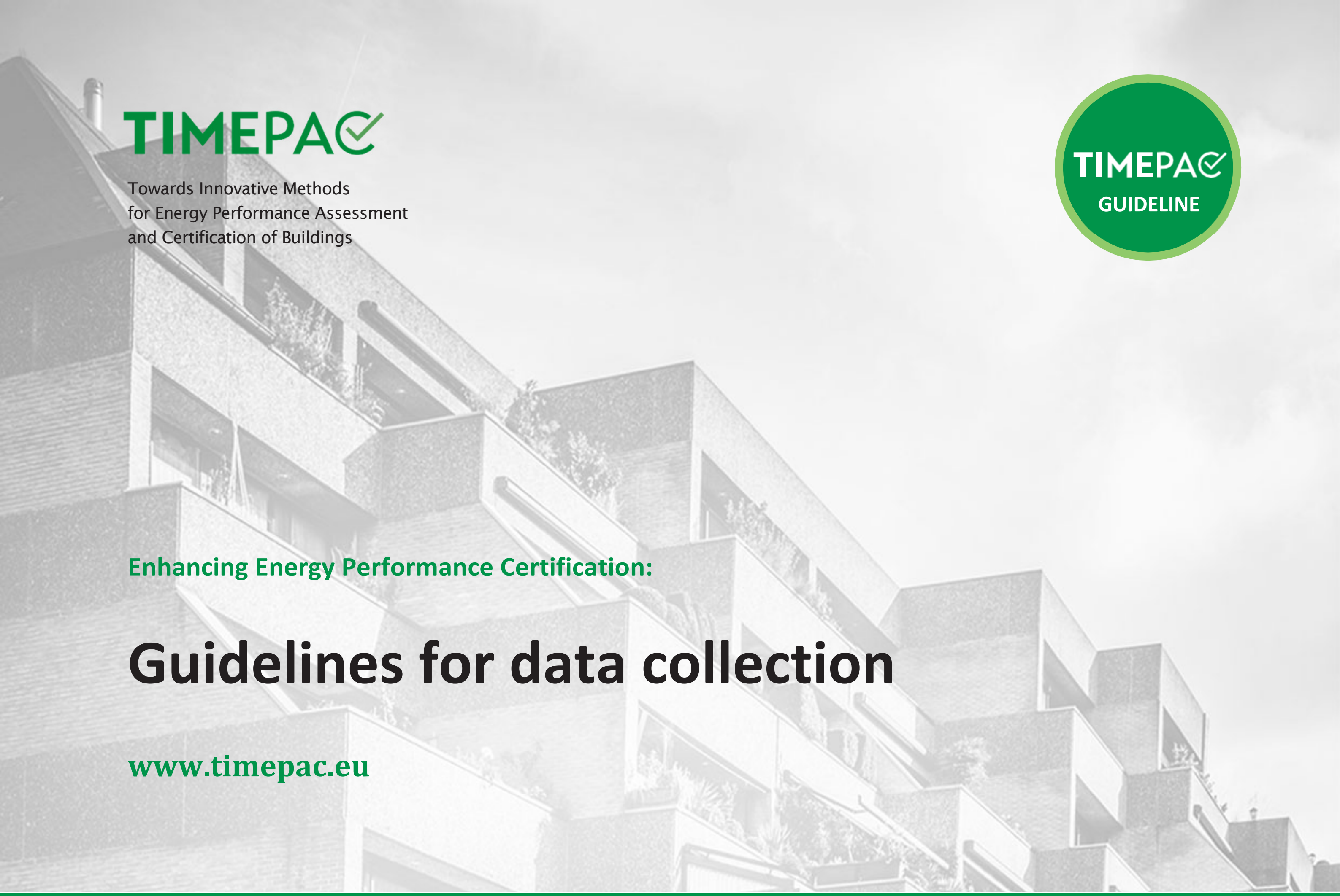

Towards Innovative Methods
for Energy Performance Assessment
and Certification of Buildings

TIMEPAC GUIDELINE

Enhancing Energy Performance Certification:

Guidelines for data collection

www.timepac.eu

TIMEPAC aims to modernize building certification practices according to the latest Energy Performance of Buildings Directive (EPBD) review. The guidelines series provides recommendations for stakeholders involved in building certification to improve their working procedures to meet the objectives of the Directive.

These guidelines aim to improve Energy Performance Certificates (EPCs) by integrating operational data, including geographical and climatic information, building geometry, thermal properties of components, technical building systems, operating conditions, performance metrics, and economic data. This information will be used to create a Building Energy Model (BEM) for assessing building energy performance, as well as for further analysis to support the development of an enhanced EPC.

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TIMEPAC "Guidelines for data collection"

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1. Introduction to the guidelines

The enhancement of the EPC schema through the integration of operational data is approached by proposing new Key Performance Indicators (KPIs). These KPIs were selected based on different analyses conducted during the TIMEPAC project, aiming to find a balance between ease of implementation and added informational value in the EPC. Specifically, the required analyses include:

1. Standard Energy Performance Assessment (SEPA),
2. Tailored Energy Performance Assessment (TEPA),
3. Calibration of TEPA against monitored data (CAL),
4. Economic evaluation of energy efficiency measures (ECM),
5. Indoor Environmental Quality evaluation (IEQ),
6. Building Automation and Control System impact assessment (BACS).

