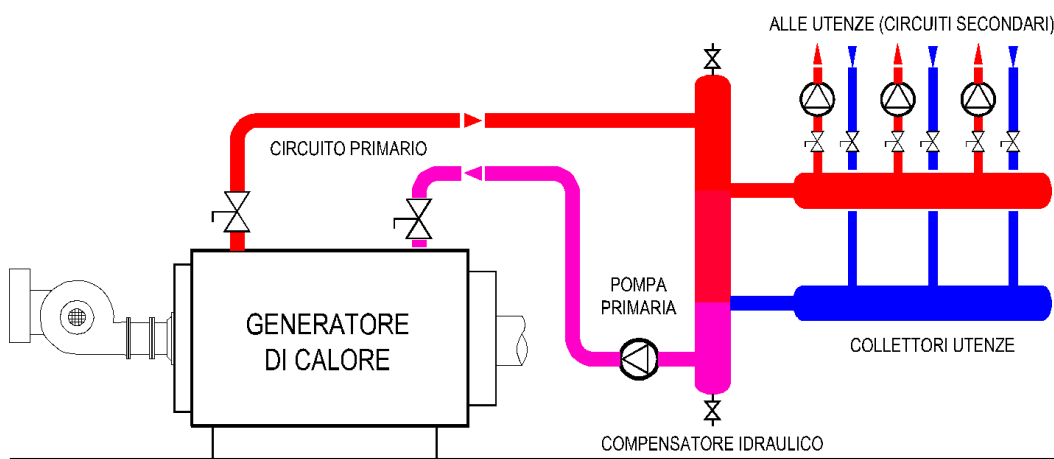


Figure 27 – Independent flow rate

— Length of the pipe runs

If the position of the collectors has been identified, the length of the pipe section can be estimated based on the dimensions of the building. A plan to scale is a good basis.

— Insulation level of pipes

This means identifying both the insulating material and its thickness.

When consulting the data catalogues, have a look at the temperature at which the conductivity is declared. The conductivity increases with temperature; you may need a correction if the average operating temperature is high.

For insulated pipes the linear transmittance is in any case proportional to conductivity whilst the increase of thickness has little influence beyond a limit value (see graph in **figure XX**). As a rule of thumb, the insulation thickness should not exceed the pipe diameter.

The length of non-insulated runs is very important because the heat loss coefficient increases by a factor 5 to 10. Any non insulated component (e.g. pump, filter, valve) shall be treated as an equivalent length of non insulated pipe.

— Temperature regime and control mode of circuits

Temperature regime means the set flow temperature at:

- design outdoor temperature;
- outdoor temperature for heating switchover;

These data should be set and can be read on the control devices.

Control mode of circuits means basically recognising if the heating circuit is hydraulically controlled by:

- a two way valve (e.g. thermostatic valves, two way on-off valves on floor heating collectors);
- a three way by-pass valve (e.g. by-pass control valve on AHU coils, three way zone valve).

This is taken into account in the detailed calculation because:

- in two way valve circuits, closing the valve (part load) decreases both thermal losses (reduced return temperature) and auxiliary energy use (reduced flow rate). Auxiliary energy use may be strongly reduced with correctly set variable speed pumps;
- in three way valve circuits, closing the valve (part load) increases thermal losses (increased return temperature) and auxiliary energy use is approximately constant (also with variable speed pumps because the flow rate in the pump is always the same).

— Pumps

— Rated power

The rated power of the pump is the power indicated on the nameplate. It is often the only data readily available.

However, the rated power is not the absorbed power. It is only the maximum absorbed power in the most demanding operating point (flow rate and head), which is not necessarily the design condition of the assessed system.

A rule of thumb is multiplying the rated power by 0,8 to get the estimated absorbed power in the design conditions.

— Absorbed power in the design point

This is the usual starting point for the calculation of the auxiliary energy use. The absorbed power is multiplied by a factor to take into account variable speed operation (variable speed operation requires a variable flow rate control type and a correctly set variable speed pump) and then by the duration of the calculation interval (e.g. 1 hour, number of hours in the month, number of hours in the bin) to get the auxiliary energy use in the interval,

The absorbed power in the design conditions can be assessed by either of the following methods depending on the available information

- The rough guess is the rule of thumb of the previous item: multiplying the rated power on the nameplate by a statistical “oversizing factor”, typically 0,8.
- The correct value can be read on the pump diagrams if the flow rate and head are known;
- If the pump is recent electronic one and the distribution is operating in design conditions, there is a chance to read the absorbed power on the display of the pump.
- Knowing flow rate and head in design conditions, you can calculate the hydraulic power and then apply an hydraulic efficiency of the pump and an efficiency of the motor to get the absorbed power.

This is what is done in e.g. EN 15316-3 that asks for flow rate and head in design conditions and then takes into account pump class and control mode to estimate the overall efficiency of the pump to get the absorbed electric energy.

- Control settings of the pump

Having an electronic pump installed is not a guarantee that the optimal (minimum) auxiliary energy use will be achieved. It shall be checked that the setting of the pump is consistent with the assumed control mode. The set pressure head shall be correct, then the proportional pressure mode usually achieves the lowest auxiliary power. The constant pressure also allows significant auxiliary energy saving whilst constant flow and constant speed mode do not benefit of part load operation.

- Check pump start and stop function (Only run when there is heat demand)

This is a general rule: check that equipment that shall standby or stay off in given conditions (example: a small system where, if the thermostat is off, the pump and the boiler shall turn-off) this actually happens as expected.

Add functional diagrams and details on the impact of the different solutions □ ONGOING

6.5.3 Input data for the detailed method

6.5.3.1 Functional diagram

The basic functional diagram shall be assessed so that the following can be identified.

- which are the service areas;
- which type of hydraulic circuit is used in each service area;
- which is the structure of the distribution network (how service areas are connected to nodes, how generators are connected to nodes)
- which type of hydraulic circuit is used for each generator

A basic functional diagram is shown in the following figure.

Sample functional diagram

Figure 28 – Direct connection

6.5.3.2 Network layout

The network layout shall be identified on the floor plans to allow estimation of the length of the pipe runs.

6.5.3.3 List of pipes

The list of pipes shall include, for each pipe, the following information.

See annex X for a sample data table to assist data collection.

1. Prepare a list of pipes

Divide the distribution network in a set of homogeneous section of pipes.

A homogeneous section means a stretch of pipes that have the same:

- Diameter;
- insulation characteristics (material, thickness);
- installation type (exposed, embedded into building elements, ...)
- location, with respect to thermal zones.

Then, for each pipe in the list, proceed in determining their properties.

2. Length of the pipe

The concept is obvious but pipes are frequently concealed or embedded into walls and floor slabs.

The length of the pipes can be estimated according to the overall size of the building (should be already known). Place boiler room, headers, main lines, raisers and local collectors on the plan and consider vertical runs to estimate the length of the pipes.

An example is provided in ... (picture with length of the pipes)
Overall size of the building (should be already known)

Place boiler room, headers, main lines, raisers, and local collectors on the plan and consider vertical runs to estimate the length of the pipes.

3. Type of pipe and nominal diameter

The nominal diameter is evidently the next important geometrical information. Both the inner and outer diameter are relevant:

- the outer diameter is the basis for the calculation of the insulation layer;
- the inner diameter is useful to calculate the heat capacity per meter of pipe (volume of water inside the pipe and the of material). This information is used in case of intermittent operation to estimate the total losses during any long shut-off (several hours). For the hourly calculation it also allows to calculate the extra load in the first hour when the system is turned on again.

The following tables indicate some properties of the common types of pipes in use in the heating systems. Steel and copper pipes are well standardised whilst multi-layer pipes sizes are still dependent on the manufacturer, that usually supplies both the pipes and the mechanical joints.

Table 7 – Common pipe diameters

Pipe identification	External diameter D_{ext} mm	Wall thickness s mm	Internal diameter D_{int} mm	Water contents v'_{int} l/m
Steel pipes				
DN10	17,2	2,00	13,2	0,14
DN15	21	2,35	16,3	0,21
DN20	27	2,35	22,3	0,39
DN25	34	2,90	28,2	0,62
DN32	42	2,90	36,2	1,03
DN40	48	2,90	42,2	1,40
DN50	60	3,25	53,5	2,25
DN65	76	3,25	69,5	3,79
DN80	89	3,65	81,7	5,24
DN100	114	3,65	106,7	8,94
DN125	140	3,65	132,7	13,83
DN150	168	3,65	160,7	20,28
Copper pipes				
10 x 1 Cu	10	1,00	8	0,05
12 x 1 Cu	12	1,00	10	0,08
14 x 1 Cu	14	1,00	12	0,11
16 x 1 Cu	16	1,00	14	0,15
18 x 1,5 Cu	18	1,50	15	0,18
22 x 1,5 Cu	22	1,50	19	0,28
28 x 1,5 Cu	28	1,50	25	0,49
32 x 1,5 Cu	32	1,50	29	0,66
Multi-layer plastic pipes				
DN 12	16	3,00	10	0,08
DN 16	20	3,00	14	0,15
DN 20	26	4,00	18	0,25
DN 25	32	5,00	22	0,38
DN 32	40	6,00	28	0,62
DN 40	50	7,50	35	0,96
DN 50	63	9,50	44	1,52

For steel pipes the diameter can be identified by the markings on valves and other components (but be sure that there are no pipe size changes on the connection of the component).

4. Insulation material (if any) and thickness

This is obvious information for insulated pipes.

It is important to identify as well as possible the insulation material. The linear transmittance, hence the losses, are linearly proportional to the conductivity of the material whilst the effect of thickness tends to be non-linear and additional layers beyond a given thickness (roughly the diameter of the pipe) does not provide significant benefit.

If the conductivity is taken from product specification, it is important to correct the value to the (average) operating temperature. Conductivity significantly increases with temperature.

The following graphs shows the linear transmittance of insulated pipes as a function of the insulation thickness and of the diameter of pipes for an assumed conductivity $\lambda=0,040 \text{ W/(m}^2\text{K)}$.

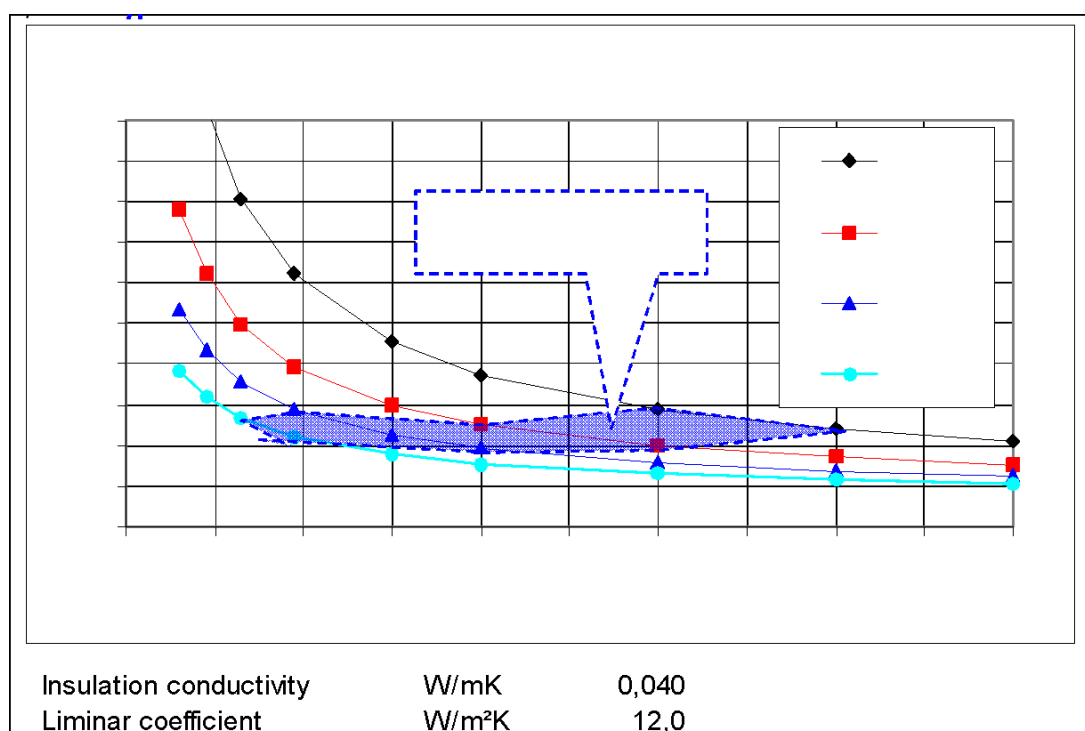


Figure 29 – Linear transmittance of pipes as a function of pipe diameter and insulation thickness

It is evident that the achievable linear transmittance does not depend that much on the pipe diameter. It is hard to reach a lower linear transmittance than $0,2 \text{ W/(m} \cdot \text{K)}$ and still unavoidable insulation defects are not accounted for in the graph in [figure 29](#). Using insulation materials with a lower conductivity (to be confirmed by documentation of the insulation material) a lower linear transmittance can be achieved.

The thickness of the insulating material is usually visible at the connection with equipment and accessories or near the bracings. It can be also be probed with a toothpick.

5. Mounting position in relation to the building elements

The calculation of losses (the equation to use) depends on the mounting position, distinguishing the following basic situations.

— Uninsulated pipes, free to air.

These pipes are calculated like radiators, considering an exponent on the temperature difference. Knowledge (and therefore inspecting and recording data) of the diameter is fundamental because it determines the exposed area and hence the losses.

— Insulated pipes, free to air.

— Buried pipe, single

The calculation of losses of these pipes also depends on:

— The conductivity of the wall where they are buried

— The depth of the pipe within the building element or the ground

— Buried pipe, double

Pipes are running often as couples (flow and return). Besides data for single buried pipes, the calculation of losses of these pipes also depends on the distance between the axes of the two pipes running parallel.

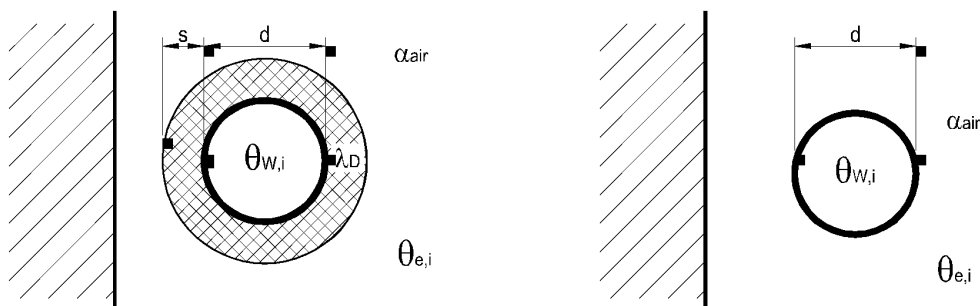


Figure 30 – Mounting positions

Standard geometrical values for embedded pipes are often assumed because it is obviously not practical to uncover pipes and measure.

6. Installation position relative to building envelope insulation and conditioned space

A fundamental aspect for the correct calculation of the distribution system efficiency is evaluating heat recovery. The heat losses of distribution networks are generally very high but the bad effect on efficiency is mitigated when heat losses are recovered. Before being recovered, heat losses shall be recoverable and this depends on the position of the pipes relatively to the insulation of the conditioned space.

The possible situations are the following.

— External pipes.

For outdoor pipes, obviously no losses are recoverable. Full insulation is required and the length of outdoor pipes shall be kept to a minimum.

— Internal pipes.

For indoor pipes, obviously all losses are recoverable. However, losses shall still be really recovered. This depends on two factors:

- the existence of an emission control system that can reduce heat emission in the heated spaces where heat losses occur;
- the heat losses not exceeding the heating needs in the heated spaces where heat losses occur.

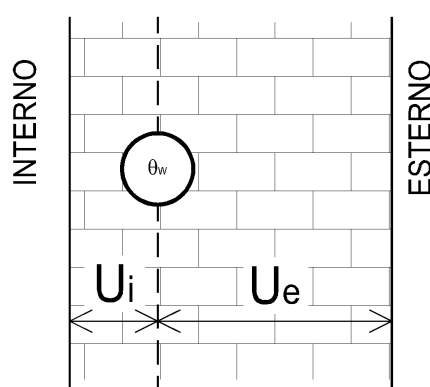
If your calculation method explicitly adds recoverable losses to heat gains, no extra information is needed. For the simplified approach a “recovery factor” will depend on the type of heat emission control.

— Pipes exposed to unheated space

The fraction of recoverable heat is the complement to 1,0 of the b_{tr} factor of the unheated space.

Please note that what matters is the position (indoor / outdoor) of the distribution pipes with respect to the insulation layer of the building envelope. If a pipe is embedded into an external wall or structure:

- if embedded in the outer side it is practically external;
- if embedded in the inner side it is practically interna;
- if there is no insulation layer, then this depends linearly on the embedding position within the wall.



Sample drawing. Show external or internal relative to insulation

Figure 31 – Mounting position relative to heated space

7. Belongs to distribution

In complex systems, there can be several distribution systems. Each pipe shall be linked to a distribution. Then the distribution network will be associated to the relevant system.

8. Length of uninsulated runs

The linear transmittance of uninsulated pipes is 5...10 times higher than that of the same pipe insulated.

Uninsulated shall be identified because if exposed they are good candidate for insulation.

9. Hanger type

Check the type of hangers for a correct insulation of the pipes:

- often the insulation is interrupted on the brackets because the normal insulation materials have no mechanical consistency. This creates an obvious thermal bridge that can be estimated as a length on non-insulated pipe (approximately, the linear transmittance of non-insulated pipes is 5...10 times higher than that of the same pipe, insulated).
- if the bracket is directly fixed on the pipe and insulated, the support acts as a thermal bridge, hard to evaluate.
- The best solution is bracing the pipe and the insulation but this requires special braces or a sufficiently mechanically resistant insulation.

This might result in adding a default correction factor of distribution losses due to hangers type.

10. Temperature regime

Losses depend on the temperature regime of the network.

The input data would be flow and return temperature of the distribution:

- With outdoor design temperature;
- With outdoor heating switchover temperature.

Some calculation methods do calculate the operating temperatures assuming that the installed capacity of heat emitters is equal to the heat load of the building. If so, no additional input data would be required but:

- you may wish to check that the calculated operating temperature makes sense;
- you may need to know the size of heat emitters if you know they were intentionally (over)sized to achieve a defined operating temperature or the building has been insulated and the emitters were designed according to the heat load before the additional insulation was applied.

11. Flow rate at design conditions

The flow rate in design conditions in each part of a distribution system should be available in the design documentation. If this information is not available, it can be estimated in the following ways.

- If the power of connected heating terminals is known, then the flow rate can be determined using a design temperature difference. Rule of thumb values of the temperature difference are:
- embedded panels: 5...7 °C
- fan-coils: 5...8°C
- radiators without thermostatic valves: 10 °C.
- radiators with thermostatic valves: 20 °C
- connexion of heat pumps and chillers: 5°C.
- Based on the diameter of the pipe, assuming a head loss of 250 Pa/m (25 mm water gauge per meter), the flow rate and the corresponding power based on $\Delta\theta$ are given in table 8.

Table 8 – Expected flow rate and transported power for main pipes

Pipe identification	Internal diameter	Water velocity @ 250 Pa/m	Flow rate @ 250 Pa/m	Φ with $\Delta\theta=5^\circ\text{C}$	Φ with $\Delta\theta=10^\circ\text{C}$	Φ with $\Delta\theta=20^\circ\text{C}$
	Dint mm	v m/s	V' m ³ /h	kW	kW	kW
Steel pipes						
DN10	13,2	0,4	0,20	1,1	2,3	5
DN15	16,3	0,48	0,36	2,1	4,2	8
DN20	22,3	0,58	0,82	4,7	9,5	19
DN25	28,2	0,68	1,53	8,9	18	35

Pipe identification	Internal diameter	Water velocity @ 250 Pa/m	Flow rate @ 250 Pa/m	Φ with $\Delta\theta=5^{\circ}\text{C}$	Φ with $\Delta\theta=10^{\circ}\text{C}$	Φ with $\Delta\theta=20^{\circ}\text{C}$
	Dint mm	v m/s	V' m ³ /h	kW	kW	kW
DN32	36,2	0,82	3,04	18	35	70
DN40	42,2	0,9	4,53	26	53	105
DN50	53,5	1,06	8,58	50	100	199
DN65	69,5	1,24	16,93	98	196	393
DN80	81,7	1,38	26,04	151	302	604
DN100	106,7	1,63	52,47	304	609	1.217
DN125	132,7	1,88	93,60	543	1.086	2.172
DN150	160,7	2,12	154,79	898	1.796	3.591
Copper pipes						
10 x 1 Cu	8	0,32	0,06	0,3	0,7	1,3
12 x 1 Cu	10	0,37	0,10	0,6	1,2	2,4
14 x 1 Cu	12	0,42	0,17	1,0	2,0	4,0
16 x 1 Cu	14	0,47	0,26	1,5	3,0	6,0
18 x 1,5 Cu	15	0,5	0,32	1,8	3,7	7,4
22 x 1,5 Cu	19	0,59	0,60	3,5	7,0	14
28 x 1,5 Cu	25	0,71	1,25	7,3	15	29
32 x 1,5 Cu	29	0,78	1,85	11	22	43
Multi-layer plastic pipes						
Multilayer 16 x 2,0	12	0,42	0,17	1,0	2,0	4,0
Multilayer 18 x 2,0	14	0,47	0,26	1,5	3,0	6,0
Multilayer 20 x 2,0	16	0,52	0,38	2,2	4,4	9
Multilayer 26 x 3,0	20	0,61	0,69	4,0	8,0	16
Multilayer 32 x 3,0	26	0,73	1,40	8,1	16	32
Multilayer 40 x 3,5	33	0,86	2,65	15	31	61
Multilayer 50 x 4,0	42	1	4,99	29	58	116
Multilayer 63 x 4,5	54	1,19	9,81	57	114	228

NOTE 1: depending on the country and local practices, the acceptable head losses may range from 200 to 300 Pa/m.

NOTE 2: This is a rough estimation, based on common design practice. The estimation is valid for the main pipes. It is not reliable for the pipes connecting e.g. single heating terminals to the header or the zone collector.

12. Head loss in design conditions

Expand clause

The head loss in design conditions in each part of a distribution system should be available in the design documentation.

- If it is not available it can be roughly estimated as the sum of: The head loss of pipes, that are given by 200...300 Pa/m, depending on local practices

The head loss of special components given in table 9.

Table 9 – Expected head loss for individual components

Description	Head loss		Notes
	Pa	m w.g.	
Large volume boiler	0	0	0 means negligible in this context
Low water contents boiler	20000	2,0	These boilers require a high water velocity
Heat pump	20000	2,0	
Heat exchanger	20000...60000	2,0...6,0	The nominal head loss should appear on the nameplate
Hydraulic compensator	0	0	
Filter	10000	1	
Heat meter	10000...20000	1,0...2,0	
Control valve	20000...40000	2,0...4,0	This value is referred to the design condition. The head loss on the control valve increases at low load

6.5.4 Simplified method

Several MS use simplified methods based on tabulated values of either

- efficiencies;
- expenditure factors;
- loss factors.

Please check your national calculation procedure and identify your distribution network type in the list.

Additional information (like temperature level of the network) may be required nationally

Some countries allow for both detailed and simplified tabular methods. If so, pay attention to the boundary conditions of the simplified method (i.e. when it is applicable).

Use the simplified method only if the boundary conditions are fully met.

Please note that the detailed calculation is more flexible in that it allows to calculate virtually any distribution network but it is not necessarily more precise than simplified methods. If a simplified method is well designed and boundary conditions are well defined there is no advantage in using a detailed method when the simplified method is applicable.

6.5.5 Additional information

6.5.5.1 EPC

See clause XXX on simplified methods

The recommendation to insulate accessible uninsulated pipes is generally very cost effective.

Example An uninsulated pipe may have a linear transmittance around 1,5 W/(m·K)
 When insulated, the same may have a linear transmittance around 0,3 W/(m·K) (see figure XX)
 If the system is operating 4000 hours/year (a heating season in mild climate) at an average temperature

of 50 °C in an environment at 20 °C, the expected saving on losses is given by:

$$4000 \text{ h} \times (50^{\circ}\text{C} - 20^{\circ}\text{C}) \times (1,5 \text{ W}/(\text{m}\cdot\text{K}) - 0,3 \text{ W}/(\text{m}\cdot\text{K})) = 144 \text{ kWh/m}$$

If you take into account heat recovery and the cost of heat, you can estimate the economic return.

The replacement of the distribution network is expensive and invasive. It can be recommended together with the insulation of an existing old building envelope if the distribution network is very old and approaches end of useful life.

6.5.5.2 RP

The age of the distribution network may suggest that the replacement of the distribution network can be soon necessary. The useful lifespan of a distribution network also depends on the history of water quality. Age only is not enough to assess the remaining life-span of a distribution network.

Check if make-up water quantity is under control (there is a meter and it is regularly checked) and that the make-up water is at least softened. This requires not only that a softener be in the boiler room but that it is operated and maintained correctly and consumables (salt) are regularly refilled.

Another index of poor status of the distribution network is tenants and O&M staff reporting leaks (corrosion is breaking through) and areas where the heating is not working well (often caused by heavy incrustations), both symptoms of poor control of water quality.

6.5.5.3 SRI

Table 10 shows the functions related to the heating distribution with their levels.

Table 10 – SRI Functions related to heating distribution

FUNCTIONALITY		LEVEL	
H-1c	Control of distribution fluid temperature (supply or return air flow or water flow) - Similar function can be applied to the control of direct electric heating networks	☐ ____%	No automatic control
		☐ ____%	Outside temperature compensated control
		☐ ____%	Demand based control
H-1d	Control of distribution pumps in networks	☐ ____%	No automatic control
		☐ ____%	On off control
		☐ ____%	Multi-Stage control
		☐ ____%	Variable speed pump control (pump unit (internal) estimations)
		☐ ____%	Variable speed pump control (external demand signal)

6.5.5.4 Inspection

The inspection of the distribution shall focus on

- missing insulation
- sizing and setting of pumps.

Check the setting of electronic pumps. As a minimum the following shall be set

- Operating mode
- Constant speed (only for constant flow rate circuits)
- Constant pressure (multiple branches, little common head losses)
- Proportional pressure (multiple branches, high common head losses)
- Constant DT (primary circuits)
- Constant flow rate (special circuits)
- Head setting, according to the estimated losses
- Operation time

6.5.6 Tips and tricks

A hot boiler room or mechanical room is a symptom of high losses.

Look at the outdoor temperature reset setting to understand operating temperature.

If the system is running, use an IR camera to locate concealed pipes.

Use the rule of thumb given in **clauses XXX** to estimate flow rate and required head (sum of heat losses) to check pump sizing and verify settings.

Electronic pumps are often oversized and set with too high head setting and sometimes a wrong control type is selected.

6.6 Storage

6.6.1 Introduction

On heating systems, the storage is used:

- either to protect the boiler when the release of heat cannot be readily interrupted, like some biomass boilers;
- or to limit the frequency of start-up during on-off operation (biomass boilers and heat pumps).

They are very seldom used with fossil fuel boilers.

A minimum water storage volume is always required for AW and WW heat pumps and biomass boilers. A too low storage volume has safety (biomass boilers), functionality, and efficiency issues. It must be stressed that only the volume “available to the generator” counts for this purpose, that is the volume of water that cannot be intercepted by any control device. The volume of water of the distribution and heating terminals doesn't count if there are control valves.

6.6.2 What to look at

Heat losses from a storage vessel depend on:

- exposed surface;
- insulation of the exposed surface;
- temperature regime inside the storage vessel and around it.

The exposed surface is related to the size of the storage vessel. This relationship is not linear because:

- the volume of the vessel is proportional to the cube of the size;
- the exposed area is proportional to the square of the size.

This means that storage heat losses are relatively higher on smaller vessels.

The insulation level of the surface is its U-value, just like a wall. Just like walls, the insulation of a storage vessel has its thermal bridges: all connected pipes and all portholes for sensors, devices and additional connections. So you should look at:

- the type of insulating material, which is often visible near connections;
- the thickness of the insulating material;
- all uninsulated portholes;
- connecting pipes without a downward syphon (see input data below for more info on this topic).

For heating systems, the temperature regime inside the storage vessel is the same as the temperature regime of the circuit to which it is connected.

On the outside, the temperature and the possibility to recover losses depend on the location where the storage is installed, which has to be specified as being either:

- outdoors;
- in a boiler room;
- in a space belonging to a thermal zone;
- in an unheated space, adjacent to a thermal zone.

6.6.3 Input data

Most of the calculation methods require in one way or another the heat loss coefficient of the storage vessel in W/K. There are two ways of getting this information:

- by reading the storage vessel label;
- by estimating it according to vessel size and insulation properties (this method may be part of the calculation method).

If the storage vessel is CE marked and the energy label available, then the losses in Watts Φ_{40} under 40 °C temperature difference between the inside and outside of the vessel can be read on it. The heat loss coefficient H_{sto} in W/K is given by:

$$H_{sto} = \Phi_{40} / 40 \text{ °C}$$

The software may ask directly the power of losses.

If the storage vessel is old (or the label information is not found), the heat loss coefficient can be estimated knowing (it assumed that the shape of the storage is a cylinder);

- the diameter D of the vessel in m;
- the height H of the vessel in m;
- the thickness s of the insulation material in m;

— the type of insulation material, hence its conductivity λ in $W/(m \cdot K)$;

Then the heat loss coefficient H_{sto} is given by:

$$H_{sto} = \left(2 \cdot \frac{\pi \cdot D^2}{4} + \pi \cdot D \cdot H \right) \cdot \frac{\lambda}{s} \quad (6)$$

Both the label information and this estimation assume that the insulation is perfect and they neglect the effect of any uninsulated porthole for sensors and devices.

If the new EN 15316-5:2025 is used, then additional data is required to divide the storage into a number of layers. For each layer the following information is required:

- volume or height of the layer or fraction of the total volume;
- connections to that layer, that may be any one or several of:
 - heat supply;
 - heat output to space heating;
 - back-up heater;

and more for domestic hot water or combined storage.

For domestic hot water storage, the effect of connected pipes should be considered. See **clause XXX** about domestic hot water storage for more details.

NOTE: The heat storage losses are sometimes included in the generator losses, like direct electric domestic hot water heaters.

6.6.4 Additional information

6.6.4.1 EPC

No additional information is required.

6.6.4.2 RP

If the proposed renovation includes a hydronic heat pump or a biomass combustion boiler, a storage will be required for the space heating service. Check if the required space is available.

6.6.4.3 SRI

If the storage is intended (sized) to allow significant load shift of the heating service, then the following function apply.

Table 11 – SRI Functions related to space heating thermal energy storage

FUNCTIONALITY	LEVEL
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H-1f Thermal Energy Storage (TES) for building heating (excluding TABS)	☐ ____% Not applicable: no significant space heating storage ☐ ____% Continuous storage operation ☐ ____% Time-scheduled storage operation ☐ ____% Load prediction based storage operation ☐ ____% Heat storage capable of flexible control through grid signals (e.g. DSM)
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6.6.4.4 Inspection

The inspection will focus on the insulation level of the storage. If the insulation thickness is low, it can be recommended to reinforce the storage insulation by adding additional layers of insulating materials. Feasibility and ease of application of additional layer shall be evaluated.

6.7 Generation**6.7.1 Introduction**

There are two main technologies for heat generation:

- boiler (combustion);
- heat pump;

and additional complementary solutions:

- district heating, meaning that generation of heat is outside the building;
- stoves, inserts and fireplaces;
- cogeneration;
- direct electric heating.

and often a combination of them.

Combustion boiler is a mature technology, with relatively stable performances for modern condensing boilers.

When natural gas is available, the only limitation to the use of a condensing boiler is the suitability of the flue gas exhaust system, that shall allow wet operation and condensate drain.

The applicability of combustion technology will be limited by the availability of renewable and carbon-free fuels since fossil fuels should be phased out in Europe.

Heat pumps are potentially high efficiency machines but their performance, both in terms of efficiency and maximum capacity, are extremely sensitive to operating conditions (1...3% per °C of source and/or sink temperature change). Also, the initial purchase cost of a heat pump (cost per kW) and the installation cost for ground coupled heat exchangers are still quite high compared to boilers.

District heating is subject to local availability. The installation inside the building consists in a heat exchanger, which has the same function as the boiler. The efficiency depends on the heat generation process at the heat supplier site.

Stoves and fireplaces are used mainly as local heaters. Adding an insert may enable a fireplace to contribute to the heating system and some stoves also provide the possibility to connect to a water based system.

Cogeneration is maintenance intensive and requires simultaneous heat and electric loads to be fully effective. Indeed, it is a combustion based technology and in the future its applicability will be limited by the availability of renewable and carbon-free fuels.

Direct electric heating, being a low exergy-efficiency use (it is equivalent to a heat pump with COP 1,0), is used as a back-up generation or to supply localised small loads (hand washing in an office restroom) that do not justify the installation of long networks and or expensive devices.

6.7.2 Combustion boiler

6.7.2.1 What to look at

When evaluating a combustion boiler, you should look at:

- make and model;
- type of fuel;
- maximum capacity;
- combustion technology;
- type of power control;
- condensing / non condensing;
- combustion efficiency;
- insulation level of boiler casing and stand-by losses.

Make and model allows you to search the internet for the technical specifications of the boiler.

The **type of fuel** used:

- determines the weighting factors of the fuel used;
- determines the available combustion technologies.

The **maximum capacity** defines the size of the boiler. Compared to the applied load and taking into account the power modulation type and range (turndown ratio), it determines the impact of the sizing relative to the load on the energy performance.

The **combustion technology** is a property of the “burner”. The suitable combustion technology depends on the fuel and it impacts the achievable efficiency, modulating range, polluting emissions and more. The main combustion technologies currently in use are the following.

- Atmospheric combustion (natural draught).

These boilers do not have a combustion air fan. Combustion air is moved by natural draught in the chimney. It is the oldest and simplest technology, very popular for gas in the past. It has a low efficiency, only the fuel flow rate can be modulated and there are high stand-by losses. It often causes safety concerns as well.

It is a candidate for quick replacement.

- Forced draught (fan on flue gas)

These boilers have a combustion air fan on the exhaust gas. This technology has been popular in the past for individual gas boilers. The efficiency is still low and modulating capability is low.

— Blown air (fan on combustion air)

This has been the classic burner plus boiler solution in the last decades, for all types of fuels. Capacity control can be on-off, staged and modulating. This technology is suitable for gas condensing boilers.

This is state of the art combustion technology for liquid fuels.

NOTE: as opposed to pre-mix technology, air and fuel are mixed directly in the flame.

— Premix (gas and air are mixed before entering the burner head and the flame).

This is the current state-of-the-art combustion technology for gaseous fuels. It allows high efficiency, low noise, high modulating range, low NOx emission.

— Special technologies for solid fuels.

There are several technologies to burn solid fuels with the lowest possible polluting emissions (e.g. inverted flame, distillation). The aim of the development to limit polluting emissions.

The **power modulation type** has an impact on the energy performance at low loads, that is most of the operating time of a boiler. The power modulation can be:

— On-Off type: no modulation is possible; the boiler is always running at maximum capacity when ON.

— Staged modulation type: the burner allows continuous operations at minimum or maximum capacity. Sometimes, additional intermediate stages can be available.

— Modulating type: the burner allows continuous operation at any capacity between a minimum and a maximum.

Both staged modulation and modulating burners operate on-off when the load is less than the minimum capacity.

Condensing boilers can operate with flue gas temperature below dew point (around 56 °C) and recover part of the latent heat of the humidity contents of the flue gas. Please note that a condensing boiler is not a boiler that do condense the humidity in the flue gas but only a boiler that allows condensation of humidity of flue gas. Condensation happens only insofar operating conditions are suitable (low return water temperature to the boiler and low power operation). Regarding condensation capability, EU classifies boilers in three types:

— standard boilers, which do not allow condensation.

— low temperature boilers, which allow operation a low water temperature but there is no condensation (meaning... a boiler preventing condensation).

— condensing boilers.

This classification is indicated in the label of the boiler and is always asked as a property of the boiler for energy performance calculation.

Condensation is common practice for gaseous fuels. For liquid fuels, condensate is much more corrosive and special materials are required for the boiler and the chimney.

Condensation boilers can be installed only if the chimney or the flue gas exhaust is suitable for condensation, meaning that:

— wet operation is allowed;

— materials are resistant to corrosion by condensate;

— a condensate drain is provided;

- freezing of condensate is avoided (insulation of the chimney) or excluded (external air temperature is never below 0°C).

Combustion efficiency is measured during maintenance and is often reported on maintenance logs. It gives an idea of the efficiency of the boiler when operating continuously. Assuming that excess air is decently set (O_2 not higher than 6%), the main factor is flue gas temperature raise. Every 20 °C temperature raise of the flue gas compared to intake air is 1% efficiency lost.

The **insulation level** of the casing is obviously relevant for the energy performance of the boiler. Envelope losses of the boiler shall be subtracted from the combustion efficiency to get net efficiency when the burner is on. If the burner operates on-off, envelope losses plus losses through the chimney during off mode (stand-by losses) may severely impact the seasonal efficiency of oversized boilers.

For large installations, several boilers may be installed in parallel for a number of reasons:

- reliability of heat generation;
- increasing the modulating range (by reducing the minimum capacity when on)
- reaching the desired capacity
- other reasons

If several boilers are installed:

- they may be identical but sometimes they are not
- check if there is any kind of cascade control
- check if there are automatic valves or other provisions to cut water circulation in stand-by boilers

NOTE “Modular boilers” are boilers that are natively designed by the manufacturer to be installed in arrays to reach the required capacity. From the point of view of energy efficiency, modular boilers are the same as boilers in parallel.

6.7.2.2 Input data

The input data depends on your national method.

If you are using EN 15316-4-2:2017 the required input data are the following.

- Fuel type.
This is obvious from observation of the burner. On systems where continuous operation is critical (e.g. hospital), a boiler may have a dual fuel feed. Note only the normal operation fuel.
- Type of boiler
Check if the boiler is standard, low temperature or condensing.
- Nominal (maximum) output power.
EN 15316-4-2:2017 requires the nominal output power at 60/80 °C operating temperature.
The nominal power is usually indicated on the nameplate of the boiler.
Be aware that the nameplate may also display:
- maximum input power to the boiler;
- maximum output power in other test conditions (e.g. 30/50 °C).

- The test data according to Ecolabeling, namely:
- net efficiency at full load and 60/80 °C operation;
- net efficiency at part load (30% of full load) and 50/30 °C operation;
- optionally for condensing boilers, net efficiency at full load and 50/30 °C operation;
- auxiliary energy use (power) at full load, 30% load and stand-by.

Some of them may be found on the nameplate but it is not always the case. If they are not found, these data can be found in the office, based on make an model of the boiler, on the website of the manufacturer.

- Installation room of the boiler

This impacts both the amount of losses (temperature around the boiler) and the possibility to recover heat losses.

If you are still using EN 15316-4-2:2007, boiler cycling method, then the input data consist of:

- combustion efficiency data, that you will find on maintenance report;
- qualitative information on envelope losses and losses through the chimney with burner off;
- data on auxiliary power;
- for condensing boilers, the temperature difference in °C between
 - the temperature of flue gas leaving the boiler;
 - the temperature of water returning to the boilerat both maximum and minimum load.

This method is still useful for boilers without CE marking and for a quick estimation of seasonal efficiency during inspections (see EN 15378-3).

If you are using EN 15316-4-8:2017 for radiant heaters and stoves, then the input data consist of:

- combustion efficiency data, that you will find on maintenance report;
- qualitative information on envelope losses and losses through the chimney with burner off
- data on auxiliary power.

6.7.2.3 Special case: centralised systems and building unit performance

If the EPC has to be issued per building unit and there is a centralised heating system, a share of the common boiler (and common distribution) has to be attributed to the assessed object. The general rule is to assume:

- for all intensive values (e.g. temperature, pressure, velocity), the same value as the centralised boiler;
- for all extensive values (e.g. power, energy, flow rate), a share of the value for the common subsystem.

The share shall be based on a unique suitable criteria. Typical criteria are:

- floor area;
- heat load;

- energy need.

Check on your local regulation which is suitable.

6.7.2.4 Additional info

6.7.2.4.1 EPC

A common suggestion is replacing an old boiler with a new gas condensing boiler.

NOTE Ecodesign directive only allows condensing boilers on the EU market.

The following aspects shall be considered when recommending and installing a condensing boiler.

- Check that the flue gas system allows wet operation. If not, it has to be upgraded as well.
- Instead of replacing the boiler, a condensing heat exchanger may be added on the flue gas exhaust. If so, check that the boiler fan has enough pressure head to overcome additional pressure losses.
- Check system operation and try to minimise return temperature to the boiler to increase condensate heat recovery.
- Provide a condensate drain system. Check your local regulation about condensate disposal for possible requirements on condensate neutralisation.
- Condensing boilers are made of materials (aluminium alloy or stainless steel) which are sensitive to water quality. Check water treatment and for large and old systems, separation may be required using a heat exchanger.

6.7.2.4.2 RP

For the purpose of the renovation passport, additional information is required to evaluate the cost and ensure the feasibility of the replacement of a fossil fuel boiler with another heat generation technology.

The main alternatives for the replacement are:

- replacing the boiler with a heat pump;
- switching to a renewable fuel (e.g. biomass);
- connecting to an efficient district heating.

In all cases, if the boiler has a short remaining expected lifespan, when replacing the boiler you have to consider moving one step towards the zero emission building. The age only of the boiler is not an indication of the remaining lifespan. If well maintained, the efficiency of a boiler is stable with time. The useful life of a boiler may well be several decades and a premature end is rather triggered by:

- poor maintenance, leading to structural issues (leaks), corrosion, scaling and other failures;
- excessive on-off cycling of the burner (oversized boiler or wrong control settings);
- increased failure rate of old components;
- unavailable spare parts.

Always check for available space in or near the boiler room. If a heat pump is recommended, you have to find space for the outdoor unit of a split unit. With emerging refrigerant like R290, the heat pump will be monoblock and installed outdoor. So you need:

- space outside the boiler room for the external unit or the whole heat pump;
- space inside the boiler room for the indoor unit and the technical and domestic hot water storage.

6.7.2.4.3 SRI

The following functions apply to combustion heat generation.

Table 12 – SRI Functions related to combustion generation subsystem

FUNCTIONALITY		LEVEL	
H-2a	Heat generator control (all except heat pumps)	☐ ____%	Constant temperature control
		☐ ____%	Variable temperature control depending on outdoor temperature
		☐ ____%	Variable temperature control depending on the load (e.g. depending on supply water temperature set point)

6.7.2.4.4 Inspection

Combustion technology

For the inspection purpose, please refer to EN 15378-3.

Boiler inspection will require a flue gas analysis and the collection of data to estimate the seasonal efficiency.

Check the suitability of other technologies. The most likely candidate is heat pump. See clause XXX about pre-conditions to install a heat pump in a building. The inspection report shall also inform if the boiler is oversized. The easiest way is comparing the measured energy use with the method indicated in **EN 15378-3 clause....**

Check whether the boiler/boiler room is operating in fully automatic mode, in a mode with regular checks by qualified personnel, or with the need for constant qualified personnel (this applies mainly to boiler rooms with a certain minimum output).

6.7.2.5 Tips and tricks

Maybe move here some of the considerations on the clauses before, like chimney and how to condense.

6.7.3 Heat pump**6.7.3.1 What to look at**

When evaluating a heat pump, you should look at:

- make and model;
- type of source and sink of the heat pump;
- heat pumping technology;
- type of capacity control;
- installation of the heat pump;
- hydraulic connection and circuits;

- control settings.

Make and model allows you to search the internet for the technical specifications of the heat pump. You will very seldom find technical information and data-sheets on-site.

Be very careful when looking for performance data. Heat pump are potentially very efficient machines but their performance, both efficiency and capacity are dramatically dependent on operating conditions, namely:

- source temperature;
- sink temperature;
- part load operation.

When reporting/reading any performance data (e.g. COP, capacity, auxiliary energy use), always indicate/check the corresponding source temperature, sink temperature and part load. Without this information, COP and capacity information is void.

There is a standard notation for that and you may found information like: “COP A7W35 = 4,8”. Unfortunately, this is incomplete information because you are told that

- the heat pump is of the air to water type
- the COP is 4,8 with air (source) temperature = 7°C and leaving water (sink) temperature = 35 °C
- ... but there is no info about at which part load this COP was measured, which could be e.g.:
- maximum capacity with the given source and sink temperature;
- optimum part load for efficiency, which is usually around 60% load;
- minimum continuous operation capacity at A7W35.

This is not surprising. Standardisation on heat pumps is far from complete and settled. Just to mention a couple of facts:

- “nominal capacity” is just “the capacity declared by the manufacturer” (see EN 14511) and not the “maximum capacity” as one may think, since this is the usual convention for most components.
- There is no definition of neither “full load” nor “part load”. The PLR defined in EN 14825 is not the part load of the heat pump, it is only a climatic part load.

There is a huge variety of **types of heat pumps**, depending on the type of source and sink.

- AW (Air--to-Water) is a quite common type, especially in combination with floor heating (or embedded air terminals).
- AA (Air-to-Air) is also a common type. A room air conditioner in heating mode is an air to air heat pump. VRF and VRV systems are air to air heat pumps.
- WW (Water to-Water or Brine to Water) is used when the source is water or a ground heat exchanger.
- WA (Water to air or Brine to air) is seldom the case.
- Mixed air, are air to water or air to air heat pumps using as a source a mixture of outdoor air and indoor air.

- Exhaust air heat pumps are using only air extracted from the heated space. They act as a simple duct extraction type ventilation system.

For water source heat pumps, determine the type of heat capture circuit.

- Vertical or horizontal ground coupled heat exchanger.

The risk is the long term drift of the ground temperature around the heat exchanger.

- Surface water or ground water, often via a heat exchanger.

The concern can be the electric energy use for the heat capture circuit, which is not included in the declared COP of the heat pump and can be very significant.

Check the length of the heat capture circuit and the depth of the water table.

And new typologies are often developing and appearing on the market, such as:

- solar assisted heat pumps, using a solar collector as a source;
- water loop heat pumps, using a primary loop as a source or sink
- four pipes heat pumps (or full recovery heat pumps), capable of providing simultaneous heating and cooling.

The type of heat pump is important because each type requires a specific calculation method. Very often, the national and regional calculation methods only cover the most common types in the respective country.

The most common **heat pumping technology** is a refrigerant compression cycle driven by an electric motor ("electric heat pump"). However there are still some application niches for

- absorption heat pumps;
- combustion engine driven heat pumps;

that require special calculation methods.

The most common type of **capacity control** is modulating ("inverter type" heat pumps). Some on-off heat pumps are still used and on large units with several compressors, staged modulation is common.

The **installation of the heat pump** is not an input data but a wrong installation may lead to severe malfunctioning. For air source heat pumps, check that the outdoor unit is free to get fresh air and no short circuit occurs. Also water connection should allow enough flow rate. A common mistake is a restriction that prevents enough water flow rate in the condenser. These checks are especially important for IR purpose but a quick look is useful indeed.

Hydraulic connection and circuits shall be accurately described because this will be the input to the calculation of operating conditions, which determine the performance even more than the choice of the make and model of the machine.

For the same reason **control settings** shall be checked. A typical mistake is running a heat pump at constant temperature instead of using an outdoor temperature reset to minimize the required leaving water temperature. The effect of such a setting is easily calculated and the sensitivity is 2...3 % efficiency loss per single 1 °C of increased leaving water temperature. So, only 4°C more is 10% efficiency loss.

All that has been listed in this clause will mostly determine the calculation method or may decide the selection of a value for tabulated methods.

6.7.3.2 Input data

The input data is strongly dependent on your calculation methods.

- First you will be asked the qualitative information listed in the previous **clause** 6.7.3.1.
- Then you are likely to go to the data-sheet of the heat pump, based on make and model, to find the **energy performance data**.
Typical data sets in use in the various calculation methods are the following.
- **Maximum capacity and COP at maximum capacity in one operating condition** (source and sink temperature, depending on source and sink type) are required.

Then

- the COP at maximum capacity for other source and sink temperature are extrapolated via default coefficients
- the effect of part load is taken into account by default correction curves.
- **Maximum capacity and COP at maximum capacity are required for a set of operating conditions** (couples of source and sink temperature).

Then

- the COP at maximum capacity for the actual source and sink temperature is interpolated or extrapolated from nearest known conditions;
- the effect of part load is taken into account by default correction curves.
- **EN 14825 data** in test points A, B, C, D and E are used to identify the correlation between exergy efficiency (or refrigerant cycle efficiency) and a main variable (evaporation temperature or actual output power).

The input data are not found in the label but in the technical fiche. The required values are the $COP_{d,X}$ (declared COP in test point X, with X= A...E) and $\Phi_{d,X}$ (declared capacity in test point X) that is the actual capacity and COP measured during the testing and declared.

Some methods require only one data set (e.g. low temperature, average climate for AW heat pumps) other require several data sets to interpolate between e.g. different leaving water temperature levels.