All analyses to be performed require the creation of a Building Energy Model (BEM), which necessitates the collection of various input data need. Moreover, specific data are required for conducting each analysis. The following list presents the categories of data to be collected for creating the BEM and for performing the analyses:

1. *Geographical and climatic data*: Required to specify the building's location and surroundings (e.g., presence of external obstacles) as well as outdoor environmental parameters (e.g., air temperature, solar irradiance).
2. *Geometrical characteristics*: required to define the dimensions of the building (e.g., floor area, internal height, etc.) and of its components (e.g., external and internal opaque and transparent components).
3. *Thermal properties of building components*: Required for determining thermal parameters (e.g., thermal transmittance, thermal capacity) of external and internal opaque and transparent components,
4. *Technical building systems (TBSs) characteristics*: Required to specify the presence, typology, and properties of TBSs for each energy service.
5. *Operating conditions*: Required to define the user behaviour regarding building/room occupancy, TBS control, appliance use, window openings, and the use of solar shading devices.
6. *Monitored data on building performance*: Include indoor environmental data, performance parameters of TBS components, and energy consumptions for each energy service and/or energy carrier.
7. *Economic data*: Cover the costs associated with each energy carrier and the cost of refurbishment.

According to the availability of the input data, and to the analysis to be performed, the required input data can be either *real* data, *conventional* (standard) data, which are data derived from technical standards, and/or *reference* data, which are data derived from similar buildings. The use of real, conventional, or reference data is presented in the following table.

Type of data to be used for the different analyses						
	Standard *EP* assessment	Tailored *EP* assessment	Model calibration	ECM assessment	IEQ assessment	BACS impact assessment
General information	Real	Real	Real	Real	Real	Real
Geographical and climatic data	Conventional (standard)	Conventional (standard)	Real	Conventional (standard)	Conventional (standard)	Conventional (standard)
Geometrical characteristics	Real	Real	Real	Real	Real	Real

Thermal parameters of building components	Real or reference	Real or reference	Real or reference	Real or reference	Real or reference	Real or reference
TBSs characteristics	Real or reference	Real or reference	Real or reference	Real or reference	Real or reference	Real or reference
Operating conditions	Conventional (standard)	Real	Real	Real or conventional	Real or conventional	Real or conventional
Monitored data on building performance	/	/	Real	/	/	/
Economic data	/	/	/	Real or reference	/	/

2. Geographical and climatic data

2.1 Data to be collected

Geographical and climatic data are requested to define characteristics of the building's surroundings – specifically, the presence of external obstacles that may shade the building, as well as outdoor environmental parameters.

The geographical data to be collected include, but are not limited to:

- Geographical location (latitude, longitude, and altitude), and/or building address
- Presence and characteristics of external shading obstacles (height and position)

The climatic data to be collected include, but are not limited to:

- Climatic region
- Aggregated climatic data (e.g., heating degree days, cooling degree days, etc.)
- Weather data (e.g., outdoor air temperature)

2.2 Data sources and data collection procedure

Generally, the required geographical data can be derived from available documentation (e.g., an existing energy performance certificate, a BIM model, etc.) or from web mapping platforms.

Among geographical data, the building's altitude is particularly important for the possible correction of the weather data (detailed later in the guideline). If latitude, longitude, and altitude are not provided in existing documentation, they can be derived from web mapping platforms using the building address. However, this step is optional and can be omitted for privacy considerations.

Characterisation the building's surroundings is also relevant. Specifically, it is necessary to identify any objects that may cast shadows on the building (e.g., other buildings, trees) and to describe them. Data sources and procedures for collecting these data are provided in Section 2.2.1.

For climatic data, the climatic region (if required) can be identified based on national documentation specific to the city in which the building is located. As for weather data, it is preferable to collect the specific, rather than aggregated, weather data. Data sources and procedures for obtaining specific weather data are outlined in Section 2.2.2.

2.2.1 Characterisation of the building's surrounding

The presence and characteristics (height and distance from the building) of external shading obstacles can be determined using the following data sources:

1. City or district plans
2. Web mapping platforms (e.g., Google Maps)
3. On-site inspections
4. In field measurements

City (or district) plans are typically the easiest way to identify nearby shading obstacles. These plans generally provide information on surrounding buildings but may not include other objects, such as trees, for which additional data sources should be consulted.

In most cases, city and district plans (see Figure 1 for an example) indicate the number of storeys of nearby buildings. By assuming an average storey height typical for the area, the height of the surrounding buildings can be estimated. If a digital version of the plan is available (e.g., CAD), distances between the analysed building and its surroundings can be measured directly. For printed plans, converting them to digital format first is recommended to facilitate distance measurement.

When city or district plans are unavailable or if other types of obstacles are present, web mapping platforms can be used. These platforms allow the identification and measurement of objects' distances from the analysed building through 2D views, which can be converted to digital drawings (e.g., CAD) for precise measurements. Additionally, 3D views on these platforms can help estimate building heights by counting storeys or deriving an "apparent" number of storeys for other obstacles.

If neither 2D nor 3D views are available, necessary data can be gathered through on-site inspections (presence of shading obstacles, number of storeys) and field measurements (height and distance).

Lastly, on-site inspections can be helpful to verify that collected data align with actual conditions.

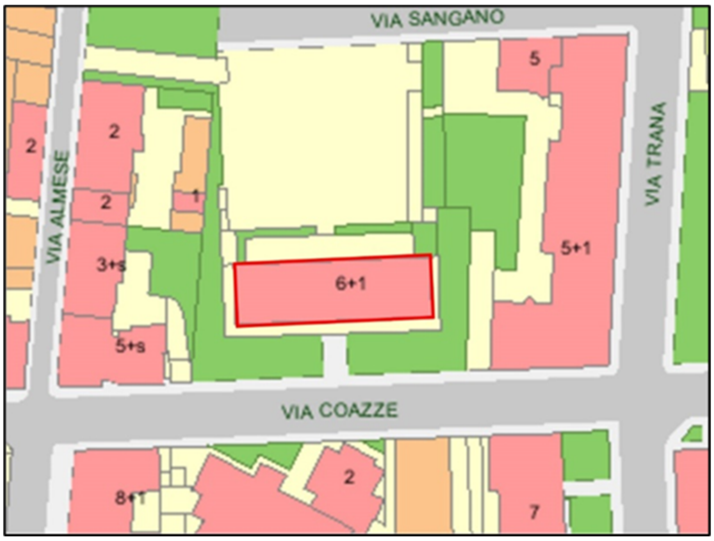

Figure 1. Example of city (or district) plan with indication of the buildings' number of storeys.

2.2.2 Weather data

The required weather data generally include external air temperature (dry and/or wet bulb), solar irradiance (horizontal and by orientation), relative humidity, wind speed, and wind direction. These data can be obtained from the following (but not limited to) data sources:

- On-site measurements: Real data recorded at the building location
- Meteorological stations: Real data recorded nearby or at the building location
- Technical standards: Standardized data for the building location.

For on-site measurements, recorded data need to be processed to match the temporal resolution of the calculation method (and checked for recording errors). For instance, if an hourly calculation method is used and weather data are recorded at sub-hourly intervals (e.g., every 10 minutes), the data should be adjusted to produce hourly values. This can be done by taking a single representative value for each hour (e.g., the recording at 12:00 representing 12:00–13:00) or by averaging all values within each hour.

When using data from meteorological stations or technical standards, preliminary checks are needed. Ideally, the weather data should come from the closest available climatic station (or standard location) to the building. Additionally, data from these sources should be adjusted for altitude differences between the climatic station (or standard location) and the building's location, following correction procedures provided by national standards. Temporal consistency between the climatic data and calculation method should also be ensured.

For model calibration, weather data must be real data recorded on-site or obtained from nearby meteorological stations. The weather data should cover the same intervals as those used for model calibration. For example, if energy consumption data are monitored from October 2017 to April 2018, weather data should cover the same period. In this case as well, temporal consistency weather climatic data and calculation method must be verified.

2.2.2.1 Generation of customised epw weather file

1. It is recommended to start from an EnergyPlus weather file for the building's location, which can be accessed here: https://energyplus.net/weather-region/europe_wmo_region_6. After selectin the country, choose the specific city. Often, multiple weather file sources are available for the same city; it is recommended to select the IWEC weather file source (Figure 2), and download the EPW weather file (Figure 3).

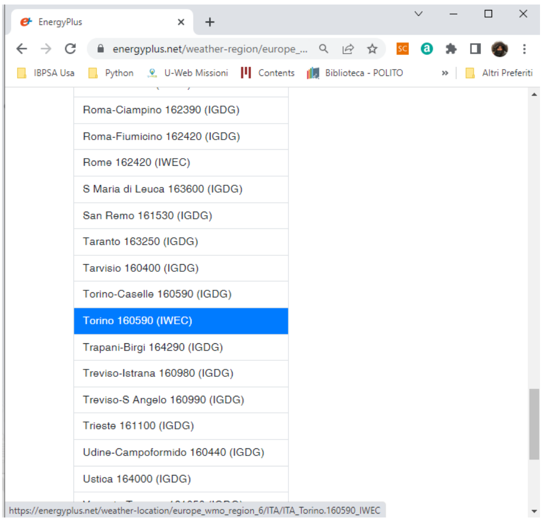

Figure 2. IWEC weather file source.

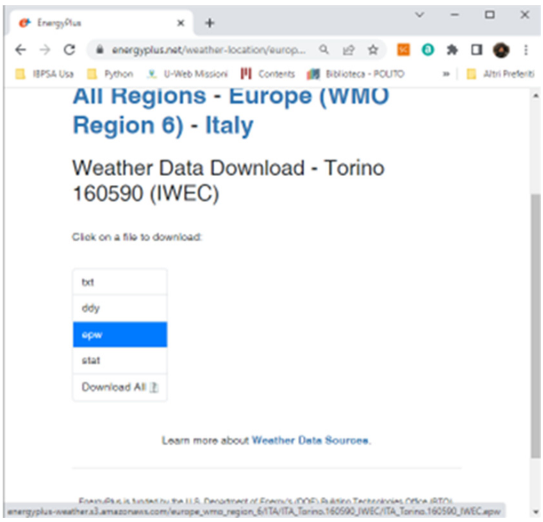

Figure 3. epw weather file.

2. For the following steps, it is mandatory to set Excel with dots (.) as decimal separator, and commas (,) as column separator, and to set the PC's date and hour format as U.S. format (e.g., hh:mm AM/PM, month/data/year).