- Then you need data on **external auxiliaries**, that is auxiliaries that were not considered when determining the declared COP. This may include e.g:
- stand-by power;
- power of the circulating pump of the ground heat exchanger or of the pump to lift ground water.

The length of the heat capture circuit and the depth of the water table (that is the lifting height) shall be recorded to make an estimate and verify the auxiliary energy use.

The value of external auxiliaries may be required at 0 load, minimum load and maximum load.

For water source heat pumps, the flow rate in the source at 0 load, minimum load and maximum load should be noted to make an estimate and verify the auxiliary energy use.

- The control type of the external auxiliaries shall also be assessed: operation can be e.g. at constant power, on-off, modulating. This is relevant for the estimation of external auxiliaries. The datasheet will also provide information on the **operational limits** of the heat pump. Every heat pump can only operate in a defined range of source and sink temperature. Your calculation method may ask this limit so that it can check if the heat pump can operate in the given calculation interval.

— The availability and capacity of the **integrated back-up heater**.

Check that the back-up heater is available and which is the setting. Depending on the context, it may be completely or partially disconnected to avoid overloads.

6.7.3.3 Additional info

6.7.3.3.1 EPC

No additional info

6.7.3.3.2 RP

If an electric heat pump is already installed, this should be already compatible with zero emission buildings.

An absorption heat pump or a combustion engine heat pump can be maintained only if a decarbonised source of heat or fuel will be available. Otherwise, the replacement with an electric heat pump may be considered.

If a combustion boiler is also installed (emergency back-up or the heat pump is designed to operate only part of the year), information shall be collected to suggest a way to eliminate the fossil fuel boiler and replace it by an electric heat pump or use a carbon free fuel.

6.7.3.3.3 SRI

SRI has a special evaluation for the heat pump generation control, as shown in **table 13**.

Table 13 – SRI Functions related to heat pump generation subsystem

FUNCTIONALITY		LEVEL	
H-2b	Heat generator control (for heat pumps)	☐ ____%	On/Off-control of heat generator
		☐ ____%	Multi-stage control of heat generator capacity depending on the load or demand (e.g. on/off of several compressors)
		☐ ____%	Variable control of heat generator capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control)
		☐ ____%	Variable control of heat generator capacity depending on the load AND external signals from grid

6.7.3.3.4 Inspection

Unfortunately, there is no equivalent of the flue gas analysis to provide a quick measurement of the efficiency of a heat pump.

If the heat pump has integrated heat and electricity meters, read and note the totals on the installation log-book. If there are previous readings, check the COP over time.

If the system has meters of heat produced and electricity used by the heat pump, look for trends and historical data and check the COP over time.

Check if air exchangers (indoor and/or outdoor unit) are clean and not damaged (e.g. hail on external unit).

Check heat pump controls settings. Check if the set flow temperature is the minimum acceptable value for the installation.

If PV is available, check if the time schedule is adjusted to maximise the operation of the heat pump when the sun is likely to be available.

When the PV is not available, check if the operation schedule can be extended to lower the required operating temperature. If there are variable electricity prices, check if the heat pump operation can be concentrated in low tariff hours (low tariff hours should match higher power availability of the grid).

For bivalent systems, check the logics that decides if the heat pump or the back-up generator is running. Check if the logic is correctly set and operating.

Check if F-gas regulation is respected. Check for any refrigerant leakage inspection report.

6.7.4 District heating

6.7.4.1 Introduction

District heating refers to the delivery of thermal energy to the building. Heat is generated by a provider and distributed to multiple buildings via a dedicated pipe network.

Since the generation occurs outside the building, the energy performance and environmental impact of the building are affected by the primary energy factors (PEFs) and emission coefficients of the delivered heat, which depend on the generation technology, fuel mix and plant efficiency of the heat provider.

Within the building, a “substation” controls the heat flow to the building. The substation includes the following.

- Typically, a heat exchanger to isolate the district heating hydraulic circuit from the building hydraulic circuit. Sometimes (direct connection) the heat exchanger is omitted.
- Control devices (temperature sensor, controller, control valve), to control the

6.7.4.2 What to look at

Identify the district heating provider. Ask the heat provider the applicable primary energy factor and CO₂ emission factor to be used in the energy performance calculations. These factors should be declared according to EN 15316-4-5 with options specified in your national or regional regulation.

Check which services are provided by the district heating: heating and/or domestic hot water.

Assess the condition of the pipes entering the building: quality of thermal insulation, age of installation, and any visible signs of heat loss. Check for pre-insulated piping systems or retrofitted insulation around older piping.

Check substation characteristics:

- type of heat exchanger (plate or shell-and-tube);
- insulation of heat exchanger, pipes and components;
- type of control (modulating or on/off);
- settings of controls and, if the system is operating, is set-points are maintained.

6.7.4.3 Input data

The following input data is required in relation with a district heating generation.

- Rated power of the connection.

This information is usually found on the nameplate of the substation or in the contractual documentation.

- Information needed to estimate heat losses of the substation and of the primary connection, that may include
- Declared daily losses of the substation under reference conditions
- Length of connecting pipes
- Presence and type of the heat exchanger
- Primary energy factor (PEF) and CO₂ emission factor.

This information should be supplied by the heat provider or default values could be available in the national or regional calculation method.

6.7.4.4 Additional info

6.7.4.4.1 RP

The long term strategy of the district heating provider shall be investigated e.g., uses or is planning to use cogeneration, carbon free fuels (biomass) or waste heat.

Look for possibilities to reduce the dependence on district heating by incorporating alternative generation sub-systems, especially for domestic hot water generation in summer. Examples are:

- thermal solar;
- heat pumps and PV.

If the long term strategy involves a reduction of the supply temperature of heat, check the possibility to run the heating systems at lower temperatures. This requires also alternative solutions for domestic hot water preparation.

If there are no clear long-term plans, think about alternative (classic) solutions to achieve zero emission level.

6.7.4.4.2 SRI

The same functions as boiler applies to district heating generation.

See **clause 6.7.4.2.**

6.7.4.4.3 Inspection

Perform a visual inspection of the following.

- Thermal insulation of pipes from the entry point to the substation.
- Substation controls settings and operation
- Hydraulic configuration
- Energy meter condition and whether it supports real time remote data access

6.8 Special cases

6.8.1 Multiple generators

When multiple generators are available:

- Data has to be collected for each generator individually.
- The control strategy of the generators set into the system has to be assessed. Basic types of priority are the following.
- Parallel operation: all generators are operated simultaneously (no actual control or manual control).
- Cascade operation: the number of generators in operation depends on the operating conditions.

Two basic alternatives for the cascade are:

- keeping the minimum possible number of generators in operation;
- keeping the maximum possible number of generators in continuous operation;
- Additional conditions for the selection of the generator in operation may include
- Time schedule, generators are available at a given time
- Selection of the generator (e.g. heat pump versus boiler in mixed systems) depending on:
 - minimum cost operation (economic criteria);
 - maximum efficiency operation (primary energy criteria)
 - minimum CO₂ emission operation.

Depending on your national or regional calculation methods and regulations, default criteria may be applied instead of the actual control scheme.

For SRI, the level of the following dedicated functionality shall be identified.

Table 14 – SRI Functions related to multiple generators for heating

FUNCTIONALITY		LEVEL	
H-2d	Sequencing in case of different heat generators	☐ ____%	Not applicable: only one generator
		☐ ____%	Priorities only based on running time
		☐ ____%	Control according to fixed priority list: e.g. based on rated energy efficiency
		☐ ____%	Control according to dynamic priority list (based on current energy efficiency, carbon emissions and capacity of generators, e.g. solar, geothermal heat, cogeneration plant, fossil fuels)
		☐ ____%	Control according to dynamic priority list (based on current AND predicted load, energy efficiency, carbon emissions and capacity of generators)
		☐ ____%	Control according to dynamic priority list (based on current AND predicted load, energy efficiency, carbon emissions, capacity of generators AND external signals from grid)

6.8.2 Room air conditioners (RAC) and VRV/VRF systems

Reversible room air conditioners can be used also for heating.

If they are the only one heating system, they are treated as a regular heat pump heating systems.

If there is a regular heating system, taking into account their contribution may be beneficial for the energy performance of the building because:

- depending on the context, primary energy factors can result in a much higher efficiency of the RAC compared to a boiler;
- using a heat pump adds the use of renewable energy.

If they coexist with a regular heating system, whether their contribution to space heating can be taken into account depends on your national or regional regulation and calculation methods. If it is allowed, the potential contribution is usually limited to the rooms where the room air conditioner is installed. The share of the heating needs for the installation room shall be determined. This may be done by a zone calculation or by allocating the needs of the entire thermal zone according to the floor area.

6.8.3 Fireplaces and stoves

Just like RAC, despite the lower efficiency, the contribution of fireplaces and stoves may result in a better energy performance because they use partly renewable fuel.

The same considerations as for RAC apply for stoves. If they are the only available heating system, then they are accounted. If they coexist with a regular heating system, whether their contribution to space heating can be taken into account depends on your national or regional regulation and calculation methods. If it is allowed, the potential contribution is usually limited to the rooms where the room air conditioner is installed. The share of the heating needs for the installation room shall be determined. This may be done by a zone calculation or by allocating the needs of the entire thermal zone according to the floor area

6.9 Practical tips and tricks

Maybe move here some tips and tricks that have been highlighted in other sections about generation or move tips and tricks in specific new subclauses.

... use an icon and frame and special sentences ...



7 Domestic hot water system data collection

7.1 Introduction

Figure 32 shown the functional diagram of a typical domestic hot water system.

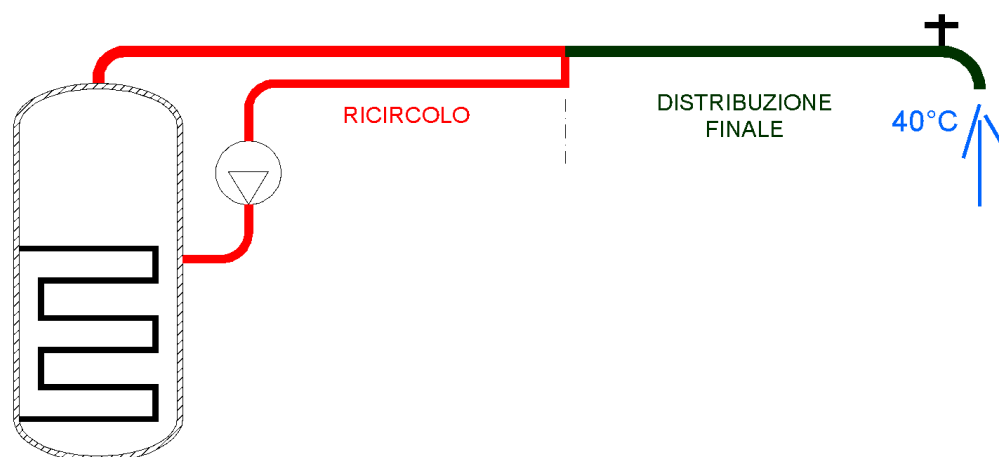


Figure 32 – Domestic hot water system functional diagram

For the domestic hot water systems, the following subsystems are considered, as and if present in the specific system.

- Heat recovery (if applicable), contributing to satisfy domestic hot water needs using heat from drain water.
- Heat emission, if flow restrictors are used to limit the flow rate at the tap.
- Final distribution: the single pipe connection from domestic hot water loop or domestic hot water generation to end-use points (taps, showers, etc.).
- Distribution loop: two pipe distribution system keeping DHW readily available at draw-off points. In small systems the distribution loop may be omitted.
- Storage, which is omitted in instantaneous domestic hot water production systems.
- Generation, which produces the domestic hot water. It can be e.g. a boiler, a heat pump, an electric heater, a thermal solar collector.

Domestic hot water system may share the generation sub-system with heating.

Domestic hot water systems may be individual or centralised. This happens indecently from the choice for the heating system.

7.2 General information on the domestic hot water system

7.2.1 Domestic hot water system service areas and operating schedule

The calculation of domestic hot water volume needs is based on space category and either:

- floor area of the domestic hot water service area or of the building unit;
- number of units of the domestic hot water service area, which are a property related to domestic hot water use in the building such as
 - number of beds in an hotel,
 - number of seats in a restaurant.

At least, one domestic hot water service area is required for each space category present in the building.

Check your national method to identify which data is required depending on the space category. A frequent data-set is:

- building unit floor area for residential buildings;
- number of units for non-residential buildings

NOTE Floor area can be the unit for some space categories.

To convert the volume needs into energy needs, the cold-water temperature is required. Usually, it is assumed as the yearly average external temperature. Sometimes, information may be available from the water supply utility.

7.2.2 Additional information

7.2.2.1 RP

No special information is required.

7.2.2.2 SRI

Table 15 shows the functions related to the overall domestic hot water system with their levels.

Table 15 – SRI Functions related to domestic hot water system reporting

FUNCTIONALITY		LEVEL	
DHW-3	Report information regarding domestic hot water performance	☐ ____%	None
		☐ ____%	Indication of actual values (e.g. temperatures, submetering energy usage)
		☐ ____%	Actual values and historical data
		☐ ____%	Performance evaluation including forecasting and/or benchmarking
		☐ ____%	Performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection

7.2.2.3 Inspection

When inspecting the domestic hot water system, check if there is a domestic hot water volume meter. If yes, read it and check for previous reading to estimate actual domestic hot water use. Actual domestic hot water use is strongly dependent on users behaviour. Abnormal domestic hot water use may reveal leaks, to the environment or even to the heating system in case of heat exchanger failure. Leaks result in water and energy waste.

7.3 Domestic hot water heat recovery

7.3.1 Introduction

The use of heat recovery to fulfil domestic hot water needs is an emerging technology. The most common solution is recovering heat from the drain water of showers. This configuration is preferred because the simultaneity of needs and availability of recoverable heat is guaranteed. This is not the case for a bath-tub.

There are three possible connections of drain water heat recovery devices, shown in figures XX through XX.

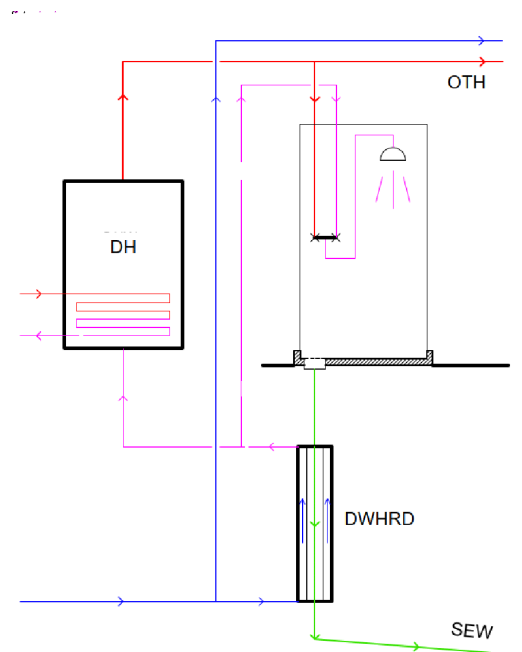


Figure 33 – Drain water heat recovery: type A connection

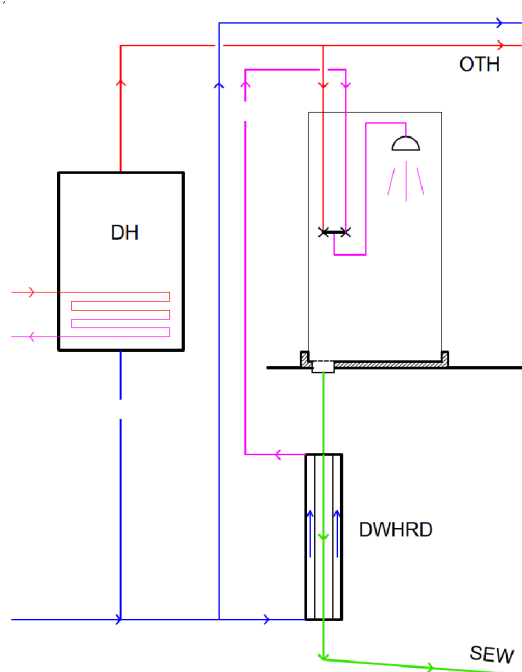


Figure 34 – Drain water heat recovery: type B connection

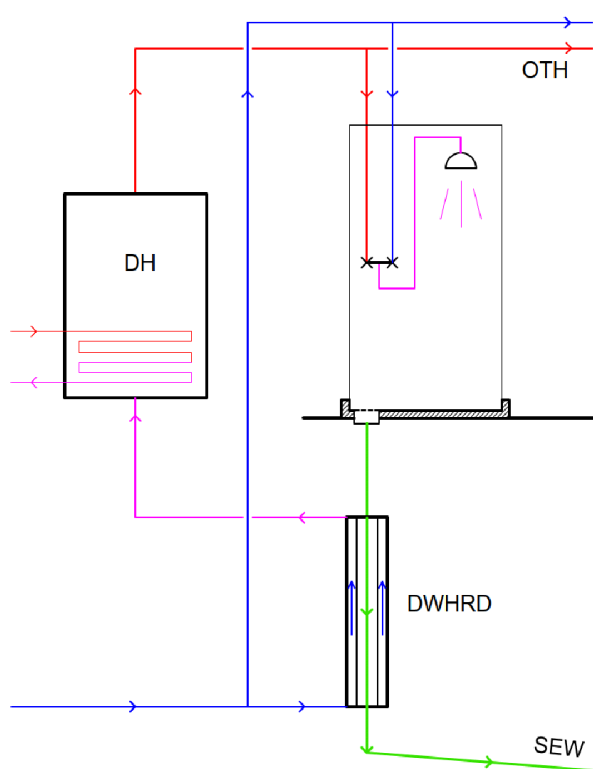


Figure 35 – Drain water heat recovery: type C connection

Type A connection is the most efficient but type B is probably the most common because it is applied individually and locally on each shower.

7.3.2 What to look at

The type of connection deeply affects the heat recovery efficiency, in conjunction with the set temperature of the domestic hot water heater.

7.3.3 Input data

According to prEN 15316-6 on drain water heat recovery, the following data shall be collected:

- how many fixtures are connected to a drain water heat recovery device and how many are not;
- the type of connection (A to C) of each drain water heat recovery device;
- the make and model of each drain water heat recovery device, so that its technical data can be found.
- the diameter and length of each preheated water connection;
- the diameter and length of each drain water connection from the shower box drain to the drain water heat recovery device.

7.3.4 Additional information

7.3.4.1 EPC

The applicability of drain water heat recovery devices should be assessed for recommendation purpose. Its has to be assessed:

- the suitability of sanitary fixtures;
- the implication in term of space required for the installation (gravity counter flow devices require a floor height below the drain) and length of connections.

7.3.4.2 RP

The same remarks as for EPC recommendations apply

7.3.4.3 SRI

Not relevant.

7.3.4.4 Inspection

Not included in the inspection.

A check on the temperature after the heat recovery may show if the systems is still operational and well maintained (clean).

7.3.5 Tips and tricks

Consider the application only on the main and most frequently used fixtures.

Applying heat recovery reduces the load on the generation system and reduces the required storage volume.

7.4 Emission

7.4.1 Introduction

The domestic hot water emission efficiency is the ability of the system to supply only the strictly required volume of water.

7.4.2 What to look at

The following aspects may contribute to limit the supplied volume of water.

- Maximum flow rate per tap or shower.
- Presence of flow restrictors or shower heads with air mixers.
- Type of mixers (manual vs thermostatic).

The effect of these devices depends on the context.

- They have no effect on the water use of a bathtub.
- Air mixers and flow restrictors may be effective for showers and hand washing.

7.4.3 Input data

In the EN EPB standards, there is no explicit consideration of emission efficiency of the domestic hot water system.

The input data will depend on your national calculation method and may e.g. include:

- number of fixtures;
- flow rates (default or measured);
- type of terminal units (e.g., low-flow, thermostatic);
- presence of specific devices (e.g. air mixer, flow restrictor).

7.4.4 Additional information

7.4.4.1 EPC

Evaluate the applicability of retrofitting domestic hot water flow limiting devices.

7.4.4.2 RP

Same as EPC.

7.4.4.3 SRI

Not relevant

7.4.4.4 Inspection

Same as EPC

7.4.5 Tips and tricks

Nothing relevant

7.5 Final distribution

7.5.1 Introduction

The losses on the final single line pipes correspond to the cooling down of the water trapped into the pipes when the tap is closed.

They are determined by:

- the heat capacity of pipes (water + metal for small pipes);
- the number of tapings per day;
- the temperature of domestic hot water in the distribution.

Once the distribution is installed, there is little to do because you should change the pipes to reduce the water contents.

7.5.2 What to look at

The important factors are length and size of single pipes.

The insulation level of the pipes can be neglected for the energy performance calculation.

NOTE A minimum insulation level of both hot and cold domestic hot water is required especially to avoid heating the cold water.

7.5.3 Input data

Final distribution losses may be addressed in very different ways in the national methods. There are two main alternatives.

- detailed calculation methods, based on the list of pipes.
- simplified calculation methods, based on tabulated efficiencies or expenditure factors or loss factors.

The same general considerations set-out for heating distribution in clause 6.5.3.3 also apply to domestic hot water final distribution. The information on the insulation level of pipes is less critical.

7.5.4 Additional information

7.5.4.1 EPC

No additional information.

7.5.4.2 RP

There is limited renovation potential once installed.

7.5.4.3 SRI

Not directly affected.

7.5.4.4 Inspection

No improvement potential.

7.5.5 Tips and tricks

None special

7.6 Distribution loop

7.6.1 Introduction

A distribution loop is installed to avoid an excessive delay between

- the moment a tap is opened
- and the moment that hot water reaches the tap.

Domestic hot water distribution loops are responsible of very high losses, even if insulated.

7.6.2 What to look at

All the considerations made in clause 6.5.2 about heating distribution losses also apply to domestic hot water distribution loops. Losses are usually higher, because the distribution loop is operating all year round. Additionally, in summer domestic hot water loop losses are not recovered and they are an additional load if heat is released in the heated space.

The following are the attention points for the domestic hot water distribution loop:

- length and size of pipes;

- insulation thickness and material;
- length of uninsulated runs;
- operation time;
- operation temperature.

7.6.3 Input data

See heating distribution, [clause 6.5.3](#), with the following notes.

- The size of the loop return pipe can be smaller than the main domestic hot water flow pipe.
- The temperature in the loop may be given by:
 - either the storage or generation set point;
 - or the mixing set point.

7.6.4 Additional information

7.6.4.1 EPC

See [clause 6.5.5.1](#) on heating distribution.

7.6.4.2 RP

No additional information.

7.6.4.3 SRI

Not relevant.

7.6.4.4 Inspection

See [clause 6.5.5.4](#) on heating distribution.

The setting of the loop circulation pump is usually constant pressure or constant speed.

7.6.5 Tips and tricks

No additional information.

7.7 Domestic hot water storage

7.7.1 Introduction

The reason for domestic hot water storage losses is not only a matter of vessel envelope losses, it is also losses of connected pipes if there is no downward syphon.

Storage vessels are tested and have an energy label. The power of losses (or the kWh/day) are referred to a temperature difference of 40 °C and do not take into account any losses from connected pipes. All available connections are closed during the testing.

When the flow of water is stopped in a horizontal or vertical pipe connected to a hot storage vessel, natural convection will keep the connected pipe hot, unless a syphon on the connection prevents this phenomenon.

If the connected pipe is a circulation loop pipe, the losses are already accounted for.

If the connected pipe is a final distribution pipe (no circulation loop), then the accounted losses are only for the cooling down after a tapping event.

This correction is not negligible. The typical heat loss coefficient of a single family house domestic hot water cylinder is in the range 1,0...2,0 W/K. One single meter of insulated pipe has a heat loss coefficient of 0,2...0,3 W/K. If the single meter of pipe is not insulated, then its heat loss coefficient will be in the range 1,0...2,0 W/K, the same as the whole storage cylinder.

Figure 36 – Effect of natural circulation within connected pipes

This component of losses has been recently introduced into EN 15316-5 and is seldom found in national standards

7.7.2 What to look at

See [clause 6.6.2](#) on heating storage.

Additionally, check all connected pipe and check:

- presence or absence of anti-thermosyphon measures (e.g., downward pipe bends)
- if there is no syphon, if they can cause additional losses by natural convection.

7.7.3 Input data

See [clause 6.6.3](#) on heating storage. Additionally, for each connected domestic hot water pipe that may be kept permanently hot and is not part of the domestic hot water circulation loop, determine:

- size;
- length of the heated section (up to the first downward bend);
- insulation material and thickness
- mounting position
- installation position

as described in [clause 6.5.3.3](#) for distribution pipes.

7.7.4 Additional information

7.7.4.1 EPC

No additional information.