3. Open the EnergyPlus's Weather Statistics and Conversions tool – automatically installed with EnergyPlus (Figure 4), then:

   a. Select the file to be converted, which is the downloaded epw weather file.

   b. Data type: the tool will automatically detect the EnergyPlus / ESP(r) format.

   c. Select Output Format: choose the CSV format for EPW data,

d. Then Save File As…

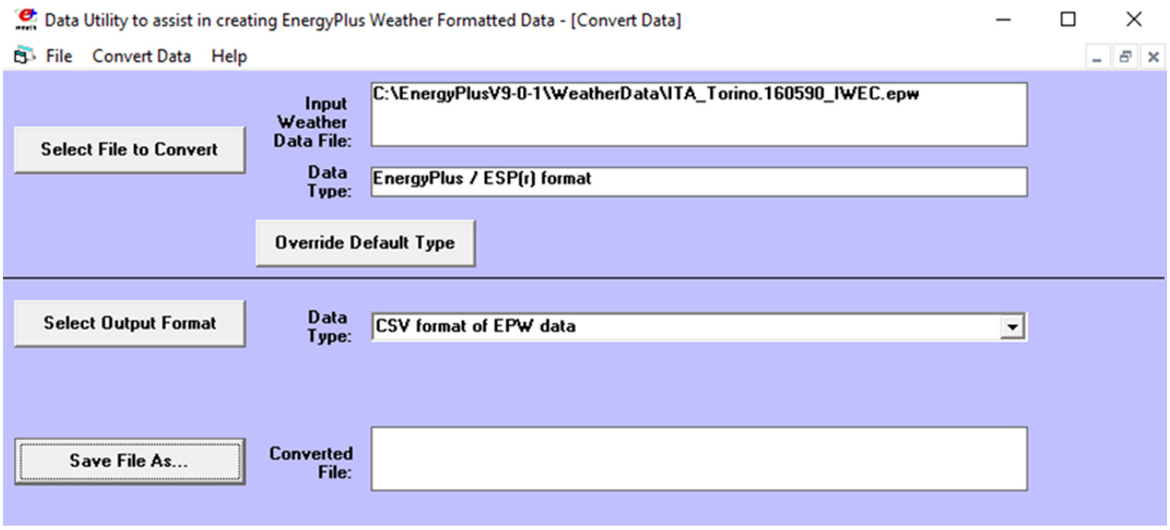

Figure 4. EnergyPlus Weather Statistics and Conversions tool.

4. Open the .csv file in MS Excel, replace the recorded weather data with updated value for the specific periods, and save the file. For any unavailable weather data, keep the existing values present in the .csv file.

5. Once the .csv weather file is modified, it neds be converted back to epw format. To do this, open the Weather Statistics and Conversions tool again, then:

   a. Select the file to be converted: this is the modified .csv weather file. When you open the .csv file, an error message will appear (Figure 5),

   b. Override default data type: select EnergyPlus Comma Separated Variable (CSV) format,

   c. Select Output Format: select EnergyPlus weather format (EPW),

   d. Save File As…

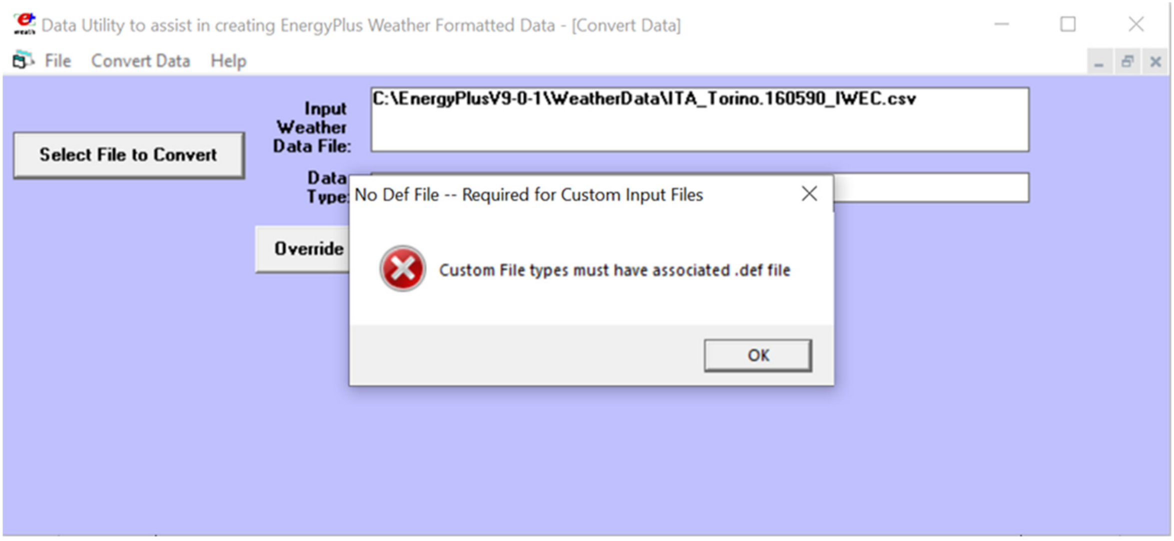

Figure 5. EnergyPlus Weather Statistics and Conversions tool error message.

6. The epw weather file is now ready and can be used in the EnergyPlus simulations. You may reset the Excel and date/hour formats to their default settings.

3. Geometrical characteristics

3.1 Data to be collected

The geometrical characteristics are necessary to define the building's spatial features. The geometrical data to be collected include, but are not limited to, the following parameters:

- Gross and net floor area (at least for each thermal zone)
- Floor-to-ceiling height
- Gross heated space volume
- Envelope area
- Envelope components dimensions (for each opaque and transparent component)
- Envelope components orientation (for each opaque and transparent component)
- Presence of fixed solar shading devices, such as overhangs or side fins (for each opaque and transparent building envelope component)

3.2 Data sources and data collection procedure

All the required information can be obtained from the following data sources (among others):

1. Provided documentation (e.g., building plans, EPC, BIM)
2. On-site inspections and field measurements (real data recorded on building site)

The first approach, which is more straightforward and less time-consuming, involves analysing available building documentation such as plans, EPCs, BIM models. Although simple, this method may present challenges due to potential inaccuracies in the documents analysed.

The second approach involves on inspections and field measurement of relevant information. This method is the most reliable but also the most time- and cost-intensive.

Moreover, depending on the calculation method, the geometrical characteristics may be defined as gross external, gross internal, or net internal dimensions (Figure 6).

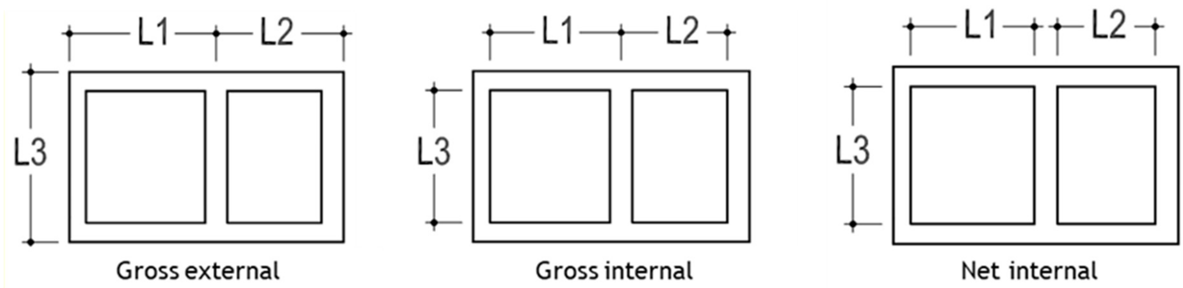

Figure 6. Different geometrical characteristic dimensions.

4. Thermal properties of building components

4.1 Data to be collected

The thermal properties of building components are necessary to define the thermal parameters for both external and internal opaque and transparent components. The thermal data to be collected include, but are not limited to, the following parameters:

- Thermal properties of opaque building components, specifically:
  - Thermal parameters of each opaque component
  - Layers and materials composing each opaque component
  - Thermal properties of the layers' materials
- Thermal properties of transparent building components (window and solar shading devices), specifically:
  - Thermal parameters of each transparent component
  - Presence and characterisation of movable solar shading devices

4.2 Data sources and data collection procedure

To facilitate the collection of required data for the building envelope, it is recommended to first create an abacus of all components characterizing the building envelope, including both opaque and transparent components. This abacus should identify each type of wall, door, roof, floor, window, etc., along with their geometrical properties (e.g., area, orientation, presence of external shading obstacles) and any solar shading devices, specifying type and position for transparent components.

4.2.1 Opaque component characterisation

Depending on the adopted calculation method, the characterisation of opaque envelope components may include:

- Aggregated thermal parameters (e.g., thermal transmittance)
- Definition of layers (materials) composing each opaque component.

The aggregated thermal parameters of each opaque component can be derived from several sources, including:

1. Calculation (simplified): Requires knowledge of component layers and materials (refer to the following sections if layers are unknown), following the EN 6946 standard.
2. Provided documentation or technical sheets: Such as design documentation or energy audit reports. Verify data to ensure values are within physically reasonable ranges.
3. Inference rules: Apply when only general information is available, by identifying a similar component or building and extrapolating the data.
4. In-field measurements: Using a calorimeter or heat flow meter to monitor the thermal flow through walls and surface temperatures over time.

To determine the layers and materials of opaque components, the following sources are useful:

1. Provided documentation or technical sheets: Includes design documentation, energy audit reports, BIM models, XML data, etc.
2. Inference rules: To estimate layers when detailed documentation is unavailable.
3. In-site inspection: Using an endoscope through a small hole or core drilling to examine materials directly.

If material thermal properties are unknown, they can be obtained from technical sheets or technical standards.

4.2.2 Transparent component characterisation

For transparent envelope components, characterization can include:

- Aggregated thermal parameters (e.g., thermal transmittance, *g*-value or *SHGC*)
- Definition of the layers (e.g., glass, air gap) of each transparent component

The aggregated thermal parameters can be derived obtained from:

1. Calculation (simplified): Requires detailed layer and material knowledge (refer to sections below if unknown), using the EN ISO 10077-1 standard.
2. Provided documentation: Sources like design documentation or energy audit reports; ensure values fall within a physically plausible range.
3. Inference rules: Suitable when only general component information is available, by identifying similar components and applying their data.
4. In-field measurements: Using tools like a calorimeter or heat flow meter to monitor long-term thermal flow through walls and surface temperatures.