7.7.4.2 RP

If the installation of a heat pump is envisaged, check space availability for a domestic hot water storage.

7.7.4.3 SRI

Table XX shows the functions related to the domestic hot water storage with their levels.

Table 16 – SRI Functions related to domestic hot water storage

FUNCTIONALITY	LEVEL
DHW-1a Control of DHW storage charging (with direct electric heating or integrated electric heat pump)	☐ ____% Not applicable, no such system ☐ ____% Automatic control on / off ☐ ____% Automatic control on / off and scheduled charging enable ☐ ____% Automatic control on / off and scheduled charging enable and multi-sensor storage management ☐ ____% Automatic charging control based on local availability of renewables or information from electricity grid (DR, DSM)
DHW-1b Control of DHW storage charging (using hot water generation)	☐ ____% Not applicable: instantaneous domestic hot water ☐ ____% Automatic control on / off ☐ ____% Automatic control on / off and scheduled charging enable ☐ ____% Automatic on/off control, scheduled charging enable and demand-based supply temperature control or multi-sensor storage management ☐ ____% DHW production system capable of automatic charging control based on external signals (e.g. from district heating grid)

The following information on domestic hot water storage may contribute to general functions related to energy management:

- Does the domestic hot water cylinder allow for connecting multiple heat sources?
- Are individual sources automatically switched according to the requirements of the control system?
Example, a combination of a gas boiler, heat pump, and electric heating coil from photovoltaics.

7.7.4.4 Inspection

No additional remarks.

7.7.5 Tips and tricks

No additional info.

7.8 Domestic hot water generation

7.8.1 What to look at

When evaluating the domestic hot water generation, you should look at

- type of generator: electric heater, boiler, solar thermal, heat pump, ...
- if the generation is shared with space heating or standalone;
- if generator is stand-alone generator's nominal capacity and operating temperature
- backup generation systems (e.g., electric resistance heater in solar DHW)

7.8.2 Input Data

Determine which generation device is used for domestic hot water preparation.

Then, for each generator:

- either see the corresponding clauses for heating generation, clause 6.7.2 through 6.7.4
- or see **clause 7.9** on thermal solar generation.

7.8.3 Additional info

7.8.3.1 EPC

No additional info.

7.8.3.2 RP

Always evaluate local versus centralised domestic hot water preparation. Centralised preparation requires a distribution loop. Small needs may well be exceeded by distribution losses, even with insulated networks.

7.8.3.3 SRI

Table 17 shows the functions related to the domestic hot water generation with their levels.

Table 17 – SRI Functions related to domestic hot water generation

FUNCTIONALITY	LEVEL
---------------	-------

DHW-2b Sequencing in case of different DHW generators	☐ ____% Not applicable: only one generator ☐ ____% Priorities only based on running time ☐ ____% Control according to fixed priority list: e.g. based on rated energy efficiency ☐ ____% Control according to dynamic priority list (based on current energy efficiency, carbon emissions and capacity of generators, e.g. solar, geothermal heat, cogeneration plant, fossil fuels) ☐ ____% Control according to dynamic priority list (based on current AND predicted load, energy efficiency, carbon emissions and capacity of generators) ☐ ____% Control according to dynamic priority list (based on current AND predicted load, energy efficiency, carbon emissions, capacity of generators AND external signals from grid)
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7.8.3.4 IR

No additional information

7.9 Thermal solar**7.9.1 Introduction**

Thermal solar is a popular technology for the preparation of domestic hot water using renewable energy. Despite the apparent simplicity, there are several pitfalls that may reduce the actual efficiency.

7.9.2 What to look at

The incident solar energy depends on:

- solar collectors aperture area;
- orientation and tilt angle of solar collectors in relation with latitude;
- any shadings.

The storage volume shall enable to accommodate the amount of heat collected in one entire day otherwise stagnation will occur. Frequent stagnation has consequences on the lifespan of the panels (thermal and mechanical stress), on the antifreeze fluid (glycol decomposition generates acids) and on the systems efficiency (once the solar field is locked into stagnation, it will recover only after sunset). The minimum storage volume is 70 l per m² of aperture area but 100 l/m² is recommended.

7.9.3 Input data

According to EN 15316-4-3, the following data is required.

- Aperture area of installed panels.
- Orientation and tilt
- Shadings

— Performance data of the solar collectors:

— peak collector efficiency η_0 ;

— heat loss coefficients, a_1 W/(m²·K) and a_2 W/(m²·K²);

— K_{hem} or IAM, incidence angle modifier

The make and model can be assessed so that the performance data is found later on the manufacturer catalogues.

— The power of the collector loop pump

— The properties of the domestic hot water storage (the part available to the solar system):

— the volume of the storage;

— the heat exchange coefficient between the collector loop and the storage in W/K;

— the heat loss properties (see **clause 7.7.3**)

— The type of the integrated back-up heater and the energy carrier used.

7.9.4 Additional information

7.9.4.1 EPC

No additional information.

7.9.4.2 RP

Maintenance costs are a significant burden with thermal solar. Check ease of access to solar collectors and collector loop.

7.9.4.3 SRI

Table 18 shows the functions related to thermal solar systems with their levels.

Table 18 – SRI Functions related to thermal solar storage charging

FUNCTIONALITY	LEVEL
---------------	-------

DHW-1d Control of DHW storage charging (with solar collector and supplementary heat generation)	☐ ____% Not applicable: no solar collector ☐ ____% Manual selected control of solar energy or heat generation ☐ ____% Automatic control of solar storage charge (Prio. 1) and supplementary storage charge ☐ ____% Automatic control of solar storage charge (Prio. 1) and supplementary storage charge and demand-oriented supply or multi-sensor storage management ☐ ____% Automatic control of solar storage charge (Prio. 1) and supplementary storage charge, demand-oriented supply and return temperature control and multi-sensor storage management
---	--

7.9.4.4 Inspection

Check the ration between the solar collector area and the storage volume.

Compare the actual domestic hot water demand with the thermal solar capacity. The thermal solar system shall be designed to meet the load during the peak production months (i.e. during summer). If the thermal solar collectors are oversized, stagnation will be frequent.

Check for correct operation of the back-up system, meaning that it is not used more than strictly necessary.

7.9.5 Tips and tricks

Owners very often do not notice thermal solar system failure because the back-up heater will provide domestic hot water in any case.

8 Cooling system data collection

Repeat the structure of heating.
 Add heat rejection system

8.1 Introduction

Cooling systems are increasing in number because of the increasing comfort requirement and the changing climatic conditions.

The concepts illustrated in **clause 6.1** for heating systems also apply to cooling systems.

The following sub-systems are considered for cooling systems:

- Emission and control
- Distribution
- Storage
- Generation

Just like heating systems, cooling systems may range from water based fan coil systems, to split room air conditioner and VRV/VRF systems.

Similar to heating, water based cooling systems are completely covered by this clause 8.

Split systems and VRV/VRF systems are also covered by this clause, taking into account that distribution losses are considered to be already taken into account in the EER of the heat pump.

For air based cooling systems, this clause 8 covers any water based generation part up to the cooling coil of the air handling unit or any ducted fan coil.

8.2 General information on the cooling system

8.2.1 Cooling service areas and operating schedules

General information on the cooling system includes the following.

- The list of service areas and their identification on a plan of the building

A “cooling service area” is a set of spaces (usually rooms) served by the same branch of the cooling system that share the same operating schedule.

The cooling system(s) does not always service the whole building. It is important to note which spaces are served by a cooling system and which are not.

- The location of the generator(s) and mechanical room(s).
- The list of the cooling systems serving that building, with the connected service areas.

This may range from one system for the whole building to several autonomous systems to a mixture of common and individual systems.

- The operating schedule of the cooling systems (operation time and set temperatures of the service areas).

For centralised cooling systems, it is recommended to prepare a functional diagram of the cooling system(s) in the building showing the connections between cooling systems and service areas.

A complete functional diagram is not required (example: safety features may be omitted). Only the information required for an energy performance assessment (e.g. how many chillers, make and model, which are the area served, how is the cooling system controlled). A lot of information (e.g. nameplate data of the pumps, time schedules) and can/should be annotated directly on the diagram.

The functional diagram should also highlight the connections between the cooling system(s) and other technical systems such as:

- connection of AHU coils and/or duct cooling coils to the cooling system
- possibly, domestic hot water preparation using a desuperheater.

8.2.2 Additional information

8.2.2.1 EPC

No additional info required.

8.2.2.2 RP

No additional information.

8.2.2.3 SRI

The level of the following functionalities about cooling system monitoring and reporting shall be assessed.

Table 19 – SRI Functions related to cooling system

FUNCTIONALITY		LEVEL	
C-3	Report information regarding cooling system performance	☐ ____%	None
		☐ ____%	Central or remote reporting of current performance KPIs (e.g. temperatures, submetering energy usage)
		☐ ____%	Central or remote reporting of current performance KPIs and historical data
		☐ ____%	Central or remote reporting of performance evaluation including forecasting and/or benchmarking
		☐ ____%	Central or remote reporting of performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection
C-4	Flexibility and grid interaction	☐ ____%	No automatic control
		☐ ____%	Scheduled operation of cooling system
		☐ ____%	Self-learning optimal control of cooling system
		☐ ____%	Cooling system capable of flexible control through grid signals (e.g. DSM)
		☐ ____%	Optimized control of cooling system based on local predictions and grid signals (e.g. through model predictive control)

8.3 Cooling emission

8.3.1 Introduction

Cooling emission losses are linked to the local sub-cooling induced by the cooling terminal. A cooling terminal must be colder than the environment, therefore the losses of the building envelope in the area around the cooling terminals are higher than what is calculated assuming a uniform temperature equal to the standard set-point condition (e.g. the typical 24...26 °C indoor temperature, depending on the national definition of standard comfort in summer).

8.3.2 What to look at

Most calculation methods, including EN 15316-2 and EN ISO 52031, are based on tabulated data depending on the properties of cooling terminals. This is by far the most common method used. In the following, it is therefore assumed that a simplified tabular method is used.

It is enough to identify qualitative properties of the cooling emission system.

Sometimes the cooling emission system is not uniform over a building. Different types of cooling terminals may be installed due to different requirements in the various areas of the building or they may have been simply added when modifying the cooling system.

The following list summarizes the aspects to be assessed, usually by visual inspection.

- Type of cooling terminals, typical solutions are:
 - embedded terminals (embedded in floor, ceiling or walls);
 - fan-coils, wall mounted (exposed) or ducted
 - unit coolers;
 - air terminals, for air based systems;
- Positioning of cooling terminals, depending on terminal type
- Embedded terminals can be embedded in heat loss elements or internal structures.
- Insulation between embedded terminals and the building structure: part of the heat will be extracted from the other side.
- Auxiliary energy use, for fan coils
- Height of the rooms, which influences stratification

8.3.3 Input data

8.3.3.1 Configuration data

Typically, the calculation of emission losses is based on tabulated values, so the assessment is related to the information needed to navigate in the default data tables. This information may require

- **Type** of cooling terminals (see list in the previous clause)
- **Positioning** of cooling terminals;
- **Operating temperature regime:** for water based cooling terminals, this can be dehumidifying (e.g. 7/12 °C in design conditions) or non-dehumidifying (e.g. 18/23 °C in design conditions).
- **Insulation level between cooling terminal and the embedding structure:** panels are usually mounted on an insulating support to reduce emission on the other side.

8.3.3.2 Auxiliary energy

Additional information is the nominal power of auxiliaries (fan) of fan coils. Fan-coils can be often operated at several fan speeds. The highest in use should be identified and the rated power for that speed should be used. Alternatively, the auxiliary energy can be estimated as a fraction (typically 2...5%) of the required energy output.

In some national standards, the effect of the auxiliary energy use is taken into account as a reduction of emission efficiency.

8.3.3.3 Non homogeneous situations

Ideally a calculation method should be performed per homogeneous service areas. You need for this a software that supports zoning of cooling system.

Several tools do not allow for this, so you might consider using a weighted average of the efficiencies for the various situations that you find in a building. The relevant weight should be specified in the national calculation method. Typical weights are

- the area served by the given configuration. It's probably the simplest and doesn't require any additional calculation.
- the cooling load in the area served by the given configuration.
- the installed power of cooling terminals:
- the cooling need for the area. It is likely to be the most accurate but requires a calculation of cooling needs for each area served by the given configuration.

Marginal different situations should be ignored.

8.3.4 Additional information

8.3.4.1 EPC

No additional info.

8.3.4.2 RP

The insulation of the building may cause overheating and the necessity to add cooling. If an existing building has no cooling system, the spaces to add a cooling system should be evaluated.

8.3.4.3 SRI

Information on SRI functions are given **in clause 8.4.4.3** about cool emission control.

8.3.4.4 Inspection

The type of cooling terminals is needed to estimate the cooling emission efficiency

In practice the evaluation follows the same method as the energy performance calculation.

See the previous **clause 8.2.3** for more details

8.4 Cooling emission control

8.4.1 Introduction

The focus is on the control of the indoor temperature.

Room temperature control losses occur because to guarantee comfort (the set-point) in the less favoured room you may overcool (and thus increase losses) all other rooms. The amount of unnecessary cooling depends on the type and quality of room temperature control.

Typically, the control losses are taken into account by a "control efficiency" or a "control expenditure factor" given as a tabulated value or sometimes calculated with some empirical correlation. The EN standard introduces the concept of "indoor temperature increase" $\Delta\theta_{dec}$ according to the emission and control type. Again, $\Delta\theta_{inc}$ can be given by tabulated values, sometimes tested values on products or empirical correlations.

NOTE: $\Delta\theta_{inc}$ is a negative value for cooling emission sub-systems.

Anyway, most calculation methods are tabulated efficiencies, expenditure factors or temperature increase, with possibly some empirical correction for special cases and the input data is a qualitative description of the type of cool emission control.

8.4.2 What to look at

The key is identifying how the indoor temperature is controlled during the cooling season. This information consists of the following.

- Level of indoor temperature control.
- The worst situation is having only a central distribution flow temperature control.
- If there are indoor temperature sensors, the next information is the level of spatial resolution of the temperature sensors and controls. The typical possible levels are:
 - by building unit or entire building (e.g. one thermostat per apartment in a representative room, acting on a zone valve);
 - by groups of homogeneous spaces (e.g. one thermostat in a representative room for day zone, one in the night zone, acting on zone valves);
 - room by room (e.g. room thermostats in each room)
 - on each cooling terminal (e.g. thermostats on fan-coils)
- Type of control action (ON-OFF, PI, PID, ...), that can be:
 - ON-OFF, which is the basic control given by e.g. a simple mechanical thermostat;
 - P, PI and PID control that can be provided by electronic controllers and electrically driven actuators.
- Operation time control, that can be:
 - continuous operation, that is the systems is always operating unless turned off manually;
 - fixed time control, that is operating following a clock and/or calendar;
 - optimised time control, that is operation time is related to reaching comfort in a given time window during a day and/or a week;
- Set point temperature control, that can be
 - constant set-point, that is the systems is always operating with the same set point, like e.g. with manual thermostatic valves
 - Set-back control, where the set-point can be changed in connection with a time control.
- Additional functions.

The level of control is the fundamental information which is always required and relevant. It is refined by the type of control action.

Time control, set-back and optimisation functions are mostly relevant for highly intermittent occupation, like for offices and schools, whereas they have little impact on continuous operation buildings (e.g. residential, hospitals).

8.4.3 Input data

The input data is the type of control among the options considered in your national or regional calculation method. See previous **clause XXX** for general information, see your calculation method for the exact list of required details about level of control, type of control action and other relevant details for the calculation.

An additional input data can be the auxiliary energy used by controls. Usually, an average constant power is assumed.

8.4.4 Additional information

8.4.4.1 EPC

The feasibility of an upgrade of the control system is to be evaluated

8.4.4.2 RP

No additional information

8.4.4.3 SRI

For each function, the respective level shall be identified.

To evaluate the SRI you must identify the level of each function, that is the highest level for which the specified control properties are fully satisfied.

The following is an extract from the input sheet of the SRI calculation tool version 4.5.

Table 20 – SRI Functions related to cooling emission

FUNCTIONALITY		LEVEL	
C-1a	Cooling emission control	☐ ____%	No automatic control
		☐ ____%	Central automatic control
		☐ ____%	Individual room control
		☐ ____%	Individual room control with communication between controllers and to BACS
		☐ ____%	Individual room control with communication and occupancy detection
C-1b	Emission control for TABS (cooling mode)	☐ ____%	Not applicable, no TABS
		☐ ____%	No automatic control
		☐ ____%	Central automatic control
		☐ ____%	Advanced central automatic control
		☐ ____%	Advanced central automatic control with intermittent operation and/or room temperature feedback control
C-1f	Interlock: avoiding simultaneous heating and cooling in the same room	☐ ____%	No interlock
		☐ ____%	Partial interlock (minimising risk of simultaneous heating and cooling e.g. by sliding setpoints)
		☐ ____%	Total interlock (control system ensures no simultaneous heating and cooling can take place)

8.4.4.4 Inspection

The evaluation of the control sub-system is performed exactly as for the energy performance calculation.

No additional procedure is required for the cooling system inspection.

8.5 Distribution

8.5.1 Introduction

See **clause 6.5.1** on heating systems. The same concepts apply to water based cooling systems.

Additionally, in the case of cooling the energy used by pumps is an additional load (in the heating case it is recovered energy).

This clause is about distribution of water based cooling systems.

8.5.2 What to look at

See **clause 6.5.2** on heating systems.

8.5.3 Input data for the detailed method

See **clause 6.5.3** on heating systems.

8.5.4 Simplified method

See **clause 6.5.4** on heating systems.

8.5.5 Additional information

8.5.5.1 EPC

See **clause 6.5.5.1** on heating systems.

8.5.5.2 RP

See **clause 6.5.5.2** on heating systems.

8.5.5.3 SRI

Table 21 shows the functions related to the cooling distribution with their levels.

Table 21 – SRI Functions related to cooling distribution

FUNCTIONALITY		LEVEL	
C-1c	Control of distribution network chilled water temperature (supply or return)	☐ ____%	Constant temperature control
		☐ ____%	Outside temperature compensated control
		☐ ____%	Demand based control

C-1d Control of distribution pumps in networks	☐ ____% No automatic control ☐ ____% On off control ☐ ____% Multi-Stage control ☐ ____% Variable speed pump control (pump unit (internal) estimations) ☐ ____% Variable speed pump control (external demand signal)
--	--

8.5.5.4 Inspection

See **clause 6.5.5.4** on heating systems.

An additional concern is preventing surface condensation on distribution pipes, which requires a minimum insulation thickness.

8.5.6 Tips and tricks

Electronic pumps are often oversized and set with two high head setting and sometimes a wrong control type is selected.

The energy used by pumps is an additional load: when possible recommend to transform three-way valve by-pass control with 2-ways valve control (variable flow rate control). This may require replacing the control valve and the pump.

8.6 Storage**8.6.1 Introduction**

On cooling systems, the storage is used to limit the frequency of start/stop during on-off operation (chiller).

8.6.2 What to look at

See **clause 6.6.2** on heating systems.

8.6.3 Input data

See **clause 6.6.3** on heating systems.

8.6.4 Additional information**8.6.4.1 EPC**

No additional information is required.

8.6.4.2 RP

No additional information is required.

8.6.4.3 SRI

If the storage is intended (sized) to allow significant load shift of the cooling service, then the functions shown in **table 22** apply.

Table 22 – SRI Functions related to space heating thermal energy storage

FUNCTIONALITY		LEVEL	
C-1g	Control of Thermal Energy Storage (TES) operation	☐ ____%	Not applicable, no significant cooling storage
		☐ ____%	Continuous storage operation
		☐ ____%	Time-scheduled storage operation
		☐ ____%	Load prediction based storage operation
		☐ ____%	Cold storage capable of flexible control through grid signals (e.g. DSM)

8.6.4.4 Inspection

No additional information is required.

8.7 Generation**8.7.1 Introduction**

For cooling generation the main generation technology is heat pumping.

District cooling is subject to local availability and still rare in Europe.

8.7.2 Heat pump (chiller)**8.7.2.1 What to look at**

See [clause 6.7.3.1](#) on heating systems, replacing COP with EER.

Additionally, water cooled chillers may have a

8.7.2.2 Input data

See [clause 6.7.3.2](#) on heating systems, replacing COP with EER.

External auxiliaries can be quite relevant.

8.7.2.3 Additional info**8.7.2.3.1 EPC**

No additional info

8.7.2.3.2 RP

No additional info

8.7.2.3.3 SRI

SRI has a special evaluation for the chiller generation control, as shown in [table 23](#).

Table 23 – SRI Functions related to heat pump generation subsystem

FUNCTIONALITY	LEVEL
---------------	-------

C-2a Generator control for cooling	☐ ____% On/Off-control of cooling production ☐ ____% Multi-stage control of cooling production capacity depending on the load or demand (e.g. on/off of several compressors) ☐ ____% Variable control of cooling production capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control) ☐ ____% Variable control of cooling production capacity depending on the load AND external signals from grid
------------------------------------	--

8.7.2.3.4 Inspection

See clause 6.7.3.4 on heating systems, replacing COP with EER.

8.7.3 District cooling

See clause 6.7.4 on district heating.

8.8 Special cases**8.8.1 Multiple generators**

See clause 6.8.1 on multiple generators for heating.

For SRI, the level of the following dedicated functionality shall be identified.

Table 24 – SRI Functions related to multiple generators for cooling

FUNCTIONALITY	LEVEL
C-2b Sequencing of different cooling generators	☐ ____% Not applicable, only one generator ☐ ____% Priorities only based on running times ☐ ____% Fixed sequencing based on loads only: e.g. depending on the generators characteristics such as absorption chiller vs. centrifugal chiller ☐ ____% Dynamic priorities based on generator efficiency and characteristics (e.g. availability of free cooling) ☐ ____% Load prediction based sequencing: the sequence is based on e.g. COP and available power of a device and the predicted required power ☐ ____% Sequencing based on dynamic priority list, including external signals from grid

8.8.2 Room air conditioners (RAC) and VRV/VRF systems

Room air conditioners and VRV/VRF systems are treated as a regular cooling system. Distribution and storage are not relevant for them. It is assumed that distribution losses are already included in the EER of the heat

pump and that the manufacturer may provide correction factors according to the extension and geometry of the refrigerant network.

8.9 Practical tips and tricks

Maybe move here some tips and tricks that have been highlighted in other sections about generation or move tips and tricks in specific new subclauses.

... use an icon and frame and special sentences ...



9 Ventilation system data collection

Inspection should have a look at flow rates

9.1 Introduction

Purpose of the ventilation system

The fundamental purpose of the ventilation system is to replace the indoor air with fresh outdoor air to keep an acceptable indoor air quality. Indoor air loads with CO₂ and contaminants emitted by occupants and by the building. It is expelled and replaced by outdoor air that should be “clean”; if not, incoming outdoor air has to be treated.

There is a huge variety of possible ventilation systems.

- Natural ventilation, actually meaning that there is no physical system for ventilation: it is assumed that occupants will open the windows to ensure an adequate air exchange rate.
- Mechanical ventilation with/without heat recovery, meaning that there is a dedicated system to ensure an adequate air exchange rate and possibly additional functions.

Mechanical ventilation systems are classified as

- Single duct, which may be
 - Extraction only
 - Supply only
- Double duct

Additional functions can be provided, completely or partially, through the ventilation system:

- heating and cooling (indoor temperature control);

- humidification and de-humidification (indoor humidity control);
- heat recovery (for double duct systems only);
- outdoor air treatment.

For more information on the classification of ventilation systems and on the naming conventions of air flows see **EN 16798-3**.

For natural ventilation, the calculation is usually straightforward: a minimum hygienic flow rate when the building is fully occupied is determined based on either the volume of the building or the floor area or an estimation of the number of occupants. A minimum flow rate may be established also for the unoccupied condition. Then an average occupancy factor is used for monthly methods or an occupancy pattern is considered for hourly methods. Data collection is simple.

For mechanical ventilation, the considered air flow rate is the actual flow rate of the mechanical ventilation system (it is usually checked against minimum hygienic). The challenge for data collection is finding the actual flow rates of existing systems, which may be poorly documented.

A big challenge and a source of variety of methods is the estimation of infiltration which may:

- exceed the minimum hygienic, for natural ventilation;
- occurs simultaneously and is influenced by mechanical ventilation when the latter is on or idle (reduced ventilation during unoccupied periods)
- occurs when mechanical ventilation is off.

The detailed calculation of infiltration described in EN 16798-7 requires the identification of all air paths and of their characteristics, which is a tough task for data collection. National methods have developed a lot of empirical equations based on qualitative information on the building and its exposure to wind to assess infiltration.