The layers and materials for transparent components can also be found in design documentation, energy audit reports, BIM models, XML data, etc. If thermal properties are missing, technical sheets or standards provide the necessary data.

Solar shading devices

It is important to identify and characterise any solar shading devices. Details for these devices can be obtained from technical sheets, provided documentation, or standards based on the device type (e.g., internal or external shades, blinds).

5. Technical building systems (TBSs) characteristics

5.1 Data to be collected

The characteristics of the technical building systems (TBSs) are needed to accurately define the behaviour of all components that manage various building services. The first step in analysing TBSs is identifying the system macro-categories associated with available services, such as heating, cooling, and lighting. For each service, it's necessary to define all properties related to emission, control, distribution, and the operational timing of the different components.

5.2 Data sources and collection procedure

Data for TBSs can be gathered primarily through inspection and analysis of building documentation. The specific sources and methods vary depending on the level of detail needed, as explained in the following sections.

5.2.1 Type of TBSs installed in the building

The first step in specifying the technical building systems is identifying the available services in the building, either through on-site inspection or by analysing existing documentation. Services can be divided into two main categories:

1. Hygrothermal control services (e.g., heating, cooling, ventilation).
2. Non-hygrothermal control services (e.g., domestic hot water, lighting, transportation within the building).

5.2.2 Characteristics of the sub-systems for each TBS

Each TBS includes several sub-systems, such as emission, control, distribution, storage, and generation. A TBS may include multiple sub-systems, depending on its specific configuration. For example, storage sub-systems may not always be present, while generation systems may serve multiple TBSs (e.g., a reversible heat pump used for both heating and cooling or heating and domestic hot water). Generation systems can also be on-site, nearby, or off-site.

To assess the properties of each sub-system, each TBS should be examined individually, either from emission to generation or in the reverse direction (Figure 7).

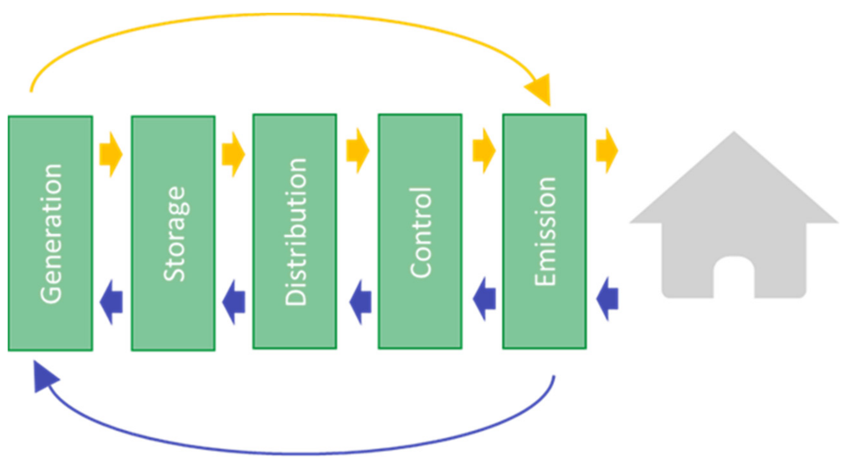

Figure 7. Analysis direction of the main TBSs sub-systems.

The properties of each sub-system can be determined in one of two ways:

- Inspection: Direct inspection and measurement allow for precise assessment of available technologies and sub-system properties. However, this process can be costly, time-intensive, and challenging, especially when sub-systems are integrated within the building structure (e.g., distribution pipes embedded in walls or floors).
- Documentation Analysis: Analysing building documentation (e.g., plans, EPC) is often more efficient and straightforward, as it provides relevant properties quickly. However, this method may not account for variations due to system aging and can lead to inaccurate conclusions if the documentation is outdated.

If only general information about a sub-system is available (e.g., component name), the technician should obtain detailed technical sheets, either from online research or by contacting the manufacturer. This information is essential for verifying the necessary specifications.

In the case of refurbishment scenarios, the required data should be derived from technical sheets.

6. Operating conditions

6.1 Data to be collected

Operating conditions help define user behaviour in relation to room or thermal zone presence, system controls, appliance use, window openings, and solar shading device usage. Key parameters to collect include:

- Occupancy:
  - Number of occupants (or occupant heat gains) for each room, thermal zone, or entire building.
  - Occupancy schedule for each room, thermal zone, or building.
- Windows opening (natural ventilation):
  - Ventilation air flow rate for each room, thermal zone, or building.
  - Windows opening schedule for each room, thermal zone, or building.
- Appliance usage:
  - Heat gains from appliance use in each room, thermal zone, or building.
  - Occupancy schedule for each room, thermal zone, or building.
- Solar shading devices and shutters management:
  - Solar shading devices activation schedule (for each room, thermal zone, or whole building, or specific orientation).
  - External shutters activation schedule.
- TBSs management:
  - Operational time of TBSs,
  - Internal set-points (for heating, cooling, etc.).

6.2 Data sources and collection procedure

6.2.1 Occupancy

To accurately model building energy use, occupancy data must be defined as either number of occupants or internal heat gains depending on the calculation method. Occupancy data and schedules should be developed for each room, thermal zone, or the entire building, depending on modelling requirements.