Another source of variety of methods is the air treatments in the air handling unit. The standard EN 16798-5 provides a detailed calculation of air treatments, resulting in an energy demand by heating and cooling coils. Several methods use simple correlations to calculate e.g. dehumidification loads.

Finally, there are no consolidated models of the electric energy use of fans. The control options can significantly reduce the energy use by fans and this is often solved by tabulated coefficients.

The following clauses refer to the EN 16798 series of standards but you must check your national calculation method and adapt to it the data collection process.

Data collection will therefore strongly depend on:

- type of ventilation;
- type of ventilation system;
- national or local methodology and the level of considered details.

9.2 General information on building ventilation

General information on building ventilation includes the following.

- The list of ventilation service areas and their identification on a plan of the building

A “ventilation service area” is a set of spaces (usually rooms) served by the same ventilation system and that share the same operating schedule.

The simplest case is: unique service area and natural ventilation for the whole building.

For each ventilation service area, the following data shall be identified:

- space category (ventilation may consider additional sub-categories);
- area and/or design occupancy data
- The type of ventilation in each ventilation service areas, that can be:
 - natural ventilation;
 - mechanical ventilation
 - hybrid ventilation
- The location of the mechanical room(s) and AHUs or VMC, if any.
- The list of the ventilation systems serving that building, if any, with the connected ventilation service areas.

This list may range

 - from empty, only natural ventilation in the whole building
 - to one unique system for the whole building
 - to several local systems (e.g. per building unit, per space category, per special spaces) to a mixture of centralised and local systems.

For simple buildings (e.g. single family houses) the entire building can be (and shall be) one unique service area.

For complex buildings with several ventilation systems, it is recommended to prepare a schematic plan of the ventilation system(s) in the building showing the connections between ventilation systems (mechanical rooms and AHUs) and the service areas.

9.3 Natural ventilation

For each service area, assess the required data to calculate the design minimum hygienic flow rate.

According to EN 16798-1 this data include:

- the space category
- depending on the space category, the floor area and/or the design number of occupants.

The number of occupants is often calculated according to default specific occupancy in persons/m²: the information to be assessed is only the area.

If validated plans of the building are available (see **clause XXX**), it is enough to identify each service area on the plan.

The comfort category is a default data for standard assessment.

National and/or local calculation methodologies may require additional data to estimate infiltration (and then consider the highest of minimum hygienic and infiltration flow rate), such as:

- blower door test results, if available;

- qualitative appreciation of building envelope air tightness and exposure to wind;
- length and qualitative tightness of operable joints of openings.

9.4 Mechanical ventilation systems

9.4.1 General information

For each ventilation system, the data collection should assess the following information.

- The **type of mechanical ventilation**, that can be:
 - single duct, extraction only
 - single duct, supply only
 - double duct
- The **design flow rates**, that include at least:
 - supply air (SUP) flow rate;
 - extracted air (EXA) flow rate;
 - outdoor air (ODA) flow rate.

Design flow rates should include maximum and minimum.

- The **additional functions and services** provided by mechanical ventilation, that can be:
 - heat recovery
 - free cooling
 - recirculation, i.e reusing part of the extract air for the preparation of the supply air;
 - heating
 - cooling
 - humidification
 - dehumidification
- The **control strategy of outdoor air (ODA) flow rate**, that can be
 - constant ODA flow rate;
 - variable ODA flow rate, depending on a control property, such as:
 - time control, according to expected occupancy;
 - CO₂ concentration;
 - Occupancy detection;
 - other;
- The **control strategy of supply air temperature**, that can be:

- no control, i.e. absence of heating and/or cooling coil in the AHU or in the terminals;
- only pre-heating or pre-cooling supply air, that is providing supply air at a given set-point;
- providing the heating and cooling service, that is controlling the room temperature to a given set-point using supply air temperature
- The **control strategy of supply air flow rate**, that can be
 - constant flow rate;
 - variable flow rate, depending on a control property

For complex ventilation systems, it is recommended to prepare a basic functional diagram of the ventilation system(s), showing the connections with its serviced areas. The functional diagram shall highlight the connections between the ventilation system and other technical systems, such as the heating and cooling system that provide hot and cold water for the coils.

Specific additional data is mentioned in the following sections

Depending on the level of details and coverage of systems, your national or local methodology may not require all the data.

In the following, more details are given on specific aspects of ventilation.

9.4.2 Design flow rates

The design flow rates are found in the design documentation or in the balancing reports.

The total flow rate for a ventilation system is often found in the AHU documentation or nameplate.

Some rough check can be made according to ducts cross section area and default air velocity. Actual, measured flow rates can be quite different from required or intended flow rates due to e.g.:

- poor or no balancing;
- filter clogging.

The source of the flow rate information should be recorded.

9.4.3 Infiltration flow rates

According to EN 16798-7, infiltration flow rates can be calculated in two ways.

- By solving the detailed air mass flow balance as a function of ventilation service area reference pressure.
This requires:
 - the identification of all air paths for the ventilation service area;
 - the collection of the data of each vent, air terminal device, ventilation duct (e.g. airflow coefficient, flow exponent, reference pressure difference)
- By national correlation methods, which require qualitative data about the building tightness.
See your national or local calculation method know which data is required.

9.4.4 Air emission (“ventilation efficiency”)

Air emission considers how air is introduced in the room and extracted from the ventilated space.

The effectiveness of the removal of contaminants depends on the type of circulation of air in the ventilated space. Two basic types of circulation of air are defined.

- Perfect mixing, which is the reference configuration.

Air supply terminals and/or extraction grilles ensure mixing of air in the room.

- Piston flow.

Air supply terminals and/or extraction grilles ensure that air flows through the ventilated space without mixing (example: supplied at floor level and extracted at ceiling level).

To determine the type of air circulation, look at the position of air supply terminals and/or extraction grilles. See EN 16798-3, clauses 8.8.2 to 8.8.4.

9.4.5 Ventilation control

Ventilation control refers to adjusting the amount of supplied outdoor air supplied to the building needs.

Bringing in outdoor air has

- both mechanical (transport)
- and treatment (bringing outdoor air from outdoor to indoor conditions)

energy costs. Therefore, outdoor air flow rate should be controlled in relation to the needs which are related to:

- desired IAQ level;
- occupancy;
- other reasons (furniture, ...).

To determine the ventilation efficiency, assess

- the control strategy of outdoor air (ODA) flow rate (see clause 9.4.1)
- the level of ODA flow rate control:
 - room by room;
 - by group of rooms
 - for the entire ventilation service area.

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9.4.6 Air distribution

The air distribution subsystem raises two concerns:

- the heat losses from the ducts and the other components of the distribution sub-system;
- the air leak of the ducts and of the AHU.

The calculation of losses of air ducts is based on similar data as losses of water pipes. The following information is required for each duct homogeneous section.

- Length of the duct

The length of the centre line is used.

- Type of cross section and size of ducts;

Cross section of ducts can be e.g. rectangular, circular, elliptical.

- Insulation material and thickness.

Usually, extract air ducts inside the conditioned space are not insulated.

- Installation position relative to conditioned space

- Type of air flow (e.g. SUP, ODA, EXH).

- Temperature regime

- Flow rate

The flow rate is relevant for detailed calculation because the temperature drop of air along the ducts depends on the flow rate.

The air tightness class of the ducts and of the AHU shall be assessed. Look for any:

- leakage test report;
- leakage class specification.

9.4.7 Air handling units

During the on-site data collection, determine the components of the AHU and their technical data. A sample list is provided in [table XX](#).

Detailed information about heat recovery and fans is given in the next clause.

9.4.8 Heat recovery

These units recover energy from exhaust air and transfer it to incoming fresh air, improving efficiency. Common types are plate, rotary, run-around coil, and heat pipe exchangers.

During data collection for energy performance calculation, look at the following aspects

- type of heat recovery unit: plate, rotary, run-around coil, or heat pipe.
- if the also latent heat is recovered
- make and model
- rated effectiveness
- availability of a by-pass
- frost protection: presence and control logic of anti-freeze or preheating systems in cold climates
- rated power of auxiliaries (drive motor for rotary heat exchangers, circulation pump for run-around coils)

9.4.9 Fans

For each fan, determine:

- Make and model, so that the technical data can be found.

- Rated power of the motor.
- Type of flow rate control devices:
- Outlet register
- Inlet vane
- Type of speed control of the motor
- Constant speed
- Variable speed

9.5 Additional information

9.5.1 EPC

No additional info required.

9.5.2 RP

IAQ is hard to guarantee without a mechanical ventilation system. Replacement of windows often leads to insufficient air exchange rate. Symptoms of low air exchange rate are the development of mold, excessive humidity in winter, odours and poor IAQ.

If no ventilation systems is installed, check for

- available space for AHU and ducts
- possible location of ODA inlet and EXH outlet

Consider both local or centralised systems.

9.5.3 SRI

The level of the following functionalities about the ventilation system shall be assessed.

Table 25 – SRI Functions related to the ventilation system

FUNCTIONALITY		LEVEL	
V-1a	Supply air flow control at the room level	☐ ____%	No ventilation system or manual control
		☐ ____%	Clock control
		☐ ____%	Occupancy detection control
		☐ ____%	Central Demand Control based on air quality sensors (CO ₂ , VOC, humidity, ...)
		☐ ____%	Local Demand Control based on air quality sensors (CO ₂ , VOC,...) with local flow from/to the zone regulated by dampers

V-1c	Air flow or pressure control at the air handler level	☐ ____% No automatic control: Continuously supplies of air flow for a maximum load of all rooms ☐ ____% On off time control: Continuously supplies of air flow for a maximum load of all rooms during nominal occupancy time ☐ ____% Multi-stage control: To reduce the auxiliary energy demand of the fan ☐ ____% Automatic flow or pressure control without pressure reset: Load dependent supplies of air flow for the demand of all connected rooms. ☐ ____% Automatic flow or pressure control with pressure reset: Load dependent supplies of air flow for the demand of all connected rooms (for variable air volume systems with VFD).
V-2c	"Heat recovery control: prevention of overheating"	☐ ____% Without overheating control ☐ ____% Modulate or bypass heat recovery based on sensors in air exhaust ☐ ____% Modulate or bypass heat recovery based on multiple room temperature sensors or predictive control
V-2d	Supply air temperature control at the air handling unit level	☐ ____% No automatic control ☐ ____% "Constant setpoint: A control loop enables to control the supply air temperature, the setpoint is constant and can only be modified by a manual action" ☐ ____% Variable set point with outdoor temperature compensation ☐ ____% Variable set point with load dependant compensation. A control loop enables to control the supply air temperature. The setpoint is defined as a function of the loads in the room

V-3	Free cooling with mechanical ventilation system	☐ ____% No automatic control ☐ ____% Night cooling ☐ ____% "Free cooling: air flows modulated during all periods of time to minimize the amount of mechanical cooling" ☐ ____% "H,x- directed control: The amount of outside air and recirculation air are modulated during all periods of time to minimize the amount of mechanical cooling. Calculation is performed on the basis of temperatures and humidity (enthalpy)."
V-6	Reporting information regarding IAQ	☐ ____% None ☐ ____% Air quality sensors (e.g. CO ₂) and real time autonomous monitoring ☐ ____% Real time monitoring & historical information of IAQ available to occupants ☐ ____% Real time monitoring & historical information of IAQ available to occupants + warning on maintenance needs or occupant actions (e.g. window opening)

9.5.4 Inspection

Inspection shall focus on checking

- if the air flow rates are still correct and balanced;
- if controls are correctly set and still operating (set-point maintained, no control loop in manual mode);
- if the operating schedule is correct;
- maintenance history: frequency of cleaning, filter replacement, and inspections;
- noise and vibration: abnormal sounds indicating wear or misalignment.

Concerning heat recovery devices, check:

- physical condition – corrosion, damage, or leaks;
- cleanliness, absence of dust, debris, or biological growth on heat exchangers;
- airflow balance, correct supply, and exhaust flow rates.
- thermal performance, effectiveness of heat transfer compared to design or rated values
- sensors, bypass dampers and operational settings.

10 Lighting system data collection

10.1 Introduction

According to the EN standard EN 15193, the calculation of lighting energy use is performed:

- per each room or uniform space;
- on a monthly basis.

The LENI calculated in the EN 15193 is the unweighted electricity use for lighting.

The data to be collected for each service area is the following.

- An inventory of luminaires with the rated power of the lamps and any ballast or driver
- The control type for the service area
- The geometric characteristics of the service area for the calculation of daylight penetration index

Depending on your national method, the energy for lighting may include:

- lighting of unheated spaces within the building like e.g. unheated staircase, basement, attic, indoor garage;
- lighting of external areas like e.g. an external parking

EN 15193 does not cover external lighting.

10.2 What to look at

The starting point is the rated power of each lamp. A measurement is not required for the purpose of this standard, the rated power of the lamp, which is often printed on the lamp, is enough. You must be careful whether the indicated power includes or not the ballast or the driver and mention it in the on-site audit report. Example:

- the rated power printed on a T8 fluorescent lamp does not include the ballast;
- the rated power printed on a compact fluorescent lamp does include the ballast.
- the rated power on a LED fixture includes the driver losses.

If the ballast or driver is not included and its power loss is not known, a default value (typical 20% of the lamp power) is used.

10.3 General information on the lighting system

The general information on the lighting system consists in the identification of the lighting service areas on the building plans. Each service area shall have uniform use category, control properties and daylighting characteristics.

The lighting service areas may include unheated space and external areas, depending on the requirements of your national or local methodology (what is included in the energy performance of a building).

Provide a list of service areas with;

- space category;
- floor area.

10.4 Lamps, luminaires and contro, options

For each lighting service area, provide a list of lamps or luminaires indicating:

- technology (e.g. fluorescent, LED);
- rated power;
- whether the rated power includes the ballast or driver;
- the control options.

A checklist for these data is provided in **table XX**.

10.5 Daylight data

For each lighting service area, provide the geometrical data to assess the daylight factor, that is a plan of the service area with:

- the size and height of the room or space;
- the position and height of the work plane;
- the position size and height of the windows;
- the position size and height of roof lights, if any;

A checklist for these data is provided in **table XX**.

10.6 Additional information

10.6.1 EPC

No additional information

10.6.2 RP

No additional information

10.6.3 SRI

Table XX shows the functions related to the lighting system with their levels.

Table 26 – SRI Functions related to lighting

FUNCTIONALITY		LEVEL	
L-1a	Occupancy control for indoor lighting	☐ ____%	Manual on/off switch
		☐ ____%	Manual on/off switch + additional sweeping extinction signal
		☐ ____%	Automatic detection (auto on / dimmed or auto off)
		☐ ____%	Automatic detection (manual on / dimmed or auto off)

L-2 Control artificial lighting power based on daylight levels	☐ ____% Manual (central) ☐ ____% Manual (per room / zone) ☐ ____% Automatic switching ☐ ____% Automatic dimming ☐ ____% "Automatic dimming including scene-based light control (during time intervals, dynamic and adapted lighting scenes are set, for example, in terms of illuminance level, different correlated colour temperature (CCT) and the possibility to change the light distribution within the space according to e. g. design, human needs, visual tasks)"
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10.6.4 IR

No additional information

11 Photovoltaic (PV)**11.1 Introduction**

Photovoltaic systems are the most popular technology for on-site the generation of renewable electricity.

It can be complemented with batteries to increase self-use of generated electricity and allow operation on produced electricity during the night.

11.2 What to look at

The incident solar energy, hence the produced electricity, depends on:

- solar panels area;
- orientation and tilt angle of panels in relation with latitude;
- any shading, even on just part of the collectors.

The efficiency of PV panels decreases with temperature. The installation of the panels should allow a maximum of air circulation around the panels to cool them.

Check if there are loads that can be either disconnected or forced to allow energy management.

11.3 Input data

According to EN 15316-4-3, the following data is required for each homogeneous group of panels;

- make an model of panels;
- peak power of installed panels under 1kW/m^2 incident solar radiation;
- orientation and tilt;
- shadings;

— level of ventilation of the panels.

The level of ventilation of the panels depends on the installation type:

- unventilated modules is the case of embedded panels
- moderately ventilated modules is the case of panels mounted parallel to the roof or wall with space behind for natural air circulation;
- strongly ventilated or forced ventilated modules is the case when the panels are free to air or with forced ventilation.

If a battery is installed, record:

- make and model of the battery;
- capacity of the battery in kWh;
- efficiency of the battery;
- the maximum allowed power during discharge.

The capacity shall be the actual with the allowed discharge (the rated capacity is higher the actual usable capacity if the maximum discharge depth is less than 100%).

11.4 Additional information

11.4.1 EPC

If no photovoltaic (PV) system is installed, check if there is any accessible roof area available for the installation of PV panels. If so, record:

- available area;
- orientation and tilt of the surface;
- any obstacle or shading.

11.4.2 RP

Same as for EPC, **clause 11.4.1**. Additionally the age and remaining life-span of panels and batteries should be assessed.

11.4.3 SRI

Table 27 shows the functions related to the electricity generation and storage with their levels. This table also reports other functions that are related to electricity storage and use in the building.

Table 27 – SRI Functions related to PV panels and electricity use in the building

FUNCTIONALITY	LEVEL
---------------	-------

E-2 Reporting information regarding local electricity generation	☐ ____% No electricity generation ☐ ____% None ☐ ____% Current generation data available ☐ ____% Actual values and historical data ☐ ____% Performance evaluation including forecasting and/or benchmarking ☐ ____% Performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection
E-3 Storage of (locally generated) electricity	☐ ____% None ☐ ____% On site storage of electricity (e.g. electric battery) ☐ ____% On site storage of energy (e.g. electric battery or thermal storage) with controller based on grid signals ☐ ____% On site storage of energy (e.g. electric battery or thermal storage) with controller optimising the use of locally generated electricity ☐ ____% On site storage of energy (e.g. electric battery or thermal storage) with controller optimising the use of locally generated electricity and possibility to feed back into the grid
E-4 Optimizing self-consumption of locally generated electricity	☐ ____% None ☐ ____% Scheduling electricity consumption (plug loads, white goods, etc.) ☐ ____% Automated management of local electricity consumption based on current renewable energy availability ☐ ____% Automated management of local electricity consumption based on current and predicted energy needs and renewable energy availability

E-8	Support of (micro)grid operation modes	☐ ____% None ☐ ____% Automated management of (building-level) electricity consumption based on grid signals ☐ ____% Automated management of (building-level) electricity consumption and electricity supply to neighbouring buildings (microgrid) or grid ☐ ____% Automated management of (building-level) electricity consumption and supply, with potential to continue limited off-grid operation (island mode)
E-11	Reporting information regarding energy storage	☐ ____% No electricity storage ☐ ____% None ☐ ____% Current state of charge (SOC) data available ☐ ____% Actual values and historical data ☐ ____% Performance evaluation including forecasting and/or benchmarking ☐ ____% Performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection
E-12	Reporting information regarding electricity consumption	☐ ____% None ☐ ____% reporting on current electricity consumption on building level ☐ ____% real-time feedback or benchmarking on building level ☐ ____% real-time feedback or benchmarking on appliance level ☐ ____% real-time feedback or benchmarking on appliance level with automated personalized recommendations

11.4.4 Inspection

Check energy production data and verify that they are consistent with the size of the PV panel installation and the local climate. If the production is less than expected, investigate the reason.

Check energy self-use data and verify that they are consistent with the production and on-site loads. If the self-use is less than expected, investigate the reason and look for possibilities to increase it, such as:

- adapting operating schedules of HVAC systems to electric energy availability
- increased heat storage, such as increasing the domestic hot water storage temperature or changing the indoor temperature set-point;
- interruptible loads.

11.5 Tips and tricks

Electricity can be conveniently stored as heat.

12 Measured energy data collection

12.1 Introduction

There are several possible reasons to collect measured energy data:

- your country allows or requires the use of measured energy data to prepare an EPC;
- to show the improvement in energy performance by comparing the energy consumption before and after renovation with metering systems (recommended option for financial measures in EPBD IV);
- Member States may use metered energy consumption under typical operating conditions to verify the correctness of the calculated energy use and enable comparison between calculated and actual performance (EPBD IV).
- for any reason, you would like to validate the calculated energy performance.

Based on EPBD IV, a calculation method is required to use the metered energy, indeed.

- ‘Energy performance of a building’ means the calculated or metered amount of energy needed to meet the energy demand associated with a typical use of the building.

This implies that normalisation of metered energy to typical use is needed.

- Measured energy is a recommended option for financial measures for energy performance improvements and reduced greenhouse gas emissions in the renovation of buildings to confirm the targeted or achieved energy savings and improvements by comparing the energy consumption before and after renovation with metering systems, provided it complies with the requirements set out in Annex I.

A comparison of measured energy before and after renovation requires the normalisation to the same conditions.

- Annex I in EPBD IV requires a calculation methodology for normalisation for local climate and use:
„Where metered energy use is the basis for calculating the energy performance of buildings, the calculation methodology shall be capable of identifying the influence of the behaviour of occupants and the local climate, which shall not be reflected in the result of the calculation“.

EPBD IV sets minimum requirements on the data set for measured energy performance.

- Metered energy use for the purpose of calculating the energy performance of buildings shall require readings of at least monthly intervals and must differentiate between energy carriers.
- Metered energy consumption for the purposes of verification and comparison may be based on monthly readings.

The reference standard is EN 15378-3. This standard specifies how to determine the energy performance of a building, based on measured energy data. Unfortunately, this standard is limited to heating and domestic hot water but similar concepts may be applicable to other services.

The practical difficulty is that it is not enough to assess the measured energy. You also have to assess the influencing factors that caused the use of that amount of energy, that is the use of the building and the climate.

There are several calculation methods for normalizing measured energy, including validation of the measured data. The input data collection depends on the method used, but typical data to be collected are:

- Energy use per energy carrier and possibly per service (heating, DHW, ventilation, cooling, lighting)

- Data on climate:
 - external temperature;
 - solar radiation.
- Use of the building:
 - internal temperature;
 - known occupancy information (e.g. vacation, intermittent use)

12.2 Data collection

12.2.1 Energy use

In most countries the new energy meters provide automatically monthly readings. Ideally, each measurement interval should be an integer number of weeks: monthly is around four weeks but this an acceptable deviation for the purpose of issuing an EPC.

12.2.2 The influencing factors (use of the building and climate)

For heating the most important influencing factors are the external temperature and the internal temperature. All MS have automatic stations for the analysis of external air quality, that include a reliable meteo-station. Where this data is available, this is an excellent source. Other suitable sources are meteo-stations linked to airports and to agriculture.

Measurement or estimation of internal temperature during energy consumption is important input parameter to take into account the behaviour of occupants and provide the basis for the normalisation to typical use. It can be estimated based on the indoor temperature settings if measured data are not available.

Another influencing factor is the quantity of used domestic hot water.

12.3 Amount of data to be collected

According to EN 15378-3, data shall be available over at least 3 years to be able to validate the correlation between energy use and climate. The collection over three years is intended to demonstrate that the use of the building is stable.

If the validation of the model fails, you may either:

- look for more information and carefully screen the data for outliers;
- start a planned data acquisition and wait for the completion of a valid data set.

12.4 Comparison of measured and calculated energy performance

Maybe in general explanation on measured energy/calculated energy:

It is recommended that measured energy be compared with calculated delivered and exported energy.

Even if not reported officially in the EPC, delivered and exported energy, shall be reported to the user by energy carrier, so that one can readily

- check for consistency of calculated energy use with measured energy use, the latter being by energy carrier;
- convert the calculated energy performance into an expected economic performance, which is required for any cost analysis.

13 Cost estimation

Introduce here the question of cost estimation

13.1 Introduction

EPBD requires that measures to improve the energy performance of buildings should also take into account the cost-effectiveness. Member States should set minimum energy performance requirements for buildings and building elements with a view to achieving the cost-optimal balance between the investments involved and the energy costs saved throughout the life cycle of the building, without prejudice to the right of Member States to set minimum energy performance requirements which are more energy-efficient than cost-optimal energy efficiency levels.

The calculation and data collection on costs by assessor may be needed in these situations:

- Energy performance certificate provides indicator expressed in energy costs
- Renovation passport shall include the information about each renovation step, including the estimated energy savings in kWh and the estimated savings on the energy bill, clearly indicating the assumptions on energy costs used for the calculation
- Calculation of cost optimal energy conservation measure (ECM) or overall design in case more options lead to the target (NZEB/ZEB). Not the lowest investment costs, but the global costs (the life cycle costs analysis based on net present value) should be used to compare different solutions of energy saving options.

The official national methodology and standardised inputs may be required for EPC and RP.

For global costs calculation the methodology in EN 15459-1 can be used taking into account use patterns, climate, investment costs, maintenance and operating costs, energy costs and earnings from energy produced. It can take into account the environmental and health externalities of energy use if relevant.

Cost estimation of ECMs should be based on standard prices either published by public authorities or by statistical office or other official source. The cost shall be referred to a standard solution, not including luxury, design and user requirements items.

In case of renovation already due to ageing of building structures and systems, only additional costs for increased energy performance shall be accounted for cost effectiveness of energy conservation measures.

According to EN 15459 the global cost is a sum of the present value of the initial investments costs, sum of annual running costs and replacement costs (referred to the starting year) as well as disposal costs if applicable. The input data required for calculation based on EN 15459-1 are:

- initial investment cost, including design, purchase, connection to suppliers, installation and commissioning process. The costs are those that are presented to the customer, but can be standardised at the national level depending on the purpose of calculation
- maintenance cost, for measures for preserving and restoring the desired quality of the building, building element or installation

- operational cost, linked to the operation of the building, including insurance, utility charges and other standing charges and taxes. It is important to take into account the green tax benefits if relevant for customer
- energy cost, including a fixed and peak charges for energy including national taxes, the external costs and metering costs. The source and what is included has to be specified
- periodic costs of year, costs to substitute investment that is necessary for age reasons; that corresponds to cost replacement of all components (or system) according to their lifespan that occur on year i . Periodic costs include all replacement costs for any components or system that occur the same year.
- cost of greenhouse gas emissions related to the energy consumption in buildings
- disposal cost for deconstruction at the end of life of a building or building element and include deconstruction, removal of building elements
- discount rate, corresponds to the interest rate which is charged or paid for the use of money for the calculation period considered

13.2 On site data collection

Most of input data for global costs calculation mentioned in the previous chapter is possible to acquire from the desk analysis and search of products including the evolution of energy and products prices.

Only few data must be achieved during on-site inspection:

- Actual situation may influence cost and even feasibility of given measures. Rule n°1: check on site what renovation option is feasible.
- Energy bills and energy contracts should be provided by customer.
- The local green taxes may be applicable and should be taken into account,

Cost of products estimate shall be found in publications from commerce chambers and/or professional associations and/or dedicated national reference. The source of data on cost (e.g. investment cost, energy cost ,...) shall be reported in the documentation.

13.3 EPC specific

If energy performance certificate provides indicator expressed in energy costs, the calculation methodology and inputs for energy costs calculation may be standardised by public authority.

13.4 RP specific

Cost evaluation and long term financial analysis is mandatory. The estimated energy savings in kWh and the estimated savings on the energy bill have to be calculated for each renovation step, clearly indicating the assumptions on energy costs used for the calculation

13.5 SRI specific

There is no cost evaluation in the SRI procedure.

13.6 IR specific

Nothing specific. IR recommendations are typically expert advice.

14 Specific on-site tasks for SRI assessment

The previous inspection procedure deals with the assessment related to EPB services, that is heating, cooling, domestic hot water, ventilation and lighting. SRI specific items have been already mentioned to facilitate the collection of all required information for the whole assessment scope when inspecting each technical system and sub-system.

However, SRI has a broader scope, that includes additional “domains” compared to EPB scope, like e.g. vehicle charging and monitoring and control functionalities.

If SRI falls within the scope of the assessment the functionalities of the following domains shall be determined

- E Electricity
- EV Electric vehicle charging
- MC Monitoring and control

Please refer to the SRI checklist, in **clause 17.24** and **table 27**, for more details.

15 Deliverables of the inspection

The expected result of the building inspection and processing of the data collected is a structured set of documentation providing

- the input data to the energy performance calculation;
- additional information to support the evaluation of ECMs proposed in the EPCs;
- If RP is within the scope of work, additional information to prepare and justify a staged deep renovation, including e.g. feasibility of possible recommendations, any facts that would impact cost of renovation;
- If SRI is within the scope of work, the level of each function for input in the SRI calculation tool;
- If IR is within the scope of work, additional information and data to provide suggestions in the inspection report.

The documentation set shall consist of a set of documents covering:

- A document or note with the data of the on-site visit, the participants to the site visit and the status of the systems and building when visited.
- schematic plans of the building with:
 - identification of the conditioned space;
 - identification of the reference geometry of the building envelope (plans and facades);
 - identification of the building elements constituting the building envelope, including size and shading;
 - identification of service areas;

- Structure of the technical systems (basic functional diagrams of the systems);
- Identification of the position of main equipment and distribution layout;
- Tables with properties of building elements and system components;
- Tables with properties of technical systems and operating hours per service area;
- Identification of delivered energy carriers and providers of nearby energy carriers (e.g. district heating and/or cooling).
Nearby energy carriers providers shall be identified because they have to provide the specific weighting factors according to applicable regulations or EN 15316-4-5.
- A series of pictures covering at least the exterior of the building envelope, the nameplates of each relevant piece of equipment, pictures of the typical installations components and their installation type; Notes and remarks

For complex buildings, it is recommended to include a synthetic narrative description of the data-set and documents to guide readers in finding the required information.

The format and the original support are free.

The information shall be clearly structured so that the source of the calculation input can be traced.

Paper notes, document and plans shall be scanned and the files added into a folder with all other information concerning the assessed object on-site visit.

16 Quality insurance

After input of the data into the calculation tool, print double check the available input listing of the tool with the inspection results documentation.

Quality insurance has several meanings in this context:

- providing complete and correct information to the responsible of energy performance calculation, generation of recommendations, production of an RP and more;
- trace the origin of input data, to support quality assessment of EPBD disclosure documents by public authorities or delegated bodies;
- guaranteeing that the information is stored and can be retrieved if the disclosure document has to be updated following any alteration of the building.

17 Inspection checklists and reporting templates

17.1 Introduction

A series of structured checklists and reporting templates is given in the following to assist the on-site data-collection process.

Given the variety of possible configurations, the checklists are organised per topics. If there are multiple similar elements in the building (e.g. opaque walls), just fill in several identical forms. Similarly, if there is e.g. no cooling system, do not use the corresponding checklist to avoid accumulating useless documentation.

For some topics, like e.g. distribution networks, alternatives are given following the most common approaches.

A basic formatting is proposed and it can/shall be adapted. There is no regulatory nor standardised format, so you are free to use any format and/or any convenient medium. Paper may be still practical to capture geometrical details but the checklist can be converted for use in a phone or tablet app. Software support may contribute to ease and quality with features like:

- highlighting next steps (to do items) or missed steps;
- automatically archiving notes and pictures taken on site.

The checklists are based on the expected most frequent input data that are collected on-site. The data that are calculated from data obtained during on-site visit (e.g. floor area, perimeter) or selected from catalogues and standards (e.g. lambda values of materials, linear transmittance of thermal bridges) are not included because you will determine them later, in the office, based on the data collected on-site.

Before using the checklists, check that they match the required input to your calculation method and software. This is not wasted time: tailoring the checklists for your needs;

- is a valuable training session;
- ensures that the checklist will be fit for your use.

After each checklist presented in the following, there is a final clause with comments and possible tips.

Add a few lines to explain the use of each checklist

17.2 Overall inspection checklist

Table 28 – Overall inspection checklist

Assessor company logo and header	
Building name/reference	
Contact information (owner/administration)	Name Phone/mail
ITEM	CHECK
The assessed object is identified	☐ Done ☐ YES ☐ NO ☐ Admin data checklist completed
The purpose of the assessment is defined	☐ EPC ☐ RP ☐ SRI ☐ IR
The contract for the assessment is signed	☐ Done ☐ Reference/date _____
The calculation method and calculation tool are defined	Method: _____ Tool: ____ _____

This checklist is intended to record the basic information. It should consist of no more than one page and be the “placeholder” for each disclosure tool. Reference is made to other checklists if more details are desired for complex buildings.

This checklist should record only the core process and details on where to find the supporting and/or archived material.

This checklist can be extended to cover the whole scope of issuing the disclosure tool (example: adding a line or an entire checklists for recommendations).

Table 29 – Building administrative data checklist

Assessor company logo and header

Building name/reference	
Contact information (owner/administration)	Name Phone/mail
ITEM	CHECK
Building address	City Street/n° more
Cadastral information	Cadaster Reg. number
Building category	☐ Residential ☐ Non residential ☐ Mixed use
...	...
Date _____	Signature _____

Notes on the use of this checklist

Ask only for essential source data input, taking into account that the software tools in use will complement it automatically.

Example: by stating the city, a software tool should provide latitude, longitude, climatic zone and more.

17.4 List of documents to be required**Table 30 – Existing documentation checklist**

Assessor company logo and header	
Building name/reference	
Contact information (owner/administration)	Name Phone/mail
ITEM	CHECK
List of tenants and contacts for access	☐ No ☐ Yes ☐ Validated
Previous EPBD disclosure tools	☐ EPC ☐ IR ☐ RP ☐ SRI ☐ None available
Previous energy audit	☐ No ☐ Yes ☐ Validated
Architectural plans	☐ No ☐ Yes ☐ Validated
Facades plans	☐ No ☐ Yes ☐ Validated

Design documentation, building envelope Evidence on building elements	☐ No ☐ Yes	☐ Validated
Design documentation, systems Evidence on equipment and components	☐ No ☐ Yes	☐ Validated
	☐ No ☐ Yes	☐ Validated
	☐ No ☐ Yes	☐ Validated
Functional diagrams, hydronic Sequence of operation	☐ No ☐ Yes	☐ Validated
	☐ No ☐ Yes	☐ Validated
Functional diagrams, aeraulic Sequence of operation	☐ No ☐ Yes	☐ Validated
	☐ No ☐ Yes	☐ Validated
Fuel delivery records	☐ No ☐ Yes	☐ Validated
Operation and maintenance records	☐ No ☐ Yes	☐ Validated
Reports of professional inspections and professional tests of the heating system and/or evenlope	☐ No ☐ Yes	☐ Validated
Date _____	Signature _____	

Notes on the use of this checklist

This checklist shall be a reminder of the documents that should/may be available. The list shall be as complete as possible. For simple buildings and/or specific cases, some documents are not needed.

The various documents may well be in different locations (e.g. owner archive, building administration archive, mechanical room) and is often forgotten.

This list can be used also to track the verification and validation process of each document.

Depending on the MS, there might be obligatory documentation to be found on-site

17.5 Site visit checklist**Table 31 – Site visit checklist**

Assessor company logo and header	
Building name/reference	
Contact information (owner/administration)	Name Phone/mail
Date of visit	Started on ___/___/___, completed on ___/___/___
ITEM	CHECK

Contact tenants and/or building administration for access	☐ Yes
Check existing documentation	☐ EPC ☐ IR ☐ RP ☐ SRI ☐ None available ☐ Energy audit ☐ Building plans ☐ Facades plan ☐ Design documents ☐ Data on building elements ☐ Functional diagram of systems, with sequence of operation ☐ Data on equipment and system components ☐ Other documents Allow to specify: OK, Rebuilt, Missing, see list
Complete reference documentation	☐ Building plans with conditioned space and use category ☐ Building plans with position of equipment and systems ☐ Building facades with indication of type of building elements ☐ Technical installation structure and service areas ☐ Technical functional diagrams ☐ Take external pictures of the building round the clock ☐ Take pictures of nameplates of the technical equipment
Assess building elements, current status	☐ Opaque walls and roof ☐ Transparent elements ☐ Thermal bridges ☐ Unheated spaces ☐ Basement and floor on ground

Assess technical system, current status	☐ Heating ☐ Domestic hot water ☐ Cooling ☐ Ventilation ☐ Lighting
Check possible ECMs	☐ Check possibility of insulating roof, walls, ... ☐ Check possible improvements on systems, ... ☐ Check ...
Date _____	Signature _____

Notes on the use of this checklist

This checklist shall be a general guide for the on-site inspection.

The inspection and data-collection for each specific aspect can be further supported by dedicated checklists.

17.6 Documentation check**Table 32 – Documentation check checklist**

Assessor company logo and header	
Building name/reference	
Contact information (owner/administration)	Name Phone/mail
ITEM	CHECK
List of tenants and contacts for access	☐ No ☐ Yes ☐ Validated
Previous EPBD disclosure tools	☐ EPC ☐ IR ☐ RP ☐ SRI ☐ None available
Previous energy audit	☐ No ☐ Yes ☐ Validated
Architectural plans	☐ No ☐ Yes ☐ Validated
Facades plans	☐ No ☐ Yes ☐ Validated

Design documentation, building envelope Evidence on building elements	☐ No ☐ Yes	☐ Validated
Design documentation, systems Evidence on equipment and components	☐ No ☐ Yes	☐ Validated
	☐ No ☐ Yes	☐ Validated
	☐ No ☐ Yes	☐ Validated
Functional diagrams, hydronic Sequence of operation	☐ No ☐ Yes	☐ Validated
	☐ No ☐ Yes	☐ Validated
Functional diagrams, aeraulic Sequence of operation	☐ No ☐ Yes	☐ Validated
	☐ No ☐ Yes	☐ Validated
Fuel delivery records	☐ No ☐ Yes	☐ Validated
Operation and maintenance records	☐ No ☐ Yes	☐ Validated
Reports of professional inspections and professional tests of the heating system and/or envelope	☐ No ☐ Yes	☐ Validated
Date _____	Signature _____	

17.7 Opaque elements table

Table with layers for opaque elements

Table 33 – Opaque elements checklist

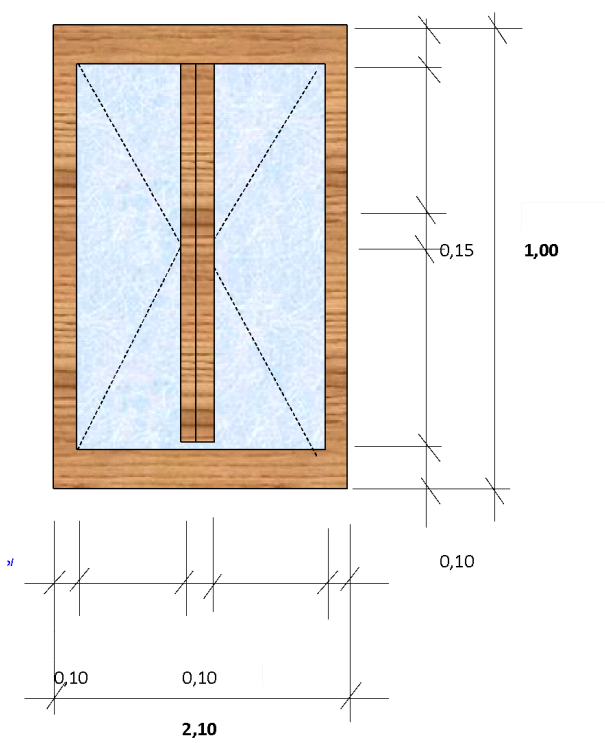
Assessor company logo and header		
Building name/reference		
01 - Code: _____	Description: _____	
Source of information:	☐ Invoice, contract, delivery document ☐ Owner, design documentation (plan) ☐ No documents, only inspection and estimation by assessor	
Color	☐ Light ☐ Dark ☐ Medium	
Description of layer/element	Thickness m	Comment

02 - Code: _____	Description: Example of data input	
Source of information:	☐ Invoice, contract, delivery document ☐ Owner, design documentation (plan) ☐ No documents, only inspection and estimation by assessor	
Color	☐ Light ☐ Dark ☐ Medium	
Description of layer/element	Thickness m	Comment
External cement-slag mortar	0.03	Original from year of construction 1983
Masonry	0.35	The same as the main façade, but thickness 30 cm behind radiators
Internal mortar	0.02	Renovated 5 years ago. Spatula, painting

17.8 Transparent elements table

Table 34 – Transparent elements checklist

Assessor company logo and header	
Building name/reference	
W1 Window code:	Description:
Source of information	☐ Invoice, contract, delivery document ☐ Owner, design documentation (plan) ☐ No documents, only inspection and estimation by assessor

☐ Indicate window size ☐ Note which part is opening and which is fixed NOTE: one window tab for each size	
Prepare figure without values of dimensions	
Type of window	☐ Single glazing ☐ Double or triple glazing ☐ Double frame ☐ Double window (or more windows in series)
known U-values from documentation	☐ U_w (whole window) _____ $W/(m^2 \cdot K)$ ☐ U_F (frame) _____ $W/(m^2 \cdot K)$ ☐ U_g (glazing) _____ $W/(m^2 \cdot K)$
Frame	Material: Thickness _____ mm Number of cavities _____
Spacer	Material: _____

Glazing	Number of panes / glasses ☐ 1 ☐ 2 ☐ 3 Distance between glasses and thickness (mm) Filling gas ☐ Air ☐ Argon ☐ Reflective coating ☐ NO ☐ Yes, reflectivity
Radiation properties	Known Solar factor, g-value: Known light transmittance:
Infiltration data	☐ Yes ☐ No Old windows with high air permeability, high natural ventilation • No • Yes ☐ Yes ☐ No Sealing interrupted ☐ Yes ☐ No Ventilation grilles Type of joints _____
Acoustic properties	☐ Yes ☐ No Special acoustic windows Special properties
Type of mounting of the window Position of wall insulating layer Additional jamb and lintel insulation Is the sill interrupted by insulation?	☐ Internal ☐ Intermediate ☐ External ☐ Internal ☐ Intermediate ☐ External ☐ Yes ☐ No ☐ Yes ☐ No
Quality of construction	☐ Yes ☐ No Extraordinary humidity
Double window	☐ No ☐ Yes, code of second window: _____
Internal curtains	☐ No ☐ Yes:
Shutters	☐ No ☐ Yes:
Shading	☐ Yes, shading code:
Special wall below the window	☐ No ☐ Yes Opaque wall code
Maintenance status of the windows	-

Note: The double or triple glazing properties are often reported on spacer as shown in **figure X**. (Ug , gas):



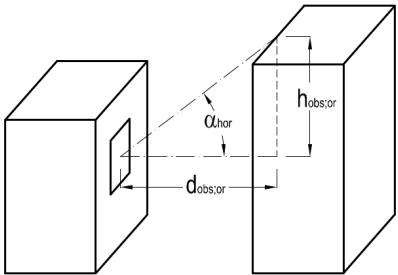
SLOVENERGOokno
SLOVENERGOokno

Example

Double glazing without low-e coating: when lighting a flame in a room and observing the reflection on the window, you will see «four flames» – two pairs of flames of the same color.

Double glazing with low-e coating (newer window): You will see «four flames», but one of them (usually the fifth reflection from the inside, which is reflected from the coating) will have a «purple color».

17.9 Shadings**Table 35 – Shadings checklist**

Assessor company logo and header										
Building name/reference										
S1 Shading code:			Description:							
Obstacles (horizon) <i>Please indicate:</i> - either distance and height - or the view-angle <i>of the obstacle in the given direction from the center of the shaded element (window or wall)</i>										
										
Direction			N	NE	E	SE	S	SW	W	NW
Distance	$d_{obs,or}$	m								
Height	$h_{obs,or}$	m								
Angle	$\alpha_{obs,or}$	°								

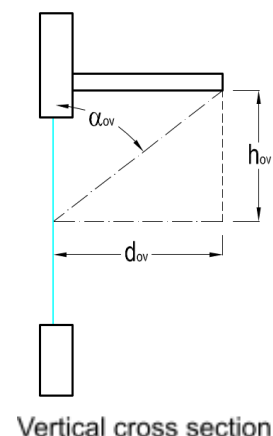
Overhang

Please indicate:

- either distance and height
- or the view-angle

of the overhang from the center of the shaded element

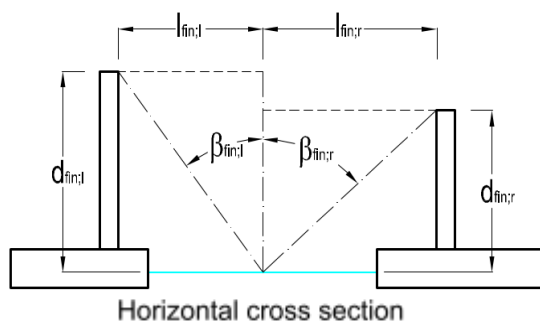
Distance	d_{ov}	m	
Height	h_{ov}	m	
Angle	α_{ov}	°	

**Fins**

Please indicate:

- either distance and height
- or the view-angle

of the fins on the right and left side
from the center of the shaded element

**Left side**

Distance	$d_{fin,l}$	m	
Width	$l_{fin,l}$	m	
Angle	$\beta_{fin,l}$	°	

Right side

Distance	$d_{fin,r}$	m	
Width	$l_{fin,r}$	m	
Angle	$\beta_{fin,r}$	°	

A frequent question is the required level of details when describing shadings. A typical question is: is there is a neighbouring building, the horizon shading will be different for windows at different floors. Also, a neighbouring building can be seen in a different direction by windows on a different location of a long wall.

A formalistic approach would require to define a different shading pattern for each window in a façade. A more rational approach would consider the following.

- If all windows belong to the same thermal zone, one may consider the shading pattern for the window in the middle of the façade for all the windows on that façade.
- If windows belong to different thermal zones (e.g. one per floor) or there are quite different shading patterns depending on the floor (e.g. two high building very close to each other, so that the windows on the top floor are free to the air and sun whilst the low floor windows are permanently shaded), then one should consider grouping only windows belonging to the same thermal zone and with similar shadings

Look for national guidelines or FAQ documentation for guidance on this topic to find the most effective balance between effort and accuracy.

General notes

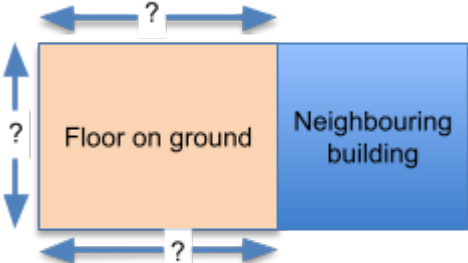
- Shading patterns apply to both windows and opaque elements. In non-insulated buildings, heat gains through opaque walls are significant in summer and even in winter in mild and hot climate.
- If the window is recessed, lintel and jamb shadings are significant. Some professional software include the calculation of the shading patterns based on the 3D model of the building and the shapes of the neighbouring buildings and obstacles. The required input is reduced in that case.

17.10 Ground floor

Sample drawing of a slab on ground + ask for details

Table 36 – Slab on ground checklist

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
GF1 - Floor code:	Description:
Source of information	☐ Invoice, contract, delivery document ☐ Owner, design documentation (plan) ☐ No documents, only inspection and estimation by assessor

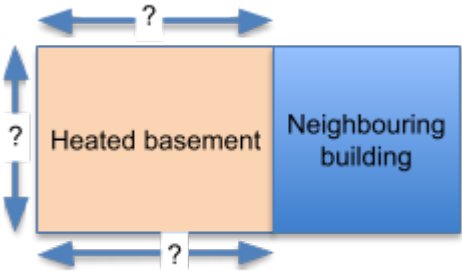
Geometry <i>Note shape and length of exposed sides. If drawings are available, highlight the exposed perimeter on the drawing. If no drawing is available, draw a sketch on the right and indicate lengths. An example is shown here:</i> 	Slab on ground plan Thickness of the walls (m)
Type of ground	☐ Clay ☐ Silt ☐ Sand ☐ Gravel ☐ Rock ☐ Unknown
Building elements	Code of floor: Type of thermal bridge, wall to floor
Horizontal edge insulation ☐ Yes ☐ No	Material of edge insulation Thickness of the edge insulation m Width of edge insulation m
Vertical edge insulation ☐ Yes ☐ No	Material of edge insulation Thickness of the edge insulation m Width of edge insulation m

17.11 Heated basement table

Sample drawing of a heated basement + ask for details

Table 37 – Heated basement checklist

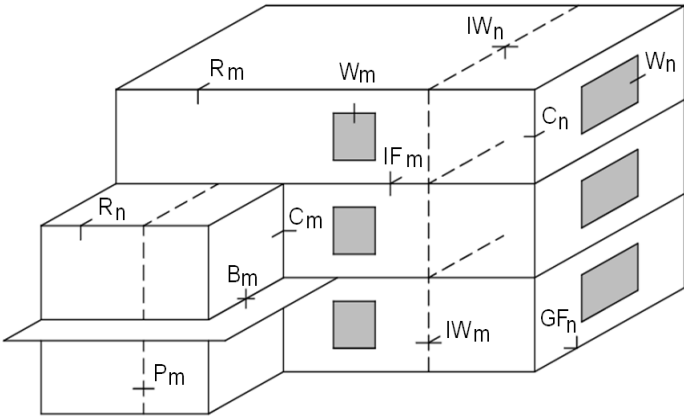
Assessor company logo and header	
Building name/reference	
ITEM	CHECK
HB1 –Basement code:	Description:

Source of information	☐ Invoice, contract, delivery document ☐ Owner, design documentation (plan) ☐ No documents, only inspection and estimation by assessor
Geometry <i>Note shape and length of exposed sides. If drawings are available, highlight the exposed perimeter on the drawing. If no drawing is available, draw a sketch on the right and indicate lengths. An example is shown here:</i>	Heated basement plan Thickness of the walls (m) Depth of the floor below ground level (m)
	
Type of ground	☐ Clay ☐ Silt ☐ Sand ☐ Gravel ☐ Rock ☐ Unknown
Building elements <i>Use the checklists for opaque elements to describe external walls (to the ground) and floor of the heated basement and provide their code on the right.</i>	Code of walls: Code of floor

17.12 Thermal bridges

Table 38 – Thermal bridges checklist

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
TB1 –Thermal bridge code:	Description:
Source of information	☐ Invoice, contract, delivery document ☐ Owner, design documentation (plan) ☐ No documents, only inspection and estimation by assessor

General information	☐ Continuous insulation (new or renovated building) ☐ New masonry with thermal bridges reduction ☐ Old construction, without insulation
Known thermal bridges <i>Mark on the figure on the right for which TB the design data are available and verified on-site</i>	
TB1 –Thermal bridge code:	Description:
Drawing <i>Draw a sketch of the TB and indicate the code of adjoining structures</i>	

17.13 Heating system checklist

17.13.1 Introduction

Heating system checklists are organised and provided per subsystem.