Data sources for occupancy definition

The number of occupants can be obtained from the following data sources:

1. Provided documentation: Offers design values representing the maximum number of occupants, typically used for each room, zone, or the entire building.
2. Interviews with the users or the building energy manager: Gathers realistic occupant numbers and usage patterns from users or the building energy manager, enabling a more accurate distribution of occupants over the operational period.
3. Technical standards (EN ISO 16798-1): Acts as a reference source when documentation and interview data are unavailable, providing maximum occupancy values by building type.

Interviews or direct documentation provide the most relevant and tailored data, while technical standards serve as a reliable baseline when no other information is available.

Steps to generate occupancy schedules

For hourly or sub-hourly calculation methods, occupancy schedules are required. These schedules outline the variation in occupant numbers or internal gains throughout the day.

If interviews are available, the questionnaire data collection should:

- Collect responses on occupancy hours for typical weekdays and weekends.
- Include special conditions, such as lunchtime occupancy for offices.

Figure 8 presents an example of questionnaire to the users of an office building, used to derive the occupancy schedule.

Floor	Working hours					Midday hours				
	Monday	Tuesrday	Wednesday	Thursday	Friday	Monday	Tuesrday	Wednesday	Thursday	Friday
1	8 or more	8 or more	8 or more	8 or more	8 or more	Yes	Yes	Yes	Yes	Yes
1	8 or more	6	8 or more	6	6	Yes	Yes	Yes	Yes	Yes
1	8 or more	6	8 or more	6	6	Yes	Yes	Yes	Yes	Yes
1	8 or more	8 or more	8 or more	8 or more	8 or more	Yes	Yes	Yes	Yes	Yes
1	8 or more	7	8 or more	7	7	Yes	Yes	Yes	Yes	Yes
1	8 or more	6	8 or more	6	6	Yes	Yes	Yes	Yes	Yes
1	8 or more	6	8 or more	6	6	Yes	Yes	Yes	Yes	Yes
1	8 or more	6	8 or more	6	6	No	No	No	No	No
1	8 or more	6	8 or more	6	6	Yes	Yes	Yes	Yes	Yes
1	8 or more	6	8 or more	6	6	Yes	No	Yes	No	No
1	8 or more	7	8 or more	7	6	Yes	Yes	Yes	Yes	Yes

Figure 8. Questionnaire answers in terms of number of working hours and presence during the lunchbreak.

The occupancy schedule should be generated from the results of the questionnaires, following these steps:

1. Max Occupancy Derivation: Establish the maximum number of occupants in each space on an hourly (or sub-hourly) timestep for weekdays and weekends.
2. Occupancy Fraction Calculation: Calculate the occupancy fraction for each timestep by dividing the number of occupants at a given time by the maximum occupancy.
3. Typical Day Schedules: Create separate schedules for a typical weekday and weekend day by averaging occupancy fractions for each timestep, if available.

The temporal discretisation of the schedules must be coherent with the calculation method timestep.

If interviews are unavailable, occupancy schedules can be based on the EN ISO 16798-1 technical standard.

6.2.2 Natural ventilation

According to the calculation method adopted, the definition of natural ventilation may be performed by defining the air flows (air changes per hours, etc.) or the windows opening profiles.

If the ventilation air flow is required, it should be defined for each room, thermal zone, or whole building, according to the modelling requirements.

The ventilation airflow rate can be derived through the following (but not limited to) data sources:

1. In-field measurements: The most accurate method, where actual air flows are measured using airflow meters or similar devices.
2. Technical standards: (If in-field measurements are not available, use minimum airflow rates defined by technical standards, such as EN ISO 16798-1, which specifies minimum airflow rates for indoor air quality based on building use (e.g., office, residential, etc.).

In case of hourly or sub-hourly calculation methods, the ventilation schedule is required, and it can be derived through the following (but not limited to) data sources:

1. Interviews with the users or the building energy manager,
2. Assumed equal to the occupancy schedule.

Generally, if an interview with the users is allowed, it is useful to ask for how many hours the windows are kept open and in which part of the day (e.g., 1 hour in the morning). Starting from these results, the ventilation schedule can be generated following the steps presented in Section 6.2.1 (Occupancy).

If interviews are not allowed, the ventilation schedule can be assumed equal to the occupancy schedule.

6.2.3 Use of appliances

Generally, the definition of the use of appliances is performed by defining the internal heat gains (from the use of the appliances) and the use of appliances schedules. The internal heat gains can be derived through the following (but not limited to) data sources:

1. Calculated from the number and type of appliances installed in the room,
2. Technical standards.

The number and type of appliances installed in the room can be derived from the provided documentation or from interviews with the users. Then, the heat gains derived from the use of such appliances can be calculated taking the specific heat gain of each type of appliance (e.g., from the ASHRAE Fundamentals). Alternatively, the heat gains derived from the use of the appliances can be derived from the EN ISO 16798-1 technical standard.

In case of hourly or sub-hourly calculation methods, the use of appliances schedule is required, and it can be derived through the following (but not limited to) data sources:

1. Interviews with the users or the building energy manager,
2. Assumed equal to the occupancy schedule,
3. Technical standards (EN ISO 16798-1).

Generally, if an interview with the users is allowed, it is useful to ask for how many hours the appliances are used at full power or kept in stand-by (e.g., 1 hour in the morning of full power, and 6 hours in stand-day). Starting from these results, the ventilation schedule can be generated following the steps presented in Section 6.2.1 (Occupancy). If interviews are not allowed, the use of appliances schedule can be assumed equal to the occupancy schedule, or it can be derived from the technical standards, according to the building use. It is suggested to refer to the EN ISO 16798-1 technical standard.

6.2.4 Solar shading devices and shutters management

The definition of the use of solar shading devices is of foremost importance for the control of solar heat gains. Generally, only the schedule of activation of the solar shading devices is required. This can be derived through the following (but not limited to) data sources:

1. Rule-based activation (provided documentation, or interviews with the users),
2. Interviews with the users or the building energy manager,
3. Technical standards.

The most accurate way to model the activation of the solar shading devices is by considering different criteria that rules their activation. These can be simple rules (such as a threshold for the incident solar irradiance on the window) or complex rules that consider different domains (e.g., visual and thermal comfort). The adoption of a specific rule can be derived from the provided documentation (design documentation of the shading devices) or, most commonly, from interviews with the users.

If the solar shading devices are not rule-based activated, a schedule of activation can be derived from interviews with the users. According to the information derived from the interviews, it is possible to create the schedules of activation. Finally, if interviews are not allowed, the activation schedule can be derived from the technical standards.

On the other hand, the external shutters are generally assumed to be activated during the night hours. In absence of any solar shading devices installed in the building, the shutter may be used as shading devices, and modelled according to the procedures presented above.

6.2.5 TBSs management

The management of the technical building systems is generally performed by controlling the operational time and the set-points (temperatures, humidity, etc.).

The operation time can be determined by the analysis of the actual use through either survey performed on the users, or the analysis of the energy consumed by each TBS. While these procedures can provide high-quality data, they both present some possible issues. The surveys are based on user-given information and therefore the reliability can be low. The energy consumption analysis, on the other hand, may be available not differentiated by each TBS but by energy carrier and, in case of more than one TBS using the same energy carriers the operation time can be impossible to derive from it. In case these procedures are not followable information, and standard values can be derived both from the legislation (e.g., if the length of the heating/cooling seasons is mandatory by national law) or from international standards (e.g., in the EN 16798-1 technical standard the daily operation profiles can be determined as a function of the building intended use).

As regards the set-points, these can be derived through the following (but not limited to) data sources:

1. Provided documentation
2. Interviews with the users or the building energy manager
3. Technical standards
4. In-field measurements

In case of model calibration activities, the set-points should be obtained for each measurement interval of the energy carriers within the heating or cooling season.

7. Monitored data on building performance

7.1 Data to be collected

Monitoring various data and parameters related to building performance is essential, especially for model calibration activities. The data to be collected for calibration include, but are not limited to:

- Indoor environmental data
- Performance parameters of Technical Building System (TBS) components
- Energy consumptions data

7.2 Data sources and data collection procedure

Building performance data can be monitored for multiple purposes, such as deriving necessary input data (as outlined in previous sections) or for model calibration. The specific data collection procedure depends on the type of data being monitored. Here, we focus on the specific procedure for collecting energy consumption data (Section 7.2.1).

7.2.1 Energy consumption

Energy consumption data are crucial to determine the actual energy costs associated with a building, especially in the context of model calibration. It is essential to differentiate between energy consumption for each energy service and carrier.

Generally, energy consumption can be determined through:

1. Meter readings: Sources can include scheduled readings, maintenance and inspection reports, logbooks, and BACS (Building Automation and Control Systems) records.
2. Bill analysis: When analysing invoices, it's crucial to check the period covered by the consumption data, as billing periods may differ from actual consumption dates. Additionally, confirm if the consumption is based on actual readings or estimates.

For calibration purposes, estimation techniques and forecasted data cannot be used.

To ensure data quality, it is recommended that measurements cover a minimum period of three years. In preparation for energy consumption data collection, it is essential to identify all generators, devices, and appliances, including those not directly related to the building's energy performance.

8. Economic data

8.1 Data to be collected

Economic data collection is essential for defining the costs involved in the economic analysis. This requires determining the prices associated with energy carriers and the costs of the various energy efficiency measures planned within the refurbishment scenarios.

8.2 Data sources and collection procedure

There are two main ways to gather economic data: conducting a market analysis or consulting local or national documentation. The specific sources and procedures may vary depending on the level of analysis, as outlined in the following sections

8.2.1 Specific cost for each energy carrier

The primary method for determining the cost of energy carriers is through analysis of the building's energy bills. This approach is the most reliable, as it accurately reflects the actual energy costs relevant to the building's characteristics, such as geographical location and the size of its technical building systems (TBSs).

Another approach is to conduct a market analysis by examining bills and expenses of similar buildings in terms of size, usage, and climate.

A third option involves using local or national reports that provide average costs for energy carriers. While these reports are helpful in estimating cost magnitudes, they are less effective for precise cost assessments.

8.2.2 Specific cost of different energy efficiency measures (EEMs)

Knowing the specific costs of different EEMs is essential for accurately assessing refurbishment scenarios.

Two methods are available to determine EEM costs: using local or national price lists or performing a market analysis.

The first method is straightforward and can directly provide the cost of individual measures, assuming specific characteristics are known. However, these price lists may not always be up-to-date and thus may not accurately reflect current costs.

To address this limitation, a market analysis may be conducted. Although more time-consuming, this approach provides a more precise estimate of EEM costs. However, it can be affected by market fluctuations, making the results applicable only in the short term.

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