If there are several space heating service areas, one checklist section shall be filled in for each service area.

17.13.2 General information

Table 39 – Space heating system checklist

Assessor company logo and header

Building name/reference	
ITEM	CHECK
Heating system ID:	Description:
Identification of the heating system	☐ Service areas have been identified and indicated on plans ☐ Heating systems list has been identified with list of connected service areas ☐ Location of boiler room(s) and mechanical room(s) identified ☐ Operation time schedule identified for each system ☐ Functional diagram available and checked for each system ☐ FOR SRI: Check functions H-3 and H-4 for each system
Generation type	☐ Fossil fuel boiler ☐ Biomass boiler ☐ Heat pump ☐ Biomass stove ☐ Other
NOTES_	

17.13.3 Emission and control checklist**Table 40 – Space heating emission and control checklist**

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
HSA –Service area code:	Description: Ceiling height ☐ Normal ☐ High, _____m

☐ Radiators Area or share Room net height	☐ On insulated external wall ☐ On non-insulated external wall ☐ On internal walls ☐ Obstruction to air circulation Temperature @ design conditions
☐ Embedded panels Area or share Room net height	☐ Floor ☐ Ceiling ☐ Walls ☐ Insulated Share on heat loss structure %
☐ Fan coils Area or share Room net height	☐ Onboard or room thermostat ☐ Zone thermostat Number and power each W ☐ Yes ☐ No Shut-off valve when fan is off
List of heating terminals	☐ Annexed list of heating terminals ☐ Size of heating terminals on plans
Room temperature control	☐ No control, manual control ☐ Outdoor temperature reset ☐ Zone control (master room control, zone valve) ☐ Single room control Control type: ☐ ON-OFF ☐ P ☐ PI ☐ PID
Operation time	☐ Continuous operation ☐ Intermittent operation ☐ Daily schedule: ☐ Night set-back ____ C° ☐ Night shut-off ☐ Weekly schedule: ☐ Week-end set-back ____ °C ☐ Week-end shut-off ☐ Optimised start-stop

Hydraulic connection of heating terminals	☐ 2 ways valve ☐ by-pass valve ☐ Double pipe ☐ Single pipe ☐ ON-OFF valve ☐ Modulating valve Hydraulic balancing: ☐ Yes ☐ No
Temperature regime	☐ Constant temperature ☐ Outdoor temperature reset ☐ Other Maximum flow temperature °C Minimum flow temperature °C
Connected to distribution	Distribution code:
SRI	☐ Checked levels of function H-1a
NOTES_	

17.13.4 Distribution**Table 41 – Distribution system checklist**

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
Heating distribution code: <i>Use a unique code to identify each needed distribution section</i> ☐ Used also for cooling	☐ Distribution is identified on the functional diagram ☐ No diagram, see description hereafter Serving: <i>Indicate service areas and nodes served by the distribution</i> Supplied by: <i>Indicate node or generator supplying the distribution</i>
Layout	☐ Horizontal distribution ☐ Vertical distribution ☐ Tichelmann ☐ Other

Hydraulic connection on the supply side	☐ Direct connection ☐ Mixing valve
Pump	☐ Yes ☐ No Make and model: Rated power: Pump control: ☐ Constant speed ☐ Constant pressure ☐ Proportional press. ☐ Other
SRI	☐ Checked levels of functions H-1c and H-1d
NOTES_	

Data table template for each distribution network.

This template is used for water-based heating, domestic hot water and cooling distribution.

Table 42 – List of pipes (water based)

Assessor company logo and header										
Building name/reference										
Pipe name	Belongs to distribution	Pipe diameter	Installation type	Where installed	Pipe length	Insulation thickness	Insulation material	Wall conductivity	Depth within wall	Distance between pipe axis
1	2	3 D_{nom}	4	5	6 L m	7 s mm	8	9 λ_G W/mK	10 z W/mK	11 e mm
Notes										

KEY

- 1 - Free name or code to identify the pipe (hint: use meaningful acronym such as "Loop_mains")
- 2 - Name of the distribution. Needed if there are several distribution systems. As a minimum there should be a heating distribution and a domestic hot water distribution.
- 3 - Pipe nominal diameter (see table XX).
- 4 - Installation type: select between
 - Uninsulated pipes, free to air
 - Insulated pipes, free to air
 - Buried pipe, single
 - Buried pipe, double
- 5 - Characterise the position of the pipe with respect to the conditioned space. You may specify either
 - External
 - Inside a conditioned space (name of the thermal zone)
 - Adjacent spacer to a conditioned space (name of the thermal zone)
- 6 - Pipe length may be evaluated according to building dimensions
- 7 - Thickness in mm. Commercial values are standardised per type of material
- 8 - Insulation material
- 9 - For buried pipes, the conductivity of the wall.
- 10 - For buried pipes, the depth within the wall
- 11 - For a couple of buried pipes, the distance between their axis

17.13.5 Storage checklist

This checklist can be used for any storage used for heating, domestic hot water and cooling.

Table 43 – Heating system storage checklist

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
Storage ID:	Description: Service ☐ Heating ☐ Domestic hot water ☐ Cooling ☐ Other

Heat loss data	☐ Losses from label W _____ kWh/day _____ ☐ Losses from size Volume _____ l Height _____ m Insulation thickness _____ m Insulation material _____															
Layers description and connections (top to bottom)	L4 _____ Height _____ m L3 _____ Height _____ m L2 _____ Height _____ m L1 _____ Height _____ m															
Connections without syphon	<table border="1"> <thead> <tr> <th>Description</th> <th>Pipe ID</th> <th>Layer</th> </tr> </thead> <tbody> <tr><td>_____</td><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td><td>_____</td></tr> <tr><td>_____</td><td>_____</td><td>_____</td></tr> </tbody> </table>	Description	Pipe ID	Layer	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Description	Pipe ID	Layer														
_____	_____	_____														
_____	_____	_____														
_____	_____	_____														
_____	_____	_____														
Installation room	☐ Indoor ☐ Outdoor ☐ Boiler room Other _____															
SRI	☐ Checked levels of function H-1f for heating ☐ Checked levels of function DHW-1a and DHW-1b for domestic hot water															
NOTES_																

17.13.6 Generation checklist

This checklist is intended

Table 44 – Heating system generation checklist

Assessor company logo and header	
Building name/reference	

ITEM	CHECK
Generation code:	Description:
Services provided	☐ Heating ☐ Domestic hot water ☐ Cooling ☐ Other
Operation time schedule	
Multiple generators ☐ Yes ☐ No	☐ Yes ☐ No Cascade control Cascade control logic
SRI	☐ Checked levels of function H-2d ☐ Checked levels of function C-2b
NOTES_	

17.13.7 Combustion boiler checklist**Table 45 – Combustion boiler checklist**

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
Boiler code:	Belongs to generation: Make Model Rated power kW
Energy carrier	☐ Natural gas ☐ LPG ☐ Light oil ☐ Other
Boiler type	☐ Standard ☐ Low temperature ☐ Condensing

Services provided	☐ Heating ☐ Domestic hot water ☐ Other
Performance data, eco-design	Full load efficiency 60/80 % Part load efficiency 30/50 % Full load efficiency 30/50 % Auxiliary, full load W Auxiliary, part load W Auxiliary, stand-by W
Alternative performance data	Combustion efficiency % Envelope losses type Stand-by stack losses $\Delta\theta$ flue/return at min _____ °C at max _____ °C Full load efficiency 30/50 % Auxiliary power at min _____ W at max _____ W Stand-by _____ W
Installation room	☐ Indoor ☐ Outdoor ☐ Boiler room Other
Additional checks	☐ Is flue gas system suitable for condensation? ☐ Is the temperature regime suitable for heat pumps? ☐ Are district heating or biomass available? ☐ Conservation of the boiler, remaining lifespan
SRI	☐ Checked levels of function H-2a
NOTES_	

17.13.8 Heat pump checklist**Table 46 – Heat pump checklist**

Assessor company logo and header

Building name/reference		
ITEM	CHECK	
Heat pump code:	Belongs to generation: Make Model	
Heat pump type	☐ Electric, compression cycle ☐ Other, energy carrier	
External and internal connections Heating mode: source = external connection sink = internal connection Cooling mode: source = internal connection sink = external connection (heat rejection)	External connection ☐ External air ☐ Exhaust air ☐ Ground (vertical) ☐ Ground (horizontal) ☐ Ground water ☐ Surface water ☐ Cooling tower (for cooling) ☐ Dry cooler/heater ☐ Other _____	Internal connection ☐ Internal air ☐ Ducted air (DX coil) ☐ Installation water ☐ Domestic hot water ☐ Other _____
Services provided	☐ Heating ☐ Domestic hot water ☐ Cooling ☐ Other	
External auxiliaries	Description: Full load _____W Part load _____W Stand-by _____W Control type:	
Integrated back-up heater	☐ No back-up heater ☐ Electric _____ kW ☐ Other energy carrier _____ kW	
Installation room	☐ Indoor ☐ Outdoor ☐ Boiler room Other	
SRI	☐ Checked levels of function H-2b	

NOTES_

17.13.9 District heating checklist**Table 47 – District heating connection checklist**

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
Code:	Belongs to generation: Make Model
Connection	Supplier Rated power of the connection kW
Services provided	☐ Heating ☐ Domestic hot water ☐ Cooling ☐ Other
Heat loss information	Heat exchanger ☐ Yes ☐ No Declared losses kW/day
Installation room	☐ Indoor ☐ Outdoor ☐ Boiler room Other
SRI	☐ Checked levels of function H-2a
NOTES_	

17.14 Domestic hot water system checklist**17.14.1 Introduction**

Domestic hot water system checklists are organised and provided per subsystem.

If there are several domestic hot water service areas, one checklist section shall be filled in for each service area.

17.14.2 General information**Table 48 – Domestic hot water system checklist**

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
Domestic hot water system reference	Description:
☐ Identification of the domestic hot water system	☐ Service areas have been identified and indicated on plans ☐ Domestic hot water systems list has been identified with the list of connected service areas ☐ Areas of residential building units and/or number of units for non-residential units have been identified ☐ Functional diagram available for centralised systems ☐ FOR SRI: Check functions DHW-3 for each system
Data for domestic hot water needs	Space category ☐ Floor area _____m ² ☐ Units n° _____ of type
Centralised systems ☐ Yes ☐ No	☐ All areas of residential building units and/or number of units for non-residential units have been identified ☐ Data for needs are available on the building plans ☐ The list is annexed
Generation type	☐ Fossil fuel boiler ☐ Thermal solar ☐ Heat pump ☐ Biomass boiler ☐ Other
NOTES_	

Table 49 – Sample building units list for domestic hot water needs

[illegible]

17.14.3 Drain water heat recovery

Table 50 – Drain water heat recovery checklist

Assessor company logo and header		
Building name/reference		
ITEM	CHECK	
Domestic hot water system reference	Building unit ID:	
Connection of drain water heat recovery	☐ Type A ☐ Type B ☐ Type C	

Device info	Make Model
Connected fixtures	N° _____ Showers N° _____ Other
Other fixtures in the building unit	N° _____ Showers N° _____ Bath tubs N° _____ Other
Preheated water connection	Pipe type and diameter Pipe length _____ m
Drain water connection	Pipe type and diameter Pipe length _____ m
NOTES_	

17.14.4 Domestic hot water distribution**Table 51 – Domestic hot water distribution checklist**

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
Domestic hot water distribution code: <i>Use a unique code to identify each needed distribution section</i>	☐ Distribution is identified on the functional diagram ☐ No diagram, see description hereafter Serving: <i>Indicate service areas served by the distribution</i> Supplied by: <i>Indicate node, storage or generator supplying the distribution</i>
Type	☐ Final distribution ☐ Circulation loop ☐ Generation loop

Pump	☐ Yes ☐ No Make and model: Rated power: Pump control: ☐ Constant speed ☐ Constant pressure ☐ Proportional press. ☐ Other
SRI	N.A.
NOTES_	

Use the template given in **table 42** to detail the list of pipes.

17.14.5 Domestic hot water storage

Use the template given in **table 43** to describe the domestic hot water storage.

17.14.6 Domestic hot water generation

Use the template given in **table 44** to describe the domestic hot water generation sub-system.

Use the template given in **table 45** to describe combustion generation sub-system

Use the template given in **table 46** to describe heat pump generation sub-system

17.15 Thermal solar checklist

Table 52 – Thermal solar checklist

Assessor company logo and header	
Building name/reference	
ITEM	CHECK

Common installation	Data type: ☐ Tested system ☐ Component data System type: ☐ Natural circulation ☐ Forced circulation Solar storage volume: _____ l ☐ Yes ☐ No Multiple storage vessels ☐ Yes ☐ No Integrated back-up heater; Energy carrier: Notes:
TS1 – Tested system data: System data <i>Use this section if ERP data of the assembly are known.</i>	Description: Aperture area: Thermal solar production in Strasbourg: _____ kWh Notes:
TS1 – Component data: Source of data Collector data <i>Please fill in one section per field with specific orientation, tilt and shading. If there is any shading, use the template for shading patterns and indicate here the reference.</i>	Description: ☐ Invoice, contract, delivery document ☐ Design documentation (plan) ☐ Component nameplates ☐ No documents, only inspection and estimation by assessor Type: ☐ Glazed collectors ☐ Evacuated tubes ☐ Other Aperture area: _____ m ² Orientation: Tilt: Shadings code: Efficiency η_0 _____ % Heat loss coefficient a_1 : _____ W/(m ² ·K) Heat loss coefficient a_2 : _____ W/(m ² ·K ²) IAM; _____ % Notes:

Loop data	Length of collector loop pipes: m Diameter of pipes: mm Insulating material: Thickness of insulation: mm Pump rated power: W
SRI	☐ Checked levels of function DHW-1d
NOTES_	

17.16 Cooling system checklist

17.16.1 Introduction

Cooling system checklists are organised and provided per subsystem.

If there are several space cooling service areas, one checklist section shall be filled in for each service area.

17.16.2 General information

Table 53 – Space cooling system checklist

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
CSA –Service area code:	Description:
☐ Identification of the cooling system	☐ Service areas have been identified and indicated on plans ☐ Cooling systems list has been identified with list of connected service areas ☐ Location of mechanical room(s) is identified ☐ Operation time schedule identified for each system ☐ Functional diagram available and checked for each system ☐ FOR SRI: Check functions C-3 and C-4 for each system

Generation type	☐ Heat pump ☐ District cooling ☐ Free cooling ☐ Other
SRI	☐ Checked levels of function C-3 and C-4
NOTES_	

17.16.3 Cooling emission and control**Table 54 – Space cooling emission and control checklist**

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
CSA –Service area code:	Description: Ceiling height ☐ Normal ☐ High, _____m
☐ Embedded panels Area or share Room net height	☐ Floor ☐ Ceiling ☐ Walls ☐ Insulated Share on heat loss structure %
☐ Fan coils Area or share Room net height	☐ Onboard or room thermostat ☐ Zone thermostat Number and power each W ☐ Yes ☐ No Shut-off valve when fan is off ☐ Yes ☐ No Condensate drain
List of cooling terminals	☐ Annexed list of heating terminals ☐ Size of heating terminals on plans

Rom temperature control	☐ No control, manual control ☐ Outdoor temperature reset ☐ Zone control (master room control, zone valve) ☐ Single room control Control type: ☐ ON-OFF ☐ P ☐ PI ☐ PID
Operation time	☐ Continuous operation ☐ Intermittent operation ☐ Daily schedule: ☐ Night set-back ____ C° ☐ Night shut-off ☐ Weekly schedule: ☐ Week-end set-back ____ °C ☐ Week-end shut-off ☐ Optimised start-stop
Hydraulic connection of cooling terminals	☐ 2 ways valve ☐ by-pass valve ☐ ON-OFF valve ☐ Modulating valve Hydraulic balancing: ☐ Yes ☐ No
Temperature regime	☐ Constant temperature ☐ Outdoor temperature reset ☐ Other Maximum flow temperature _____ °C Minimum flow temperature _____ °C
Connected to distribution	Distribution code:
SRI	☐ Checked levels of function C-1a, C-1b and C-1f,
NOTES_	

17.16.4 Cooling distribution**Table 55 – Distribution system checklist**

Assessor company logo and header

Building name/reference	
ITEM	CHECK
Cooling distribution code: <i>Use a unique code to identify each needed distribution section</i> ☐ Used also for heating	☐ Distribution is identified on the functional diagram ☐ No diagram, see description hereafter Serving: <i>Indicate service areas and nodes served by the distribution</i> Supplied by: <i>Indicate node or generator supplying the distribution</i>
Layout	☐ Horizontal distribution ☐ Vertical distribution ☐ Tichelmann ☐ Other
Hydraulic connection on the supply side	☐ Direct connection ☐ Mixing valve
Pump	☐ Yes ☐ No Make and model: Rated power: Pump control: ☐ Constant speed ☐ Constant pressure ☐ Proportional press. ☐ Other
SRI	☐ Checked levels of functions C-1c and C-1d
NOTES_	

Use the template given in **table 42** to detail the list of pipes.

17.16.5 Cooling storage

Use the template given in **table 43** to describe the cooling storage.

17.16.6 Cooling generation

Use the template given in **table 44** to describe cooling generation.

Use the template given in **table 46** to describe the heat pump or chiller.

Use the template given in **table 47** to describe the district cooling connection.

17.17 Ventilation system checklist

17.17.1 General information

Table 56 – Ventilation general information checklist

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
General information on the ventilation of the building	☐ Service areas have been identified and indicated on plans, with space category and area and/or design occupancy data ☐ Ventilation systems list has been identified with list of connected service areas ☐ Location of mechanical room(s) is identified ☐ Operation time schedule identified for each system ☐ Functional diagram available and checked for each system ☐ Checklist filled for each system ☐ FOR SRI: Check functions V-6 (IAQ monitoring)
NOTES_	

Table 57 – Ventilation AHU checklist

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
Ventilation system ID	Description:
Type of mechanical ventilation	☐ single duct, extraction only ☐ single duct, supply only ☐ double duct

Total design flow rate	SUP m³/h EXT m³/h ODA m³/h
Additional functions and services	☐ heat recovery ☐ free cooling ☐ recirculation; ☐ heating ☐ cooling ☐ humidification ☐ dehumidification
Heat recovery	Make Model Rated effectiveness % ☐ Plate ☐ rotary wheel ☐ Run around coil ☐ rotary wheel ☐ Latent heat recovery ☐ By pass available ☐ Frost protection ☐ Auxiliaries W
Control strategy of outdoor air (ODA) flow rate	☐ constant ODA flow rate; ☐ variable ODA flow rate, depending on ☐ time control, schedule: ☐ CO2 concentration set point: _____ ppm ☐ Occupancy detection ☐ Other

Control strategy of SUP air temperature	☐ no control, free floating SUP temperature ☐ pre-heating, fixed set-point °C ☐ pre-cooling, fixed set-point °C ☐ outdoor temperature reset Heating mode °C cooling mode °C ☐ Keeping heating set-point min and max SUP temperature °C ☐ Keeping cooling set-point min and max SUP temperature °C ☐ Other
Control strategy of SUP air flow rate	☐ Constant flow rate m ³ /h ☐ Variable flow rate control variable min/max m ³ /h ☐ Other
SUP fan	Make Model Rated power W Flow control ☐ outlet register ☐ inlet vane Speed control ☐ Constant speed ☐ Variable speed Pressure control ☐ No control ☐ Constant pressure ☐ Proportional pressure ☐ Optimised pressure set-point ☐ Other _____

EXT fan	Make Model Rated power W Flow control ☐ outlet register ☐ inlet vane Speed control ☐ Constant speed ☐ Variable speed EXT flow rate control ☐ No control ☐ Constant flow ☐ Based on SUP flow ☐ Based on building pressure ☐ Other _____
Ventilation efficiency	☐ Mixing flow ☐ Piston flow
NOTES_	

Table to be reorganised:

- SUP flow rate can be controlled locally (VAV / CAV boxes) or centrally (AHU)
- ODA flow rate is independent only with recirculation systems, otherwise SUP = ODA

- SUP temperature can be controlled centrally or by central pre-heating (or pre-cooling) and reheat on terminal units (also electric reheat in old systems)

Maybe it is simpler to ask for a (validated) functional diagram with indication of control options.

17.18 Distribution networks table, air

Data table for an air distribution network

Table 58 – Air distribution checklist

Assessor company logo and header							
Building name/reference							
Duct name	Belongs to distribution	Air type	Duct size	Where installed	Duct length	Insulation thickness	Insulation material
1	2	3	4	5	6	7	8

			D _{nom}		L m	s mm	
.....							
Notes							

KEY

- 1 - Free name or code to identify the duct (hint: use meaningful acronym such as “OA intake”)
- 2 - Name of the distribution. Needed if there are several distribution systems.
- 3 - Air type: use the codes “OA”, “SUP”, “EXH” defined in EN 16798-7.
- 4 - If the duct is circular, then Ø___mm, if rectangle A x B mm.
- 5 - Characterise the position of the duct with respect to the conditioned space. You may specify either
 - External
 - Inside a conditioned space (name of the thermal zone)
 - Adjacent spacer to a conditioned space (name of the thermal zone)
- 6 - Duct length may be evaluated according to building dimensions
- 7 - Thickness in mm. Commercial values are standardised per type of material
- 8 - Insulation material

17.19 Lighting checklist

The following checklist shall be filled for each lighting area. A lighting area can be part of a room, an entire room or a group rooms with the same lighting properties.

Table 59 – Lighting area checklist

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
Lighting area identification	
Space category and sub-category	
	Floor area m ²

Luminaires	☐ LED ☐ Fluorescent ☐ Halogen ☐ Other _____ N° x power _____ X W Ballast / drive is included ☐ Yes ☐ No
Control type	Without occupancy detection ☐ Manual ON/OFF ☐ Manual ON/OFF + timer OFF With occupancy detection ☐ Auto ON/ Auto dimmed ☐ Auto ON / Auto OFF ☐ Manual ON/ Auto dimmed ☐ Manual ON / Auto OFF ☐ Lighting level (lux) control
Daylight evaluation Horizon angle ° Overhang angle ° Fin angle ° Glass fraction Light transmission factor ☐ Yes ☐ No Self cleaning glasses	Plan of the space with position and elevation of work plane and windows
Notes	

17.20 PV checklist

Table 60 – Photovoltaic checklist

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
General data	Grid connection power: kW Battery usable capacity: kWh
PV1 – PF field code:	Description:
Panels <i>Please fill in one section per field with specific orientation, tilt and shading. If there is any shading, use the template for shading patterns and indicate here the reference.</i> <i>No ventilation is for embedded panels</i> <i>Moderately ventilated panels are those mounted parallel to the building element with space for air to flow behind the panel.</i>	Panels peak power: kW Orientation: Tilt: Shadings code: Module ventilation: ☐ None ☐ Moderate ☐ Strong/forced Inverter power; kW ☐ Water cooled ☐ Combined with thermal solar with code:
Notes	

17.21 Measured energy data

A checklist is proposed to guide the on-site collection of measured energy use data.

This checklist assumes that fuel delivery notes or invoices and or O&M records are collected and analysed later in the office. You may specify in the checklist if you copied measured energy data into a table.

Table 61 – Measure energy use data collection checklist

Assessor company logo and header	
Building name/reference	
ITEM	CHECK

Each row is intended for one measurement interval.

Table 62 – Energy use data

Assessor company logo and header	
Building name/reference	

Reference 1	Initial date 2	Initial reading Unit: _____ 3	Final date 4	Final reading Unit: _____ 5	Deliveries Unit: _____ 6
Notes					

KEY

(1) Free text with reference or code to the source document such as invoice or delivery note date or number

(2) Date of the initial reading

(3) Initial reading (please indicate the unit in the header row).

(4) Date of the finale reading. It can be omitted (i.e. it is assumed equal to the date of the initial reading in the next row) if consecutive readings are available (example: a series of consecutive invoices)

(5) Final reading (please indicate the unit in the header row). It can be omitted (i.e. it is assumed equal to the initial reading in the next row) if consecutive readings are available.

(6) Deliveries: this column is intended for liquid and solid fuels with a tank or stock.

Readings can be e.g.:

- Sm³: gas amount in an invoice;
- m³: reading of a gas counter, please indicate the pressure at the measurement point in the notes;
- kWh if the delivered energy is electricity;
- l or kg for oil, the reading is the amount of fuel in the tank;
- any length unit, if the reading is the level in a tank or stock: please indicate tank geometry and size in the notes or in the measured energy data collection check-list;

17.22 SRI checklist

The checklist in the following table is based on version 4.5 of the SRI tool prepared by the EU commission ***SRI_calculation-sheet_v4.5.xlsx***.

The checklist includes all functionalities considered by SRI.

- Functionalities which are related to EPB technical systems are also mentioned under the respective clause about special input data for SRI purpose,
- Additional functionalities which are not related to EPB technical systems are also listed under the general clause about special input data for SRI purpose,

Please start indicating which domains are relevant for the assessed building.

Energy Performance of Buildings Standards calculations and implementation

Then indicate the level of each functionality in the assessed building. For details about how to decide which is the correct level for each functionality, please refer to the following documents:

- Standardized On-site Audits of Smart Readiness Indicator (SRI) for Buildings – V 4.0
- Practical Guide SRI calculation framework v4.5.pdf
- SRI training package for assessors.pdf

NOTE several functionalities and their level are taken from EN ISO 52120. However, there are:

- additional levels for some functionalities, especially related to interaction with the grid
- additional functionalities, especially for non EPB technical systems.

If the level is not uniform throughout the entire building, you may check several levels and indicate for each one the respective % area. Please note that the current tool V4.5 only supports two levels for each functionality.

For several functionalities, the “non applicable” option has been added to allow to document why a functionality is not relevant for the assessed object.

Table 63 –SRI on-site assessment checklist

Assessor company logo and header	
Building name/reference	
ITEM	CHECK
Domain present	☐ H Heating ☐ DHW Domestic hot water ☐ C Cooling ☐ V Ventilation ☐ L Lighting ☐ DE Dynamic building envelope ☐ E Electricity ☐ EV Electric vehicle charging ☐ MC Monitoring and control
FUNCTIONALITY	LEVEL

H-1a	Heat emission control	☐ ____% No automatic control ☐ ____% Central automatic control ☐ ____% Advanced central automatic control ☐ ____% Advanced central automatic control with intermittent operation and/or room temperature feedback control
H-1c	Control of distribution fluid temperature (supply or return air flow or water flow) - Similar function can be applied to the control of direct electric heating networks	☐ ____% No automatic control ☐ ____% Outside temperature compensated control ☐ ____% Demand based control
H-1d	Control of distribution pumps in networks	☐ ____% No automatic control ☐ ____% On off control ☐ ____% Multi-Stage control ☐ ____% Variable speed pump control (pump unit (internal) estimations) ☐ ____% Variable speed pump control (external demand signal)
H-1f	Thermal Energy Storage (TES) for building heating (excluding TABS)	☐ ____% Not applicable: no significant space heating storage ☐ ____% Continuous storage operation ☐ ____% Time-scheduled storage operation ☐ ____% Load prediction based storage operation ☐ ____% Heat storage capable of flexible control through grid signals (e.g. DSM)
H-2a	Heat generator control (all except heat pumps)	☐ ____% Constant temperature control ☐ ____% Variable temperature control depending on outdoor temperature ☐ ____% Variable temperature control depending on the load (e.g. depending on supply water temperature set point)

H-2b	Heat generator control (for heat pumps)	☐ ____% On/Off-control of heat generator ☐ ____% Multi-stage control of heat generator capacity depending on the load or demand (e.g. on/off of several compressors) ☐ ____% Variable control of heat generator capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control) ☐ ____% Variable control of heat generator capacity depending on the load AND external signals from grid
H-2d	Sequencing in case of different heat generators	☐ ____% Not applicable: only one generator ☐ ____% Priorities only based on running time ☐ ____% Control according to fixed priority list: e.g. based on rated energy efficiency ☐ ____% Control according to dynamic priority list (based on current energy efficiency, carbon emissions and capacity of generators, e.g. solar, geothermal heat, cogeneration plant, fossil fuels) ☐ ____% Control according to dynamic priority list (based on current AND predicted load, energy efficiency, carbon emissions and capacity of generators) ☐ ____% Control according to dynamic priority list (based on current AND predicted load, energy efficiency, carbon emissions, capacity of generators AND external signals from grid)
H-3	Report information regarding heating system performance	☐ ____% None ☐ ____% Central or remote reporting of current performance KPIs (e.g. temperatures, submetering energy usage) ☐ ____% Central or remote reporting of current performance KPIs and historical data ☐ ____% Central or remote reporting of performance evaluation including forecasting and/or benchmarking ☐ ____% Central or remote reporting of performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection

H-4 Flexibility and grid interaction	☐ ____% No automatic control ☐ ____% Scheduled operation of heating system ☐ ____% Self-learning optimal control of heating system ☐ ____% Heating system capable of flexible control through grid signals (e.g. DSM) ☐ ____% Optimized control of heating system based on local predictions and grid signals (e.g. through model predictive control)
DHW-1a Control of DHW storage charging (with direct electric heating or integrated electric heat pump)	☐ ____% Not applicable, no such system ☐ ____% Automatic control on / off ☐ ____% Automatic control on / off and scheduled charging enable ☐ ____% Automatic control on / off and scheduled charging enable and multi-sensor storage management ☐ ____% Automatic charging control based on local availability of renewables or information from electricity grid (DR, DSM)
DHW-1b Control of DHW storage charging (using hot water generation)	☐ ____% Not applicable: instantaneous domestic hot water ☐ ____% Automatic control on / off ☐ ____% Automatic control on / off and scheduled charging enable ☐ ____% Automatic on/off control, scheduled charging enable and demand-based supply temperature control or multi-sensor storage management ☐ ____% DHW production system capable of automatic charging control based on external signals (e.g. from district heating grid)

DHW-1d Control of DHW storage charging (with solar collector and supplementary heat generation)	☐ ____% Not applicable: no solar collector ☐ ____% Manual selected control of solar energy or heat generation ☐ ____% Automatic control of solar storage charge (Prio. 1) and supplementary storage charge ☐ ____% Automatic control of solar storage charge (Prio. 1) and supplementary storage charge and demand-oriented supply or multi-sensor storage management ☐ ____% Automatic control of solar storage charge (Prio. 1) and supplementary storage charge, demand-oriented supply and return temperature control and multi-sensor storage management
DHW-2b Sequencing in case of different DHW generators	☐ ____% Not applicable: only one generator ☐ ____% Priorities only based on running time ☐ ____% Control according to fixed priority list: e.g. based on rated energy efficiency ☐ ____% Control according to dynamic priority list (based on current energy efficiency, carbon emissions and capacity of generators, e.g. solar, geothermal heat, cogeneration plant, fossil fuels) ☐ ____% Control according to dynamic priority list (based on current AND predicted load, energy efficiency, carbon emissions and capacity of generators) ☐ ____% Control according to dynamic priority list (based on current AND predicted load, energy efficiency, carbon emissions, capacity of generators AND external signals from grid)
DHW-3 Report information regarding domestic hot water performance	☐ ____% None ☐ ____% Indication of actual values (e.g. temperatures, submetering energy usage) ☐ ____% Actual values and historical data ☐ ____% Performance evaluation including forecasting and/or benchmarking ☐ ____% Performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection

C-1a	Cooling emission control	☐ ____% No automatic control ☐ ____% Central automatic control ☐ ____% Individual room control ☐ ____% Individual room control with communication between controllers and to BACS ☐ ____% Individual room control with communication and occupancy detection
C-1b	Emission control for TABS (cooling mode)	☐ ____% Not applicable, no TABS ☐ ____% No automatic control ☐ ____% Central automatic control ☐ ____% Advanced central automatic control ☐ ____% Advanced central automatic control with intermittent operation and/or room temperature feedback control
C-1c	Control of distribution network chilled water temperature (supply or return)	☐ ____% Constant temperature control ☐ ____% Outside temperature compensated control ☐ ____% Demand based control
C-1d	Control of distribution pumps in networks	☐ ____% No automatic control ☐ ____% On off control ☐ ____% Multi-Stage control ☐ ____% Variable speed pump control (pump unit (internal) estimations) ☐ ____% Variable speed pump control (external demand signal)
C-1f	Interlock: avoiding simultaneous heating and cooling in the same room	☐ ____% No interlock ☐ ____% Partial interlock (minimising risk of simultaneous heating and cooling e.g. by sliding setpoints) ☐ ____% Total interlock (control system ensures no simultaneous heating and cooling can take place)

C-1g	Control of Thermal Energy Storage (TES) operation	☐ ____% Not applicable, no significant cooling storage ☐ ____% Continuous storage operation ☐ ____% Time-scheduled storage operation ☐ ____% Load prediction based storage operation ☐ ____% Cold storage capable of flexible control through grid signals (e.g. DSM)
C-2a	Generator control for cooling	☐ ____% On/Off-control of cooling production ☐ ____% Multi-stage control of cooling production capacity depending on the load or demand (e.g. on/off of several compressors) ☐ ____% Variable control of cooling production capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control) ☐ ____% Variable control of cooling production capacity depending on the load AND external signals from grid
C-2b	Sequencing of different cooling generators	☐ ____% Not applicable, only one generator ☐ ____% Priorities only based on running times ☐ ____% Fixed sequencing based on loads only: e.g. depending on the generators characteristics such as absorption chiller vs. centrifugal chiller ☐ ____% Dynamic priorities based on generator efficiency and characteristics (e.g. availability of free cooling) ☐ ____% Load prediction based sequencing: the sequence is based on e.g. COP and available power of a device and the predicted required power ☐ ____% Sequencing based on dynamic priority list, including external signals from grid

C-3	Report information regarding cooling system performance	☐ ____% None ☐ ____% Central or remote reporting of current performance KPIs (e.g. temperatures, submetering energy usage) ☐ ____% Central or remote reporting of current performance KPIs and historical data ☐ ____% Central or remote reporting of performance evaluation including forecasting and/or benchmarking ☐ ____% Central or remote reporting of performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection
C-4	Flexibility and grid interaction	☐ ____% No automatic control ☐ ____% Scheduled operation of cooling system ☐ ____% Self-learning optimal control of cooling system ☐ ____% Cooling system capable of flexible control through grid signals (e.g. DSM) ☐ ____% Optimized control of cooling system based on local predictions and grid signals (e.g. through model predictive control)
V-1a	Supply air flow control at the room level	☐ ____% No ventilation system or manual control ☐ ____% Clock control ☐ ____% Occupancy detection control ☐ ____% Central Demand Control based on air quality sensors (CO ₂ , VOC, humidity, ...) ☐ ____% Local Demand Control based on air quality sensors (CO ₂ , VOC,...) with local flow from/to the zone regulated by dampers

V-1c	Air flow or pressure control at the air handler level	☐ ____% No automatic control: Continuously supplies of air flow for a maximum load of all rooms ☐ ____% On off time control: Continuously supplies of air flow for a maximum load of all rooms during nominal occupancy time ☐ ____% Multi-stage control: To reduce the auxiliary energy demand of the fan ☐ ____% Automatic flow or pressure control without pressure reset: Load dependent supplies of air flow for the demand of all connected rooms. ☐ ____% Automatic flow or pressure control with pressure reset: Load dependent supplies of air flow for the demand of all connected rooms (for variable air volume systems with VFD).
V-2c	"Heat recovery control: prevention of overheating"	☐ ____% Without overheating control ☐ ____% Modulate or bypass heat recovery based on sensors in air exhaust ☐ ____% Modulate or bypass heat recovery based on multiple room temperature sensors or predictive control
V-2d	Supply air temperature control at the air handling unit level	☐ ____% No automatic control ☐ ____% "Constant setpoint: A control loop enables to control the supply air temperature, the setpoint is constant and can only be modified by a manual action" ☐ ____% Variable set point with outdoor temperature compensation ☐ ____% Variable set point with load dependant compensation. A control loop enables to control the supply air temperature. The setpoint is defined as a function of the loads in the room

V-3	Free cooling with mechanical ventilation system	☐ ____% No automatic control ☐ ____% Night cooling ☐ ____% "Free cooling: air flows modulated during all periods of time to minimize the amount of mechanical cooling" ☐ ____% "H,x- directed control: The amount of outside air and recirculation air are modulated during all periods of time to minimize the amount of mechanical cooling. Calculation is performed on the basis of temperatures and humidity (enthalpy)."
V-6	Reporting information regarding IAQ	☐ ____% None ☐ ____% Air quality sensors (e.g. CO2) and real time autonomous monitoring ☐ ____% Real time monitoring & historical information of IAQ available to occupants ☐ ____% Real time monitoring & historical information of IAQ available to occupants + warning on maintenance needs or occupant actions (e.g. window opening)
L-1a	Occupancy control for indoor lighting	☐ ____% Manual on/off switch ☐ ____% Manual on/off switch + additional sweeping extinction signal ☐ ____% Automatic detection (auto on / dimmed or auto off) ☐ ____% Automatic detection (manual on / dimmed or auto off)
L-2	Control artificial lighting power based on daylight levels	☐ ____% Manual (central) ☐ ____% Manual (per room / zone) ☐ ____% Automatic switching ☐ ____% Automatic dimming ☐ ____% "Automatic dimming including scene-based light control (during time intervals, dynamic and adapted lighting scenes are set, for example, in terms of illuminance level, different correlated colour temperature (CCT) and the possibility to change the light distribution within the space according to e. g. design, human needs, visual tasks)"

DE-1	Window solar shading control	☐ ____% No sun shading or only manual operation ☐ ____% Motorized operation with manual control ☐ ____% Motorized operation with automatic control based on sensor data ☐ ____% Combined light/blind/HVAC control ☐ ____% Predictive blind control (e.g. based on weather forecast)
DE-2	Window open/closed control, combined with HVAC system	☐ ____% Manual operation or only fixed windows ☐ ____% Open/closed detection to shut down heating or cooling systems ☐ ____% Level 1 + Automated mechanical window opening based on room sensor data ☐ ____% Level 2 + Centralized coordination of operable windows, e.g. to control free natural night cooling
DE-4	Reporting information regarding performance of dynamic building envelope systems	☐ ____% No reporting ☐ ____% Position of each product & fault detection ☐ ____% Position of each product, fault detection & predictive maintenance ☐ ____% Position of each product, fault detection, predictive maintenance, real-time sensor data (wind, lux, temperature...) ☐ ____% Position of each product, fault detection, predictive maintenance, real-time & historical sensor data (wind, lux, temperature...)
E-2	Reporting information regarding local electricity generation	☐ ____% No electricity generation ☐ ____% None ☐ ____% Current generation data available ☐ ____% Actual values and historical data ☐ ____% Performance evaluation including forecasting and/or benchmarking ☐ ____% Performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection

E-3 Storage of (locally generated) electricity	☐ ____% None ☐ ____% On site storage of electricity (e.g. electric battery) ☐ ____% On site storage of energy (e.g. electric battery or thermal storage) with controller based on grid signals ☐ ____% On site storage of energy (e.g. electric battery or thermal storage) with controller optimising the use of locally generated electricity ☐ ____% On site storage of energy (e.g. electric battery or thermal storage) with controller optimising the use of locally generated electricity and possibility to feed back into the grid
E-4 Optimizing self-consumption of locally generated electricity	☐ ____% None ☐ ____% Scheduling electricity consumption (plug loads, white goods, etc.) ☐ ____% Automated management of local electricity consumption based on current renewable energy availability ☐ ____% Automated management of local electricity consumption based on current and predicted energy needs and renewable energy availability
E-5 Control of combined heat and power plant (CHP)	☐ ____% No CHP ☐ ____% CHP control based on scheduled runtime management and/or current heat energy demand ☐ ____% CHP runtime control influenced by the fluctuating availability of RES; overproduction will be fed into the grid ☐ ____% CHP runtime control influenced by the fluctuating availability of RES and grid signals; dynamic charging and runtime control to optimise self-consumption of renewables

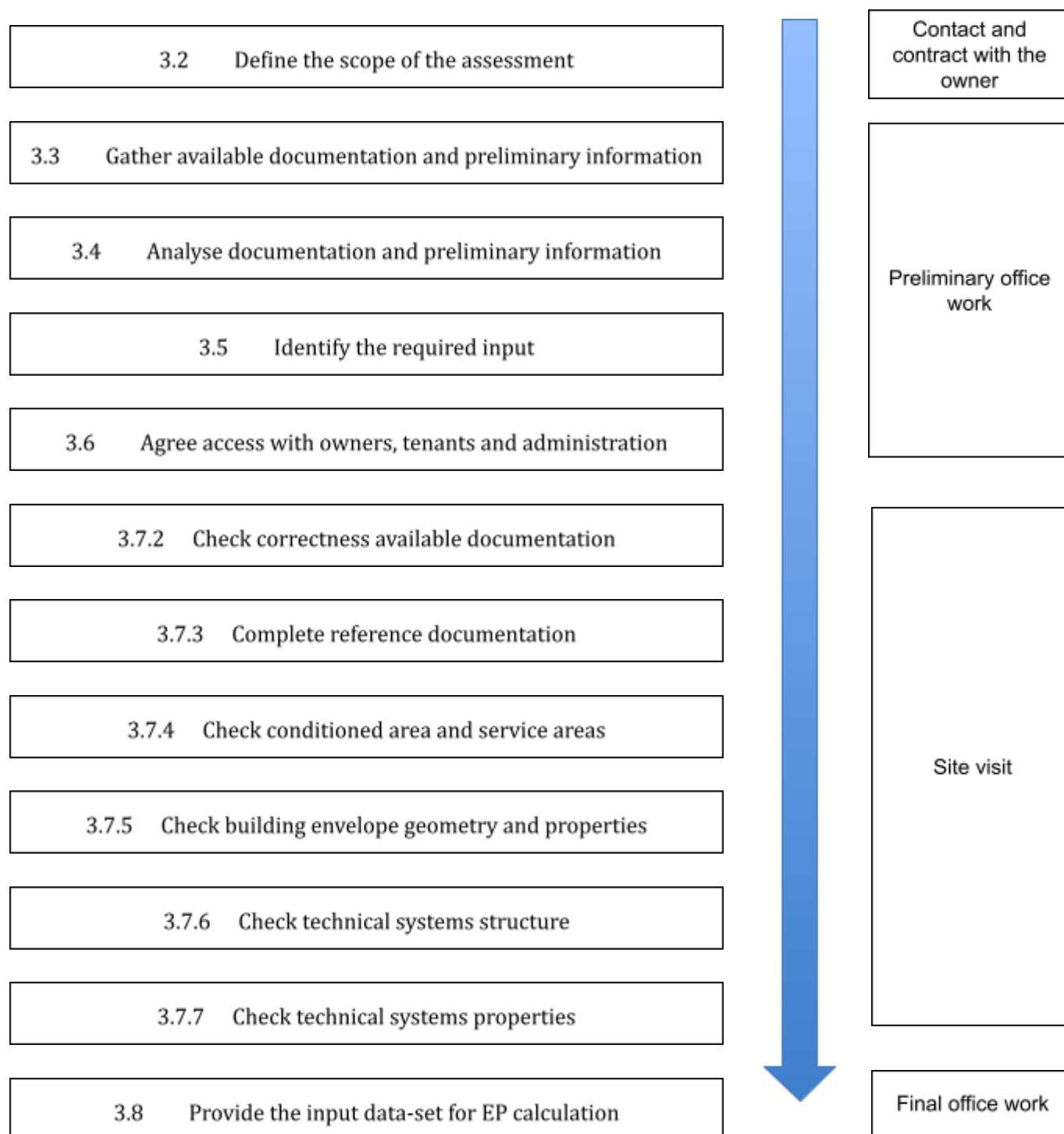
E-8	Support of (micro)grid operation modes	☐ ____% None ☐ ____% Automated management of (building-level) electricity consumption based on grid signals ☐ ____% Automated management of (building-level) electricity consumption and electricity supply to neighbouring buildings (microgrid) or grid ☐ ____% Automated management of (building-level) electricity consumption and supply, with potential to continue limited off-grid operation (island mode)
E-11	Reporting information regarding energy storage	☐ ____% No electricity storage ☐ ____% None ☐ ____% Current state of charge (SOC) data available ☐ ____% Actual values and historical data ☐ ____% Performance evaluation including forecasting and/or benchmarking ☐ ____% Performance evaluation including forecasting and/or benchmarking; also including predictive management and fault detection
E-12 ____	Reporting information regarding electricity consumption	☐ ____% None ☐ ____% reporting on current electricity consumption on building level ☐ ____% real-time feedback or benchmarking on building level ☐ ____% real-time feedback or benchmarking on appliance level ☐ ____% real-time feedback or benchmarking on appliance level with automated personalized recommendations
EV-15	EV Charging Capacity	☐ ____% not present ☐ ____% ducting (or simple power plug) available ☐ ____% 0-9% of parking spaces has recharging points ☐ ____% 10-50% of parking spaces has recharging point ☐ ____% >50% of parking spaces has recharging point

EV-16	EV Charging Grid balancing	☐ ____% Not present (uncontrolled charging) ☐ ____% 1-way controlled charging (e.g. including desired departure time and grid signals for optimization) ☐ ____% 2-way controlled charging (e.g. including desired departure time and grid signals for optimization)
EV-17	EV charging information and connectivity	☐ ____% No information available ☐ ____% Reporting information on EV charging status to occupant ☐ ____% Reporting information on EV charging status to occupant AND automatic identification and authorization of the driver to the charging station (ISO 15118 compliant)
MC-3	Run time management of HVAC systems	☐ ____% Manual setting ☐ ____% Runtime setting of heating and cooling plants following a predefined time schedule ☐ ____% Heating and cooling plant on/off control based on building loads ☐ ____% Heating and cooling plant on/off control based on predictive control or grid signals
MC-4	Detecting faults of technical building systems and providing support to the diagnosis of these faults	☐ ____% No central indication of detected faults and alarms ☐ ____% With central indication of detected faults and alarms for at least 2 relevant TBS ☐ ____% With central indication of detected faults and alarms for all relevant TBS ☐ ____% With central indication of detected faults and alarms for all relevant TBS, including diagnosing functions
MC-9	Occupancy detection: connected services	☐ ____% None ☐ ____% Occupancy detection for individual functions, e.g. lighting ☐ ____% Centralised occupant detection which feeds in to several TBS such as lighting and heating

MC-13 Central reporting of TBS performance and energy use	☐ ____% None ☐ ____% Central or remote reporting of real-time energy use per energy carrier ☐ ____% Central or remote reporting of real-time energy use per energy carrier, combining TBS of at least 2 domains in one interface ☐ ____% Central or remote reporting of real-time energy use per energy carrier, combining TBS of all main domains in one interface
MC-25 Smart Grid Integration	☐ ____% None - No harmonization between grid and TBS; building is operated independently from the grid load ☐ ____% Demand side management possible for (some) individual TBS, but not coordinated over various domains ☐ ____% Coordinated demand side management of multiple TBS
MC-28 Reporting information regarding demand side management performance and operation	☐ ____% None ☐ ____% Reporting information on current DSM status, including managed energy flows ☐ ____% Reporting information on current historical and predicted DSM status, including managed energy flows
MC-29 Override of DSM control	☐ ____% No DSM control ☐ ____% DSM control without the possibility to override this control by the building user (occupant or facility manager) ☐ ____% Manual override and reactivation of DSM control by the building user ☐ ____% Scheduled override of DSM control (and reactivation) by the building user ☐ ____% Scheduled override of DSM control and reactivation with optimised control

MC-30	Single platform that allows automated control & coordination between TBS + optimization of energy flow based on occupancy, weather and grid signals	□ ____%	None
		□ ____%	Single platform that allows manual control of multiple TBS
		□ ____%	Single platform that allows automated control & coordination between TBS
		□ ____%	Single platform that allows automated control & coordination between TBS + optimization of energy flow based on occupancy, weather and grid signals

Annex A – Data collection flow chart



Energy audit flow chart, for comparison: not so much detailed and some iterations
It will be removed in the final text

